BOOK OF ABSTRACTS

RAMIRAN 2015

16th International Conference
Rural-Urban Symbiosis

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Rural-Urban Symbiosis

Abstract book

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Preface

Residues originate in rural and in urban systems. Many contain biogenic ingredients, e.g. food and green waste, livestock manure, feces, sewage and other sludge's, harvest residues, digestates, agro-industry residues, and more. Commonly residues are known to pollute environments, cause hygienic problems or they are cost-intensive to collect and treat. Since fossil raw materials are becoming scarce, biogenic residues are more and more a topic of utilization. Application options are manifold. They range from energetic utilization, e.g. to provide electicity and heat for households, industries and agricultural facilities, up to substantial applications ranging from bulk products such as composts and specific products like mineral fertilizers or biochemicals. A special challenge is the interface between rural and urban systems. In this context the mutual understanding is often limited, usually due to a lack of knowledge or contradicting interests.

The conference aims at providing information on the state-of-the-art and on innovations, strengthening cooperation and interconnections among different stakeholders and working out deficits as well as finding solutions for a better understanding and for improved material flows.

The abstract book contains conference contributions to following areas:

- Keynotes on interdisciplinary issues (K: 3 oral presentations)
- Quality fertilizers from residues (TA: 29 oral presentations and 22 posters)
- Sustainable soils (TB: 8 oral presentations and 6 posters)
- Advances in emission prevention (TC: 25 oral presentations and 17 posters)
- The bioresource challenge (TD: 21 oral presentations and 8 posters)
- Sustainable regions (TE: 22 oral presentations and 12 posters)
- General thematic lectures (G: 5 oral presentations)

To deepen networking and to strengthen interdisciplinary not only among researches, but also with practitioners, politicians and public, some further initiatives were included in the conference:

- Podium discussion on rural-urban symbiosis
- Science and art presentations
- Manure management post-conference workshop
- Urban gardening post-conference workshop

The conference was attended by more than 200 delegates from more than 30 countries. Additional to the abstracts, reviewed 4-page-papers are available from the RAMIRAN webpage (www.ramiran.net). Selected contributions were additionally invited for a more detailed publication in a special issue of the open-access online Journal „Energy, Environment & Sustainability".

Ina Körner
Conference Chair

About RAMIRAN

The "Recycling of Agricultural, Municipal and Industrial Residues in Agriculture Network (RAMIRAN)" is a research and expertise network dealing with environmental issues relating to the use of livestock manure and other organic residues in agriculture. RAMIRAN evolved in 1996 from the much smaller FAO Animal Waste Network, that had been active since 1978, and the scope was expanded to include other organic residues (industrial and municipal) which are used on land as organic manures and soil amendments. It is in principal a European network, but it is also open to interested experts from other parts of the world.

The network provides an invaluable means of exchanging ideas, information and experiences on topics that are becoming increasingly important at a national and international level. The main objectives of the network are to:

- Promote the exchange of methodologies, materials and processes;
- Progress knowledge on the environmental assessment of organic residues recycling in agriculture;
- Identify research priorities and initiate innovative collaborative activities that make use of the synergies resulting from the international network.

The main activity of RAMIRAN is a scientific conference organized every two years, usually attended by 150-250 participants. The RAMIRAN conferences are respected as the leading event in the field of manure and other organic residues used in agriculture in Europe. They provide an extensive overview of ongoing research and knowledge transfer activities concerning manure and other organic residues. This overview of *who is who* and *who does what* is an important prerequisite to the networking activities that RAMIRAN wants to foster.

With its participants, RAMIRAN holds a tremendous resource of knowledge and expertise in a wide range of topics across the whole of Europe and some countries in Northern America, Asia and even Oceania. The network represents a unique opportunity to mobilise this resource through network activities above and beyond the regular conferences. To use this potential, RAMIRAN fosters task groups, short-term teams with a clear task that can be achieved in a defined time of ideally 1-2 years and maximum four years. These tasks make use of the potential of RAMIRAN arising from its membership of experts. This means that, for example, surveys about management techniques, environmental, economic or social issues in connection with manure and other organic residues or interdisciplinary studies are ideal topics for such tasks. Past examples include residual Nitrogen effects from organic residues, anaerobic digestion and utilization of digestates. In 2003 and 2011 a group produced a "Glossary of Terms on Livestock Manure Management" which has proved very valuable in harmonizing the use of terms relevant to organic residues and their environmental relevance. At the 2013 conference in Versailles, it was suggested that the Glossary should be translated into different languages (a Russian version is now available) and that RAMIRAN should support its members to produce "Country Manure Profiles" providing an overview of the current practices and knowledge concerning organic residue management in the different countries.

With the special topic "Rural-Urban Symbiosis" the 16th RAMIRAN conference is focusing on closing the loop linking rural production and urban consumption systems and on the development of more sustainable solutions for the handling of residues. Once again this reflects the changing perception from waste and emissions towards benefits and resource use efficiency that has occurred throughout the lifetime of RAMIRAN. As Co-chairmen of the Network we thank the organizers for arranging this exciting and successful conference!

Tom Misselbrook and Harald Menzi
Network Coordinators

Thematic areas of RAMIRAN 2015

TA: Quality fertilizers from residues

Agricultural production depends on the supply of plants with nutrients. Efficiency in agricultural production considers not only yields, but also product qualities and fertilizer footprints. Fertilizers provide nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), and sulphur (S) as macronutrients in varying proportions and forms. Furthermore micronutrients are needed in trace amounts, which are valuable not only for plant production, but also in follow up chains such as food consumption or anaerobic digestion. Trace nutrients in many foods have declined over the last half century and rock phosphate as the main source of P fertilizers will deplete in 50-100 years. In some locations, over-fertilization leads to water contamination, while in others high fertilizer prices leads to nutrient deficiencies in soils. The main source for N fertilizers is ammonia generated via the energy intensive Haber-Bosch process from atmospheric N. It is estimated that this process alone demands around 1.4% of the world's total energy consumption. Agricultural, municipal and industrial residues contain varying quantities of N, P and other nutrients and trace elements. They are often disposed of with environmentally damaging effects or through costly treatment processes e.g. by waste water treatment or incineration.

TB: Sustainable soils

Soil is a living body. It is a complex medium comprising mineral particles, organic matter, water, air and living organisms. Soil is an essential, very slowly-renewable resource, which provides many vital ecosystem services such as food and the production of other bioresources as well as filtration and retention of toxic substances and nutrients. Demands on soil are increasing as the world population and the per capita food demand continue to grow. In addition, the pressure to reduce consumption of fossil resources has led to a growing demand to provide bioresources as alternative sources for energy and raw materials. Soil overuse is increasingly leading to soil degradation, both in the EU and at a global level up to desertification. In line with sprawling urbanization, arable land is decreasing in quantity as well as in quality. Lacking direct legislation, soil degradation is now having trans-boundary impacts along with high economic costs. One means of improving soil quality is the use of organic residues generated by human activities as soil amendments for enhancing soil carbon levels and soil structure. However this practice is not without risks, namely the introduction of harmful substances such as antibiotics and other pollutants or unwanted nutrient losses.

TC: Advances in emission prevention

Farming is a source of emission of pollutants to the atmosphere and to water. A well-known problem is nutrient leaching and surface run-off, which may cause eutrophication of surface and groundwater bodies and is detrimental to drinking water quality and human health. The most-studied climate relevant gases are methane, carbon dioxide and nitrous oxide. Their atmospheric concentrations have increased in the last centuries due to human activities, including agriculture. Another important rural emission pathway is ammonia volatilization, arising largely from livestock manures and urea-based fertilizers. Together with other reactive nitrogen compounds, e.g. NO_X from processes in transport and industry, it leads to N deposition that damages susceptible ecosystems and leads to soil acidification Particulate matter originates from a range of agricultural sources, in particular the formation of secondary particulates from ammonia emissions, and may lead to a variety of health problems and associated social costs. In the future emissions may also be caused by new anthropogenic substances/compounds such as nanoparticles from nanomaterials. Urban emissions are numerous and may lead to the introduction of polluting substances (antibiotics, pharmaceuticals, heavy metals etc.) into agricultural chains with a feedback on urban systems.

TD: The bioresource challenge

The sustainable use and the protection of natural resources are essential for enduring food production and quality of life. In this context, bioresources will play a key role. Bioresources are non-fossil biogenic resources which can be used for multiple purposes: to produce food, substantial products such as paper, biobased plastics, biochemicals and composite materials or energy carriers such as bioethanol, biogas and heat. Bioresources are renewable, but they are not available in unlimited quantities and have limits to their utilization. Biobased economy encapsulates the vision of a future society no longer wholly dependent on fossil resources. The basics are bioresources originating from plants, animals, microorganisms or residues. In biorefineries they are converted into a multitude of products such as chemicals, materials, feed, fuels, and other energy carriers. Biorefineries are complex and integrated systems consisting of many process units. They take advantage of the various components contained in bioresources such as cellulose, hemicelluloses, starch, lignin, proteins, fats, oils, extractives and their intermediates. To date, the biorefinery industry is still in a nascent state, mostly using ligno-cellulosic feedstocks on larger scale. However, many concepts and approaches exist. Frequently discussed biorefinery systems with a connection to agriculture include sugar, starch, vegetable oil, lignocellulose, green, synthesis gas and biogas biorefinery.

TE: Sustainable regions

A sustainable agricultural system aims to deliver sufficient productivity, through the use of minimal and non-hazardous inputs, while maintaining soil quality and contributing to the reduction of environmental problems. The recycling of residues for fertilizing and soil quality improvement is still limited in practice. But urban and rural residues are increasingly not only a topic of disposal but of utilization. This provides an opportunity to bring rural and urban systems closer together again. However, practices involving recycling of residues might also cause environmental problems and lead to the evolution of unwanted compounds and pests.

Zero Waste is a visionary goal connected with changing people's lifestyle and behaviour and traditional waste management practices. A holistic and integrative approach for their improved utilization is the "Civilization biorefinery" - a system aiming for complete and efficient utilization of secondary, tertiary and quaternary regional bioresources in a rural-urban symbiosis. It consists of three major parts - collection of the local bioresources, their conversion in a local network of centralized and decentralized technical units into material and energy products and the utilization of these products.

Towards Nitrogen neutrality at RAMIRAN 2015

Nitrogen (N) is an essential element for food provision - plants need to be fertilized and animals as well as humans need N as a nutrient too. But N can also cause manifold problems. There are *problems of too much N* - losses into environment contribute to eutrophication, acidification, global warming, and more. But there are also *problems of too little N* - soil resources depleting and endangering the livelihood of farmers, and threatening food security. A lot of effort is needed to better balance N-management.

The concept of N-neutrality recognizes that there are institutional and individual responsibilities. A large event like RAMIRAN 2015 causes a considerable N-footprint that needs to be offset. By participating in the N-neutrality program we want to raise awareness of the topic and show possibilities for progression towards N-neutrality. To become N-neutral, the approach suggested by the European Commission's Joint Research Centre (JRC, Institute for Environment and Sustainability Monitoring of Agricultural Resources) was considered.

At RAMIRAN 2015 the following activities were taken into consideration to lower the footprint or reactive nitrogen (Nr):

1. **Provision of tasty food with reduced Nr impact at RAMIRAN 2015**

   Our first aim regarding food was to provide tasty food in sufficient amounts. But we also selected the menus regarding their N-footprint. For the lunch break we evaluated 28 meals and selected 10. In the coffee breaks we provided various selections of fresh fruits, which have generally a low N-footprint. Additionally the unconsumed fruit mixes will be given to needy people. For the gala dinner a table served menu was chosen instead of buffet to reduce food waste. Furthermore we asked for special diets of the participants (mixed cost, vegetarian, vegan, allergies and intolerances) in the registration procedure and considered the results in food provision.

2. **Calculating of the Nr-impact of RAMIRAN 2015**

   The N-impact of food provided at RAMIRAN 2015 was calculated on the basis of the N-footprint approach by Leip et al. (JRC). For that purpose we collected data regarding type and amount of all menu ingredients. For instance the average N-footprint of the meals prepared for lunch had a 9 % smaller Nr-footprint compared to an earlier conference in the same canteen and same working days. Additionally we studied the waste generation and the waste whereabouts in order to find out about used, recovered or lost Nr amounts.

3. **Compensating the Nr-impact of RAMIRAN 2015**

   All participants of RAMIRAN 2015 were asked to contribute a voluntary compensation fee (30 €) to equalize the remaining N-impact of consumed food as much as possible. The money will be donated to a sustainable food project in Indonesia (BEST, Institute for Integrated Social Economic Development, NGO) which focuses on demonstration of vertical gardening as a special urban farming solution e.g. for onions, lettuce and celery. The installations have the potential to be widely used in urban areas contributing to the provision of high quality food, helping 'reconnect' people with their food systems, and save land.

More information to the N neutrality approach and the calculations for the lunch meals are to be found in this abstract book (Leip et al., 2015, page 10).

Art at RAMIRAN2015

"Art is the queen of all sciences communicating knowledge to all the generations of the world."
Leonardo da Vinci

The conference is not only an interface between rural and urban regions as well as between scientists, practitioners and politicians. It also shall connect the practical world with culture and art. Following artistically activities were carried during the conference to give it an communicative, but also enjoyable and relaxing atmosphere:

Acting for sustainability: A group of young researchers and practitioners with interdisciplinary experience in environmental governance uses theatre to promote intercultural dialogue on sustainability in the context of academic and public conferences. By combining scientific knowledge with artistic expression they appeal to the emotions, thus engaging their audience at a deeper level than can be achieved through mere intellectual argumentation and create a level of communication that engages participants with the heart as well as the mind.
(http://scientific-theatre.org/; Freiburg Science Theatre, t.floerkemeier@scientific-theatre.org)

Art from tetrapak: Christiane Lüdtke is a Hamburg artist. Sculpturing is one line of her activities. At RAMIRAN 2015 she presents a further line: etchings from tetrapak materials. Etching is traditionally method of printmaking where a metal surface is used to create a relief, which delivers the printing matrix. Mrs. Luedke is using Tetrapak as printing matrix which gives the pictures a very lively structure. She presents funny etching from various human situations as well as book marks.
(http://christianeluedtke.de/; kunst@christianeluedtke.de)

Rural-urban colors: Photographic images – original and artistically edited – were arranged to relaxing films for the conference breaks and upgraded with some statistical data to the conference for information. The focus of the images is on structures and colors from urban and rural environments taken from various distances. It ranges from extreme close-ups, where very small subjects appear in the photograph greater than life size up to photos taken with wide perspective.
(http://www.bioresource.eu; BioResourceInnovation, BRI, i.koerner@bioresource.eu)

Art at the Hamburg University of Technology: TUHH hosts various artworks ranging from photographs, over paintings up to sculptures, partly from internationally known artists (e.g. Hanne Darboven, Berto Lardera, Chui Wang, Alfred Mahlau). They are distributed within the buildings and the campus park. Some of the most impressive artworks were explained via a tour through the university. Information includes the manifold ways they came to the university, the techniques used and the partly difficult standing of art in a technical environment.
(http://kunst-tuhh.de/; stieglitz@tuhh.de)

The cell factory: Biorefineries are the foundation of the biobased economy. The major actors in biorefinery systems are microorganisms. The complexity of the processes within a microbial cell was visualized via a 3-D-model with an almost 1-meter-diameter. The model represented a fungal cell including their organelles. Also various enzymes were visualized in 3-D-form. The exhibition unit is accompanied by biorefinery feedstockes and products.
(http://www.tuhh.de/ibb/home.html; aze@tuhh.de).

Examples are shown on pages (1, 5, 11, 41, 64, 73, 80, 106, 124, 146, 155, 178)

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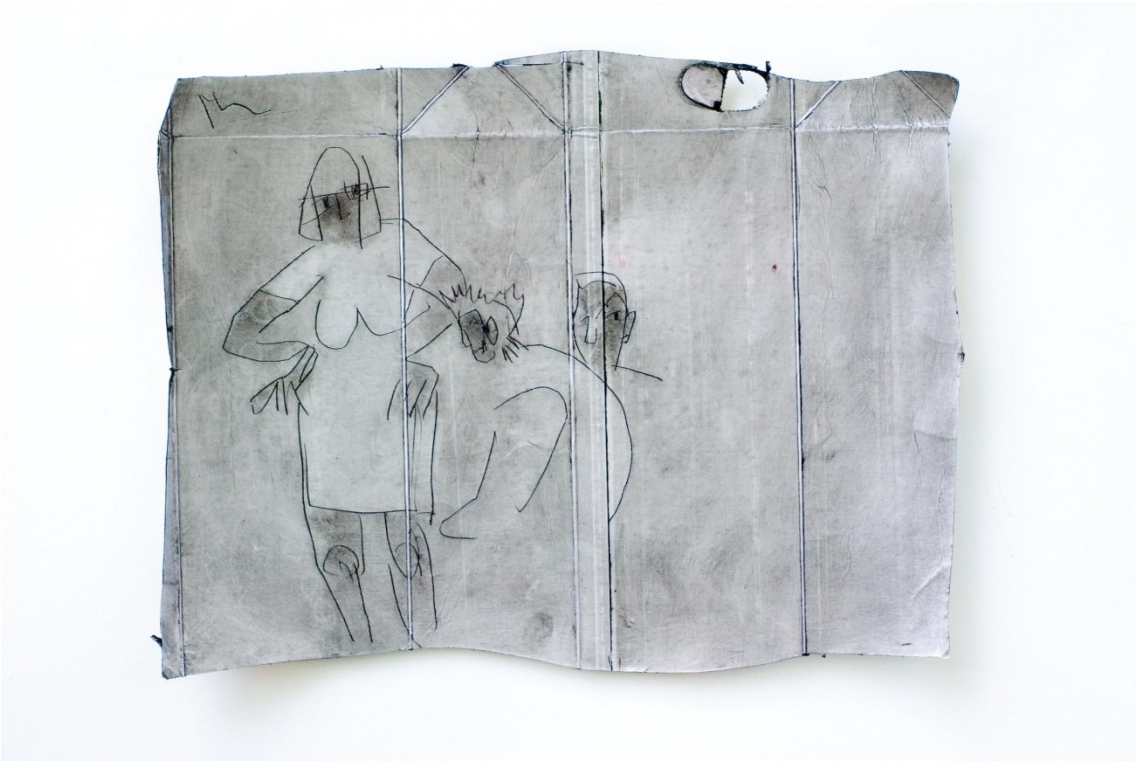

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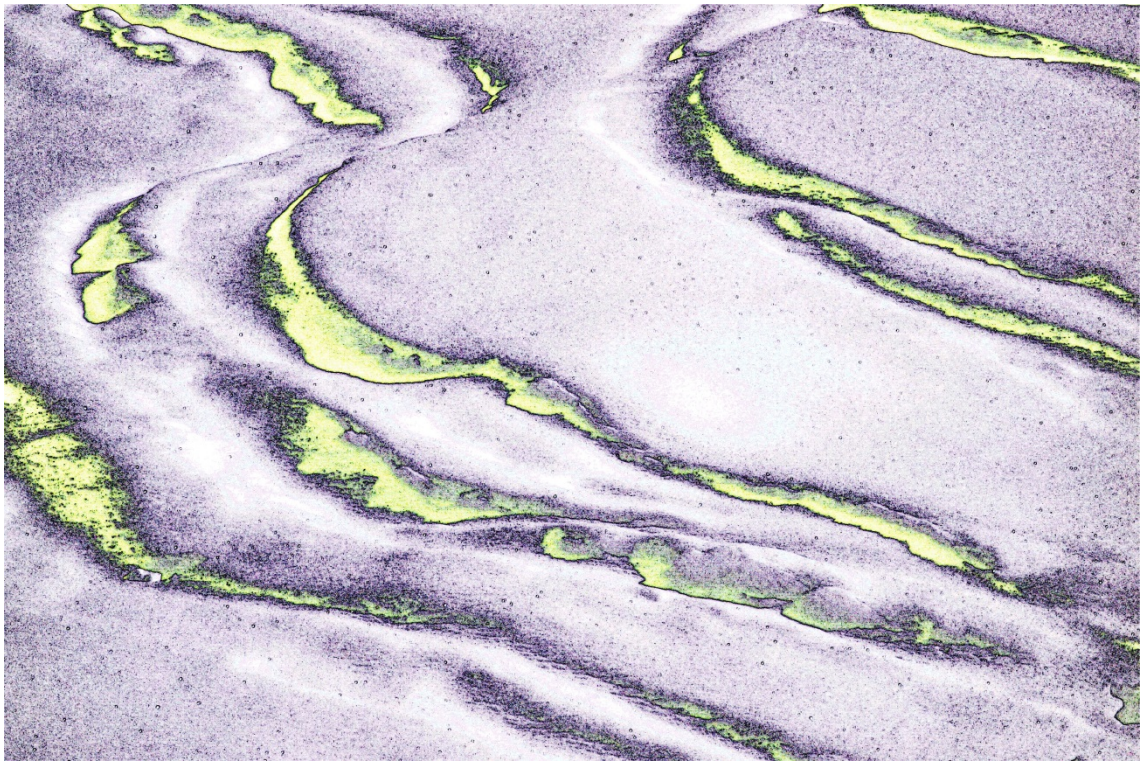

Snow, processed photograph

K_01 Biobased economy in Germany – Sustainable supply of bioresources

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Objectives

The bioeconomy offers a diverse range of possibilities for establishing sustainable products that are viable for the future, and for further developing specific branches of business. There are areas of potential and growth opportunities for employment and value-added in the bioeconomy, both in industrial biotechnology and in renewable raw materials for material use and use as an energy source, as well as in the classic sectors of food and feed production

Use of Biomass for the Production of Materials

Internationally, Germany ranks among the front-runners in the material use of renewable raw materials. Yet the use of renewable raw materials for producing plastics, fibres, cosmetics, paints and varnishes, colours for printing, building materials, right through to pharmaceuticals and other materials, proceeds to a large extent without state funding-support. What is primarily crucial to the use of these raw materials is economic advantages, but technological assets and the possible reduced burden on the environment are also factors [1].

Use of Biomass for Energy

In 2012, with a share of almost 65.5 % of total renewable energy consumption, bioenergy supplied by far the largest share of renewable energy in Germany; this is also because it can be used for producing both electricity and heating and also fuel, while at the same time it is storable. In electricity, biomass accounts for 6.8 % of gross electricity consumption, and is currently the second most important renewable energy source behind wind power. Electricity production that is reliable and can be called off according to demand, obtained from solid, liquid or gaseous biomass, is able to balance out the fluctuating energy sources, such as wind and photovoltaics (at 7.7 % and 4.7 % of gross electricity consumption respectively) and also to service peaks in demand. This will continue to be an essential role that bioenergy plays. The largest renewable-energy contribution to the heating supply is made by biomass, at 91 %. This includes solid and liquid biogenic fuels, biogas, sewage treatment gas, landfill gas and the biogenic share of waste. In turn, solid biogenic fuels, such as wood, make up the largest share by far (74.5 % in 2012). In the heating sector, solid bioenergy sources, such as pellets or firewood, already act as an economically viable alternative to fossil-based energy sources for heating. In the mobility business, where regrowing resources are by far the most important source for the use of renewable energies, biofuels would not be economically viable without public funding-support, because they cannot at present compete with fossil-based fuel sources [1].

Land Consumption

On the basis of agricultural yields and the data obtained in the individual markets it was calculated that 3.5 million ha have been used to produce renewable resources for energy markets. Further 0.8 million ha have been cultivated to provide raw materials for the material use. The cultivated land aiming at production for energy market is four times as great as for the production of raw material for the material use. Another 11.1 million ha of forests are used for the production of wood. Wood is used in roughly equal parts for material and energetic use. Biofuels and oil plants need the largest amount of acreage with cultivated areas of 2.4 million ha and 2.6 million ha, followed by energy and starch crops [2].

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K_02 Synergistic interaction of sanitation, biowaste utilization and energy systems towards water and food security

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Objectives

Water renewal, flood and draught prevention, balanced climate, food security and biodiversity all rely ultimately on well fed living topsoil. Humus is the single most important resource on the physical plane, all life depends on it. Agriculture based on synthetic chemistry is polluting soil and water resources to an absolutely inacceptable level. Clean fossil phosphate is not available any more and contamination of soil with uranium (700 tons per year in Germany alone) and cadmium by mineral fertilizers is an outrageous act that shows a shocking lack of political leadership.

Methodology

All of us have Glyphosate in our urine, from the most common herbicide. This substance is a chelator that binds trace elements in the field, why should the food of such production be eaten? A comple phase out of agriculture based on synthetic chemistry is overdue. Organic agriculture with well fed humus can be more productive and will not end by depleted toxified soils. In order to go for 100% organic agriculture there is a need for proper management of bio-resources that can feed the life in the top soil. Instead of looking for expensive technical solutions for the manure overloads there should be a shift towards free grazing on adequate space and in a way of Holistic Planned Grazing that can build humus, especially when combined with tree crops for restoration and fodder. This way animals can have a good life, too and give healthy meat.

Results

Sanitation must be developed towards full recovery of nutrients and organic matter as soil conditioners, there are some approaches available but a lot of further development is needed. Once again politcs are failing to set resonable targets for recovery of crucial nutrients - phosphate will run out - and for full water protection also from micro pollutants like pharmaceutical residues and synthetic hormones from the pill. Household biowaste should be turned into soil conditioners and agro-biowaste must be reused to feed humus. Composting can be inefficient because too much of the material will be lost, production of food for humus does make more sense. The current shift towards renewable energy is going in the right direction but some development needs to be revised. Bioenergy should look an woodgas technology in order to combine heat- and power production (or cooling) with charcoal production. Parts of this charcoal can be used to upgrade soil with the Terra Preta approach thus producing long term humus. Enourmous amounts of wood can be produced by restoring degraded areas around the world in a framework of Rainwater Harvesting. Ideally trees planted will have a good proportion of food and fodder production at the same time. All in all such development shows very interesting pathways for reversing climate change and for a good future for the whole biosphere.

Conclusion

It is obvious that these suggestions will upset a lot of business interests, however, ruining the planet is the worst business possible in the long run. In addition such shifts will provide millions of new opportunities and a billion new jobs, too.

K_03 Energy recovery and added value molecules extracted from agricultural bioresources and organic waste – A review of research needs, perspectives and prospects

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Objectives

In Europe, the two major treatment schemes of organic waste processing are anaerobic digestion and composting. In the near future, it would become a challenge to consolidate such processes (by encouraging quality products and profitable utilization) and to develop new "processes" like the production of ethanol and more generally speaking the production of added value molecules.

Methodology

This review will exemplifies a wide variety of research approaches collected through four topics:

- optimisation of the agronomic utilization,
- optimisation of anaerobic digestion
- Bioethanol production,
- Added value molecules

Results

Indeed, 45% of European soils, show a deficit in organic matter content and organic wastes represent a resource well adapted as soil amendment and/or organic fertilizer. Unless the well-known composting strategy, the anaerobic digestion (AD) process has gained much interest within the last decade to contribute to the EU energy issue (dependency on imports). AD offers a combination of environmental, economic and societal advantages. It allows a capture of methane from waste through the production of renewable energy and heat. This technology allows therefore to reduce greenhouse gases from a number of sources and to reduce the consumption of fossil energy and compare well in terms of environmental impacts with landfilling or even with direct composting (Mata-Alvarez et al., 2000).

Concurrently, some authors like Bouchez (2015, personal communication) Ren et al. (1997) and Temudo et al. (2007 and 2008) have experimentally demonstrated the possibility of producing ethanol from a mixed culture reactor receiving molasses or simple substrates (glucose and glycerol).

The production of molecules of high added value or of industrial interest will be encourage in the future due to various reasons: (i) the depletion of mineral phosphates resources (mines) which may strongly push towards the recycling of organic phosphates,(ii) the reduction of oil activities.

Conclusion

One of the goal of the future within organic waste management will be the synergism between research bodies, academic organizations (universities) with the industry and municipalities to reconsider the whole life cycle and chain value of the products, components etc.

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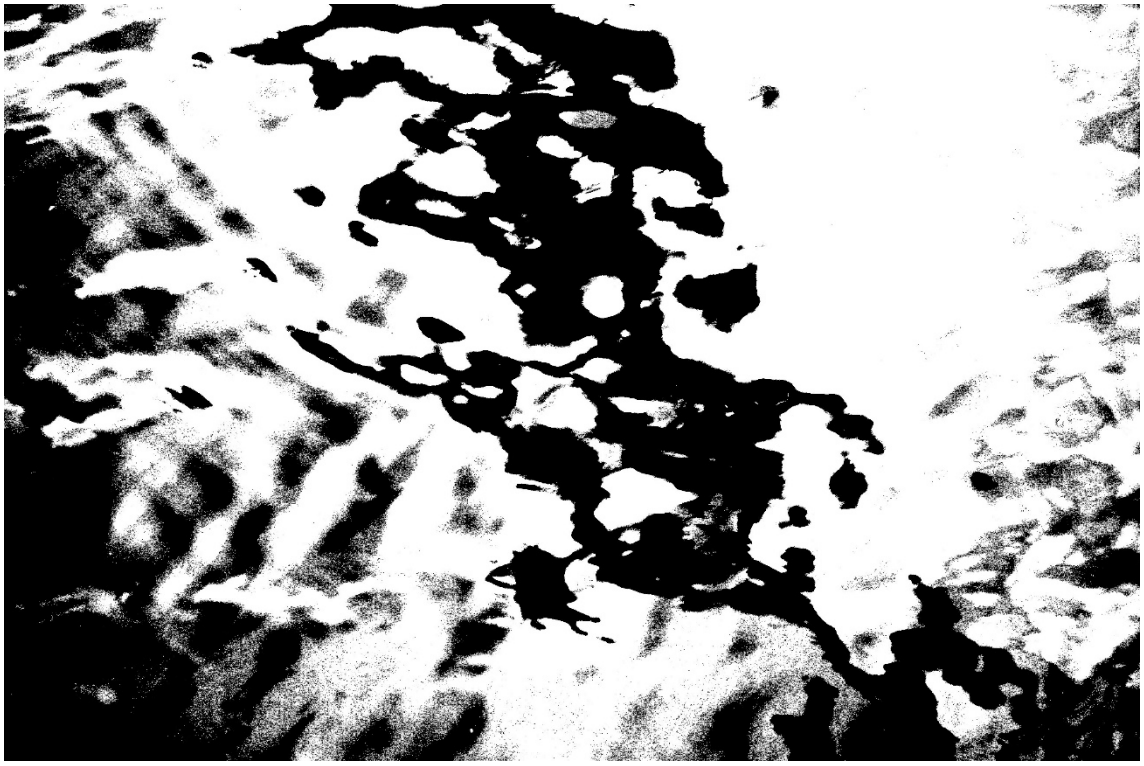
General Thematic Lectures



Water, processed photograph

G-O_01 Dealing with future European manure management challenges

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Objectives

European livestock produce about 1,270 million ton manure/year. Manure disposal represents a multiple challenge and raises a real need for more appropriate treatment options. Concomitantly, manure is also an important resource of nutrients and organic matter and their recycling may support societal transformation to a circular economy [1]. We present a vision for what potential policy responses should be to ensure a sustainable future manure management.

Methodology

The analysis focuses on exploring three core area intricately linked to sustainable future manure mangement: nutrients, energy and environment. Each of these issues is reviewed in terms of what policy responses should be with regard to manure management and what the trade-offs might be. Each of these three areas will focus on what should be done i) from a scientific perspective; ii) from an acceptability perspective, both market and social; and iii) from a policy and regulatory perspective.

Results

Separation of animal manure or slurry into solid and liquid fractions may improve manure management as it makes handling more feasible, and enables fractions with a nutrient content in better balance with the plant/crop requirements. The solid fraction can serve as a co-substrate in biogas plants, and thus offers both an operational and economic advantage over digestion of non-separated manure alone [2]. Separation technology can be greatly improved, but these technologies have not been optimized economically or energetically or considering the end use of the products i.e. as plant nutrient and energy resources. Combustion, gasification or pyrolysis of the solid fraction may enable utilization of the energy content of the solid fraction; however, major obstacles exist in optimising thermal treatment processes for these relatively wet biomasses, and the fertilizing properties of the residual products varies greatly. Anaerobic digestion and combustion may also result in reduced C input to the soil, but technologies returning the most recalcitrant components of the manure as bio-based fertilizer could enhance soil C sequestration and quality and may reduce environmentally detrimental gas emissions from soil [3]. All these parameters will affect market and societal acceptability of such manure-based fertilizers. Technologies and policies to address the manure challenge should also account for (further) potential environmental effects of manure (mis)management.

Conclusion

We will present a vision for how to address the dual challenge posed by increased manure production. We will focus on responses – scientific as well as policy oriented – that can reduce the environmental effect whilst optimizing the potential of manure as a bio-based fertilizer and energy resource.

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G-O_02 Marketing of biogas fermentation residues – The providers´ perspective

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Objectives

The aim of this study was to investigate different approaches of biogas digestate marketing. Supporting and inhibiting factors as well as different customer groups were analyzed. The results will be a helpful source for all actors who aim at marketing digestate. Marketing of these products has been pointed out as a research gap and will be approached within this study for the first time [1].

Methodology

Especially within new fields of research, such as digestate marketing, an exploratory approach is a suitable starting point within qualitative research [2]. A semi-structured interview guide was designed beforehand and a total of 18 experts, familiar with the marketing of digestate, were interviewed. All interviews were recorded on tape and afterwards transcribed. The transcribed interviews then underwent a qualitative content analysis [3].

Results

Main reasons why digestate is marketed are regional nutrient surpluses and a lack of own land on the side of plant operators. The digestate products range from solid to liquid products and from upgraded to raw digestate. Upgraded products are pellets, granulate and compost among others. An important factor for upgrading digestate is the heat incentive bonus under German law. Upgraded products have an increased marketability due to their high nutrient concentration and reduced weight. Depending on the different characteristics, customers such as farmers, organic fertilizer manufacturers and garden owners are targeted. The sales situation is site specific and dependent on the regional context. Therefore prices for raw digestate range from -15,-€ up to +6,-€ per ton. Eliminating inhibiting factors such as legal uncertainties could help to increase their utilization. Product certification can be used to increase the marketability. The study further revealed that private customers perceive biogas as negative in general. Therefore operators think it is advisable to conceal the origin of the product. Customers appreciate specialized product such as rose fertilizer over uniform products.

Conclusion

More effort should be invested by plant operators to secure and increase digestate quality and the pursuit of marketing. A promising attempt for smaller biogas plants, is to collaborate with others and do joint marketing. New markets such as horticultural companies should be approached and the attempts be professionalized. For private customers the biogas origin should not be stressed but their preferences are to be studied by consumer research.

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G-O_03 Implementing anaerobic digestion into the german agricultural emission inventory

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Objectives

Biogas production is a source of renewable energy and aims at reducing greenhouse gas emissions. Substrates for digestion often originate from agriculture and digestates are used as fertilizers. Therefore emissions from agriculture are affected by biogas production.
The IPCC (2006) guidelines for GHG inventories require to consider anaerobic digestion as method of manure treatment. For the German emission inventories a method was developed and implemented also considering the digestion of energy crops, as they have a great share in German biogas production and considerably affect the amount and properties of digestates. This methodology was used to calculate the emissions of GHG and NH_3 for the year 2013.

Methodology

Emissions are calculated along the chain of biogas production and digestate utilization. For methane the method described in IPCC (2006) was used as a basis. Due to errors in considering volatile solid contents it needed to be adapted. Also parameters needed to be chosen, that are available or can be deduced from research results.
For N_2O and NH_3 emissions no guidebook methodology is given. Therefore a methodology was developed to calculate emissions especially from pre- and post-digestion storage and the application of digestates. The methodology follows the calculation procedures for manure storage and application. Changes in NH_4^+ content during digestion are accounted for.
A procedure for the acquisition of activity data was also set up. It is based on the register of the transmission network operators and allows to identify each of the more than 8800 biogas plants. Data on substrate input and the distribution of gastight storage of digestates were available for a subset of biogas plants. By assuming analogy of substrate input for biogas plants of similar size and regional setting, overall input of the different substrates for biogas production was deduced.

Results

Integrating anaerobic digestion into the inventory calculations decreases emissions from manure management. Annual CH_4 emissions are reduced by 36.2 Gg (12.5%), N_2O by 0.43 Gg (4.3%) and NH_3 by 21.4 Gg. Emission reductions of all gases are mainly due to reduced emissions from storage of manures as a great share of digestate storages in Germany are gas tight.
If the method is also applied to the digestion of energy crops, additional emissions need to be accounted for. For German conditions, with a great amount of energy crops being used, these are 44.6 Gg for CH_4, 5.5 Gg for N_2O and 50.9 Gg for NH_3. This is mainly due to emissions from digestate storage (for CH_4) and the spreading of digestates (for NH_3). Additional N_2O emissions are mainly being derived from the N-input with digestates into soils.

Conclusion

The method of calculation allows to monitor the effect of changes in substrate use as well as digestion and digestate management on the emissions.
Assumptions on duration of pre-storage of manures and parameters of digestion still need to be verified. Resarch on leakages from biogas plants and emissions from digestate spreading is necessary. In order to acquire activity data on substrate input as well as storage and spreading techniques for digestates, surveys need to be adapted and improved to meet future needs.

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G-O_04 Macroalgae as a resource for biobased industry

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Objectives

In the light of current environmental challenges, such as climate change and the depletion of fossil fuel reservoirs, a global switch to biodegradable and renewable products is highly demanded. Thus, different concepts have been developed in the last years for the utilization of plant biomass based on starch or lignocellulose. Recently, degradation of marine biomass has also become more attractive. Especially macroalgae represent a promising alternative feedstock due to their abundance and high content of carbohydrates [1]. The efficient hydrolysis of macroalgae biomass is a challenging task and requires efficient enzymes for the bioconversion of the highly complex substrate, which consists of polysaccharides like laminarin, carrageenan and alginate.

Methodology

For the identification of marine biomass-degrading enzymes both a sequence-based screening approach and an activity-based screening approach were performed simultaneously. Enzymes of interest were produced heterologously in *Escherichia coli* and were purified to homogeneity by affinity and size-exclusion chromatography. Biochemical properties of the promising biocatalysts were determined by a further characterization of each purified enzyme. Enzyme performance during macroalgae hydrolysis was determined by HPLC analyses.

Results

We report on the successful identification of various macroalgae-degrading enzymes by sequence-based screening approaches of metagenomic datasets from extreme environments. Furthermore, we present biochemical characteristics of some of these promising biocatalysts that were heterologously produced in *Escherichia coli*.

Conclusion

We present results of the project LIPOMAR, "lipids and surface active molecules from marine biomass", that was established by a consortium of academic and industrial partners. Especially, the enzymatic bioconversion of beach-stranded macroalgae e.g. brown algae or seaweed and the identification and characterization of corresponding enzymes are of great interest.

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G-O_05 Towards nitrogen neutrality – Assessment of the tool on the example of conferences

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Objectives

Nitrogen (N) Neutrality [1] is a new tool to increase awareness on environmental impacts related to the losses of reactive nitrogen and the responsibility of an individual person or other entities. It includes measures to reduce and also to compensate losses of reactive nitrogen, in contrast to other available N footprint tools [2]. The objective of this paper is to assess the implementation of the N neutrality approach at the RAMIRAN2015 and compare it with the implementation of previous conferences (N2013 conference, http://n2013.org/?page_id=351 and 18th N workshop, http://www.nitrogenworkshop.com/nitrogen-neutrality/).

Methodology

To calculate achievements towards N neutrality for the conferences, three steps were carried out: (1) quantification of the N footprint of the food supplied at the conferences. For Europe, generic (food production) N footprint factors are available [3] (this information should be available with and without implemented mitigation measures to quantify how much Nr release reduction has been achieved); (2) Choosing a project which may have a negative N footprint or where an additional reduction of the N footprint can be achieved; (3) Linking the N footprint of the conference and the project via the financial support that is collected at the conference as compensation fee and evauating the achievements towards N neutrality.

Results

At N2013, 38% of the participants contributed up to US$ 50 to the N neutrality implementation collecting about US$ 3,000 USD which supported the UN-Millennium Villages enhancing sustainability and reduce N losses in a rural community in Uganda. It was estimated that this achieved a compensation of 73% of the N-footprint of conference [1]. At the 18th N workshop, only 13% of participants contributed to the N neutrality implementation collecting about 600 € which was used to support the ReFood project reducing food waste and related Nr losses. The contribution planned for the RAMIRAN conference is 30 € per participant. The project chosen for support is an ongoing Urban gardening project in Yogyakarta, which will be replicated in Tangerang Selatan and Jakarta, Indonesia. The paper will provide the quantification for the three identified steps for the RAMIRAN conference and compare the results with the two previous conferences.

Conclusion

N neutrality has proven to be an efficient tool for increasing the sustainability of a conference. However, even though the concept and general methodology is well developed, the complexity of the food chain and N interactions in the environment leaves many options for its implementation. RAMIRAN2015 is an important milestone to formulating standards and improve future implementations.

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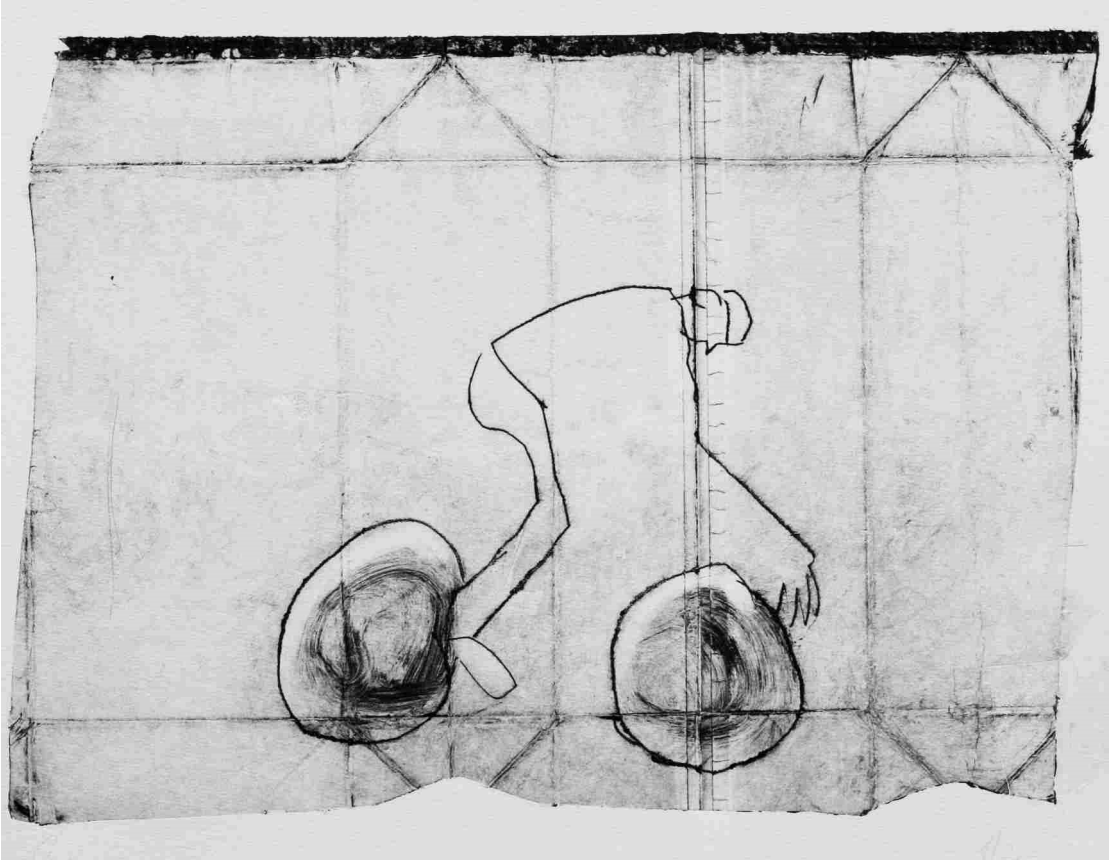
Thematic area TA – Quality fertilizers from residues (Oral presentations)



Christiane Lüdtke: Art from Tetrapak

TA-K_01 Example of a country manure management profile – Switzerland

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Background

In the framework of the RAMIRAN network, "task groups" make use of the potential arising from its membership of experts in transnationally compiling information concerning the use of organic residues in agriculture. At the conference in 2013 it was suggested that such a task group could produce manure management profiles for different countries to give an overview of the current state of practice on manure management. This contribution gives a first example of such a profile using Switzerland as a case study.

General approach

This manure management profile aims at giving an overview on the current management practice, the relevant framework conditions (policy, structural conditions etc.), recommendations and management aids. This information is mainly based on the results of representative surveys on farm management technique (most recent for 2010; Kupper at al. 2014), on the national nutrient balance, on the official "guidelines on fertilization of arable crops and grassland" (edition 2009), on legal constraints, on published and unpublished scientific reports and on expert knowledge.

Manure management in Switzerland in a nutshell

In 2010 livestock excreta contributed about 60% of the nitrogen (N; approx. 40% of plant available N) input to crop and grassland production and approximately 80% of phosphorus (P) and 85% of potassium (K) inputs, respectively. Looking at the manure N flows (total N), a) cattle, pigs, poultry and other livestock contributed 79%, 11%, 4% and 6 % of the N excretions, respectively; b) 70% was spread as slurry and 30% as solid manure, c) approximately 80% of the slurry and 70% of the solid manure was used on grassland, d) 37% of the N excreted was lost in form of ammonia and e) 25% of the slurry was spread with reduced low emission technology (mostly trailing hose). Between 1990 and 2010 many farm management aspects with high relevance on manure management changed considerably, e.g. for dairy cows the duration of grazing approximately doubled, the share of cows kept in loose housing systems increased from 6% to nearly 50% and the share of animals in housing systems producing no solid manure increased from 30% to over 50%.
The official guidelines on fertilization provide detailed information on nutrient excretions of livestock, quantities of and contents of manure produced by different livestock categories as well as nutrient requirements of different crops. In the framework of the requirements of the direct payments program all farms have to annually submit an N and P balance. 60% (base value; reduction for solid manure, arable crops, grazing) of the N applied in form of manure and 100% of the P is counted as plant available. The maximum surplus tolerated is 10%. Thanks to these policy requirements, the use of mineral fertilizer decreased between 1990 and 2010 by approximately 30% (N) and 70% (P), while the amount in agricultural products increased by nearly 25% for N and over 50% for P. Thus the surplus was reduced by 15%, 75% and 55% for N, P, and K, respectively.

Conclusion

Manure is and always was by far the most important fertilizer in Swiss agriculture. Between 1990 and 2010 the share of manure in fertilization increased and the nutrient efficiency of agriculture was improved considerably. This was mainly achieved through the nutrient balance restrictions which lead to improved manure management and enhanced awareness of the farmers.

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TA-K_02 Organic residue management options in a Chinese peri-urban region with intensive animal husbandry and high nutrient loads

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Objectives

The "N and P costs" of food production in China almost doubled between 1980 and 2005 [1]. In the peri-urban region of Beijing with very high livestock densities, industrialized land-less animal operations are facing a large number of small-scale crop farmers. High amounts of organic residues are improperly disposed of, causing severe environmental pollution. At the same time, China is seeking to expand its energy production from biogas. The aim of the research was to compare different manure treatment systems under nutrient, soil fertility and economic aspects.

Methodology

A large-scale pig farm in Shunyi District of Beijing with attached biogas and composting plants was chosen as pilot farm 2008-2011. A soil screening study of 26 plots under the five major cropping systems was carried out. Nutrient flows were derived for the farm and N and P balances calculated for the surrounding cropland [2]. In a life cycle assessment, the required cropland area for a sound disposal of animal wastes was calculated for different manure treatment options [3].

Results

Extremely high amounts of farmyard manure of about 45 ± 69 t DM ha^{-1} yr^{-1} were applied to most of the observed field plots (n=19) in 2008, resulting in the investigated soils being over-supplied with nutrients from organic and inorganic sources. The mean annual soil surface N balance surpluses amounted to 1548, 519 and 531 kg N ha^{-1} yr^{-1} for the vegetable, orchards and cereal crop production systems, respectively, those for P were 492, 130 and 83 kg P ha^{-1} yr^{-1}.
Based on the nutrient demand of a typical winter wheat-summer maize double-crop rotation in Shunyi District under balanced conditions of 338 kg N, 56 kg P and 263 kg K ha^{-1} yr^{-1}, the resulting cropland demand for a sustainable land application of biogas effluent would range between 139 and 288 ha yr^{-1}, depending on the amount of manure solids added to the biogas plant, or entering the composting facility for organic fertilizer production. For the currently over-supplied cropland, the land area required would be almost twice as high, while the pilot pig farm only cultivates 10 ha. This underscores the necessity for nutrients to be exported out of this peri-urban region in form of marketable products, or for nutrient recovery from effluent via technological means. Governmental subsidies to compost production are now in place in several Chinese provinces. Outlying areas of the North China Plain have low soil organic matter, total N and low-medium available P contents.

Conclusion

Reduction of livestock densities is essential for environmental reasons. The question of whether to promote manure processing or whether to focus on energy production from biogas and subsequent nutrient removal from effluent can only be solved on a case by case basis in China. It is assumed that the market price for quality fertilizer products is likely to increase. Hence, good composting procedures may become economically attractive without subsidies in the future.

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TA-O_01 Development of a mobile app for manure management – 'The Farm Crap App'

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Objectives

To create a mobile application that helps farmers and growers put a nutritive and economic value on slurries and manures, and aid with manure management by calculating crop available nitrogen, phosphate and potash in different manures and slurries at different spreading rates based on the soil type, season and crop type. Allow farmers to visualise their applications in terms of nutrients via an image library. To aid record keeping for nutrient management plans.

Methodology

DEFRA's Fertilizer Manual, RB209[1] was used to populate the calculator function of the app. RB209 provides industry derived estimates of mean nutrient contents of different manure types and the percentage of those nutrients that are crop available, depending on when and how the manure is applied. The app utilises the financial data from Manner NPK[2], assigning a monetary value to the manure applied, user editable in the iOS version.

Results

Data from farm advisory visits in the south west (n=2034) highlighted that for the livestock sector manure and nutrient management plans were in the top three recommendations that required action. Developing a user friendly tool was a key driver for the research team. Once a beta version was developed this was presented to farmer discussion groups, agricultural students, farm advisors, industry partners and the scientists behind RB209 and Manner-NPK. The feedback from these consultations was incorporated into the final version of the app. Creative and innovative ways were used to engage with the various stakeholders, including buckets of slurry, photo boards, videos, quizzes and role plays. The final versions of the app were launched at Grassland and Muck (Stoneleigh, UK) in May 2014. Nine months after the launch, the app has been downloaded in excess of 1300 times.

Conclusion

For livestock farmers, good manure management planning can be a key component of farm profitability. Applying nutrients at recommended rates can potentially double yields of most crops, and getting this wrong risks yields, profits and breaching environmental and compliance regulations. The Farm Crap App allows farmers to access science in a very practical way allowing them to see direct benefits to their farm business from manure management.

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TA-O_02 Farmers' reasons to accept bio-based fertilizers – A choice experiment in Flanders

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Objectives

Different regions in Western Europe are large importers of chemical fertilizer, while at the same time livestock intensive regions faces disposal problems of the nutrients in animal manure. If processing transforms farm waste streams into biobased fertilizers, what are the reasons for farmers to accept these products? What is the willingness to pay for the different attributes of this fertilizer?

Methodology

A discrete choice experiment was conducted in Belgium to reveal the importance of key characteristics for new bio-based fertilizers compared to current fertilizers. Attributes to these alternative fertilizers were identified by experts, stakeholder meetings and interviews. A conditional logit regression was used to determine revealed preferences and willingness to accept for the different attributes.

Results

The online survey had 173 respondents currently using chemical fertilizers on their farms. Among the respondents 52% engage on livestock production as a main activity, 32% on crop production and 15 % on horticulture.
Results show that farmers have significant preferences a granular form of the fertilizer over pasty or liquid forms, a concentrated product, certainty in the nitrogen content, presence of organic carbon and hygienisation of the fertilizer at lower price than the conventional ones.
Additionally the results show that the equivalent value for the presence of organic carbon equals a 22.85% reduction in price, while a solid form or the sanitation state of the product are valued similar, being the value assigned to the presence of both attributes equivalent to a reduction of 13% on the price. The paper will motivate in depth the choice of the attributes and levels, the farm preferences for these fertilizers and it will give a complete overview of the economic trade-off for every attribute.

Conclusion

Our investigation suggests that demand for these new biobased fertilizer products could increase if the processing industry could take into account the above preferences for new fertilizers. We could clearly identify which characteristics prime for the Belgian farmers. However these proposed preferences by the farmers are not always straightforward to processers and market due to technological constraints, legal and logistic issues.

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TA-O_03 Agricultural reuse of the digestate from microalgae anaerobic digestion and co-digestion with sewage sludge

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Objectives

Microalge-based wastewater treatment systems have drawn attention to combine wastewater treatment and bioenergy production. The most straightforward process is anaerobic digestion, which produces biogas along with a digestate that may be reused in agriculture. However, the suitability of this digestate for agricultural reuse has yet to be determined. The aim of this study was to characterize the digestate from anaerobic digestion and co-digestion with primary sludge in terms of nutrients, pathogens, emerging contaminants, heavy metals and dewaterability.

Methodology

Microalgal biomass consisted of a microalgae-bacteria consortia grown in a pilot raceway pond treating wastewater from a municipal sewer in Barcelona (Spain), while thickened primary sludge was collected in a municipal WWTP near Barcelona. Anaerobic digestion was performed in two lab-scale mesophilic reactors (1.5 L), treating either microalgal biomass or a mixture of microalgal biomass and primary sludge (25%-75% VS, respectively). Influent and effluent (digestate) were characterised weekly (integrated samples) over a period of 6 weeks of stable operation. Samples were analysed for pH, TS, VS, COD, TKN, N-NH_4^+, P, Ca^{2+}, Mg^{2+}, Na^+, K^+, pathogens, emerging contaminants (galaxolide, tonalide, triclosan, caffeine, triphenyl phosphate, methyl dihydro-jasmonate, ibuprofen and naproxen), heavy metals, and dewaterability by means of the capillary suction time (CST).

Results

According to the results, microalgae and co-digestion digestates had high and fairly similar organic matter content (68 and 66% VS/TS). However, the concentrations of TKN (4500 mg/L and 2500 mg/L) and N-NH_4^+ (1400 mg/L and 780 mg/L) were about half in the co-digestate as compared to the digestate. Other macronutrients (P, Ca^{2+}, Mg^{2+}, Na^+, K^+) presented similar concentrations in both cases.

Regarding digestate hygienisation, low *Escherichia coli* and bacteriophage removals were observed (< 2 ulog/100ml) during the anaerobic digestion under mesophilic conditions. Thermophilic digestion or thermal pretreatments may be used to improve digestate hygenisation and also digestion performance.

With respect to emerging contaminants, the most hydrophilic compounds, such as caffeine, were significantly removed (by 95%) during the anaerobic digestion; whereas galaxolide and tonalide were still present in the digestate.

An important aspect for digestate management and final disposal is its dewaterbility. While microalgae digestate presented poor dewaterability (35 $s \cdot gTS^{-1} \cdot L$), after co-digestion the results were consistently improved (7 $s \cdot gTS^{-1} \cdot L$).

Conclusion

Microalgae digestion and co-digestion digestates presented high organic matter content and macronutrients, especially organic and ammonia nitrogen, available for agricultural reuse as organic fertilizer. However, pathogen removal under mesophilic conditions was poor and ought to be improved with advanced treatments. Only some emerging contaminants could be removed during anaerobic digestion. Dewatering proprieties were significantly improved after co-digestion, which appears as a promising alternative to improve microalgae digestion and move towards 0 waste generation in microalgae-based treatment systems.

TA-O_04 Strategies to utilization of animal manure in China – A review

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Background

Rapid development of livestock production and increased discharge of manure to water body have resulted serious environmental problems in China. However, there still lack of information about the managerial measures of mitigating manure losses.

Methodology

In this study, the total manure losses from the China's livestock production were analyzed, by using data from statistics and surveys. And several mitigation options were indentified though a comprehensive review of literatures.

Results

The results of this study showed that, the total manure production was 768 Tg in 2012, which contained about 158.0 Tg of nitrogen (N), 38.0 Tg of phosphorus (P). In total, about 30-50% of the N and P were discharge to the vast environment in China. Many of the recent studies have addressed these problems, and indentified several options to mitigate the nutrient losses, such as balanced feed management, solid-liquid manure separation, improved manure storage, composting, biogas production and balanced manure application. However, one of the main obstacles was manure was mainly losses via discharge to water body in China1. The effectiveness of these mitigation options on reducing the N and P losses was relatively low, except the composting. Because the N and P conserved through these options may still discharged to the environment at the end, if the manure was not be utilized. So, the composting of manure to boost the manure recycling in the future is highly recommended in this study. However, 23% of N and 11% of P in manure were lost during the composting. And the cost of the composting manure was still high for non-cash crop producer. A state-wide survey was needed to increasing the understanding of current manure compost management. And further studies related to developed low economic and environmental cost composting technologies were needed, to increase the manure recycle rate and reduce the nutrient losses simultaneously.

Conclusion

Composting can be a possible solution to reduce the manure nutrient losses from livestock production in China. However, technologies are needed to reduce the economic cost of compost manure and reduce the nutrient losses during the manure composting in the future.

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TA-O_05 Effects of pig slurry acidification, separation techniques and pyrolysis on nitrogen and carbon mineralization and nitrous oxid emissions after application to soil

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Objectives

The objective of this work was to evaluate the effect of pig slurry acidification and separation (using three different technologies on solid and liquid fractions of pig slurry) on: i) nitrogen (N) mineralization in soil; ii) soil CO_2 and N_2O emissions; and iii) the effect of soil water content on these processes. Biochars produced from the solids were also evaluated.

Methodology

Pig slurries were continuously acidified to pH 5.5 in an animal house or stored unacidified. Then solid (S) and liquid (L) fractions were separated using a screw press (SP), decanter centrifuge (SP) or flocculation+drainage (FD). Also, biochar (BC) was produced by pyrolysis (400ºC) of the separated S. The acidified (A) and non-acidified (NA) fractions were applied at a rate of 400 kg N ha^{-1} to a sandy loam soil. The mixes were incubated at pF1 (near saturation) or pF2 (field capacity), and kept at 15 ºC in the dark for 160 days. Soil N_2O and CO_2 emissions and inorganic N contents were estimated during the incubation.

Results

N mineralization over 160 days after the application of different treated fractions of pig slurry ranged from 24-69, 29-77, 0-10 % of TN added for S, L and BC respectively. N mineralization of S-NA fractions ranged between 24-34 % of TN added and the acidification increased these amounts up to 36, 61 and 69 % of TN added for SP, DC and FD respectively. The acidification of L fractions separated using SP and FD reduced the amount of mineralizable N by 34 % and 28 % respectively compared to NA samples. Moreover, the amount of inorganic N available was reduced by 10 and 8 % in BC-A compared with BC-NA separated using DC and FC respectively. In general, N mineralization was reduced at the high water content (pF 1).

Soil N_2O emissions were significantly higher in S and L incubated at high water content (pF 1). Under these conditions, acidification increased the N_2O emission between 2 and 3 times in S and L fractions, except for S separated using SP. Furthermore, N_2O emissions from S fractions were influenced by separation technology, being higher for DC>SP>FD. The application of BC resulted in very low N_2O emissions in all cases. CO_2 emissions were around 15% and 80% of TC added for BC and S respectively, which was similar for all treatments. In L fractions, acidification reduced CO_2 emissions by up to 40% of the TC added, compared with L-NA samples for all treatments. CO_2 emissions were similar in L and C incubated at the two water contents, while it was reduced under high water content after S fraction application.

Conclusion

The N mineralized in soil amended with S and L fractions of pig slurry was similar, while the BC application resulted in very low N mineralization, N_2O and CO_2 emissions. The acidification of slurry resulted in the separated S fractions having increased mineralizable N compared with NA, but also increased N_2O emissions. Contrary to this, the acidification of slurry resulted in L and BC fractions having reduced N mineralization in soil and also increased N_2O emissions after L application. The use of more advanced separation techniques (FD>DC>SP) for acidified slurry produced S fractions with increased soil N availability. Finally, high soil water content decreased mineralization and nitrification in soil, and reduced CO_2 emissions after S application. It also increased N_2O emissions after S and L application. Further studies are needed to evaluate the effect of various types of acidified manure application in soil at long term.

TA-O_06 Band application of acidified slurry as an alternative to slurry injection – An integrated evaluation

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Objectives

A field experiment was performed to evaluate the efficiency of surface application of acidified cattle slurry relative to non-acidified slurry injection, to supply plant nutrients with low nitrogen and carbon losses to air and water.

Methodology

Twenty-four plots (1m x1m x 1m soil depth) were used in this experiment, half of them containing soil material from an Haplic Arenosol and the other half containing soil material from a Haplic Cambisol. The traditional double cropping system Maize (spring) / oat (autumn) was established between September 2012 and September 2014 in these two different soils. Untreated slurry (S) and acidified slurry (AS), obtained by addition of concentrated sulphuric acid to pH 5.5, were applied before oat and maize sowing at a rate of 90 and 170 kg N ha^{-1}, respectively. Five treatments were considered: 1) control; 2) injected S (SI); 3) surface applied S followed by soil incorporation (SS); 4) surface applied AS (AS); 3) surface applied AS followed by soil incorporation (ASS). During the 2 years experiment, the following information was collected in all plots: NH_3, CO_2, CH_4 and N_2O emissions, nitrate leaching during oat growth, plant yield, slurry nutrients use efficiency and finally soil quality with special emphasis on soil enzymatic activity.

Results

Application of acidified slurry before oat sowing followed or not by soil incorporation, led to residual NH_3 emissions similar to those observed in SI treatments while significant NH_3 losses were observed in SS treatment. At spring application, before maize sowing, residual NH_3 emissions were observed from SI and ASS treatments but a small amount of NH_3 was also released from AS treatment, even if at a significantly lower rate than from SS treatment. SI led to the highest N_2O emissions during the summer period but to the lowest during oat production where similar N_2O emission rates were observed in SS, AS and ASS. CH_4 emissions were observed only during the first hours following application in all amended treatments. No significant differences were observed between AS and ASS in terms of N_2O, CH_4 and CO_2 emissions. Nitrate leaching was affected by slurry acidification even if the soil characteristics remained the main parameter influencing nitrate leaching. All over the experiment, higher dry matter yields were obtained in ASS, AS and SI treatments relative to SS but differences between SI and ASS or AS were not always significant. It is still to refer that an higher P uptake was observed in AS and ASS treatments relative to SI and SS. After 4 consecutive slurry applications, no negative effects on enzymatic activity or soil properties were observed in AS ad ASS relative to SI or SS.

Conclusion

Our results showed that surface application of acidified slurry is a good alternative to slurry injection and that soil incorporation can be avoid after application of acidified slurry. Indeed, AS application allowed minimizing N and C losses by gaseous emissions and keep or even increase crop yields. Nevertheless, the impact on nitrate leaching is not clear and relies strongly on the soil type. The long term effect of acidified slurry application still needs to be evaluated even if results of these 2 years experiments indicated that it did not impact negatively the soil quality.

TA-O_07 The recycling potential of phosphorus in Norwegian waste products in a system's context

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Keywords
Substance flow analysis, plant-availability, pot experiment, mineral fertilizer equivalent

Objectives
Substituting mineral phosphorus (P) fertilizer with recycling fertilizers is one important step towards increased P sustainability. Therefore, the objective of the presented study was to compare the total amount of P in Norwegian waste products, as quantified by P flow analysis, to plant-available P in selected waste products, as studied by a pot experiment.

Methodology
P flow analysis was applied to the Norwegian food system (average for the years 2009-2011) to estimate the total amount of P in waste products. A pot experiment was conducted to compare plant-available P in selected waste products with mineral P fertilizer. Ryegrass (*Lolium multiflorum* var. *italicum*) was used as the experimental crop and a nutrient-deficient sand-peat mixture at two pH levels as experimental soil. Mineral fertilizer equivalents (MFE) were calculated, where uptake of mineral P = 100%.

Results
In 2009-2011, 8400 Mg P/yr were applied to Norwegian soil as mineral fertilizer, all of which was produced by imported rock phosphate. In total, 28400 Mg P/yr was estimated to be in waste products, of which the most important were animal manure (12000 Mg P/yr with 60% as cattle manure), losses in aquaculture in the form of fish excrements and feed (fish sludge, 9000 Mg P/yr), meat bone meal (MBM, 2074 Mg P/yr), sewage sludge (1887 Mg P/yr), and food waste (1142 Mg P/yr). The results of the pot experiment showed that P plant-availability in waste products may, among other parameters, depend on soil pH and waste treatment technologies. Applying the results of the pot experiment to the P flow analysis, the theoretical recycling potential in Norway varied therefore between 13400-19200 Mg P/yr with MFE of cattle manure = 100%, fish sludge = 60-97%, MBM = 10-70%, sewage sludge = 12-39%, and food waste = 20-85%. In 2009-2011, 20% of MBM, 50% of P in sewage sludge and 3% of food waste was returned to agricultural land, representing 160-690 Mg plant-available P/yr.

Conclusion
Our results suggest that, in Norway, P recycling is currently far from optimized. Combining P flow analysis with results from a pot experiment, we demonstrate that all P in mineral fertilizer could theoretically be replaced by secondary P. The study does, however, not include other critical parameters that could limit recycling such as distribution, technology, waste quality, regulations and attitudes.

TA-O_08 Nitrogen recovery from digested slurry with simplified ammonia stripping technique

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Objectives

Among the treatments to reduce nitrogen surplus from livestock slurry, ammonia stripping is an effective technology, but currently expensive and difficult to manage. In this work we evaluated a simplified and slow release ammonia stripping system to examine if nitrogen could be removed from slurry and collected in an acid solution, thus turning it into a mineral fertilizer the reduced its potential environmental impact.

Methodology

A pilot plant consisting of 3, 50 L reactors was used. Reactors were thermally controlled at 30, 40, and 50 °C and continuously mixed. Ammonia volatilisation was obtained by pumping an air stream of 10 L min^{-1} in the headspace of the reactors. Two tests lasting 4 days each were carried out using a digested slurry. The first test was conducted at the natural pH of digestate (about 8) and the second at an adjusted pH at 9 (by adding sodium hydroxide). The pH and Total Ammoniacal Nitrogen content were determined daily.

Results

The N removal efficiency of this slow-release system was close to that of faster treatments that use higher pH and temperature [1].
In the first test (pH 8) the initial concentration of ammonia in the digestate was 2.68 g L^{-1} and the removals were 24% at 30°C, 40% at 40°C and 57% at 50°C.
In this test pH increased from 8 at the start to 8.9 in the reactor with slurry held at 30°C, to 8.82 in the 40°C reactor and to 8.67 in the 50°C reactor.
In the second test (pH 9) the initial concentration of ammonia in the digestate was 2.54 g L^{-1}. N removals were 30% at 30°C, 52% at 40°C, and 74% at 50°C. At the end of the test, the pH remained constant in the reactor at 30°C, but increased to 9.09 in the 40°C reactor, and to 9.11 in the 50°C reactor.
The increased pH was promoted by loss of CO_2. In the second test, in which pH was manually increased, the further pH increase was limited.
Although at equal reactor temperatures, the second test achieved better results, in the first test the pH increased close to the modified pH of the second test.

Conclusions

These results show that digestion at pH 9 and 50 °C promotes the greatest reduction of ammonia. Nevertheless, ammonia reduction at pH 8 and 40 °C is interesting because it represent a common condition at typical biogas plants and it would be advantageous to raise the reactor pH rapidly, accelerating the volatilization of CO_2, by optimizing the aeration system [2].The system is promising but should be optimized to be implemented in practice.

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TA-O_09 Struvite recovery from methanogenic landfill leachate by chemical precipitation

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Objectives

Methanogenic landfill leachates are characterized by high ammonium and inert COD loads. Removal of ammonium by chemical precipitation as struvite is a fast and reliable process. Struvite or magnesium ammonium phosphate with a low water solubility, is an attractive slow-release fertilizer. The research work integrated membrane processes (RO and/or NF) and investigated the feasibility of recovering struvite from various process streams considering the effect of pH.

Methodology

1M solutions of $MgCl_2$ and H_3PO_4 were dosed in small volumes in 1:1 molar ratio at equal intervals. Experiments were performed with 1 litre batches of raw leachate, concentrate of reverse osmosis and permeate of nanofiltration after RO. To understand the effect of pH, experiments were conducted with the permeate at pH values ranging from 8.0-9.5. Supernatant samples over time were analyzed using DIN 38406-E5-1 method for ammonium-nitrogen. Samples from two batches were analyzed for TOC, IC and TN. The precipitate was dried and analyzed using XRD and wet chemical techniques.

Results

In all experiments, a linear decrease was observed in the supernatant ammonium-nitrogen concentration with the addition of $MgCl_2$ and H_3PO_4. Alongside, a reduction in supernatant TOC was measured in the experiments with raw leachate and also NF permeate which suggests the occurrence of co-precipitation, which is inevitable. The precipitate from NF permeate was white, that from raw leachate was slight brown in colour and that from RO concentrate was further dark. TOC content of about 8.28 mg/g and only 4.05 mg/g was measured in the products from raw leachate and NF permeate respectively.

The effect of pH on removal rate was found to be marginal besides the loss of ammonia by volatilization during the experiments at higher pH values. However, the purity of the product was found to be dependent on the pH. A precipitate with up to 93% MAP (based on ammonium-nitrogen content) was obtained at pH 8.0 from NF permeate. X-ray diffractograms confirmed the presence of struvite in all but one of the precipitate samples (except from RO retentate).

Conclusion

Combination of right membrane process with chemical precipitation results in a robust process for the removal cum recovery of ammonia from landfill leachate. Purity of the product depends strongly on pH and the initial concentration of organics. For agricultural utilization of the precipitate, a product with high purity, free from organic pollutants and/or heavy metals, would be highly desired. The study establishes the possibility to obtain a clean fertilizer product with low risks. It is hence worthwhile to integrate MAP precipitation with membrane technologies. Further research is necessary to comment on the economics of the process.

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TA-O_10 Combination of biochar and clinoptilolite for nutrient recovery from liquid fraction of digestate

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Introduction and objectives

The liquid fraction of digestate contains nutrients, particularly nitrogen and potassium, predominantly in ionic forms. Ion exchange and adsorption technologies can potentially be applied to recover and concentrate these valuable nutrients.

In a number of publications, ion exchange with clinoptilolite has been shown to be very effective for the removal of ammonium from domestic wastewater. Furthermore, more than 90% removal efficiencies for both ammonium and potassium from source-separated human urine have been reported in the literature [1, 2]. Biochar has recently been suggested as bio-sorbent material for removing various types of contaminants from wastewaters [3]. Combination of clinoptilolite and biochar could be an alternative solution for the concentration of nutrients from the liquid fraction of digestate.

To the best of our knowledge, the combination of clinoptilolite and biochar to remove nutrients from the liquid fraction of digestate has not been investigated.

Methodology

The liquid fraction of pig slurry digestate was sampled from Morsø Bioenergy (Denmark). Clinoptilolite (particle size 1-3 mm) was preconditioned with 0.01 M NaCl in a continuous column system with 1 BV h^{-1} flow rate for 24 h. Holm oak biochar (pyrolysed at 650 °C) was used with particle size 1-4 mm.

Combination of clinoptilolite and biochar was tested in 3 different experimental setups. In the first experimental setup, biochar and clinoptilolite samples were homogenously mixed and filled in one column. The second and the third experimental setup had two columns each where clinoptilolite and biochar were filled in different columns separately. Columns were filled with the mass ratio of 1:1 for biochar and clinoptilolite.

The experiments were run for 72 hours and sampling was done every 24 h. Ammonium, orthophosphate, potassium, total nitrogen, total phosphorus and total organic carbon were analysed in all samples.

Results

The experimental work is in progress and the results will be shown at the conference.

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TA-O_11 Wood ashes – A new fertilizer for agriculture

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Objectives

Today's increasing energy demand is associated with an increase of renewable resources usage such as biomass. Wood burning generates ashes, which are currently discharged due to their elevated trace element concentrations that exceed the Switzerland authorized thresholds for application on agricultural lands as recycled fertilizer. This is a significant loss of natural nutrients, especially as the amount of ashes grows from the increased interest in renewable green energy. The objectives of this study were to (i) characterize ashes coming from the wood power plant Enerbois (Canton of Vaud, Switzerland) and (ii) test their use as potassium fertilizer.

Methodology

Sequential extraction procedure (Rauret et al. 2000), x-ray diffraction analyzes (XRD) and scanning electron microscope analyzes (SEM) were used to study the chemical speciation and mineralogical composition of macro elements and trace metal elements (TME) contained in these ashes. Greenhouse experiment was conducted by Agroscope in Changins to study the agronomic effectiveness of these ashes as a source of potassium on sunflower, a very high demanding potassium crop.

Results

The ashes had high amounts of calcium (Ca) and potassium (K) but contained also trace elements, particularly copper (Cu), zinc (Zn) and nickel (Ni). The efficiency plant utilization of K contained in ashes was equivalent to that of KCl fertilizer that was used as reference. Under N-P-K-Mg limiting and non-limiting conditions, the ashes had a positive effect on the sunflower biomass increase and the absorption of K but the amount of absorbed Ni and Zn decreased, probably due to the negative effect of liming on the solubility of these elements. The experimental results showed that despite the elevated contents of Ni and Cu above the current Switzerland authorized thresholds for recycled fertilizers, the relatively low content of K limits primarily the amount of ashes to be applied.

Conclusions

The results of this study show that the ashes from the central Enerbois (i) present a low risk to soils and crops and could be used as potassium fertilizer on acid soils, (ii) contain TME but in "slowly" or "unavailable" forms and (iii) further research is needed on the effects of these ashes on acid and neutral soils at field/farm level.

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TA-O_12 The influence of raw materials and storage time in composts maturity

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Objectives

This study aimed to assess the maturity degree of organic composts/fertilizers used in agriculture. It was intended to evaluate the influence of the compost source and the storage time in the maturity of compost. Simultaneously, it was studied the compatibility of three methodologies used to assess the maturity degree.

Methodology

Four types of composts were analyzed, without storage (T0) and with 24 months (T1), from different processes: municipal solid waste (Compost A, B and C) and poultry manure (Compost D). Humic substances (HS) extract from the four composts as well as the HS extract from a landfill leachate were tested. As a control it was used a commercial liquid fertilizer. The maturity assessment was carried out by Germination Test, Growth Test and Cation Exchange Capacity (CTC).

Results

The germination index (GI) showed that the organic composts analyzed were potentially phytotoxic, indicating a low maturity degree. At the time T0, the composts from the same source registered different GI, between 0% and 23%. Compost D showed the highest GI value (33%). Similar trend was obtained for the time T1; the composts with similar raw material revealed different GI values, nevertheless for all composts the GI increased. The GI value for all HS extracts was higher than for the composts, as well as for the extract HS from the landfill leachate. The values obtained for the CTC ranged between 26 and 138 Cmol/kg of compost, with composts A and D showing the utmost and the lowest value, respectively. Again, it was observed different profile among the composts with similar raw material. The growth test was carried out only at time T1; it was found that composts A and D showed the highest (119%) and lowest (66%) value, respectively. Comparing the results obtain for the 3 methodologies, at time T1, it was observed that compost A registered the highest GI and GT value, and compost B showed the highest CTC value.

Conclusion

The composts showed low maturity degree, which may cause germination inhibition. The results indicated that composts with similar source have different maturation degree, suggesting that maturation is independent of the compost source. Nevertheless, the storage time endorse an increase of maturation degree. The results indicate that the various methodologies used are not consistent with each other; therefore it is important deeper the study on this subject.

TA-O_13 Reduction of ammonia emissions by acidification and injection of cattle slurry applied to perennial grassland

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Objectives

Ammonia (NH_3) emissions are responsible for several environmental problems and may be high after the application of slurries. In Denmark a new officially permitted system exists to lower the pH of slurry by adding concentrated sulphuric acid (H_2SO_4) shortly before application in the field. Lowering the pH suppresses the dissociation of NH_4^+ to NH_3 + H^+ and thus lowers NH_3 volatilization. To test different praxis available NH_3 abatement techniques, a collaboration project between Kiel University, Aarhus University and the Danish Knowledge Centre for Agriculture was established. In a field trial injection and acidification of cattle slurry were compared to bandspreading.

Methodology

The field trial was conducted in 2012 and 2013 at 2 perennial grassland sites at the German Coastal Marsh (site A; 40% clay soil) and on a sandy soil (site B) in Southern Denmark. Following treatments were tested: 1. Control, 2. Bandspreading, 3. Injection A (open slot, 17.5 cm slot distance), 4. Injection B (35 cm slot distance), 5. Acidification A (pH 6.5), 6. Acidification B (pH 6.0). Slurry was applied plotwise at each application date (site A: n = 8 and site B: n = 6, respectively) and application rate was determined total ammoniacal nitrogen (TAN) based. Yield and N-uptake was determined and ammonia emissions were measured by a combined method of calibrated chamber measurement and passive flux samplers in each plot [1]. The field trial was set up as a fully randomized block design (4 replicates) with plots of 9m x 9m. Between the plots guard areas of the same dimension were established to reduce the influence of NH_3 drift between plots, resulting in a chess-board design. N_2O emissions were observed on site A with a static chamber approach (Hutchinson and Mosier, 1981).

Results

Losses of NH_3 always were significantly highest for bandspreading with an average of 14% of $TAN_{applied}$; Injection A and B and acidification A and B showed reduced losses of 31.4, 60.6, 42.2 and 68.9% compared to bandspreading, respectively. The consumption of acid (96% H_2SO_4) to reduce pH from raw slurry (pH 7.2 - 7.4) was about 2.7 and 4.8 l t^{-1} slurry. N_2O emissions were low in 2012 (0.13 – 0.38% of N_{total}) and not differing significantly in 2012, while in 2013 (0.07 - 0.75% of N_{total}) abatement techniques tended to show higher N_2O emissions and significantly higher losses compared to band spreading were shown by Injection B. Dry matter yields did not differ significantly, but in average 95.5, 105.3, 103.2 and 114.8% of band spreading yield were obtained from injection A and B and acidification A and B, respectively. At site B, N uptake from acidification B was significantly higher than from band spreading and injection B in 2012, while no significant differences occurred in 2013. At site A in 2013 acidification B showed significant highest N uptake.

Conclusion

Ammonia losses of slurry applied to grassland can be reduced by 60 – 70% by using injection or acidification techniques that are already available in practice. That may result in higher yields and N uptake, while volatile N deposition is lowered. But first results indicate, that under specific conditions injection of slurry may enhance N2O emissions.

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TA-O_14 Drying of separated manure digestate solids – Effects of acidification, temperature and ventilation on nitrogen loss

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Objectives

The objective of this study was to assess the independent and combined effects of different acidification levels and drying conditions on dewatered digestate nitrogen content. It was hypothesized that a) gradual acidification of the solids will progressively reduce nitrogen losses during thermal treatment and b) that higher drying temperature will result in higher nitrogen losses.

Methodology

Solids obtained after decanter centrifugation of digestate was collected from a biogas plant in Denmark using mainly dairy manure as feedstock. The batch drying experiment was conducted in a laboratory conductive oven and the pH of the digestate was adjusted from the initial value of pH 9.2 to pH 6.6 and 5.5 with addition of concentrated sulfuric acid. The drying operating conditions included four different drying temperatures between 70 °C and 160 °C and two moisture evaporation rates, regulated by the application of external forced aeration.

Results

Dewatered digestate followed similar drying pattern to other porous material. Results indicate that acidification significantly reduces nitrogen losses during drying of the solid digestate. Acidifying the solids was able to preserve more than 75% of their original ammonium content. However, no overall significant difference was found between the two acidification levels tested on the nitrogen quantity retained in the digestate solids. The acid treated in comparison with the non-acidified digestate solids had slightly decreased carbon content and organic nitrogen concentrations. Increasing losses of nitrogen with elevated drying temperatures were identified only in the case of the non-acidified samples.

Conclusion

Moderate additions of sulfuric acid before thermal drying can be an effective pre-treatment of the digestate solids in cases where management strategies focus on the retention of nitrogen on the dried product. The thermochemical treatment of the solids results in a concentrated organic fertilizer with potentially much higher nitrogen availability.

TA-O_15 Thermal drying does not increase nitrogen release from an anaerobically-digested biosolid

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Objectives

We investigated the effect of thermal drying method (in a waste water treatment plant, WWTP, or laboratory oven) and drying temperature (70, 130, 190, and 250 °C) on the nitrogen (N) content of anaerobically-digested (AD) sludge, subsequent N release to soil, and soil nitrous oxide (N_2O) emissions under field-moist or near-saturated soil moisture conditions.

Methodology

AD and WWTP-dried sludge (dried on a belt drier 95 - 200 °C) were derived from a WWTP in Denmark. For laboratory-dried sludge, AD sludge was dried in a laboratory oven at 70, 130, 190 or 250 °C to < 5 % GMC. Sludges were added to soil at a 2 % rate (dry weight), soil water contents were adjusted to pF 2 or pF 1, and the samples were placed in an incubator at 15 °C in the dark. Soil ammonium and nitrate contents and soil N_2O and carbon dioxide emissions were analysed frequently over 120 days.

Results

Sludge ammonium contents were reduced by at least 32 % after thermal drying, and decreased most in sludges dried at high temperatures (~88 % reduction in 190 and 250 °C-dried sludge). Compared to AD sludge, thermal drying did not increase the % of mineralised organic N (*min-N*) in the sludge. At pF 2, AD sludge *min-N* was 42.9 ± 3.2 %, 53.5 ± 1.4 % for WWTP dried sludge (which was not significantly different). *Min*-N was lower in laboratory-dried sludges, between 38.6 % (laboratory-dried sludge at 70 °C) and 19.9 ± 1.2% (laboratory-dried sludge at 250 °C). In soils maintained at pF 1, *min-N* was much lower than at pF 2, suggesting that the soil was too moist for optimal activity of soil biota.

Soil N_2O emissions were significant in all sludge-amended soils maintained at pF 1. Between 2.4 and 6.4 % of total sludge N was emitted in 120 days. At pF 2, emissions were lower but still significant (between 0.17 and 1.79 %), and soils amended with 70 and 130 °C lab-dried sludge had the greatest N_2O production. Soil with 250°C-dried sludge had the lowest N_2O and CO_2 production.

Conclusion

Thermal drying reduced total and inorganic N contents of AD sludge, and did not increase sludge *min-N*. From this evidence, we concluded that drying this AD sludge was not a suitable treatment to increase N availability, findings which go contrary to the literature[1]. Sludges dried at high temperature (250 °C) were more recalcitrant than the others. More research is needed to confirm the influence of drying and drying temperature on mineralization of N from anaerobically digested biosolids.

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TA-O_16 Improving product quality and limiting nutrient losses of solid fraction of cattle slurry by composting and ensiling

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Objectives

Separating cattle slurry into a solid and liquid fraction is gaining more interest by dairy farmers. We evaluated if composting and ensiling of the solid fraction (SF), whether or not mixed with byproducts, could (i) optimize the quality of the SF as fertilizer and soil improver, and (ii) reduce nutrient losses during storage.

Methodology

Storage experiments on a concrete floor were conducted during April-June 2014. Five SF treatments consisting of the same volume (24 m³) were compared: (1) composting SF, (2) composting SF with straw and grass, (3) composting SF with farmyard cattle manure (FCM), (4) composting SF with clinoptilolite, and (5) ensiling SF with straw and grass. During the experiment gaseous emissions and product quality were monitored.

Results

SF is characterized by a high moisture content, low C/N ratio and poor structure. During composting pure SF, a low oxygen availability appeared which resulted in a frequent but not feasible need to turn the compost. Moreover high emissions of CO_2, NH_3 and CH_4 were noticed. Adding a straw and grass mixture or FCM resulted in higher temperatures (> 70°C) during composting, a dryer end product and more microbial fixation of mineral N indicated by a lower NO_3^--N and NH_4^+-N content and less NH_3-emissions. Adding clinoptilolite, a zeolite with a high cation exchange capacity especially for NH_4^+-N [1], resulted in lower NH_3-emissions, but had no effect on other quality parameters. No differences in organic matter content, C/N and C/P ratios between the different treatments were observed.

Ensiling SF with a straw and grass mixture resulted in lower temperatures compared to composting, due to a limited organic matter decomposition. The losses of organic matter, dry matter and nitrogen were smaller during ensiling. The silage end product had a higher NH_4^+-N concentration, C/N and C/P ratio and moisture content, and a lower NO_3^--N concentration.

Conclusion

Adding straw/grass or FCM to the SF resulted in higher temperatures due to a better composting process, probably assuring deactivation of weeds and pathogens. Because gaseous emissions were high, we suggest to compost a small fraction of SF with structure-rich byproducts or to compost in closed systems. Ensiling SF resulted in a product in which organic matter and nutrients were better conserved than during composting. Differences in product stability are currently assessed by an incubation test.

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TA-O_17 Scaling up pig slurry composting from laboratory to farm

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Objectives

The liquid character of the pig slurry, together with its high concentration of N as NH_4-N, may limit its composting. Then, solid-liquid separation is a necessary pre-treatment for later composting of the solid fraction. The objective of the present work is to develop a composting strategy for the treatment of the solid fraction of pig slurry and its establishment at the farm level.

Methodology

Three composting experiments were run: laboratory reactors for selecting the bulking agent; pilot-plant for defining methodology; and farmhouse scale for establishing the technology in a pig farm.

Laboratory reactors: Four mixtures were prepared using the solid fraction of pig slurry (SPS) with different bulking agents: cotton gin waste (CW), maize stalks (MS), barley straw (BS), and garden pruning wastes (PW). The SPS:bulking ratio were (% weight): R1= 83:17 (SPS:CW); R2= 92:8 (SPS:MS); R3= 94:6 (SPS;BS); R4= 87:13 (SPS:PW). Mixtures were placed in 5 L batch reactors (in duplicate), consisting on thermal insulated cylinders with 14 cm inner-diameter and 40 cm height. Temperature probes connected to a data logger (HOBO-Data Logger) were placed in the centre, inside the reactors, and internal and external temperatures were registered automatically.

Pilot-plant: Two composting mixtures were prepared by mixing SPS with CW at two proportions: 70:30 % (w), and 56:44 % (w). Trapezoidal piles of 2000 kg each were composted using the Rutgers static pile system with forced aeration at temperature demand (set at 65 ºC). The piles were turned two times for homogeneisation, the moisture was weekly controlled (> 40 %) and the temperature was monitored using two probes for each pile. The bio-oxidative phase of composting lasted for 107 days, and the composts were left to mature for two months (total time 167 days).

Farm scale: A trapezoidal pile (19.3 m^3) was prepared with SPS and CW at 75:25 % (w), using the mechanical turning available at the farm (5 turnings); the moisture was adjusted (> 40 %) at the time of sampling. The bio-oxidative phase lasted for 142 days, and 45 days of maturation (total time 187 days). The temperature evolution was monitored daily during the bio-oxidative phase (HOBO-Data Logger). Samples were taken periodically by mixing seven subsamples from seven representative sites of the pile, from the whole profile (from the top to the bottom of the pile).

Results

The thermal profile and the microbial degradation measured by CO_2-C emissions at the laboratory scale indicated that GP and CW were the most adequate bulking agents for SPS composting due to their high degradability, especially CW showing a quick energy production (157 kJ in 24 h), indicating fast microbial activity. In pilot-plant, CW controlled the excessive moisture of the SPS and developed adequate thermal profiles of the composting process. However, increasing CW proportion prolonged the thermophilic phase and the total composting time, leading to a final product with lower C and N concentrations and humic characteristics. The farm scale experiment confirmed the viability of SPS:CW composting at 75:25 % weight proportion, obtaining a good quality compost with humified organic matter, without requiring new equipment and infrastructure.

Conclusion

The composting of SPS requires the mixture with about 25-30 % weight of cotton gin waste as a bulking agent for adequate development of the process, obtaining good compost for agricultural use. The concentration of Zn and Cu coming from pig slurry from piglets can limit the compost quality. The process is technically and economically feasible for the farm.

TA-O_18 The influence of feeding on excreta characteristics of dairy cows

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Objectives

The most sustainable strategy to mitigate NH_3 emissions should focus on reducing its direct precursor, i.e. the urea fraction in animal manure. The large body of evidence for positive correlations between N-input, ruminal protein balance, milk urea, urinary N or urea N excretion and ammonia emissions shows that feeding strategies and diet characteristics are clearly related with the N footprint and excretory patterns of dairy cows (Reijs, 2007; Van Duinkerken et al. 2011). N flows in livestock systems are associated with N losses which reduce the fertilizer value of manure and the N use efficiency of animal production systems. The objective of the present study was to identify feeding measures and indicators for low N and particularly low urinary N excretion of dairy cows under Swiss conditions.

Methodology

In a meta-analytical approach, 13 Swiss feeding and N-balance trials mostly taken from doctoral theses were analyzed to establish relationships between N-input, N-excretion and excretory pattern and diet characteristics. The N-balance trials were based on quantitative urine and feces collection for barn-fed cows. 80 % of the data set represents repeated, individual cow observations which explain the extent of data variability. A subset of 31 dry cow observations was included in the evaluation. The statistical evaluation focused on univariate regressions to describe relationships between dietary factors and excretory patterns. Where appropriate, data was grouped by diet type (season), lactation stage or study.

Results

The range of winter and summer diets and performance levels reflect situations encountered under practical farming conditions. In total, 404 data sets were evaluated. The large range in dietary protein supply comprising protein deficient (CP <120 g/kg DM) to protein surplus diets (CP > 180 g/kg DM) clearly affected the excretory patterns with a distinct seasonal influence. Manure output ranged from 28 to 104 kg per day of fresh matter for lactating cows. The urine volume increased along with the dietary protein content and N turnover while feces output mostly varied with dry matter intake. In comparison to fecal N, urinary N concentration was highly variable. Dry matter intake proved to be a better single predictor than N intake, explaining 80 % of the variation in fecal N excretion. However, a curvilinear relation between N digestibility and dietary CP content was found. Based on this regression, fecal N output/day can be derived from N intake. Urinary N output correlated with dietary protein content and N/VOS or CP/NEL ratios underlining the dependency from metabolic energy-protein interactions. Unbalanced rations and excess dietary N lead to high urinary N and urea N output which have a high emission potential. Particularly summer rations proved to be difficult to balance in cases of limited use of supplemental high energy feed stuffs. The N footprint, expressed as N excretion g/kg ECM, correlated positively with the CP/NEL ratio of the diet.

Conclusion

Feeding influences excreta characteristics and excretory patterns of dairy cows. For low N footprint and N emissions, the energy/protein ratio at the dietary and ruminal level and the total protein supply need to be optimized.

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TA-O_19 Innnovative technique to improve phosphorous recycling yield from wastewater treatment plant (WWTP) sludge by producing high quality fertilizer (struvite)

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Objectives

The goal is to improve P recycling as quality fertilizer (struvite) from municipal wastewater by adapting an innovative process to recover both soluble and immobilized phosphorus (P) from sludge [1][2]. The innovation is to favor biological instead of chemical P dissolving. The objectives of this study were to optimize dissolving and to assess suitability of the liquid to enter the struvite crystallization step.

Methodology

Sludge (S) from 6 different WWTP based on chemical and/or biological P (bio-P) removal were characterized.
Chemical and biological acidification test were performed. Ionic composition and VFA were measured during the acidification.
Biological test were performed by adding co-substrates (coS) in anaerobic conditions. The influence of, coS/S ratio and pH was studied to optimize P release.

Results

Less than 25% of total P can be dissolved by acidifying thickened sludge to pH_4 chemically. A maximum of 45% was obtained in recirculated sludge from a combined process (bio-P removal + $FeCl_3$). Depending on the nature of the substrate and on the ratio coS/S, up to 70% was reached biologically. Best results were obtained from the combined bio-P + $FeCl_3$ process sludge and sugar as coS. Tests performed on “pure” coS (sugar, albumin and butter) alone or mixed and on real food wastes have shown that it should be possible to predict acidification potential and P release of coS from their biochemical composition.
Biological acidification test performed at controlled pH and cations analysis allowed making hypothesis about forms of phosphorus sensible to biological dissolving and mechanisms involved. A small amount of available carbon is enough to release biologically accumulated P but pH has to be maintaining around 4-5 to avoid chemical precipitation. Potential for separation of the P-enriched liquid from sludge and further P crystallization as struvite is discussed.

Conclusion

It is possible to biologically dissolve up to 70% of P from WWTP sludge even if Fe salts are partly used in the P removal process. The optimal conditions were determined in batch test and have to be confirmed in a continuous reactor. The coS composition will determine the ability to dissolve P biologically. The suitability of the acidified sludge for further separation (texture), struvite crystallization (ionic composition of the liquid) and, if the case arises, further methane production (AGV in sludge and/or liquid phase) have to be experimentally confirmed.

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TA-O_20 Phosphorus fertilizer from sewage sludge ashes by thermochemical treatment – Benefits and challenges

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Objectives

Mineral phosphorus (P) fertilizers are solely produced from phosphate rock. Europe completely depends on imports since there are no relevant phosphate rock deposits on the continent. Furthermore, phosphate rock is contaminated with heavy metals such as Cd and U that pollute the farmlands and pose environmental risks [1]. Sewage sludge ash (SSA) might be a promising source for recycling fertilizer since it contains large amounts of P (up to 13 %). However, fertilizer from SSA has to comply with the respective ordinances, particularly the heavy metal limit values stated in the fertilizer ordinance, and requires sufficient P bioavailability. Thus, we conducted a complete survey of SSA from German mono-incineration facilities [2] and developed a thermochemical treatment for SSA to reduce toxic elements and increase P bioavailability.

Methodology

Approximately 300,000 t/a SSA accrue in 26 German mono-incineration facilities. 24 of these took part in the survey, mostly with monthly samples covering a period of one year. We covered more than 97 % of all German SSA enabling a complete assessment of the SSA for P recovery potential, heavy metal content and P bioavailability.
SSA was treated in a rotary kiln at 900 - 1000 °C under reducing conditions. Thus, toxic elements were separated via gas phase. Additionally, alkaline additives (sodium or potassium -sulfates, -carbonates or -hydroxides) are added for increasing the P bioavailability because these react with phosphate phases in the SSA to highly bioavailable phases. The thermochemical process was investigated lab-scale in crucibles and optimized in rotary kilns in medium scale up to an industrial demonstration trial. The product of the demonstration trial is currently tested in a field trial.
SSA samples and thermochemically treated samples were dried, grinded, homogenized, and dissolved with microwave-assisted digestion (HNO_3/$HClO_4$/HF). The elemental composition was determined with ICP-OES and ICP-MS. P solubility in neutral ammonium citrate (P_{NAC}) was chosen as indicator for P bioavailability and determined according to the respective standard.

Results

The median P concentration in SSA was 7.9 % (medium 7.3 %, minimum 1.5 %, maximum 13.1 %). The resulting annual P recovery potential is up to 19,000 t. Thus, more than 12 % of the so far required mineral fertilizer could be replaced by secondary phosphates. The concentrations of Cd and U in the ashes (3.3 mg/kg and 5.8 mg/kg) are significantly lower than in phosphate rock and mineral fertilizers. Two thirds of SSA exceeds one or more limit value stipulated by the German fertilizer ordinance. Furthermore, the P_{NAC}-solubility mean value of SSA was only 32 %.
The thermochemical treatment with tested alkaline additives achieves P_{NAC}-solubility comparable to TSP. In the demonstration trial 2 t thermally treated ashes with a high P_{NAC}-solubility were produced. 61 % As, 80 % Cd, 68 % Hg, 39 % Pb and 9 % Zn were removed via the gas phase. First plant trials in pots show that the product has a fertilizer effect comparable to TSP.

Conclusion

German sewage sludge ashes show a significant P recovery potential. The thermochemical treatment in a rotary kiln with alkali additives is a suitable process to transform sewage sludge ash to a product which could be used as phosphorus fertilizer.

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TA-O_21 Innovative bioresource management technologies for recovery of ammonia and phosphorus from livestock and municipal wastes

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Background

The recovery of nutrients from wastes for re-use as concentrated plant fertilizers is a new paradigm in agricultural and municipal waste management. Currently the potential impact of manure on the environment represents one of the world agriculture's major challenges. Many areas of intensive livestock production generate more manure nutrients than available cropland can assimilate due to a net import of nutrients. Nutrient pollution is one of the most widespread, costly and challenging environmental problems in the world. It is caused by too much nitrogen (N) and phosphorus (P) in the environment. Nutrient pollution has diverse and far-reaching effects on the economy, impacting many sectors that depend on clean water. The agricultural sector remains the major source of ammonia emissions. Therefore, significant efforts are required to abate ammonia emissions from livestock operations. In this context, new technologies to recover the N and P are needed. The aspect of N and P reuse is also important for farmers because of increasing demand and cost of inorganic fertilizers. Fertilizer prices have escalated in recent years, thus there is renewed interest on developing technologies to recover and recycle nutrients from wastes.

Objective

In this paper we show development of systems and methods by USDA to recover nitrogen and phosphorus from livestock wastes conducted over a 10-year period that went from pilot recovery module development to full-scale demonstrations on livestock farms and commercialization.

Results

One technology was the production of concentrated calcium phosphate concentrates from livestock effluents. The amount of P removed, and consequently the N:P ratio of the effluent, could be adjusted in this process to match specific crop needs. We tested three configurations of the technology on swine farms showing consistent results. It was technically feasible to flocculate and dewater both the P and raw manure in a simultaneous operation, significantly reducing cost of equipment. Another invention is the quick wash process. It selectively recovered concentrated P with 90 percent plant available P from chicken manure and municipal bio-solids. Two other methods discovered use gas-permeable membranes at low pressure and can recover and concentrate most (99%) of the ammonia in the manure and contribute to cleaner air in livestock facilities. For liquid applications, the gas-membrane manifolds are submerged in the manure liquid. For air applications, the membrane manifolds are suspended above the litter, and the gaseous ammonia is removed inside the barns close to the litter.

Conclusions

The recovery of N and P from wastes will be increasingly important in agriculture because of the high cost of commercial fertilizers and the environmental damage of the release of reactive nitrogen and phosphorus. Advanced treatment technologies have been developed to address nutrient reuse in livestock wastes. The examples show a shift from municipal treatment methods in the near past to a new body of knowledge with methods adapted to the specific characteristics of these wastes and a different purpose for treatment. Further, for the first time we are seeing technologies developed for agricultural waste crossing the discipline boundaries and being adopted by the municipal wastewater treatment industry.

TA-O_22 Soil changes and nutrient uptake induced by organic residues

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Objectives

Under the hypothesis that plants respond to soil or substrate changes induced by compost addition, the objective of this paper is to study the effect of composted organic residues in soil properties and nutrient uptake by plants.

Methodology

Composted grass and sheep manure in a 3:1 proportion was prepared. These composted residues (C) were mixed 1:1 with a clay soil (S). One of these mixtures was evaluated as a treatment (SC), two were respectively added with 20% (SC-20) and 30% (SC-30) perlite; a fourth treatment consisted in soil complemented with 20-20-20 (N-P-K) fertilizer (SF). They all were compared with soil alone, making a total of five treatments. The experiment was conducted in greenhouse conditions under a completely randomized design with five replicates. The species *Ammi majus* (bishop's weed, lady's lace) was used to measure Fe, Cu, Mn and Zn uptake and dry (DM) matter production. Substrate pH, OM, EC and CEC were measured.

Results

The lower DM production was obtained with S and SC treatments, showing no direct effect of compost on yield. The highest result was obtained with SC-20 which was statistically the same with SC-30 and SF where pH increased and CE decreased significantly compared to S and SC. These results showed a relationship between changes in soil pH and CE with DM production. CEC values were high as expected in a clay soil and, although there were significant differences among treatments, no effect on DM production was observed.

Fe, Cu, Mn, and Zn critical content in *Ammi majus* were not available, but there were not visible signals of deficiency, suggesting that substrates supplied enough of them. However, there were significant differences in Mn in plants among treatments, whose absorption seems to be favored by compost in treatment SC and by the lowest pH in treatment SF.

Conclusion

The hypothesis that addition of compost increases yield was proved since dry matter produced with soil added with compost was significantly higher than with soil alone (α=0.05). However, the effect was not directly on plant, since it was observed in this experiment, the effect on plant was related to the changes induced by compost in the soil. The effect in Fe, Cu, Mn and Zn uptake was not the same for all; regardless of critical concentrations in plants, the absorbed amounts were significantly different only for Mn.

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TA-O_23 Multi-criteria indexes to evaluate the effects of repeated organic amendment applications on soil quality

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Objectives

The soil application of organic waste products (OWP) favours the recycling of nutrients, the crop production, the increase of soil biological activity and biodiversity. It may also lead to soil contamination. All these effects occurred simultaneously and must be considered in the evaluation of the practice. This study aims at deciphering the long-term impact of repeated applications and the short-term effect of an additional application on soil quality using 5 different Soil Quality Indices (SQI)[a] :fertility, microbial activity, biodiversity, physical properties and productivity and one pollution index by heavy metals.

Methodology

A long term field experiment was used (QualiAgro, Ile de France) where repeated applications of 4 amendments (a municipal solid waste compost, MSW; a biowaste compost, BIO; a co-compost of sewage sludge and green waste, GWS and a farmyard manure, FYM) have differentiated soil characteristics and crop production compared to a control treatments without organic residue and receiving mineral fertilizer or not (CONT+N and CONT). The OWP are applied every 2 years, in September, at doses equivalent to 4 t C/ha (4 replicates) on a maize-wheat succession. We used 2 sampling dates: 3 weeks before application (cumulative residual effect of 7 applications) and 3 weeks just after the 8th application (short-term additional effect of a recent application), in 2011. More than 30 different variables were used: chemical (pH, P_{olsen}…), physical (bulk density, plasticity…) and biological (microbial biomass, enzymatic activity…) soil indicators. All of these were classified in 6 classes: fertility, microbial activity, biodiversity, physical properties, productivity and pollution. Five SQI and one pollution index by heavy metals were estimated using a weighted additive index calculation method described by Velasquez et al. (2007)[a]. Only parameters with statistically significant differences ($p<0.05$) were taken into account, the maximum value of data set permits to normalized the data set, a principal component analysis was used for each data in order to explain the variability and at the end, the combination of all indicators selected and weighted by anterior steps defined SQI.

Results

The repeated applications of organic amendments increased soil fertility and microbial activity compared to control treatments as revealed by the corresponding indices. The largest improvements were observed in treatments that increased more the soil organic matter content (GWS, FYM and BIO) compared to MSW. The regular application of OWP did not significantly modify the SQI dedicated to biodiversity. A recent additional application did not lead to significant supplementary effect on the SQI. Physical properties, productivity and pollution index need more time to be explained.

Conclusion

The use of SQI allows the aggregation of different indicators to evaluate specific ecosystem services (soil fertility, soil biodiversity, vegetal productivity…) and disservices (heavy metal contamination) of the introduction of OWP in soil. A more complex aggregation can be used to analyse the practice in global view like with a Life cycle Assessment.

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TA-O_24 Effect of manure-based phosphorus fertilizer and biochar on biomass yield of spring barley and faba bean in comparison to conventional fertilizer

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Objectives

This study aims to test the fertilizing performance of an innovative pig manure-based phosphorus fertilizer (referred to as P-Salt) on biomass yield and quality of barley and faba bean in comparison to conventional fertilizer. A further objective is to investigate whether additional application of biochar, which is considered a soil amendment, results in increased biomass yield.

Methodology

This work is part of the EC-funded research project "BioEcoSIM" (grant agreement no. 308637). P-Salt and biochar are recovered from the liquid and solid fraction of separated pig manure, respectively. They were tested in a greenhouse experiment with spring barley and faba bean on two soils with particularly low nutrient content, loess and sand. In addition to phosphorus (P), P-Salt also contains nitrogen (N). Treatments of P-Salt and conventional synthetic fertilizers (ammonium nitrate and calcium dihydrogen phosphate) as a reference were applied in three levels: optimal nutrient supply (100%), deficient supply (50%) and oversupply (200%). Biochar was applied in two concentrations (0.1% and 0.2% w/w) in combination with the 100% level of P-Salt. Untreated controls were included. The experiment was established with four replications. Fresh and dry matter yield were determined after six weeks. Plant and soil samples were analysed for N, P and potassium (K).

Results

The influences of the factors 'treatment', 'soil' and their interaction 'soil*treatment' were highly significant ($P<0.0001$) in both crops. The P-Salt treatments resulted in significantly higher increases in dry matter yield (DMY) than the conventional fertilizer in both crops and both soils. P concentration in the biomass was similar following all P-Salt treatments including the combination with biochar. The highest biomass N concentration was measured in the crops treated with conventional fertilizer.

Barley: the combination of biochar and P-Salt slightly increased DMY compared to P-Salt alone; however, this effect was only statistically significant in sand. Conventional fertilizer considerably increased P concentration in barley compared to P-Salt.

Bean: in sand, DMY performance was higher in the P-Salt and combined P-Salt/biochar treatments than in the conventional fertilizer treatments. The highest P uptake was found in bean treated with P-Salt.

Conclusion

This study found P-Salt to have a very good fertilizing effect. It even led to higher DMY in barley and bean than conventional fertilizer. The slow release of nutrients can prevent leaching and makes P-Salt a suitable fertilizer for light soils with high sand content. The influence of biochar needs to be further specified. Generally, the recycling of nutrients from pig manure offers an attractive solution for dealing with the accumulation of manure which is particularly problematic in regions with high livestock densities. The high performance of this new fertilizer seen here is a promising precondition for continued research.

TA-O_25 Improving nitrogen fertilization effect from residues in spring and winter cereals

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Objectives

The three main objectives with this study was 1) to assess carbon/nitrogen-ratio (C/N-ratio) as a tool to predict mineral fertilizer equivalent (MFE) of different organic residues, 2) to estimate second year nitrogen (N) effects of different residues and 3) to test whether N effects on yield from different kinds of residues can be improved with incorporation or early application when applied to growing winter wheat.

Methodology

A total of nine field experiments in each of the crops spring oats and winter wheat was conducted at three locations in Sweden during the years 2012-2014. In oats, the yield effects from fertilizing with eight different residues were compared with the yield response on mineral N fertilizer. From this, MFE was calculated and compared with C/N-ratio of the residues. The second year crop was only moderately fertilized with N, to study second year N effects of the residues. In winter wheat, yield effects of fertilizing with three different residues with and without soil incorporation were compared with yield response of mineral N fertilizer to calculate MFE. In some experiments there were additional treatments with late autumn fertilization with chicken manure and pelleted meat meal.

Results

The relation between C/N-ratio and MFE from compiled data from the oat experiments (MFE=83%-C/N*4%), was very similar to the relation found in a former pot experiment [1]. The variation was larger in the field (r^2=0.26) than in the pots (r^2=0.84). Looking at one experiment at a time did reduce the r^2-value, but also altered the regression coefficient. The C/N-ratio tended to be more important in experiments with later sowing and shorter period for crop N uptake.

The crop N offtake of the next crop increased by on average 3 kg N ha^{-1} or 3% of added total N with residues compared to the treatment without N fertilization. Compared to the treatments with mineral fertilizer, there was hardly any residual effect.

Soil incorporation of residues to winter wheat led to significant yield increases in some experiments, but not all. Incorporation of pelleted meat meal with a sowing machine gave increased yield by 940-1300 kg ha^{-1} in three different experiments, although difference was only significant in one. Direct incorporation of biogas residues increased yield by 940 kg ha^{-1} and MFE from 21 to 44 % in one experiment on a clay soil. Incorporation of chicken manure with harrow increased yield by 740 kg ha^{-1} in one experiment, but it was not statistically significant.
Application of chicken manure in late autumn/winter (February-November) reduced yield by 600 - 1550 kg ha^{-1} compared with spring application. Autumn application of meat meal pellets had no significant effect on yield compared to spring application without incorporation.

Conclusion

Mineral fertilizer equivalent of different residues can be estimated from C/N-ratio. The second year N effects of organic residues were small. Incorporation of residues in growing winter wheat can increase yields and MFE for all three types of residues, depending on conditions, but is most likely to be successful for meat meal pellets. Autumn/winter application reduced yield and MFE, mainly for chicken manure, and cannot be recommended.

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TA-O_26 Recycled phosphorus fertilizers from urban residues tested in agricultural crop production

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Objectives

In the European Union, 11 million tons of sewage sludge dry mass is available every year and several techniques have been developed to recover Phosphorus (P) from waste water treatment. A range of different recycled P-fertilizers was tested in pot and field experiments with Trifolium pratense L. and Zea mays L. for their P-availability in comparison to $Ca(H_2PO_4)_2$ and Phosphate Rock (PR).

Methodology

The investigated recycled P-fertilizers included two struvites, P-RoC, Mephrec-P, thermochemically treated sewage sludge ash (SSA), and coal. Control treatments were unfertilized, fertilized with phosphate rock (PR) and $Ca(H_2PO_4)_2$. Used soil substrate was a silty loam with CAL-P content of 2.2 mg P 100 g^{-1} soil and pH 7.2 ($CaCl_2$). Fertilizers were applied according to 50 mg P kg $soil^{-1}$. Clover was harvested for three times, biomass and P-content of clover and maize plant tissue was determined.

Results

At first harvest date of clover, the struvite treatment reached a biomass and P-content significantly higher than the SSA, the unfertilized and the PR treatment, and did not differ from the $Ca(H_2PO_4)_2$ treatment. The SSA treatment was significantly decreased and not different from the unfertilized control and the PR treatment. At second harvest date, struvite, SSA, unfertilized and PR did not differ from each other in biomass. In SSA, a significantly decreased P-content was measured compared to the $Ca(H_2PO_4)_2$ treatment, which itself was not different from the struvite. There were no significant differences between all treatments at third harvest date. More distinct differences due to recycled P-fertilizers were shown in the experiment with maize. Concerning biomass and P-content, three treatment groups could be distinguished: The SSA, coal and PR treatment performed in the same, lowest range of the unfertilized treatment. Intermediate values were measured in Mephrec-P, P-RoC and one of the struvites, while a second struvite reached significantly higher values and was not different from the $Ca(H_2PO_4)_2$ treatment. Results from the field experiment will be evaluated until the conference.

Conclusion

Absent differences between treatments in the experiment with clover that could be detected in maize with the same soil leads to the assumption that clover is able to mobilize P from soil and fertilizer even under conditions of high soil pH. Comparable results with struvite have been reported on maize [1] and wheat [2], indicating high availability of the contained P, which can make struvite a promising supplement for conventional P-fertilizers in future. SSA seem less suitable on alkaline soils.

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TA-O_27 Sulphur availability from organic materials applied to winter wheat crops

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Objectives

This paper reports results from experiments investigating crop available sulphur (S) supply from organic materials. The findings will help improve current recommendations on the use of organic materials as sources of crop available S and enable farmers to reduce their manufactured fertilizer S use accordingly.

Methodology

Field experiments were carried out at 3 sites cropped with winter wheat over 3 harvest years from 2010 to 2012 (2 harvest years at each site; 6 harvest years in total). At each site, there were 7 organic material treatments, namely autumn applied cattle farm yard manure (FYM), pig FYM, 2 biosolids products and broiler litter, and spring applied broiler litter and cattle or pig slurry. Crop yields and quality on the organic material treatments were compared with those on inorganic fertilizer S response treatments (supplying 0, 12.5, 25, 50 and 75 kg/ha SO_3) to determine the fertilizer S replacement values and hence the S availability of the applied organic materials.

Results

There was a response to S in 3 of the 6 sites/years. For the spring applied organic materials, 'extractable' SO_3 (i.e. readily available SO_3) was a good indicator of crop available S, ranging from *c.*15% of total SO_3 for cattle FYM to *c.*60% of total SO_3 for broiler litter. Results showed that for spring applied organic materials, 'extractable' SO_3 was equivalent to inorganic fertilizer S i.e. the S use efficiency for spring applications was 15% of total SO_3 for cattle FYM, 25% for pig FYM, 60% for broiler litter, 35% for slurry and 20% for biosolids. Lower S use efficiencies were measured from the autumn applied organic materials i.e. 5–10% of total SO_3 for livestock manures and 10–20% of total SO_3 for biosolids, suggesting that readily available S supplied by the organic materials was lost via overwinter leaching.

Conclusion

This work has led to a better understanding of the available S supply from organic materials, allowing guidance to be produced for farmers on the availability of S from applications of organic materials. This is likely to improve farm profitability by reducing S applications to cereal crops receiving applications of organic material

Thematic area TA – Quality fertilizers from residues (Poster presentations)

Christiane Lüdtke: Art from Tetrapak

TA-P_01 Apparent nitrogen recovery in Italian ryegrass (*Lolium perenne*, L.) from the solid fraction of two digestates

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Objectives

Plant available N released after the incorporation into the soil of digestate solid fractions (DSF) is a basic knowledge in order to draw up affordable fertilization plans. The objective of this work was to estimate, with a greenhouse pot experiment, the amount of N recovered in Italian ryegrass after application of two different DSFs.

Methodology

A sandy loam soil was added with: 1) water (CO); 2) ammonium sulphate (AS); 3) DSF from cattle slurry (CS) and 4) DSF from slaughtering waste (SW). Both DSFs were applied at a rate of 340 kg N/ha while AS at a rate of 100 kg N/ha. Above ground biomass and N uptake were determined 45, 66 and 123 days after sowing. Roots biomass and N content were measured 123 days after sowing. Apparent N recovery (ANR) was calculated as the ratio of N plant uptake (net of CO) to N applied with DSFs or AS.

Results

Total AGB in CO (2.3 g/pot) was lower compared to that of fertilised treatments (3.1, 4.2 and 5.0 g/pot in AS, SW and CS, respectively). At day 123, root biomass was almost equal to cumulated AGB in all treatments. The same effect of treatments on AGB and root biomass was observed on the availability of N for ryegrass. Cumulative ANR in AGB was higher in AS (72%) compared to the organic fertilizers (37% in SW and 13% in CS). Similar differences were found at the 1st cut, when ANR in AGB was 49, 21 and 3% in AS, SW and CS, respectively. In the 2nd and 3rd cut about 20% of applied N was recovered in AS and SW treatments, while a lower percentage (10%) was recovered in CS. Recovery of applied N in roots was 5% in CS, 8% in SW and 9% in AS.

Conclusion

The results of this pot experiment confirmed the high variability in short-term N disposal from DSFs of different origin. Solid fraction of digested cattle slurry, with high C to N ratio and low NH_4-N content, can immobilise consistent amounts of N during decomposition into the soil. Opposite, solid fraction from non-fibrous materials, with low C to N ratio, is quickly mineralised, releasing much N for crop growth.

TA-P_02 Optimal placement of pelleted organic fertilizer in spring oat

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Objectives

The objective with this project is to investigate the fertilization effect on yield and weed density of spring oats depending on placement of pelleted organic fertilizer at different soil depths and distances from crop. This abstract present the first year results.

Methodology

The effects on crop nitrogen uptake, grain yield and weed density of placing pelleted meat bone meal (MBM) at different soil depths and at different distances from the seed row was tested in two field experiments in Sweden. One was on silty clay and one on sandy loam. The treatments were randomized within four blocks. Each plot was only 70 cm long and 100 cm wide and sown and fertilized by hand. The seeds were sown at 4 cm depth and the pellets were placed at two or three depths (1, 4 and 8 cm) and at three distances (0, 4 and 12.5 cm) from row. There were also control treatments without N fertilization, with mineral N fertilizer and with surface broadcasting with shallow (0-1 cm) incorporation. All fertilized treatments received 60 kg total N ha^{-1}. Weeds were counted in beginning and end of June and were then harvested to measure dry matter yield. The oat was harvested at ripening, by cutting the straw at soil surface in a net area of 50 cm x 50 cm within each plot. Plant samples were threshed in the laboratory and grains and straw were measured separately and analyzed for N contents.

Results

On the clay soil, there was a tendency for higher grain yield the closer to crop row (p=0.058) and the deeper in the soil (p=0.054) the pellets was placed with no interaction between depth and distance from row (p=0.45). Grain yield increased on average with 300 kg ha^{-1} when incorporated to 4 cm compared to 1 cm (p=0.054). Placement of pellet 0 cm from crop row gave 470 kg ha^{-1} higher yield than placement 12.5 cm from crop row (p=0.051). There were a significantly higher number of weed plants in some treatments, which had more shallow incorporation in combination with some distance to crop row. The weed biomass was significantly higher in two treatments, one with broadcasting and one with placement far from the crop row. However, the weed density was still rather low and did probably not affect the crop yield.

On the sandy soil, there was also a tendency to differences in yield depending on both incorporation depth (p=0.07) and distance to crop row (p=0.06) without interaction between depth and distance from row (p=0.30). Grain yield increased by on average 500 kg ha^{-1} if applied at 8 compared to 4 cm depth (p=0.02), partly because placing pellet together with seeds were unfavourable in this trial. The difference in yield between incorporation at 1 and 8 cm depth was smaller (230 kg ha^{-1}) and not significant (p=0.068). Placement 4 cm from the crop row increased yield with on average 485 kg ha^{-1} compared to placement 12.5 cm from crop row. There were no significant differences between treatments in number of weed plants or weed biomass on 24 June, probably because of the vigorous crop competing well with weeds.

Conclusion

It is too early to draw conclusions from only one year of results. However, the results indicate that placement of organic fertilizer close (<4cm) to the crop row can improve yield and reduce weed biomass compared to broadcasting and fertilizing between rows, although not always significantly. Incorporation of fertilizers was in this case favorable on clay soil, but on the sandy soil only when incorporated directly under seed row.

TA-P_03 Reuse potential of urine as a source of plant micronutrients

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Objectives

The main objective of this study was to investigate the potential of urine as a source of plant micronutrients in comparison with commercial fertilizer. Specifically, the study wanted to find out the biomass yield of corn (*Zea mays*) and the micronutrient uptake of the plant with urine application.

Methodology

A pot experiment with corn was conducted under greenhouse condition. Woodchips were used as the growing medium to make sure that no other sources of plant nutrients would be available for plant uptake. Urine was compared with a commercial granular fertilizer containing Nitrogen, Phosphorous, Potassium, Boron, Zinc and Manganese and water was applied for the control. Urine was collected from members of the institute and the dilution rate used was 3:1 for water and urine respectively. For the fertilizer treatment, 18 grams was applied per pot and irrigated with water. Irrigation schedule was the same for all pots including the volume of water and urine treatment applications. Heat and light was provided where light duration was set at 12 hours per day. Environmental temperature and humidity was monitored overtime. After 26 days from planting, the plants were harvested and analyzed for biomass production and micronutrient uptake. Inductively Coupled Plasma Spectrometry was used in analyzing micronutrient concentrations.

Results

Biomass accumulation obtained were 1.10, 170.30, and 195.60 grams per plant fresh weight (average) for the control, urine and fertilizer treatments respectively. No significant difference was found between urine and fertilizer treatments which implies that the efficiency of urine as a source of plant micronutrients is highly competitive with commercial fertilizer. However, very high significant difference was found between the control and urine treatments. This means that all the nutrients in urine were efficiently taken up and utilized by the plants. It also means that the woodchips did not contain significant amounts of available plant nutrient. Plant tissue analysis revealed micronutrient uptake of Boron, Zinc, Copper, Iron and Manganese at 10, 25, 2.20, 25 and 63 mg/kg dry weight concentrations per plant (average) respectively from the urine treatment. Other studies have also found out micronutrients in urine at different concentration levels (1,2).

Conclusion

Urine is a good source of plant micronutrients. The micronutrients can be utilized efficiently by any crop for efficient physiological plant processes resulting to biomass production and urine does not pose any harmful effects.

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TA-P_04 Effect of fertilizer source on honey bees number in black cumin plant

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Objectives

Loss of biodiversity is may be occur by different problems such as high and unbalanced application of chemical fertilizers for crop production, that it cause to disorder in agroecosystem functions. The objective of this study was to evaluate honey bees number in black cumin (*Nigella sativa* L.) plant treated with chemical fertilizer, organic manure and their combination, in semi-arid conditions, Iran.

Methodology

The experiment was conducted in randomized complete block with four replications at research farm of Shahrekord University in 2013. Treatments were consisted of three sources of fertilizer (Chemical fertilizer, broiler litter, and integrated fertilizer 50:50. Honey bees number per plot (2.5 × 2.25 m) for black cumin plants was counted in flowering stage (during eight days).

Results

The results showed that effect fertilizer source was significant for honey bees number per plot in the first, second and seventh days. Honey bees number per plot were in the following decreasing order; in the first day, integrated= organic manure > chemical fertilizer, in the second day, integrated= organic manure > chemical fertilizer and in the seventh day, integrated≥ organic manure ≥ chemical fertilizer. In the first, second and seventh days, increase honey bees number per plot in integrated and organic treatments compared to chemical fertilizer were 145 and 100 %, 140 and 120 %, 83 and 33%, respectively.

Conclusion

In general concluded that the application of organic manure in protecting of pollinators insects can play better than conventional systems. Therefore, more researches is needed to investigate the composition of produced nectar of plant flowers in organic conditions.

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TA-P_05 Agronomic assessment of the fertilizing capacity of agroindustrial waste composts in Chimborazo province (Ecuador)

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Objectives

The aim of this experiment was to determine the effects of different agroindustrial waste composts on the soil properties and on plant yield and some marketable parameters of two successive horticultural crops.

Methodology

The field experiment was conducted at the Tunshi Research Station of the Polytechnic School of Chimborazo (Ecuador). Six treatments, in a completely randomised design with three replicates per treatment, were set up in experimental plots of 6 m^2 each. The treatments were: control without amendment (C); mineral fertilizer (175, 60 and 200 kg ha^{-1} N, P_2O_5 and K_2O, respectively) (M); poultry manure (PM) (9.7 t ha^{-1}), a traditional amendment used as a reference in this study; compost elaborated using flower waste and poultry manure (C1) (9.3 t ha^{-1}); compost elaborated using broccoli waste and poultry manure (C2) (28 t ha^{-1}) and compost elaborated using tomato waste and poultry manure (C3) (16.7 t ha^{-1}). The amendment application rate was adjusted to supply 175 kg ha^{-1} of nitrogen. After the incorporation of these treatments, the cultivation of broccoli (*Brassica oleracea* cv. Avenger) and subsequent cultivation of lettuce (*Lactuca sativa L.* cv. *capitata*) were carried out. Soil physico-chemical and chemical properties and the yields and marketable parameters of each crop studied were determined.

Results

Before broccoli planting, no significant differences in the pH values were observed among the different organic treatments in relation to the control soil, whereas the addition of the mineral fertilizer (M) to the soil resulted in a significant initial decrease in soil pH. At the end of the experiment, only the soils with compost reached values of this parameter higher than those of the control soil. Organic amendment and M treatments resulted in a significant and temporary increase in the electrical conductivity of the soils studied at the beginning of the experiment, especially in the case of inorganic fertilizer. However, no differences were found among the different treatments respect to the soil salinity, after lettuce harvesting. The addition of organic fertilizer initially increased the soil organic carbon content in comparison to M and control soils. However, the final values of this parameter were similar in all treatments. Similar results were also obtained in the case of the soil N concentration at the end of the experiment. This fact could be due to the contribution of organic compounds from roots of both crops, which remained in the soil after harvesting. In general, the incorporation of the organic amendments, especially the composts, produced a significant increase in the soil concentrations of P and K in comparison to M and C treatments.
Regarding the crop yields, the highest yields of broccoli were obtained with the M and PM treatments. However, the lettuce yields were higher with the organic fertilizers in comparison to C and M treatments, indicating the residual fertilizing capacity of these amendments. In general, the marketable parameters were higher in the vegetables cultivated with composts.

Conclusion

From the data obtained, it can be concluded that the application of the agroindustrial waste composts to soil produced positive effects on soil fertility and these composts did not lead to phytotoxic effects on the broccoli and lettuce plants.

TA-P_06 The influence of anaerobic digestion on the concentration of antibiotics, heavy metals and on phosphorous-solubility of digestates

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Objectives

Digestates are a nutrient rich source, especially with view to the finite resource P. Manure and sewage sludge are often used as co-substrates in biogas plants, thus digestates may be contaminated with antibiotics [1] and heavy metals [2]. Different substrates and digestates were analysed to assess the effect of digestion on the content of selected antibiotics and heavy metals and on the P-solubility.

Methodology

Composite samples of the input materials and digestates were taken from biogas plants using different substrates. The concentration of tetracyclines, sulphonamides, fluoroquinolones was analysed using LC-MS, while the heavy metal concentration was determined by aqua-regia digestion and analysed via ICP-MS. The P-solubility of the samples was assessed by water- and CAL-extraction from fresh and oven-dried samples. P determination was done colorimetrically.

Results

First analyses showed that the concentration of relevant heavy metals (e.g. Cd, Cr, Ni and Pb) in the digestates were generally elevated compared to the corresponding substrate due to mass loss. However, the concentrations of these heavy metals in the digestates usually did not exceed the limit values settled in the German Fertilizer Ordinance (DüMV). Thus, the use of digestates as a fertilizer will usually not be restricted by their heavy metal concentration. However, preliminary results of the analysis of antibiotics revealed that veterinary antibiotics can still be found in the digestates. Obviously anaerobic digestion does not lead to a complete degradation of antibiotics.
The P-extractions have not been finished yet but it can be expected that the digestion process will not have a significantly negative effect on the P-availability of digestates.

Conclusion

Generally, anaerobic digestion does not have a negative influence on the P-availability of digestates in comparison to the substrate. Furthermore, the heavy metal concentration of most digestates does not exceed the limit values of the German Fertilizer Ordinance which also suggests that digestates are suitable fertilizers. However, the detectability of veterinary antibiotics in digestates indicates that further processing of these materials is necessary to provide a non-hazardous nutrient source.

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TA-P_07 WAVALUE – A new process to produce commercial fertilizers from digestate generated at biogas plants

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Objectives

The aim of this project (Wavalue) is to develop and test a new technology to formulate and granulate organic wastes, specifically biogas plants digestate evaluating, performance, costs , Life cycle analyses . With the WAVALUE project, we are trying to introduce a process to transform digestate, or the by-products generated during the treatment processes, into high-value commercial fertilizers. These fertilizers are granulated, totally spherical with sizes between 1and 4 mm in diameter and have a N:P:K value that has been tailored to meet market demand.

Methodology

The process for transforming digestate into commercial fertilizers comprises two basic steps:
1) Nutrient composition balancing: Liquid digestate is first mixed with other high nutrient organic wastes and/or commercial fertilizer chemicals in order to fortify and balance the N:P:K value to commercially viable levels recognized in the industry.
2) Drying and granulation: The liquid or slurry mixture from 1) above is then introduced into a Spouted Bed- type dryer/granulator where completely round granules of various sizes are produced. The dry granular product appears to be physically similar to commercial mineral fertilizers but differs in that it could contain between 20 and 100% organic materials.

Results

Developed fertilizer products include a wide range of NPK values, from relatively low (for example 9-2-2 with 70% organic matter) when digestate is the main component of the mixture, to high NPK values (11-15-11 with 20% organic matter) when combined with mineral fertilizers.
Because of the reactions that take place between organic matter and added mineral nutrients, those fertilizers have slow release behavior. That makes them specially suitable for gardens, sport courses or horticulture. A special type of fertilizer that can be produced are the microgranules. Microgranules are granules between 0,5 – 1,5 mm diameter. Because of their small size, they can be applied together with the seed, under the same labor. That puts the fertilizer in a “ultralocalizated” position, allowing a total availability of the fertilizer for the plant, at first moments of germination. Then, the fertilizer dose can be strongly reduced, without losing any production.
On the other hand, two life cycle analysis have been conducted, to compare the impact of the production of two fertilizers: one of the fertilizers developed in this project (12-12-12), and an equivalent dose of a very popular and similar mineral fertilizer (15-15-15). The result of the comparison is that the fertilizer produced by the WAVALUE process, produces 50% less impact on the global warming (IPCC 2007 – kg CO_2 eq index).

Conclusion

The process shows a high potential for the treatment of organic waste, reducing costs and improving environmental indicators being, moreover, more efficient in both aspects, economic and environmental.

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TA-P_08 Effects of thermal drying on phosphorus availability from sewage sludge

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Objectives

Thermal drying of sewage sludge implies sanitation[1] and improves practical handling options of the sludge; however, it may also affect its value as a P fertilizer. The main objective of this study was to assess whether thermal drying of sewage sludge, as well as temperature during the drying process, affects plant P availability.

Methodology

The experiment included dewatered sewage sludge (19% DM) and thermally dried sewage sludge (95% DM) collected at a Danish wastewater treatment plant, as well as laboratory-dried (70, 130, 190, and 250°C; DM>99%) sub-samples of the dewatered sludge, and triple superphosphate (TSP). Plant P availability of the sludges and TSP was studied in 1) a 192 days soil incubation experiment with sampling for DGT analyses over time 2) a pot experiment evaluating P uptake in spring barley after 6 weeks growth.

Results

In both experiments, amendment with non-dried sludge implied a higher P availability than the dried sludges.

Incubation experiment: Whereas P availability from the TSP-amended soil clearly decreased over time, the sludge-amended soils stayed at the same level or slightly increased. However, the ranking on P availability for the different amendments remained the same throughout the experiment (average C_{DGT} in µg l^{-1} is shown in brackets): TSP (186) > dewatered sludge (66)> dried sludge (42) > control soil with no P amendment (19). No differences in P availability were found between the four laboratory-dried sludges.

Pot experiment (laboratory-dried sludges were not included): All P amendments increased the dry matter yield and P uptake in the plants compared to no P amendment. Plant P uptake at harvest was at a similar range for TSP and dewatered sludge, while amendment of dried sludge compared to dewatered sludge reduced the plant P uptake with 27%.

Conclusion

This study clearly showed that thermal drying reduces the plant P availability from sewage sludge, whereas no evidence was found for the drying temperature to have a major effect. Additionally, the results indicate that non-dried sewage sludge can serve as P source for spring barley on a comparable level with mineral P fertilizer.

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TA-P_09 Recycling vegetable waste, sewage sludge, wood ash and sawdust by composting

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Objectives

The objective of the research was the recycling, by composting, vegetable waste with sewage sludge, sawdust and wood ash in order to obtain and characterize ecological, low cost materials used both as bio-fertilizers and adsorbents of heavy metals (Cu^{2+}) from wastewater.

Methodology

4 typs of composts (with different ratios between raw materials) were synthesized and characterized at laboratory scale.The composting process was monitored (15 weeks) by weekly investigating some physical-chemical parameters: pH, electrical conductivity (EC), content on carbohydrates, amino acids and C/N ratio. The compost maturity and stability was determined by FT-IR spectroscopy and germination tests. The composts were also tested as adsorbents of toxic metals from wastewater.

Results

All the four compost obtained (C1 - 100% vegetables; C2 - 80% vegetables, 10% sawdust, 10% wood ash; C3 - 70% vegetables, 20% sewage sludge, 10% sawdust; C4 - 70% vegetables, 10% sewage sludge, 10% sawdust, 10% wood ash) present at the end of composting process value of pH, EC, C/N ratio, germination index in accordance with the recommended conditions of stability and maturity for the compost to be accepted as bio-fertilizer: pH: 6÷9; EC: 2,0÷ 3,5 mS/cm; C/N ratio: 20÷35; PSG>60%; GI>85%. The FTIR spectra confirmed the biodegradation of complex compounds such as proteins, poly carbohydrates, etc. into simpler compounds like carboxylic acids, alcohols, phenols, amines and their salts, amides etc. The composts C3 was used for Cu^{2+} removal from wastewater. The adsorbent compost structure and morphology was investigated, before and after adsorption process of copper, by FTIR, AFM and XRD techniques. The heterogeneity of the adsorbent C3 determines a physical, multilayer, cooperative adsorption, on heterogeneous compost surface.

Conclusion

The results obtained evidenced that a ratio of (10-20%):(90-80%) between sewage sludge, wood ash and sawdust: vegetable waste is adequate for obtaining a good compost, useful both as bio fertilizer or adsorbent of Cu^{2+} from polluted waters, in which the sewage sludge, wood ash and sawdust were valorized and recycled together with vegetable waste. Adsorption of toxic metals on compost substrate represents a sustainable, low-cost process useful in wastewater treatment.

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TA-P_10 Evaluation of distillery organic waste compost efficiency on vineyard soil properties and grape quality

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Objectives

The objective of this work was to study the effects of a distillery organic waste compost with respect to different traditional organic fertilizers on some physico-chemical, chemical and biological characteristics of a vineyard soil and on the grape yield and quality during a year period.

Methodology

The field experiment was carried out during the 2013 season in a 15 year old 'Monastrell' vineyard (*Vitis vinifera* L.) of about 1.1 ha, situated in Monovar (Alicante-Spain). Four treatments, in a completely randomised design with three replicates per treatment, were set up in experimental plots (43 m^2), each containing 10 vines planted with a row spacing of 3 m × 1.5 m (row x vine) equivalent to 2300 vines ha^{-1}. The treatments were: treatment without organic fertilizer (C); sheep/goat manure (SGM) (5.5 t ha^{-1}); distillery organic waste compost (DC) (5.6 t ha^{-1}) and sheep/goat manure compost (SGC) (17 t ha^{-1}). The amendment application rate was adjusted to supply 170 kg ha^{-1} of nitrogen. No additional inorganic fertilzation was applied throughout the experiment and only one irrigation was carried out during the growing season (140 days). pH, electrical conductivity, oxidisable organic carbon, organic nitrogen and soil respiration were measured during 210 days after organic fertilizer addition to the soil. Also, grape yield and grape quality parameters were determined.

Results

The soil application of organic fertilizers improved soil fertility, since soil respiration and organic C and N were increased significantly by the organic fertilzation with these amendments, this soil fertility improvement being higher with SGC treatment. Also, the addition of these organic fertilizers did not alter the soil salinity, except in the case of SGC. This fact could restrict the use of this amendment. The addition of the SGM and SGC treatments reduced the soil pH value, which could increase the plant micronutrient assimilation, especially in the case of Fe, reducing the common iron chlorosis of plant of this area. Finally, the grape yield was significantly increased with the organic fertilizers in comparison to control treatment (C). However, organic amendments did affect neither the alcohol production capacity of the fruit nor pH, total acidity and polyphenol level of grape.

Conclusion

From the data obtained it can be concluded that the use of the distillery organic waste compost improved soil quality and increased grape yield, obtaining similar results to those observed with the traditional organic fertilizers. However, no differences were found among the different treatments respect to the grape quality. This fact indicates that the use of distillery waste organic compost as organic fertilizer can be a method to maximize the use of residual nutrients from the organic wastes generated in the distilleries associated to the winery industry.

TA-P_11 Procedure for defining new Swiss standard values for the nutrient excretions of dairy cows

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Background

For the compulsory farm nutrient balance and fertilization planning Swiss farmers need standard values for livestock excretions of nitrogen (N), phosphorus (P) and other minerals. For the new edition of the fertilization guidelines (to be published 2016) a major review and revision is foreseen for all major livestock categories. We will present the general approach adopted for this revision using dairy cows as a case study. They are the most important contributor of N livestock excretions and production has changed considerably in the recent past.
These standard values should reflect typical current conditions on farms. Because they are also used in policy instruments, especially for the N and P balance equilibrium that every farm has to fulfill, a pragmatic and simple and at the same time precise and robust approach is necessary.

General approach

In principle, the excretions will be derived from balance calculations of nutrient intake in feed minus nutrient retention in milk produced and body growth. Different major roughage diet compositions will be defined based on a representative farm management survey conducted in 2010. These diets will be used for the balance calculations, using different milk yields, calving dates and lactations. An existing model based on the official feeding recommendations will be used to simulate feed intake, retention and excretion on a weekly basis in dependence of lactation stage, milk yield and diet composition. The results of the balance calculations for N, P, potassium (K), magnesium (Mg) and calcium (Ca) will be weighted relative to the importance of the different rations according to the survey mentioned above.
For roughage contents the also newly revised standard values for the mineral content of grass, hey and grass silage will be used. They differentiate between different sward types, grassland use intensities, development stages of swards at harvest, first or following utilization per year and cut swards vs. grazing.

Expected results

Provisional results and suggestion for standard values will be available in summer 2015.
The standard excretions will be defined for an annual average milk yield (probably 7500 kg), but correction factors or equations will be provided for differing milk yields and other major influencing factors. In addition to the excretions, corresponding standard values for the roughage consumption will be presented because these are needed in the nutrient balance calculation. Very special production systems, e.g. cows with full grazing regime during the whole summer and milk yields around 6000 kg, will probably be presented as special categories. Apart from this, a detailed documentation will provide a) a clear description of all the assumptions used and b) suggestions how special conditions could be accounted for (e.g. separate values for lactating and dry cows or atypical K content of the grass based roughage). The new excretion values will be taken into account for the nutrients content of manures also presented in the fertilization guidelines.

Outlook and conclusions

Regular cheeks and revisions of standard values on excretion are very important if such values are used in farm management planning or policy implementation. Together with the nutrient balance restrictions, reliable and robust standard values on nutrients in manure have in the past contributed greatly to the strongly improved awareness of farmers about the value of manure and proper manure management, which have led to an impressive decrease of fertilizer use and corresponding improvements of nutrient use efficiency (see T1-O_Menzi). Hopefully the new and more differentiated values will continue and strengthen this process.

TA-P_12 Changes to the nutrient contents of pig and poultry manures in England and Wales

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Objectives

Data on pig and poultry manure nutrient composition published in the guidance documents currently available in England and Wales [1] may be out of date due to changes to livestock diets, and housing and manure management systems which have occurred since the underlying data were collected in 2000-2002.
The aim of this project was to collect and analyse pig and poultry manure samples to ensure that the advisory data on their 'typical' nitrogen (N), phosphorus (P) and potassium (K) contents are up-to-date and representative.

Methodology

Around 280 samples of pig slurry, pig farmyard manure (FYM), laying hen manure, broiler and turkey litter and duck FYM were collected from farms throughout England and Wales The sampling programme was targeted to reflect the spatial distribution of producers and to ensure that samples were collected from farm types and manure management systems which are representative of current practice. Samples were analysed for dry matter, total N, P, K, sulphur (S) and magnesium (Mg), ammonium-N, nitrate-N and uric acid-N (poultry manures only) using standard methods.

Results

Preliminary analysis of the manure analysis data indicates that there has been little change to the nutrient content of pig FYM, but that the total N and P contents of pig slurry have reduced perhaps due to changes to pig feed conversion ratios and reductions in the dietary crude protein content of pig diets, together with the increased use of phytase (currently used in 70% of pig diets [2]).

The dry matter and total N content of layer manures has increased, reflecting the switch away from deep-pit systems towards on-belt manure removal, which leads to drier manures and hence to lower N losses from ammonia volatilisation. Similarly, the dry matter, total N and readily available N (i.e. ammonium-N plus uric acid-N) contents of broiler litter have increased, probably reflecting the increased use of heat exchange units. However, the P content of broiler litter is substantially lower; this is probably a result of the increased use of phytase which is currently used in around 90% of poultry diet formulations [1].

Conclusion

Data from this project will be used to ensure that advisory data on the 'typical' nutrient content of pig and poultry manures are up-to-date and representative, so that the guidance documents continue to provide accurate and relevant nutrient management advice for farmers and growers.

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TA-P_13 Phosphorus availability in the tropical soils of Reunion – Comparison of various methods

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Objectives

Application of organic wastes is expected among other beneficial effects to enhance phosphorus (P) availability in soils, but this fertilizer effect largely depends on soil properties [1].
Phosphorus availability in the soils of Reunion (a French tropical island in the Indian Ocean) has been poorly studied [2]. Despite a similar volcanic origin, these soils are expected to exhibit very different P availability due to their distinct pedogenic evolutions.
Accordingly, the aims of this preliminary study are i) to determine P availability in a wide range of soils of Reunion supplied or not with various mineral and organic fertilizers and ii) to evaluate the relative relevance of different soil P tests and their respective correlation with P uptake in various crops (phytoavailability).

Methodology

Fifty soil samples were collected in 5 field trials, encompassing the main soils types (i.e. hydric andosol, chromic andosol, andic cambisol, nitisol and hyperskeletic fluvisol), and cropping systems (fodder, sugar cane, market garden crops) of Reunion.
Phosphorus availability in soil samples was measured with 4 chemical methods: i) CaCl2 (0.01M) extraction to mimic soil solution ii) DGT (diffusive gradient in thin films) technique to estimate the diffusive and kinetically-labile pools and iii) the Olsen (0.5M NaHCO3 at pH 8.5) and Olsen-Dabin (0.5N NaHCO3 + 0.5N NH4F at pH 8.5) extractions that respectively target the moderately and weakly available pools.
Phosphorus concentration in shoots was then measured on plant digests by ICP-MS.

Results

Available P is expected to vary highly with both soil types and the chemical method used. Phytoavailable P is further expected to vary between crop species.
The analysis of data distribution will highlight the capacity of each chemical method to discriminate the soils tested. The search for correlations between chemical methods could then reveal differences or similarities between results obtained with the different methods.
Linear regressions of phytoavailable P against soil available P and comparison of the coefficient of determination obtained between each chemical method will highlight the efficiency of each soil P test to reflect phytoavailable P. With some methods, available P is expected to be correlated with P uptake in most of the soils tested, while it could be correlated just in some soil types with others, such as Olsen-Dabin extraction, which is known to extract a large pool of P weakly available.

Conclusion

Olsen-Dabin extraction, which is the traditionally soil P test used in Reunion to fit P fertilization to crop requirements, is expected to be unsuitable for tropical soils such as those of Reunion [3]. One other method able to distinguish P availability as a function of soil types and fertilization management and more closely related to P phytoavailability will be selected and further used to discriminate the respective contribution of soil types and organic fertilization on P availability in soils.

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TA-P_14 Utilization of precipitated phosphorous in plant production

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Objectives

The aim was to find out, if plants can utilize phosphorous from the sludge collected from agricultural drainage water. The water treatment method developed by Saloy Ltd. uses iron sulfate to bind organic matter and phosphorus from drainage water in an emission catcher. A vertical separation pipeline connected to the sediment pond reduces the amount of suspended solids in the water. Pipeline also operates as a sediment pond for the sludge precipitated by the emission catcher.

Methodology

Sludge from two sources (Pien-Saimaa and Sauvo) were tested at the Häme University of Applied Sciences during summer 2014 in a growth tunnel. The experimental species was barley. Sand used as a substrate in the golf courses was used as reference. There were total number of six treatments. For both sludge: 20% of sludge, 20% of sludge with nutrients. References: Pure sand, sand with fertilizer. Calcium was added to all treatments. Soil, drainage and plant biomass was analyzed.

Results

There was a clear difference between the sludge in the nutrient concentration of the drainage, reduction of phosphorous in the substrate during the experiment and in biomass production. The biomass production of barley was highest in the treatment which contained sludge from Pien-Saimaa and commercial nutrients. Difference in biomass production between this treatment and the reference with commercial fertilizer was not significant (df=5, F=1,2, p=ns). However, all the treatments that contained sludge from Sauvo produced less biomass than the reference with fertilizer (Sauvo-sludge with fertilizer: df=5, F=38,1, p=0,02. Sauvo sludge without fertilizer: df=5, F=53,7, p=0,001), but still the produced biomass was higher than in the unfertilized reference

Sludge from Pien-Saimaa released more phosphorous during the experiment than the sludge from Sauvo. Concentration of phosphorous in the drainage from Pien-Saimaa varied from 0,7 to 3,5 mg/l, while drainage from other treatments contained less than 0,6 mg/l of phosphorous. The trend was same in iron concentration of the drainage.

Conclusion

There was a clear difference in the tested sludge. Added sludge did not prevent the growth, and no harm-full effects was observed. Sludge from Pien-Saimaa released more phosphorous and iron during the experiment, and that was observed as increase in biomass of barley.

TA-P_15 Acidification of cattle slurry – Effect on ammonia emissions and dry matter yield after spreading non-digested and digested slurry on grassland

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Objectives

The objective of the project was to determine the effect on NH_3 emissions and dry matter yield of acidification of digested and non-digested slurry, applied on two different occasions to grassland. The overall aim was to help develop future guidelines on whether acidification should be recommended for Swedish conditions from an environmental and economic perspective.

Methodology

Field experiments were conducted in grass ley at two Swedish sites in 2013 (Rådde and Bjertorp) and at one site in 2014 (Lanna), all approximately 100 km north-east of Gothenburg. The effect on grass yield of anaerobically digested and non-digested cattle slurry, with and without acidification, was compared with the effect of mineral nitrogen fertilizer. Slurry was band-spread with trailing hoses on two occasions in each experiment, after the first and second cut in 2013 and in spring and after the first cut in 2014. The experiments were organised in a randomised complete block design. Treatments without acidification were applied first, followed by application of acidified slurry at rate of about 25 tonnes ha^{-1}. Sulphuric acid was added to reach pH below 6, which required 2-3 L m^{-3} for non-digested slurry and 6-9 L m^{-3} for digested. Dry matter yield and forage N content were measured for two cuts. Nitrogen fertilizer replacement value (NFRV) for total N in digested and non-digested cattle slurry with and without acidification was calculated from their respective effect on N uptake in relation to that of mineral fertilizer. Ammonia emissions were measured in the experiment at Lanna with an equilibrium concentration method [1] in spring and after first cut in three blocks, with repeated measurements until the emissions subsided.

Results

Dry matter yield and N offtake were greater in acidified treatments than in the corresponding treatments without acidification at all sites and cuts. On average, NFRV increased with acidification from 25% to 39% in undigested cattle slurry and from 44% to 74% in digested slurry. At Lanna, where ammonia emissions were measured, NFRV increased from 32 to 57% for undigested slurry and from 67 to 85% for digested slurry at spring application. Overall, acidification reduced NH_3 emissions. In spring the reduction was about 25% for undigested slurry, while the effect was more pronounced for the digested slurry, with more than 90% reduction. The results from summer application have not yet been analysed, but will be presented in the main paper.

Conclusion

Ammonia emissions can be reduced and grass yield improved by acidification of cattle slurry. The effect on ammonia emissions is larger for anaerobically digested slurry than for non-digested. With both digestion and acidification, the nitrogen fertilizer effect on yield can be nearly threefold that of untreated slurry.

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TA-P_16 Solubility of Copper and Zinc and particle size fractionation in compost made from the solid fraction of pig slurry

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Objectives

Elevated concentrations of Copper and Zinc in pig slurry and their recovery in the solid fraction after a solid-liquid separation treatment can be the limiting factor for obtaining high quality compost for agricultural use. The objective of this work was to study both the solubility of these metals in solid-pig slurry composts and their distribution in the different particle size fractions; and their potential toxic effects in plant germination and seedling growth.

Methodology

The solid fraction was obtained from a piglets and sows farm located in southeast of Spain, after slurry separation by a screw-press (without flocculants).Two composting piles were prepared in the farm using cereal straw and cotton gin waste as bulking agents (3:2 and 2:1 v:v ratios, respectively) by the turning pile system. The bio-oxidative phase lasted for 75 and 120 days for the first and second pile, and the total composting times (including maturation period) were 170 and 187 days, respectively. The mature composts were sampled and mechanically sieved at different particle sizes: < 0.05 mm; 0.05-0.5 mm; 0.5-1.0 mm; 1-2 mm; and >2 mm. The mature composts and the different particle size fractions were analysed for total and soluble Cu and Zn by microwave assisted acid digestion (HNO_3/H_2O_2) and 0.1M $CaCl_2$ extraction, respectively. The potential phytotoxicity of compost was evaluated by plant growth tests (ISO 15 799.1999) using different mixtures of mature compost and artificial soil (prepared according to OECD 207.1984), and seeds of *Zea mays*. The germination index (GI) was assessed with *Lepidium sativum* (Zucconi et al., 1981).

Results

The total concentrations of Cu and Zn increased during composting from 203 and 2931 to 351 and 5552 mg kg^{-1}, respectively, in compost with cereal straw and from 175 and 2380 to 391 and 5651 mg kg^{-1}, respectively, in compost with cotton gin waste, due to the organic matter degradation and the net loss of mass. But the concentration of the metals soluble forms did not changed during the process. In both composts, the highest Zn concentration was found in smallest particle size fraction (0.05 mm), which was the one with the lowest TOC content; while the highest Cu concentration was found in the largest particle size fraction (>2mm), which showed the highest TOC content. These results suggest that the Zn content in mature compost was mainly linked to hardly soluble inorganic compounds, while the ability of Cu to form stable complexes with organic compounds favored its retention in the organic matter rich fraction. The mean percentage of total metal solubility was very low in the mature composts (0.75% of total-Zn and 0.4% of total-Cu). This low metal solubility provoked no relevant toxic effects to plants, with high GI (87.8 and 80.2 % for the cereal straw and cotton gin waste composts, respectively) and moderate plant growth EC_{50} values (42.1% y 66.0% for the same compost, respectively).

Conclusions

The high Cu and mainly Zn concentrations in the solid phase of pig slurry led to metal rich composts. However, despite the elevated total concentrations the low solubility of both metals in the mature composts avoided any significant toxic effect to plants. The elimination of the smaller particle size fraction would help to remove a significant amount of the total Zn content.

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TA-P_17 Risk arising from disposal of animal wastes to soil

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Objectives

The present study focused on microbiological and parasitic risks related to disposal of animal manure to soil. Raw pig slurry was inoculated with Salmonella typhimurium and carriers with Ascaris suum eggs were introduced into the slurry. The slurry was stored at 4o, 20o and 42oC for 115 days and plate counts of Salmonella typhimurium and number of devitalised non-embryonated model Ascaris suum eggs were determined on days 0, 7, 12, 22, 32, 40, 55, 90 and 115 of storage. Selected physico-chemical parameters were determined in the slurry. We observed that S. typhimurium survived in the slurry for less than 115 days at 4oC and for less than 90 days at 20oC and 42oC. Devitalization of A. suum eggs increased with temperature and time of storage but complete devitalization was not achieved even after 115 days at 42oC. Physico-chemical parameters showed changes related to decomposition processes but did not allowed us to draw definite conclusion regarding their influence on devitalization of pathogens. The results indicate potential risk to human food chain that can be prevented by strict observation of legislative provisions and appropriate treatment of animal manure.

Methodology

The experiment was carried out on raw pig slurry inoculated with S. typhimurium. Carriers with model non-embryonated A.suum eggs were added to the slurry. The slurry (5 l) was stored for 115 days in closed plastic containers at temperatures 4oC, 20oC, 42oC. Plate counts of S. typhimurium were determined on days 0, 7, 12, 22, 32, 40, 55, 90 and 115 of storage and devitalisation of A. suum eggs was observed in comparison with A.suum eggs stored in distilled water. The following changes in physical and chemical properties of the slurry were monitored: pH, dry mater (DM), chemical oxygen demand (COD) and ammonium ions (NH4+).

Results

S. typhimurium survived in the slurry for less than 115 days at 4oC and for less than 90 days at 20oC and 42oC. Devitalization of A. suum eggs increased with temperature and time of storage but complete devitalization was not achieved even after 115 days at 42oC. Significant difference in devitalisation of A.suum eggs in slurry and distilled water was observed at all storage temperatures. Physico-chemical examination of slurry increased at all three temperatures, however, it did not correlate with the level of ammonium which varied considerably.

Conclusion

Legislation in advanced countries requires acceptable procedures for the disposal, processing and application of animal manures. However, there are still aspects that may raise some risk for safety of human food chain and require further investigations. Our study showed that complete devitalization of A.suum eggs was not achieved even after 115 days at 42°C, the temperature not commonly reached in pig slurry. The best way of elimination of risk related to animal grazing or growing crops on manured soil is to put stress on preventive actions and measures and strict observation of legislative provisions.

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TA-P_18 Phosphorus recovery prior to land application of biosolids using the "Quick wash" process developed by USDA

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Objectives

To present the case study of a new treatment process, called "quick wash", that was developed by the USDA-ARS for extraction and recovery of phosphorus from animal manure solids but research has shown the approach is equally effective to recover phosphorus from biosolids prior to application to soil. This presentation will discuss the adaptation of this process to the recycling of municipal biosolids and the potential environmental benefits for urban and rural communities.

The quick wash process

As an alternative to improve the nitrogen (N) and phosphorus (P) balance in animal wastes, the quick wash process was developed for rapid wet extraction of P from raw solid manure and recovery of manure P in solid concentrated form [1]. This process consists of selectively extracting P from solid animal waste using mineral or organic acid solutions, and recovery of P from the extract by adding lime and an organic polymer forming a calcium-containing P precipitate. The quick wash process has three products: 1) a washed solid residue with a N:P ratio optimal for use in crop production; 2) a concentrated solid P material that can be transported long distance and used as an effective P fertilizer; and 3) a liquid effluent that could be applied to nearby cropland as liquid fertilizer or recycled into the treatment system.

Environmental benefits

Excess soil P beyond the assimilative capacity of soils is currently a major factor to discontinue application of biosolids to land nearby municipal wastewater treatment plants. For this reason, municipalities incur in hefty fees for transportation and landfilling biosolids that otherwise could be used as soil amendment to maintain soil quality. However, recovering P from biosolids using the quick wash process can provide environmental benefits for both rural and urban communities. The quick wash process selectively recovers more than 80 % of the P from solid waste, while leaving most of the N in the washed solid residue. Consequently, the washed solid residue has a more balanced nutrient composition for crop production and is safe for land application. Because the quick wash process is conducted at ambient temperature, it avoids loss of oxidizable organic carbon (C) and N from washed solid residues. Thus, the land application of washed solid residues contribute with C and N to maintaining soil quality while reducing the environmental risks of excess soil P. The concentrated phosphorus materials contain more than 90% of its phosphorus in plant available form that provides a recycled phosphorus source for use as crop fertilizer [2].

Conclusion

Nutrient pollution, caused by too much P in the environment, is one of America's most widespread, costly and challenging environmental problems, impacting many sectors of the U.S. economy that depend on clean water. These environmental problems can be mitigated with the quick wash process, because P is selectively extracted from animal wastes and municipal biosolids prior to land application. The inclusion of this process in a waste management system offers farmers and municipalities a new and welcomed opportunity to minimize P losses into the environment and sustain soil quality while recovering and recycling phosphorus as a valuable product.

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TA-P_19 Improvement of soil nitrogen's mineralization modeling with a better consideration of organic restitutions

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Objectives

In France, soil N mineralization is currently [1] calculated by implementing a mineralization rate to an active N organic stock of arable layer.
In most tools based on nitrogen balance method, the size of active stock is considered equal to 35 % of the total arable layer stock. This part is then adjusted by a coefficient (Fsys) according to crop residues and exogenous organic products restitutions practices.
But this way of calculation is not accurate enough in all situations. A study was carried out in 2014 to improve it.

Methodology

When yearly carbon inputs (crop residues, farmyard manure…) are equal to yearly carbon outputs due to mineralization of organic nitrogen stocked in the arable soil layer, the C balance reach an equilibrium. In this situation, active Nitrogen stock is proportional to inputs.
When yearly nitrogen and carbon inputs from crop residues and exogenous organic products are equal to yearly outputs with arable layer stocked organic nitrogen mineralization, the humic balance is equilibrated and active stock reaches a level which is proportional to inputs.
So a method of estimation of soil N mineralization was implemented, taking into account a calculation of active N organic stock of arable layer using organic restitutions history which was parameterized on long term field experiments. The method was evaluated on 7 trials comparing mineral and organic fertilization.

Results

After 10 applications of livestock organic products during 10 to 20 years, the active N organic stock increase, represent approximately 2.5 % of carbon input.
The comparison between measured and simulated soil N mineralization based on active N organic stock calculation from soil organic matter content, crop residues and exogenous organic products restitutions during experimental duration, showed an important improvement of statistical accuracy with the new method compared to currently one.
The more important improvement is observed in cases of high soil N mineralization (200 à 300 kg/ha/an).

Conclusion

This new and promising method will be tested in other agricultural and climatic conditions to verify his prediction quality and robustness.
Thereafter the method will be implemented using test-case which will combine type amount and supply frequency of organic product.

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TA-P_20 Impact of pollutants from animal farms on quality of potable water

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Objectives

Safety of drinking water sources is essential for prevention and control of waterborne diseases. Due to anthropogenic activities there are territories where the sources of drinking water for individual or mass consumption are contaminated to such degree that the water from them is neither suitable for drinking and watering of animals nor for food processing and other purposes related to our everyday life. Our chemical investigations showed that the limits for nitrates and chlorides were exceeded in sources for individual supply. Examination of sources for individual supply indicated also bacteriological contamination. Coliform bacteria, an indicator of faecal contamination were present only in sources for individual supply and the limits were exceeded particularly in spring, summer and fall. E. coli were absent in sources for mass supply but sources for individual supply failed to comply with the E.coli standard throughout our investigation.

Methodology

The present study was conducted to monitor the quality of drinking water in different seasons in 5 sources of different type located in eastern Slovakia. Sources 1 and 5 were intended for public mass supply (MS) and 2, 3 and 4 were wells for individual supply (IS). Eastern Slovakia is mostly an agricultural area with many farms, some of them keeping cattle and producing milk for human consumption. The samples collected were examined for basic chemical (pH, ammonium ions, nitrites, nitrates, chlorides, COD_{Mn}, free chlorine) and microbiological parameters (plate counts of total coliforms, E.coli and bacteria cultivated at 22 and 37°C) indicating contamination, particularly with faeces or sewage, and for levels of 11 metals.

Results

Chemical examination showed that excessive level of ammonium ions was detected only in samples collected from source 2 and nitrites were exceeded in this source in autumn. Higher levels of nitrates were detected in sources 4 in autumn and source 3 in winter. They were present in all sources at every sampling in spring and only in traces in the remaining seasons. Chlorides were detected particularly in winter in samples from sources 2 and 3 (exceeded the acceptable level). COD_{Mn} exceeded the acceptable level in source 4 in summer. Free chlorine was detected in sources 1, 2 and 5, but only occasionally. Bacteriological examination showed that E. coli were present in sources 3 and 4 in all seasons. Coliform bacteria as an indicator of potential faecal contamination were present only in sources for individual supply. Llimit values for the examined metals were not exceeded and in majority of samples were well below them.

Conclusion

Contamination of the examined sources could be associated with keeping and grazing of farm animals or application of their excrements on soil. Sources for individual supply were fenced, but their surroundings were not kept up and protected adequately. This may produce situation which results in contamination of ground water in the entire location. Drinking water should be subjected to complex evaluation covering all risks from exposure to chemical substances and microbiological agents.

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TA-P_21 Vegetable crop residues as feedstock for composting and silage – Production cost and product quality

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Objectives

The crop residues of vegetables are important for nutrient and organic matter cycling. However, these residues often may lead to nitrogen leaching risks. This study investigates the feasibility of removing crop residues, followed by composting or ensiling as a means to reduce N leaching losses.

Methodology

Crop residues of cabbage were mechanically harvested. Leek residues were obtained from preparing harvested leek plants for market. For composting, residues of white cabbage or leek were mixed with wood chips and bark, grain and maize straw. Residues of leek were also mixed with straw and alternative brown materials, i.e., heath chopper or used tomato or strawberry substrate. For silage, crop residues of white cabbage, celery, cauliflower or leek were mixed with chopped maize straw.

Results

Collection of both cabbage residues and maize straw was not very effective as the collected material had a high soil particle load. This resulted in a suboptimal composting process and a low organic matter content in the composted end products. A high quality compost was obtained when using leek crop residues combined with the alternative brown materials with a high degree of purity. However, compared to the used growth substrates, heath chopper seemed to induce a better structural condition to the compost pile guaranteeing a sufficient oxygen supply. The establishment of a compost pile based on wood chips and crop residues implied a net variable cost of 55 to 77 euro per ton crop residues, which primarily reflected the cost of wood chips used as a structural material.

Silage quality was optimal for the mixtures with leek and celery, and less optimal for the other mixtures. This was related to higher NH_4^+-N concentrations and lower compressibility of the mixtures with cauliflower and white cabbage. Ensilaged leek residues showed potential to be used as fodder. The net variable costs for ensilage of leek residues amounted to 9.9 euro per ton crop residues.

Conclusion

Ensilaging conserves the nutrients and organic matter for reuse on the field after the winter or for other applications. As ensilaged residues remain highly biodegradable, they will possibly cause a temporary N-immobilization when applied as a soil improver. Composting results in stabilization of the organic matter before application on the field and lowers the risk of nutrient losses after application. Composting allows to add residues during the process in function of their availability.

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TA-P_22 Bioavailability of phosphorous in thermally treated sewage sludges and pig manure

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Objectives

To substitute mineral P fertilizers with nutrient rich by-products, hydrothermal carbonization (HTC) and pyrolysing may be used to produce safe fertilizers from these materials. In this study we evaluated the effects of these methods on P solubility and bioavailability when sewage sludges (SS) and pig manure (PM) were used as a raw materials.

Methodology

Sewage sludges (SS) treated with (SSH) or without (SSL) iron containing P precipitation chemicals and pig manure (PM) were thermally treated. SS was treated with HTC-method and PM was pyrolysed. Solubility of P in these materials was tested by using a modified Hedley fractionation scheme [1] and P bioavailability was further tested in a growth experiment by using barley (*Hordeum vulgare*) as a test plant and superphosphate as a reference P source.

Results

Labile inorganic P (Pi) (Water + 0.5 M $NaHCO_3$ soluble Pi) content in SS varied from 2 (SSH) up to 24% (SSL) of the total P. Ratios of Fe:P were 3.6 and 1.1 in these two SS, respectively. Most of the P was bound to iron (0.1 M NaOH extractable P), 65 and 47%, respectively. Labile Pi and iron-bound Pi fractions in PM were 47 and 2%, respectively. Thermal treatment of these organic P sources depressed labile Pi contents both in SS and PM. In SS it was decreased to 9 (SSL) and 1% (SSH) and in PM to 13% of the total P. Less soluble iron-bound Pi content decreased to values of 34 and 33% in SSL and SSH, respectively, whereas respective acid soluble Pi content increased from 22 and 29% to 55 and 65%. The same was observed in PM as acid soluble Pi fraction increased from 47 to 63%.

Bioavailable P fraction of SS was drastically depressed by the use of precipitation chemicals, from 68 to 10%. Corresponding value for PM was 30%. Thermal treatments depressed P bioavailability down to 6 (SSL) and 1 % (SSH) in SS and to 17% in PM. Although labile Pi share was at a higher level in PM than in SSL, P was less bioavailable in PM. However, thermal treatment reversed the situation; P originating from PM was utilized more efficiently than from SSL.

Conclusion

Bioavailability of P in sewage sludge is drastically reduced by the increasing amount of P precipitation chemicals used at the waste water treatment plants. Thermal treatment (HTC) depressed P utilization even further to a very low level as estimated in the one-year growth experiment. Pyrolysing of pig manure affected less on P bioavailability. Probably transformation of P to acid-soluble form depressed the instant bioavailability, but reversibility of the process in unknown.

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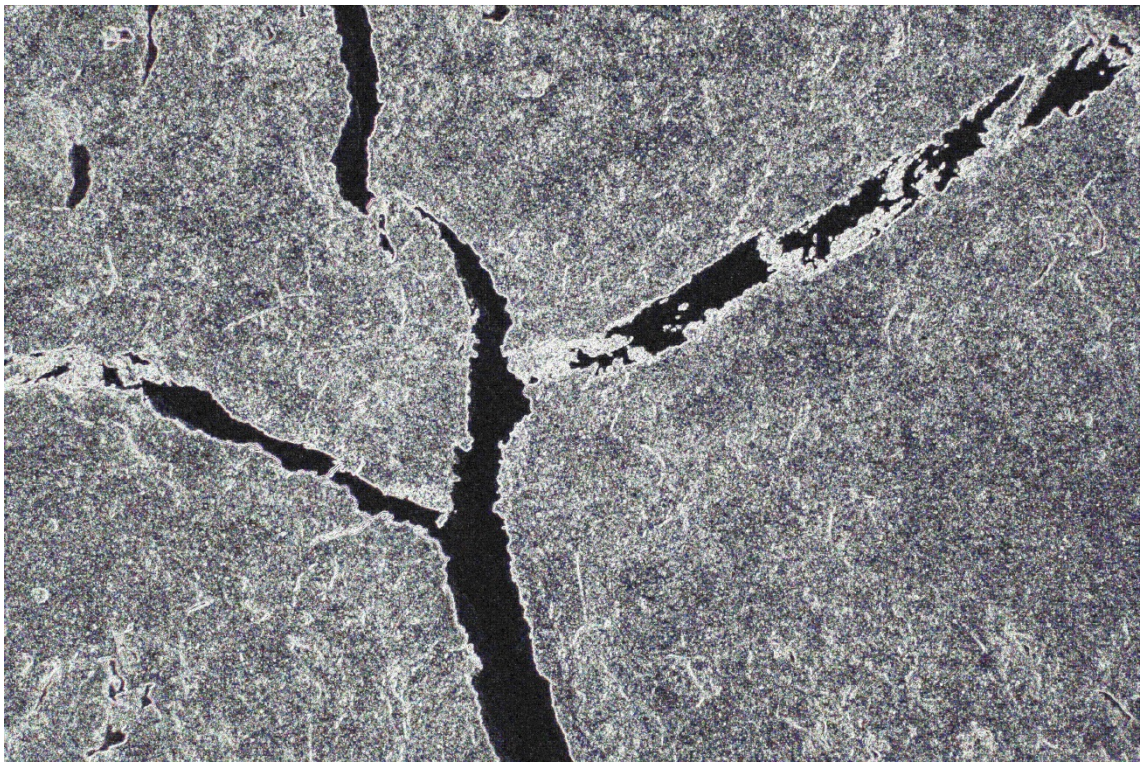
Thematic area TB – Sustainable soils
(Oral presentations)



Dry soil, processed photograph

TB-K From soil application of sewage sludge to nutrient recycling – A soil science outlook

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Background - conditions for sustainable cycling of plant nutrients

Efficient cycling of plant nutrients in society requires (i) equitable redistribution of nutrients on arable land, (ii) application of nutrients in plant available form, and (iii) use of 'safe and clean' products. Our position is that these conditions can be achieved if nutrient extraction rather than redistribution of whole wastes on arable land is general practice[1].

Experiences from long-term field experiments with sewage sludge

Several long-term field experiments in Sweden showed that crop utilization of N and P applied with sewage sludge was rather low. This was explained by the chemical composition of sewage sludge with an unfavorable N:P ratio (1.5:1) and a small portion of nutrients being water soluble. Metal accumulation in soil due to long-term application of sewage sludge to soils did not significantly affect trace metal contents of cereal crops, neither of essential nor of polluting metals[3]. Sewage sludge acidified soils as a result of oxidation of organic S to sulfate and organic N to nitrate. Earlier observations that metal addition through sewage sludge stressed and decreased the size of the microbial biomass in soil were no longer detected[3]. Metal contents in Swedish sewage sludge steadily decreased since the 1990th.

Core problems and possible solution

Plant nutrient cycles are so far not closed. For example, use of sewage sludge on arable land is limited in several European countries. There are several reasons for this: (i) water contents in sewage sludge are too high for economic long-distance transportation and equitable redistribution; (ii) plant nutrients are mainly present in less soluble and water insoluble forms having a low fertilizer value; and (iii) concerns about unwanted pollutants added to soils remain.
We propose that further treatment of sewage sludge is necessary to improve recycling. One way forward will be combustion of sewage sludge followed by extraction of ash to produce inorganic fertilizer. The concept will be illustrated presenting a new methodology for P fertilizer production from ash.

Conclusion

The trend to expand combustion of sewage sludge in cities will make ash a key waste type in future. Treatment of ash is necessary to be able to recycle phosphorus. Thus, new technologies for production of water soluble inorganic P fertilizers using ashes as a raw material need to be developed. Substitution of phosphate rock based P fertilizers with ash-based P fertilizers may help to achieve cycling of P and extend life-time of phosphate rock reserves.

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TB-O_01 Sustaining soil quality by farm compost application and non-inversion tillage, and resulting nitrogen dynamics

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Objectives

For intensive vegetable rotations, we investigated to what extent compost application and non-inversion tillage sustains soil quality and alters nitrogen (N) dynamics during a short-term (2008-2011) multi-year field trial.

Methodology

Main crops were broccoli (*Brassica oleracea*, var. Italica Group), carrots (*Daucus carota*) and leek (*Allium porrum*), respectively. Farm compost, based on vegetal residues, was applied each autumn, starting in 2008, at three different rates, namely 0, 15 and 45 Mg ha^{-1}. Non-inversion tillage with a chisel plough was compared with mouldboard ploughing, both till a depth of ca 30 cm. In 2011, different doses of top mineral N dressing were applied, i.e., 0, 30 and 60 kg N per hectare.

Results

The highest compost dose more than compensated for organic matter losses by mineralization. The decrease in pH was considerably limited by compost application, irrespective of the dose applied. Application of compost and non-inversion tillage clearly resulted in more soil microbiota in the top layer. Considering the functional groups in the soil food web, effects differed between soil management measures for some groups.
Only small differences were perceived in N dynamics between treatments. Differences in N availability in the soil profile between compost doses only appeared in the first half of the second growing season with carrots as main crop. Differences in tillage method resulted in differences in fresh biomass and N uptake for broccoli in 2009 in case of non-inversion tillage (over the whole growing season) and for leek in 2011 in case of ploughing (only in the youth crop stage). Obtained differences in soil condition between soil improvement strategies did not result in differences in N utilization of a top mineral N dressing by the leek crop. Over all treatments, N uptake by the crop did not differ between doses.

Conclusion

Farm compost application and non-inversion tillage counteracted soil degradation, which was otherwise inevitable under this intensive vegetable cropping system in the three-year study period. Adopting these soil improvement measures does not necessitate an adaption of the nitrogen fertilization of vegetables in the short term.

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TB-O_02 Preplant compost application improves landscape plant establishment and sequesters carbon in compacted soil

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Objectives

Compost use is advocated as a component of sustainable landscape management in urban areas. Compost is often added to other soil components to provide a target level of organic matter in "topsoil" in urban projects. This study was conducted to (i) assess the potential benefit of compost application for a variety of landscape plant species, (ii) to evaluate the need for tillage following compost application, and (iii) to assess the longevity of compost effects on soil properties.

Methodology

To simulate soil compaction often present at urban sites, an agricultural soil (Willamette silt loam) was prepared by compacting with a vibrator-roller (typically used for parking lot construction) to a bulk density of 1.5 g/cm^3 (10 cm depth). Experimental design was a 3 x 2 factorial with three compost treatments (biosolids/sawdust compost, yard debris compost, no-compost control) and two compost placements (no tillage or rototilling after compost application), replicated 4X. After compost application (8 cm depth), planting holes were drilled with a screw type power auger, transplants installed, and all plots mulched with conifer bark. Eight perennial plant species were installed in Sept 2008, and maintained without summer irrigation in a Mediterranean summer climate (Aurora, OR, USA). Mineral soil (0-20 cm) samples were collected from under the surface organic layers each fall.

Results

Most plant species grew faster with compost, but did not respond to preplant tillage. Soil pH, nutrients and carbon (C) were equivalent for both compost placements (surface or tilled-in), suggesting downward migration of compost constituents without tillage. Biosolids compost supplied more plant-available nitrogen (N) and more acidity than yard debris compost.

Conclusion

Plant coverage of bare ground was achieved most rapidly when drought tolerant plants were grown in soil that received preplant compost application. Surface compost application on compacted soil, a practice employed by some landscape contractors for establishment of low-maintenance plantings, produced generally favorable outcomes. Four years after planting, soil C remained higher with preplant compost application.

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TB-O_03 Organic matter stability and accessibility characterization – Towards a tool for organic residue diagnostic before land spreading

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Objectives

Considering a zero waste production objective, the recycling on cropped soils of organic residues (with or without previous biological treatment) is becoming crucial for the valorization of carbon and nutrients. An indicator of residual organic carbon (IROC) [1] already exists based on fiber fractionation but not applicable to all the organic residues. Therefore, there is a need to find a relevant common methodology to describe a larger diversity of organic matter stability and accessibility and to diagnostic the treatment of a residue before its land spreading. The potential of a recently published method to characterize the organic matter biodegradability and bioaccessibility of municipal sludge [2] was extended to a wider range of organic biologically treated residues.

Methodology

- Chemical fractionation: based on the work of [2], it consists on extracting 4 fractions from the solid phase according their chemical accessibility using chemicals of stronger extracting power. A sulfuric acid extraction was added in order to extract cellulose-like fraction.
- 3D fluorescence spectroscopy was applied on the extracted fractions based on [2].
- Soil incubation tests: 10 g of organic wastes were incubated with 100 g of agricultural soil during 90 days, at moisture and temperature controlled conditions, with a CO_2 trap.

Results

The modified characterization methodology based on both chemical fractionation and 3D fluorescence spectroscopy was relevant enough to classify a large panel of organic wastes according to their nature, their complexity and their chemical accessibility. From this observation, the next step was to use such characterization method to predict the fate of organic matter in soil in order to diagnostic their biodegradability, thus their potential capacity at increasing soil organic matter contents as the usual indicator IROC does [1]. To do that, soil incubation tests of several input and output samples obtained under different conditions of anaerobic digestion and composting, were set-up in order to work with contrasted samples. A Gompertz model was applied to each cumulated curve of mineralized carbon percentage in order to quantify the carbon mineralization potential and the kinetic parameters associated. A Partial Least Square (PLS) regression was applied on these data using fractionation and fluorescence spectroscopy data as explicative variables. PLS model allows correlating the potential carbon mineralization with the characterization of organic matter and its carbon accessibility in the different fractions.

Conclusions

These results present a first step towards the quality control of organic residues (depending on the treatment processes and the quality of the incoming organic waste). Besides, this characterization methodology will be applied to a wider range of organic residues in order to enlarge the applicability domain of the usual IROC in soil and to precise not only the size of the most influent fraction but also its nature.

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TB-O_04 Effect of food waste biochar usage in farmland on carbon sequestration and vegetable growth

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Introduction

For global warming prevention, it is important to study on sequestration mechanism of carbon in soil of farmland where biochar and compost are used. By using biochar carbonized with biomass materials such as waste wood, bamboo and agricultural materials in farmland, carbon storage in the soil for long period is expected. As the soil properties are improved and soil microorganisms' concentration increase with addition of charcoal to the soil, the plant growth promotion in the farmland is also expected. In Japan biochar has been used for a long time as environmental improver, soil improver in a farmland, water purification material and odor adsorbent.

In this study, vegetables were grown in the farmland where biochar powder from food waste was used in the soil In order to establish the sequestration mechanism of carbon in the soil used with biochar, analysis method of the undegradable carbon (UDC) amount in the soil was developed for quantitative estimation of the carbon sequestration.

Material and Methods

Food waste from supermarkets was pressed in order to decrease the moisture content less than 65 wt%. Biochar was prepared from the food waste as a raw material which was carbonized at 500°C-600°C. The biochar was pulverized into the grain size of less than 3 mm.

For the analytical method of estimation of UDC amount, the total carbon amount (T-C) and the inorganic carbon amount (TIC) derived from carbonate in the soil of the farmland were measured with the solid sample combustion method. The organic carbon amount (TOC) was measured with the Tyulin method (the titration method). The UDC amount was estimated by deducting the TIC amount and the TOC amount from the T-C amount.

Results and Discussion

Some characteristics of the biochar were estimated as follows; the fixed carbon of 65 wt% the ash content of 5 wt% in the biochar, the specific surface area of 105 m^2/g, the bulk density of 0.2 g/ml and the pH value of 8.1.

The biochar powder was used at the rate of several tons/ha. Some kinds of vegetables were grown in organic cultivation method. Estimation method of UDC content based on the biochar used in the farmland soil was also established. The T-C, TOC and UDC amounts in the soil used with the biochar remained larger than those in the soil with the compost. Growth stimulation of vegetables in the farmland used with both the biochar and the compost was observed.

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TB-O_05 Simulation of carbon and nitrogen mineralization after application of ammonium sulphate, pig slurry and maize stalks to agricultural soil

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Objectives

Measurements of organic matter decomposition into the soil are essential for model calibration. The objectives of this work were: 1) to study in the laboratory, with optimal soil water content and constant temperature, the decomposition of maize stalks (ST) in presence of ammonium sulphate (AS) and pig slurry (PS) and 2) to test the ability of 3 simulation models to represent the studied system.

Methodology

A loam soil was added with labelled (^{15}N) or unlabelled materials with the resulting treatments: 1) unfertilised soil; 2) ST^{15} + AS + PS; 3) ST + AS^{15} + PS and 4) ST + AS + PS^{15}. During 180 days, we measured CO_2 emission, microbial biomass C, N and ^{15}N and soil mineral N content (SMN and SM-^{15}N). Three models of increasing complexity – 2 modifications of ICBM 2B/N (Kätterer and Andrén, 2001) and CN-SIM (Petersen et al., 2005) – were calibrated using measured C, N and ^{15}N experimental data.

Results

All models simulated quite accurately C respiration throughout the incubation period (Relative Root Mean Squared Error = 8-25%). High rates of CO_2 emission were simulated with the decomposition of labile pools and low rates with slow-decomposing recalcitrant pools. The simplest model (with one pool for ST and one for PS) strongly overestimated SMN immobilisation from day 3 to day 21, both in the treatments with AS^{15} and PS^{15} (RRMSE = 27-30%). The other two models were able to represent quite well the dynamics of SMN in the soil (maximum RRMSE = 25%) with fast increase of nitrate concentration in the first days and slower rates of nitrification thereafter. Worse performances were obtained with all models for the simulation of SM-^{15}N in the treatment with ST^{15} (RRMSE = 64-104%): experimental data showed positive mineralization of stalk-derived N from the beginning of the incubation, while models strongly underestimated ST^{15} mineralization until day 21. Simulation performances of the three models were a compromised between the errors in the simulation of C and N dynamics. These models, especially the simplest one, overestimated, or underestimated, SMN to better match CO_2 measurements.

Conclusion

This preliminary work emphasised the importance of testing models with both C and N measurements. This reduced the risk of obtaining model parameters suitable for the simulation of N (or C) dynamics that lead to unrealistic simulation of C (or N) decomposition. Moreover, the application of ^{15}N labelled materials enabled to highlight some model inconsistencies for the simulation of added organic matter decomposition into the soil.

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TB-O_06 Determining the mechanisms of nitrous oxide emission under contrasting soil disturbance levels and organic amendments

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Objectives

Soil management practices can affect soil abiotic factors (e.g., pH, temperature, water saturation, nitrate and labile organic carbon contents) and the abundance of nitrifying and denitrifying bacteria communities regulating N_2O efflux from soils. The objective of this study was to investigate the impact of N sources on N_2O emissions from a Nitisol under contrasting soil disturbance levels.

Methodology

We evaluated short-term N_2O emission from a Rhodic Nitisol under contrasting soil disturbance [undisturbed (US) and disturbed soil (DS)] and N sources [140 kg N ha^{-1} as urea, raw swine slurry (RS), anaerobically digested swine slurry (ADS), composted swine slurry (CS), and a control treatment without N]. N_2O emissions were correlated with soil temperature, water-filled pore space (WFPS), dissolved organic carbon (DOC), ammonium (NH_4^+-N) and nitrate (NO_3^--N) contents, and dominant nitrifying and denitrifying catabolic genes. Real-time quantitative PCR (qPCR) was used to assess specific catabolic nitrifying-ammonium monooxygenase (amoA), and denitrifying nitrate- (narG), nitrite- (nirS), nitric oxide- (norB) and nitrous oxide reductases (nosZ) genes [1,2].

Results

N_2O emissions from US amended with ADS and CS was 47.5 and 16.6% lower than RS (5.6 kg N_2O-N ha^{-1}), respectively. However, no differences in N_2O emissions were observed among the fertilization treatments in DS. Water-filled pore space (WFPS) was consistently higher in the US increasing N_2O emission in comparison to DS. The WFPS effects on N_2O emissions was pronounced above 0.6 cm^3 cm^{-3} ($r=0.565$, $p<0.001$). Increased NO_3^--N contents in DS stimulated N_2O emission ($r=0.667$, $p<0.01$) but had negligible effects in US. The increasing soil NO_3^--N ($r=0.396$ and $p<0.05$) and WFPS (0.391 and $p<0.05$) was accompanied by the increasing abundance of nitrate reductases (*narG*) genes. Nitric oxide reductase (*qnorB*) gene was mostly affected by soil WFPS ($r=0.313$ and $p<0.05$) while the proportion of *narG/nosZ* genes decreased with higher DOC/NO_3^--N ratios ($r=-0.409$, $p<0.01$). N_2O emission had significant correlations with *narG* ($r=0,620$, $p<0.001$), *narG/nosZ* ($r=0.722$, $p<0.001$) and *qnorB/nosZ* ($r=0,603$, $p<0.001$) genes. Soil fertilization increased the abundance of *narG* gene (RS and CS) and the ratio of *narG/nosZ* (UR, RS, and CS) and *qnorB/nosZ* genes (CS) in the soil, enhancing N_2O emissions. Multivariate analysis revealed a higher similarity on the variance of soil N_2O emissions with the abundance and ratios of denitrifying bacteria communities in the US while soil abiotic factors were the major mechanisms that regulated soil N_2O emissions from DS.

Conclusion

Higher soil moisture regime and the application of RS and CS in US increased the *narG/nosZ* and *qnorB/nosZ* ratios and N_2O emissions in relation to DS. N_2O emissions are regulated by a complex interaction between soil abiotic factors and abundance of denitrifying bacteria communities in conservative agroecossystems (US). In oxidative environments such as DS, however, N_2O emissions seem to be mostly regulated by soil abiotic factors.

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TB-O_07 Evolution of zinc concentration in soil in *Pinus radiata D.* – Don silvopastoral systems limed and fertilized with sewage sludge

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Objectives

The objective of this study was to evaluate during 14 years the effect of three doses of sewage sludge (160, 320, and 480 kg total N ha^{-1}) combined with lime (2.5 t CaCO3 ha^{-1}) or without lime on the total Zn concentration in the soil compared to control treatment (no fertilzation) in a silvopastoral system established with *P. radiata* D. Don in an acid soil of Galicia (NW Spain).

Methodology

The experimental design was randomized block with 8 treatments: 2 lime doses (0 and 2.5 Mg ha^{-1}) added in 1998 combined with 4 sewage sludge doses (0, 160, 320 and 480 kg total N ha^{-1}) applied in 1998, 1999 and 2000. The plots were sown with mixed pasture and established in a 5-year old *P. radiata* D. Don silvopastoral system. In 2001, 2002 and 2003 a mineral fertilizer was applied in the plots fertilised with sewage sludge. From 1998 to 2012, total Zn in the soil was estimated in the laboratory.

Results

In the first years of the study, the concentration of total Zn in the soil increased probably due to the fertilzation with sewage sludge. However, after mineral application (2001), it was observed a reduction of the levels of total Zn in the soil which could be explained because the mineral fertilzation probably increased the organic matter mineralization and therefore Zn release. On the other hand, the lime did not affect the levels of total Zn in soil. However, the effect of sewage sludge was evident through the study and the sewage sludge dose was directly related to the concentration of Zn in soil. The total concentration of this element increased more with the high doses of sewage sludge than with the low doses probably by the higher inputs of Zn to the soil [1]. In all cases, the total Zn values obtained were below the maximum specified by Spanish law for soils in which sewage sludge is applied (150 mg kg^{-1}) (R.D 1310/1990) [2].

Conclusion

The results obtained show a large residual effect of sewage sludge application, mainly when the high doses of sewage sludge were applied. Therefore, in acid soils such as those in this study it is necessary to evaluate during long periods the effect of sewage sludge on the Zn concentration in the soil to avoid an environmental risk.

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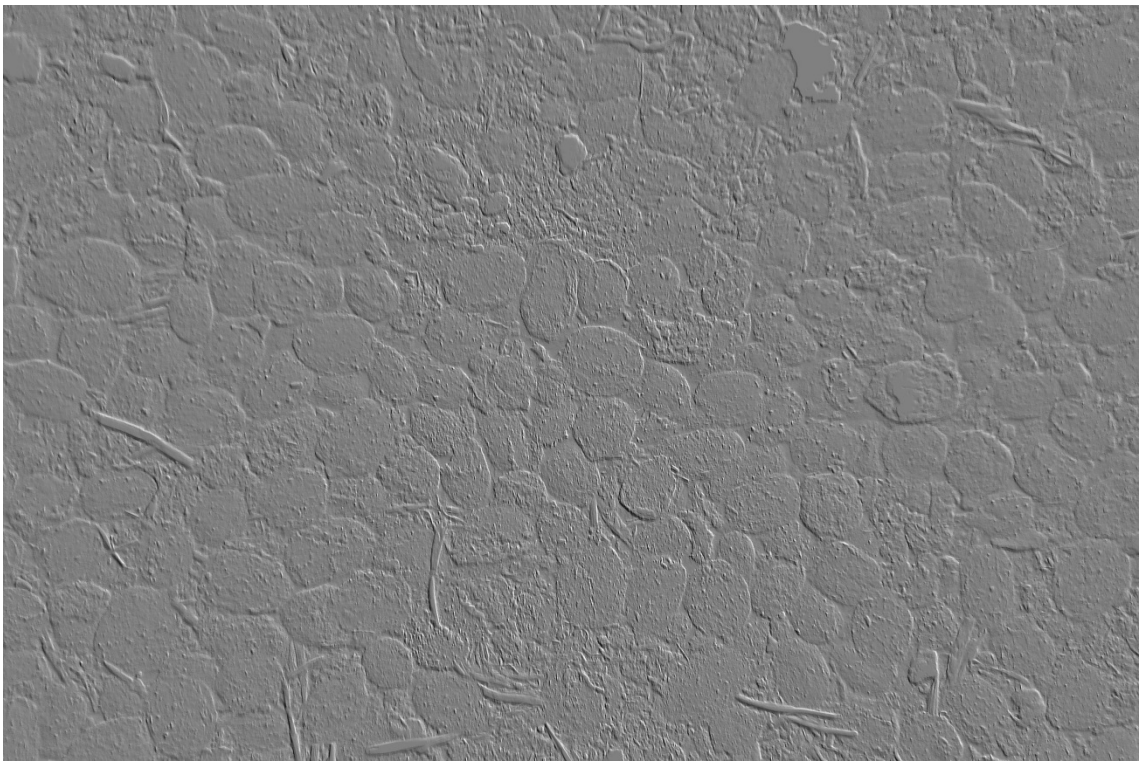
Thematic Area TB – Sustainable soils
(Poster presentations)



Animal excrements, processed photograph

TB-P_01 Fast estimation of the labile carbon fraction of organic waste products by FTIR photoacoustic spectroscopy

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Objectives

The aim of this study was to combine Fourier transform infrared photoacoustic spectroscopy (FTIR-PAS) and Partial least square regression (PLSR) analysis to predict the mineralisable fraction of C in various organic waste products (OWP) and identify functional groups associated with it.

Methodology

385 composted and non-composted OWP (urban or industrial waste, animal manure, anaerobically digested wastes etc.) were oven dried at 40˚C and finely ground. The mineralizable fraction of OWP C was determined by incubation in soil in hermetically sealed jars. CO_2-C evolved was trapped in NaOH and titrated by colorimetry. The mid-infrared spectra (4000-600 cm^{-1}) of these samples were recorded by FTIR-PAS with a resolution of 4 cm^{-1}, while PLSR analysis was used to correlate them to the labile fraction of C and develop prediction models.

Results

The PLSR analysis led to calibration models predicting an acceptable fraction of the variation in the mineralisable carbon fraction (R^2=0.78) and with an RMSE of 2.15 (% of total organic carbon). A test set, including randomly selected samples from all OWP types, was adopted in order to validate the robustness of this model and its predictive power on unknown samples. Using the previously developed model on the test set resulted in a prediction of the mineralizable fraction of C which was still good (R^2=0.77, RMSE= 2.31). The model was performing similarly to the model developed on the same samples using NIR spectroscopy by Peltre et al. [1].
The interpretation of the regression coefficients of the calibrated models (i.e. the regions of the spectrum used for this prediction) revealed a positive correlation of the mineralisable fraction of C with regions corresponding to easily degradable compounds (aliphatics, polysaccharides and carboxylic acids), and a negative correlation with the more recalcitrant forms of carbon (aromatic compounds and lignin).

Conclusion

In this study the ability of FTIR-PAS to predict the labile fraction of C was proven. The accuracy of this prediction was similar to that obtained by near infrared spectroscopy. Furthermore, FTIR-PAS provides the advantage of interpreting the spectrum regions that used for this prediction, which enhances the robustness of the model.

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TB-P_02 Soil amendment using fresh and stabilised organic materials – Effects during a wheat-maize cropping sequence

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Objectives

The main objective of this work was to study the effect of the use of a fresh organic amendment (sewage sludge) compared to a stabilized organic material (compost from animal manures) during a wheat-maize cropping sequence. For this, the effect of the treatments on the soil physico-chemical, chemical and biological properties, on GHG emissions and on the yield of the two crops studied were evaluated.

Methodology

The treatments established were the following: control soil without amendment (control), soil amended with aerobic sewage sludge (SS) and soil amended with animal waste (goat and rabbit manure) derived compost (CS). The experiment was developed in plots of 9 x 19 m2 and the treatments were applied as a single application dose of 210 kg N/ha. After the incorporation of the organic amendments, the cultivation of wheat (Triticum aestivum cv. Galera) and subsequent cultivation of maize (Zea mays var. Pioneer P1758Y) were carried out. Soil physico-chemical, chemical and biological properties, GHG emissions (CO2, CH4 and N2O) and the yields of each crop studied were determined.

Results

The incorporation of the organic amendments produced a significant increase in the concentrations of organic C, organic matter and in the different forms of N evaluated (organic and inorganic N). The C stock in the soils was incremented with the addition of the organic amendments, showing the highest increase the soil amended with compost. Khorramdel et al. (2013) also observed during maize cropping a higher C sequestration (4,1 t/ha) in low input management systems using compost and manures in a dose of 30 t/ha and hand weeding, compared to other systems of medium or high management input, in which the dose of amendment is reduced and the presence of inorganic fertilizers and field practices (tillage, etc.) is increased (0.01 t/ha in the high input management system).The application into soils of the organic amendments also enhanced the activity of the soil microbiota, increasing the rates of the soil respiration. This reactivation of the activity of the soil microorganisms was also reported in other studies using fresh and stabilized organic materials as soil amendments (Bastida et al., 2008). Also, GHG emissions varied among the different treatments and crop period, observing the highest emissions at the beginning of the wheat crop.
Concerning the crop yields, low differences were observed in the yield of wheat with the different treatments compared to the control soil; however, this fact was not observed for the maize, showing the soils amended with sewage sludge the lowest yields.

Conclusion

The incorporation of the fresh and stabilized organic amendments to the soils produced a clear increase in the soil organic matter and nitrogen contents, also producing in the short-term an improvement of the soil C pool, this effect being more notable in the soil amended with compost. Also, the different treatments only showed a clear effect on the crop yield of the second crop established.

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TB-P_03 Effect of repeated soil application of organic waste amendments on draught force and fuel consumption for soil tillage

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Objectives

The objectives of this study were (i) to establish relationships to allow the estimation of draught force and tractor fuel consumption for soil tillage from easily measurable parameters such as soil texture, carbon content and organic waste products (OWP) amendment history and (ii) to determine whether the relationships between SOC and draught force are OWP-specific.

Methodology

Draught force required for soil tillage was measured in all plot of the CRUCIAL field experiment (near Taastrup, Denmark) where different types of OWP had been yearly applied since 2003 [1], including household waste compost, sewage sludge, cattle manure, cattle slurry and animal deep litter. The measurement setup consisted in three 65 mm wide spring tines operating at a working depth of 12 cm. Each tine was connected to a transducer recording the horizontal and vertical forces [2]. Soil texture, soil organic carbon content and soil cohesion were also measured.

Results

Repeated OWP application increased the SOC content from 1.4 % SOC for the control NPK treatment to up to 3.5 % SOC for the compost applied at an accelerated rate. Bulk density was also changed by OWP additions and strongly correlated with SOC. Specific draught for soil tillage was significantly explained by SOC, clay content, bulk density and soil cohesion, and could be predicted with fairly good accuracy from a multiple linear regression as a function of SOC and clay content. However, no evidence was found that the quality of SOC accumulated for different organic wastes influenced the specific draught. Overall, the decrease in draught force could lead to a decrease in tractor fuel consumption for soil tillage of up to 25 % for compost applied at an accelerated rate and up to 14 % for compost applied at a normal rate.

Conclusion

This reduced fuel consumption could represent an important environmental benefit of the soil application of OWP. This benefit should therefore be included in environmental assessments of waste recycling, such as life cycle assessment, in order to provide a more comprehensive environmental balance of waste recycling through soil application.

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TB-P_04 Use of *Phoenix dactylifera* pruning biomass for the development of more fibrous and recalcitrant composts

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Objectives

The main objective of this work was to study the role of pruning biomass obtained from date palm (*Phoenix dactylifera)* as ingredient in several co-composting scenarios designed to obtain more fibrous and recalcitrant composts to be used with agronomic purposes linked to soilless uses and to enhance the recovery of the physical properties in degraded soils.

Methodology

Four ternary composting experiments, conducted in triplicate, were established by mixing 17% of sewage sludge (dry weight basis, d.w.) in all the scenarios with a combination of date palm pruning biomass (rachis + leaf), DPPB, and grass clippings, GC, in the start-up mixtures in the following proportion 17:66, 42:41, 67:16 and 83:0% DPPB:GC d.w, respectively. The mixtures (about 140 kg each) were composted in an enclosed, passively aerated composting vessel. All piles were turned 3 times during the composting process (7, 20 and 30 days) in order to improve both the homogeneity of the material and the biodegradation process. After the last turning, the temperature of the piles were stable and near to that of the surrounding atmosphere, and therefore the bio-oxidative phase of composting was considered finished. The composts were matured in the same vessel over a period of one month. The moisture of the piles was controlled weekly by adding the necessary amount of water to obtain a moisture content not less than 40%. The piles were sampled four times (at 0, 15, 30 and 60 days, correlated with the initial phase, thermophillic phase, end of bio-oxidative phase and maturity). The samples were taken by mixing seven sub-samples from seven sites of the pile, from the whole profile (from the top to the bottom of the pile). Each sample was air-dried, and ground to 0.5 mm for analysis. Throughout the composting process, the temperature evolution was monitored and different chemical parameters were determined. In the mature composts, several parameters related to recalcitrance (Chemical stability degree (SD)) and physical properties were also evaluated.

Results

Thermal profiles of the mixtures were negatively affected by DPPB compared to CCB biomass, according to EXothermic Index, EXI (calculated as the daily summation of the temperature increment in the pile compared to the ambient temperature in the bioactive period) (EXI = -3.66 DPPB (%) + 584, R^2 = 0.85). In general, the increasing presence of DPPB enhanced organic matter, organic carbon and C/N ratio in the mature composts. However, CCB presence increased the NPK contents and especially Na and K contents compared to DPPB. In this line, salinity were directly related to CCB presence, this aspect being one of the main constrains for compost intended for soilless use purposes. Cation exchange capacity was negatively correlated to DPPB presence. However, recalcitrant carbon contents in the composts were higher with the increasing presence of DPPB according to the chemical stability degree (SD).

Conclusions

Co-composting strategies can vary strongly the nature and uses of derived compost. In our experiment, the use of DPPB biomass in composting induced significant increases of organic matter and compost stability compared to CCB. However, more NPK fertilizing capacity and salinity were observed in CCB compost.

TB-P_05 Manure-derived biochars behave also as fertilizer

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Objectives

A plant growth experiment inside a climatic growth chamber was conducted with a hypothesis stating that manure based biochars would have fertilizing value for the crops as characterized by rich in nutrients. Furthermore, size of the effect would vary with specific biochar and soil properties.

Methodology

The experiment was carried out in a controlled environment (20 °C). Two types of soil with contrasting pH and texture (alkaline sandy soil and acidic silt-loam) were used. Five different types of biochars derived from different feedstocks and produced at different pyrolysis temperatures (poultry litter (PL) biochars at 400 and 600 °C, swine manure (SM) biochars at 400 and 600 °C and wood chip (WC), from a kiwi orchard, biochar at 1000 °C) and a control (without biochar) were included. Three replications per biochar treatment were made. Biochars were amended at 2% dry soil weight basis (~20 t ha^{-1}) and soil moisture was adjusted at 65% water filled pore space. Seeds of Italian ryegrass (*Lolium multiflorum L.*) were sown in plastic pots (13.5 x 13.5 cm) filled with soil biochar mixture (1.5 kg dry soil pot^{-1}). No extra fertilization was done. A total of five harvests were made during the entire growth period of 150 days. Roots were extracted at the end of the analysis for further analysis.

Results

Results from biochar characterization showed higher N and P content of PL400 and SM400 biochars. After 150 days, the total dry matter yield of ryegrass shoots in PL biochar amended soils were significantly higher (11.2 ± 0.62 g pot^{-1}, $P<0.05$) compared to control (8.0 ± 0.62 g pot^{-1}). Similarly, root biomass yields were significantly higher ($P<0.05$) in PL treatment (1.3 ± 0.07 g pot^{-1}) compared to control (0.6 ± 0.07 g pot^{-1}). Soil type had a significant effect on both shoot and root dry matter yield while no significant interaction was observed between soil type and biochar treatments. This enhanced growth of ryegrass was associated with a high nitrogen content of PL400 biochar (N = 5.8%) which eventually may have been available for the plant uptake. On the other hand, both control and wood chip biochar (N = 0.27%) amended soils demanded extra nitrogen as indicated by lower yield. It is also notable that part of the soil mineral nitrogen got immobilized in WC biochar treatment due to its high C:N ratio (320:1). A significant positive correlation existed between the total dry matter shoot yield and the nitrogen content of biochars ($n = 5$, $r = 0.872$, $P<0.05$).

Conclusion

The total dry matter yields of ryegrass (root and shoot) were related to both nutrients content of biochars and soil characteristics. Both PL and SM biochars showed a good potential to be utilized as N,P-fertilizers as significant amount of N and P is still recovered in the chars. This property of manure based char could fulfill additional N demand for the crops [1]. This study results can be helpful to set new biochar standards and regulations for the policy makers based on biochar quality composition and also to rate the mitigation potential of these biochars in reducing negative environmental impacts [2].

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TB-P_06 The impact of rock mineral wool on water retention in a conventional growth medium, and development of zonal pelargoniums

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Objectives

The rock mineral wool used as a component of the plant growth media was investigated. The types and sizes of the growth medium components are crucial factors of water retention capacity (1). The rock mineral wool can retain large quantities of water and air that promotes root growth and provides a good mechanical structure ensuring the stability of growing plants (2). With appropriate proportion of rock mineral wool, we wanted to improve the water retention capacity of the growth media in order to ensure enough macro-pores to drain the excess water away and to maintain an adequate level of oxygen.

Methodology

The present study includes a conventional growth medium for pot plants and rock mineral woll. The rock mineral wool was used as 2x2 cm cubes, and 2 and 4 cm thick discs. The cubes were added to a convetional growth media in 4 different volume percentages. In the first experiment, the water retention capacity of the growth media were tested in pots without plants. The water retention capacity of the media was determined weekly using classical approach based on weighting. In the second experiment, we tested the growth respond of the zonal pelargoniums cultivar 'Tango® Dark Red' to different growth media with rock mineral wool.

Results

The analyses of water retention capacity in pots without plants indicated that the growth media which contained 60 and 40 vol. % of the rock mineral wool in the form of cubes had significantly higher water retention capacity than the conventional growth medium (without rock mineral wool). At the final measuring date, 63 vol. % more water was retained in the growth medium which contained 60 vol. % of the rock mineral wool, compared to the conventional growth medium. No significant effect on water retention was observed in pots with 2 and 4 cm discs of the rock mineral wool. However, the growth medium with 4 cm discs of rock mineral wool had a positive effect on the development of the zonal pelargonium which formed a significantly higher amount fresh weight and dry matter of the aboveground parts in comparison with plants which were growing in the conventional growth medium. A similar positive effect, although not significant, was observed in the treatment with 60 vol. % of the rock mineral wool.

Conclusion

The results show that the rock mineral wool as a component in growth media can have positive effect on water retention capacity and plant development. By improving the water retention capacity of the growth media, lower amounts of water for plant watering are needed. By increasing the volume fraction of the mineral component in growth media, the quantity of peat used as a primary ingredient can be reduced as well. The reduction of water and peat may have positive effect on the economy and the ecological aspects of production.

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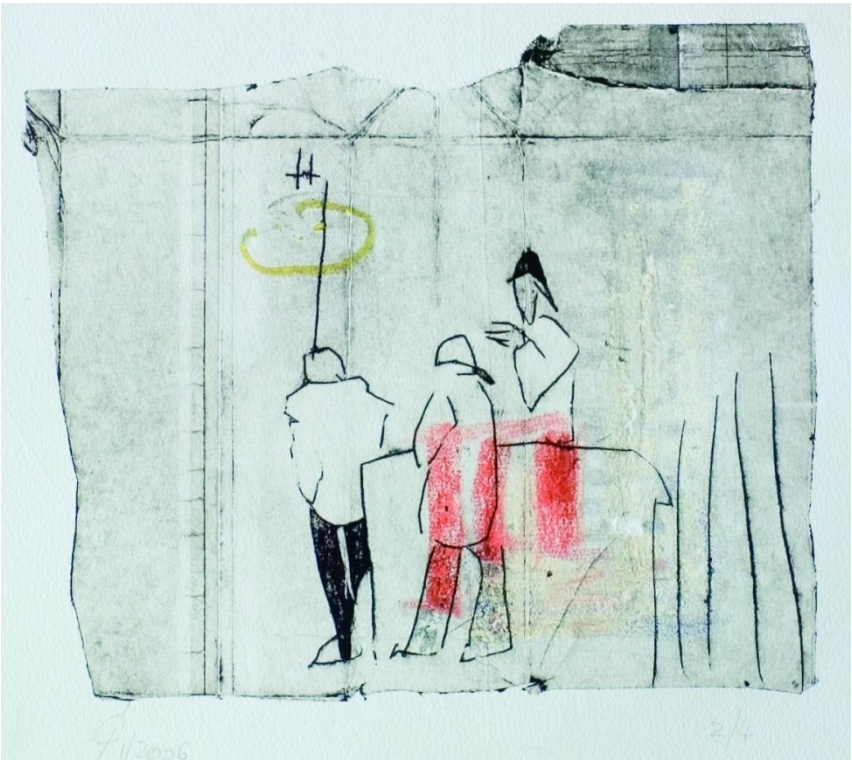
Thematic Area TC – Advances in emission prevention (Oral presentations)



Christiane Lüdtke: Art from Tetrapak

TC-K Predicting ammonia loss from field-applied manure – The ALFAM2 project

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Objectives

The overall goal of this work is to develop tools for predicting ammonia emission from field-applied manure. Specific objectives are to: 1) construct a database of ammonia emission measurements, 2) quantify relationships between management practices, environment, manure characteristics, and emission, 3) develop a mathematical model for predicting ammonia emission, and 4) create software tools for predicting ammonia emission.

Methodology

Ammonia emission measurements and associated weather, manure, and application data were solicited from researchers in Europe and North America. Twelve research group generously contributed data, which were combined with an earlier database (ALFAM [1]). Relationships between predictors (e.g., application methods, manure characteristics, and weather) and ammonia emission were quantified using empirical regression models and a new multi-pool emission model.

Results

To date, the complete database contains more than 16000 observations from about 300 experiments carried out in 12 countries. Most observations are for cattle or pig manure. Reported cumulative NH_3 emission ranges from about 1% of applied total ammonia nitrogen (TAN) to more than 100%. Preliminary results confirm significant reductions in emission due to use of band spreading or trailing shoe application (ca. 50%) and injection (ca. 80%) compared to broadcast application. Manure characteristics (e.g., dry matter) and weather also influenced emission rates and cumulative emission. A two-pool model for ammonia emission, which includes “fast” and “slow” TAN pools, proved to a flexible tool for describing ammonia emission over time and also differences in emission trajectories related to application method, manure characteristics, and weather. Additional data compilation, analysis, and model development is ongoing. Ultimately, results will include a publicly-available database and emission model.

Conclusion

Compilation of existing ammonia emission data from Europe and North America provides a useful database for estimating ammonia emission from field-applied manure, and developing quantitative models for predicting emission under a wide range of conditions. This work was made possible by the generous contributions of data by many individuals.

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TC-O_01 Ammonia emission after slurry application to grassland

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Objectives

Losses after field application of slurry from livestock is a key loss path contributing between 30 and 50% to the agricultural ammonia (NH3) emissions released by European countries The objective of this study was to quantify NH3 emission levels for application of slurry to grassland and to evaluate the effects of different abatement techniques.

Methodology

Slurry was applied within 17 field experiments on square plots of approx. 900m2 mainly using the reference technique splash plate (SP). NH3 concentrations were measured above the fertilized area at approx. 1 m using impinger sampling devices. The corresponding emission rates were estimated with a backward Lagrangian stochastic model (WindTrax) [1], generating the model input from sonic anemometer measurements.

Results

The average NH3 emission after application of cattle slurry (CS) using the reference technique SP amounted to 25% of applied TAN (Total Ammoniacal Nitrogen) ranging from 10% to 47% TAN. The use of low emission techniques showed a clear effect. An average reduction of 51% for application with trailing hose (TH), 53% for trailing shoe (TS) and 76% for shallow injection (SI) was found, compared to the reference technique SP. This is in rather good agreement with the ranges given by [2]. Three field experiments compared CS to pig slurries (PS). PS revealed systematically lower emission levels to CS. The reason for this difference could not be completely allocated by the analyzed slurry properties, even though DM content may partly account for the difference in the measurements. Application around noon produced higher emissions than in the morning and in the evening, as was found in previous studies such as [3]. This can be related to the much higher NH3 emission potential at noon together with the high proportion of the total loss emitted directly after application, which was found in all experiments.

Conclusion

The NH3 emission levels for the reference technique SP were generally found to be below 50% TAN, even under conditions with a high potential for emissions. The different abatement techniques significantly reduced the emission level compared to SP. The emission mitigation achieved was in the expected range.

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TC-O_02 The importance of pH for ammonia emission from animal manure

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Objectives

The intention of this proceeding is to present the important pH-related reactions that affect ammonia (NH_3) emission. New models and equations used to estimate pH in the surface of the sources of emissions have been developed and it is shown how surface pH changes over time and affects predictions of NH_3 release from solutions.

Methodology

Information about NH_3 emission as affected by pH in the surface are collated and used to document the need to include this pH in models for predicting emission of NH_3. The information is used to develop a physical-chemical-biochemical conceptual model of pH changes in the surface of liquid manure stored or applied on soil. This pH will be used to develop models that more accurately predict NH_3 emission from these sources.

Results

It is the uncharged species NH_3 (aq) (free ammonia) that can volatilise, and it is a base, so its concentration and emission rate are dependent on the solution pH. Emission occurs from the surface, and so it is surface pH that affects NH_3 emission. Computations show that after TAN concentration in the source, pH is a most important factor in controlling NH_3 release to the atmosphere. It is shown that pH is related to the concentration of pH buffers, including total inorganic carbon ($TIC=CO_2+HCO_3^-+CO_3^{-2}$), organic acids (VFA), TAN and organic particles. TIC, VFA and TAN are volatile and the emission of these to the atmosphere will affect pH [1, 2]. Calculations of pH in the surface of a source must, therefore, include convective and diffusive transport of TAN and pH buffer components as well as emission of CO_2, NH_3 and VFA. In addition the pH models must account for aerobic transformation of the components at the surface and anaerobic transformation in bulk slurry.

Conclusion

There is a shortage of models that give the relationship between NH_3 emissions from stored and applied slurry to pH and TAN concentration at the surface of the source, although these variables must be known to give correct estimates of NH_3 emissions. Model for assessing NH_3 emission can be improved by including pH changes in the surface layer of an NH_3 source as affected by physical, chemical, and biochemical processes.

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TC-O_03 Impact of field acidification and application methods on ammonia emissions, yield and nitrogen efficiency of organic liquid manures

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Objectives

The connection between ammonia emission and crop yields is still uncertain. The objective of this study is to investigate, which effect methods of liquid manure application have on ammonia emissions and crop production. Simultaneous and replicated field testing gives improved knowledge of this linkage. A novel measurement approach presents better understanding of agricultural emission patterns to make prevention more certain.

Methodology

A set of different applications, treatment methods and manures were tested within four field experiments two times on summer barley and two times on winter wheat, within a randomized block design of four distinguished blocks (n = 4). The measurement was done with combined methods: a calibrated dynamic chamber determined absolute ammonia fluxes and acid traps for replicate sampling (according to Gericke et al. 2011, Quakernack et al. 2012). The crop yields and nitrogen uptake were obtained by destructive sampling. In each trial three up to ten treatment factors were tested concurrently, contingent on different application methods, slurries and their combinations, including incorporation, acidification and injection.

Results

Preliminary results show significant differences between the different application methods and acidification levels. Further contribution will give full insight in the effects of various strategies to reduce ammonia losses, tested at the same time under identical conditions. Correlations between ammonia emissions and yield components will be presented. Results are of particular relevance for testing and validating ammonia loss models.

Conclusion

A better understanding on the right conditions, such as the best acidic level for certain manures at the right time with the certain application technique and treatment method, can lower the ammonia emissions. Having an optimal nitrogen plant uptake with concurrent emission reduction is feasible, even within the given necessities of agricultural crop production. Therefore knowledge about treatment and usage of organic liquid manures needs to be imparted into famers' daily practice at its best use and efficiency.

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TC-O_04 Emission situation of anaerobic digestion of agricultural residues and bio-waste

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Objectives

With respect to the climate protection, a quantitative assessment of the emissions of energy generation from biomass and biological waste treatment is important. The DBFZ investigated the emission situation of biogas plants in Germany within research projects with project partner of selected biogas plants to analyze the emission situation of biogas plants. The results of the emission measurements are used to assess the ecological impact of AD and to describe possible mitigation measures to reduce the occurring greenhouse gas (GHG) emissions.

Methodology

Emissions were measured at anaerobic digestion (AD) plants of the separately collected organic fraction of household waste (bio- waste) as well as agricultural biogas plants using energy crops and manure. The emission analysis included the determination of methane (CH_4), nitrous oxide (N_2O) and ammonia (NH_3). Based on the measured emissions greenhouse gas (GHG) balances were calculated as well as the analysis of GHG credits. That means, the electricity production and heat utilization of biogas as well as the credits of the various fermentation residues (e.g. fertilizer and humus effect of fermentation products and composts) were analyzed to estimate the specific greenhouse gas performance of the investigated facilities. Finally the measurements with respect to mitigation of GHG emissions were analyzed and described.

Results

The results show that GHG emissions from AD processes can be minimized, if the technology and operation of the plant are adjusted accordingly. Methane emissions dominate GHG emissions from biogas plants. Based on the investigations significant emission sources were identified. The open storage of active material (e.g. insufficient fermented residues from batch fermentation systems), open digestate storage tanks and missing acidic scrubbers in front of bio-filters or insufficient air supply during the post-composting of digestate can cause relevant GHG emissions. Consequently avoiding open storage of insufficient fermented residues and using aerated post-composting with short turnover periods, smaller heaps and an optimized amount of structure (woody) material can reduce GHG emissions. The consideration of GHG credits can optimize the overall GHG performance of the biogas facilities. GHG credits can be generated for the substitution of fossil fuel or avoided GHG emissions of fermentation products (e.g. combined heat and electricity from biogas; fertilizer and humus effects from fermentation residues).

Conclusion

Depending on the used technology and the kind of operation, GHG emissions like methane, nitrous oxide and ammonia are occurring. Basically, the kind of operation of the plant and the handling of digestate determine the amount of GHG emissions. In general the emission situation is not uniform, the plants show very different emission rates. It can be stated that all investigated biogas facilities showed potential for optimization.

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TC-O_05 Abatement of ammonia emissions from digested manure using gas-permeable membranes

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Objectives

A new strategy to avoid NH_3 emissions from anaerobically digested manure was tested. For this purpose the gas-permeable membrane process to recover ammonia from digestate with high nitrogen load was used. The system contributes to reduce NH_3 emissions, and recover nutrients from the digestate whilst converting ammonia into an ammonium salt fertilizer.

Methodology

Experiments were conducted in 2-L vessels consisting of PET jars for an effective digestate volume of 1.3 L. Diluted H_2SO_4 was continuously circulated through tubular gas-permeable membranes inside the digestate vessels and back into an acid tank in order to recover NH_3. Digestate was replaced 7 times as NH_3 was depleted in order to concentrate NH_3 in the acid.

Results

Seven consecutive batches using gas-permeable membranes were used to prevent NH_3 emissions from the digested manure and therefore to concentrate this nutrient in the acid solution. Digestate with an average of 4,780±630 mgNH_4^+-N L^{-1} was used. It is important to emphasize that the acidic solution was the same during the entire experiment that processed seven batches of manure. The recirculation of this liquid in a closed loop between the digestate vessel and the acid tank achieved an NH_4^+concentration in the recovery solution (46,585±1,974 mgNH_4^+-N L^{-1}) about 10 times higher than the original digestate (4,780 mgNH_4^+-N L^{-1}. A total N mass of 13,980±590 mgN was recovered in the acid from the digestate during the experimental period. These findings are in agreement with those reported by García and Vanotti [1] who observed a high N recovery from manure with different NH_4^+ strengths using the gas-permeable membrane technology.

Conclusion

Ammonia was successfully recovered from digested manure avoiding its volatilization to the atmosphere and preventing air pollution. Therefore, gas-permeable membrane technology could be combined with anaerobic digestion to avoid ammonia emissions and at the same time recovering the N as a valuable nutrient in the form of a concentrated ammonium salt fertilizer.

Acknowledgements

Cooperation with USDA-ARS Project 6657-13630-001-00D “Innovative Animal Manure Treatment Technologies for Enhanced Environmental Quality” is grateful acknowledged. Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

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TC-O_06 Reduction of ammonia emissions and related greenhouse gas fluxes from separated anaerobic digestates

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Objectives

Separation of organic manures can cause increasing ammonia and concomitant greenhouse gas (GHG) emissions from the solid phase. In addition to the environmental damage, ammonia emissions are a loss of valuable nutrients, in particular in organic agriculture. Therefore, a new approach including incubation of manures with microbes and a nutrient source what tested to reduce NH_3 emissions without increasing greenhouse gas (GHG) fluxes.

Methodology

The effect of varying doses of melasse and incubation enhancers on NH_3 and GHG emissions were tested in a lab trial. Solid phase (500 g, n = 4) of anaerobic digestates (AD) was mixed with microbes (indigenous microbes, IM) and nutrients. NH3, N2O, CH4, CO2 emissions were determined with a photoacoustic field gas monitor for 4 weeks [1]. Secondly, 4 heaps (0.5 t, n = 2) of AD solid phase were mixed with the most effective mixture and stored for 6 weeks on farm. NH_3 emissions were quantified by passive flux acid traps [2] and nitrogen compounds were determined.

Results

Addition of IM with melasse yielded in many cases in a strong reduction of NH_3 emissions by up to 35 % in the incubation trial. High rates of melasse addition resulted in a positive GHG balance compared to untreated AD due to strongly increased N_2O fluxes. However, strong reductions of NH_3 emissions (30%) were also obtained with very low doses of melasse without affecting GHG emissions after pre-incubation of a microbe-melasse mixture for one day before mixing with AD or addition of biochar. Mineral nitrogen contents were increased and pH-values decreased compared to the untreated control. The on-farm experiment confirmed the results on the incubation trial applying the pre-incubation approach. Ammonia emissions were strongly reduced (35%) in particular at the beginning of storage. Mineral nitrogen contents in the lower layers of the heap were increased by 50%, containing both NO_3^- and NH_4^+. Low doses of melasse addition and higher mineral N contents may make this approach economically feasible.

Conclusion

Ammonia emissions from separated AD can be reduced by addition of IM and melasse as incubation starter without increasing GHG emissions. In this trail only one type of AD from organic farming with comparably low ammonium N concentrations was tested. To confirm this approach other solid phase substrates with higher ammonium N concentration should be investigated.

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TC-O_07 Model-based quantification of indirect nitrous oxid emissions in a crop rotation with biogas digestate-fertilized OSR

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Objectives

Emissions of nitrous oxide (N_2O) from arable land are a major contribution to the global GHG balance. To quantify their amount, direct and indirect N_2O emissions have to be considered. Direct N_2O emissions can be measured directly at the place of origin with techniques like chambers or FTIR.
Indirect N_2O emissions are N_2O emissions resulting from reactive nitrogen compounds like ammonia or nitrate, displaced from one system into another. They account for one third of the total global agricultural N_2O source and approximately two thirds of the uncertainty in the total source [1].
Fertilizing OSR with biogas digestates may lead to high amounts of ammonia volatilization. The high N content in the plant residues enables a fast mineralization, which can cause N leaching after OSR harvest. The aim of the present work was to quantify indirect N_2O emissions through a model-based N balance approach.

Methodology

Starting in autumn 2012, a field experiment including a crop rotation (OSR, wheat, barley) was carried out two years in the northern part of Germany. In spring OSR was fertilized with biogas digestate (180 kg NH_4-N, without and with nitrification inhibitor (NI)). Wheat and barley were fertilized using mineral fertilizer (CAN; 220 kg N and 200 kg N respectively). NH_3 emissions were detected after digestate fertilizing events by use of Draeger tube measurement technique [2]. Direct N_2O emissions were measured weekly using manual chambers. Soil mineral N (SMN) samples were taken three times per growing season.
To quantify indirect N_2O emissions we used measured data, a dynamic simulation model to calculate N leaching and a semi-empirical model for NH_3 volatilization. SMN data at the beginning of the experiment were used as initial model data. Fertilization (experimental data) and modeled mineralization were used as system input, whereas modeled N uptake by plants, nitrogen leaching and gaseous N emissions (N_2O, NH_3 (measured); NO_x, N_2 (modeled)) were regarded as system output. Finally we calculated indirect N_2O emissions using corresponding IPCC TIER 1 emission factors.

Results

Regardless of inhibitor treatment, in 2013 and 2014 we measured 45 and 40 kg NH_3-N per ha total NH_3 emissions, respectively. It results in calculated indirect N_2O emissions of about 0.45 kg N per ha and 0.4 kg N per ha, respectively, originating only from ammonia volatilization. That means, for example, indirect N_2O emissions in a range of 37% (without NI) and 64% (with NI) of the measured direct N_2O emissions in 2014, respectively (data not shown). In autumn 2013, a SMN value of 25-30 kg N ha^{-1} in a depth of 60-90 cm under wheat following OSR gives indication of a high N leaching potential which leads to considerable indirect N_2O emissions.

Conclusion

Fertilizing OSR with biogas digestate leads to relatively high amounts of indirect N_2O originating from ammonia compared with measured direct N_2O emissions. High SMN values after OSR potentially lead to high N leaching.

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TC-O_08 Controlled drum composting with limited climate impact – Emissions and heat recovery

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Objectives

EU Directive 1069/2009 requires manure to be sanitised before being sold on the market. Approved sanitisation plants use a drum composter to reach compost temperatures of 52°C for at least 13 hours. This project examined release of ammonia (NH_3), nitrous oxide (N_2O) and methane (CH_4) from drum composting, including pre- and post-composting stages, and compared measures to reduce emissions.

Methodology

Two composting plants, both using mainly horse manure, were studied. For the drum composter and one pre-composting hall, air flow and gas concentrations were measured on-line with flow meters and by gas sampling and analysis with FTIR and FID. For pre-composting (duration 0.5-1 week) and post-composting (duration 2.5-3 months), NH_3 was measured with a micrometeorological mass balance method [1] and CH_4 and N_2O gas were sampled with a closed chamber technique [2].

Results

In plant 1, emissions of greenhouse gases and ammonia were limited and rather low compared with literature or default values. Pre-composting had the greatest impact on global warming, followed by post-composting, while drum composting had the least impact. The dominant GHG was CH_4, mainly originating from pre-composting, but also the post-composting step. Most of the N_2O was produced during post-composting. Total NH_3 emissions from the three composting steps comprised ~3% of total N in substrate (compared with 11% of total-N from frequently turned compost of horse manure with straw). Post-composting gave the highest NH_3 emissions (1.4-2.1% of total N), while losses from the drum composter were only 0.5-0.6% of total-N, corresponding to only ~290 kg N per year.

Potential energy in exhaust air for use by the heat exchanger amounted to ~54 MWh per year, while trapped NH_3 from the drum composter was 17 and 35% of total NH_3 discharged for plants 1 and 2, respectively.

Conclusion

In total, GHG and NH_3 emissions from the three composting steps were moderate. The climate impact could be reduced mainly by replacing heat from fossil fuel with heat exchanged from exhaust air from the drum composter.

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TC-O_09 Emission patterns of separated digestate obtained from field pilot-scale stores

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Objectives

This study determined gaseous emission patterns from field pilot-scale stores of a co-digestate cattle slurry and its respective separated fractions. We evaluated if mechanical separation exacerbates or reduces the environmental impact of storage in warm climatic conditions. Some operational information were determined concerning the effect of management actions on NH_3 and GHGs emissions.

Methodology

The experimental setup comprised a pilot-scale storage facility where each fraction (untreated, liquid and solid) was stored in duplicate for a period of 90 days in warm climatic conditions. Flux measurements, based on the dynamic chamber method, took place twice a month. NH_3 and GHGs concentration (CH_4 and N_2O) were analysed by acid traps and a photo-acoustic trace gas analyser (P-TGA) system, respectively. Effects of mechanical separation and disturbance were assessed by ANOVA (Wilcoxon Test, $P < 0.05$).

Results

The NH_3 emission pattern was similar to the temperature trend. The NH_3 emissions from disturbed slurries ranged between 125.6 and 38.8 mg m^{-2} h^{-1}, while those from the undisturbed slurry were significantly (38%)less ($P < 0.01$). Mechanical separation had a significant effect only on CH_4 and N_2O emissions. In particular, a 39% reduction in CH_4 emission ($P < 0.01$) was observed for disturbed slurries. For undisturbed slurries the mean flux was 94.6 mg m^{-2} h^{-1}. Concerning N_2O, significant increments ($P < 0.01$) occurred from both disturbed and undisturbed slurries, with a peak observed from the solid fraction (16.9 mg m^{-2} h^{-1}).
As expected [1, 2] N_2O fluxes were mainly related to the presence of solid fractions and to crust formation on undisturbed slurries, especially for untreated ones characterized by a high TS content. However, in terms of CO_2 equivalent (CH_4 + N_2O) mechanical separation resulted in lower emissions. Mixing operations significantly increased N losses that mainly occurred in form of NH_3.

Conclusions

In field conditions, gaseous emission patterns were influenced by many factors (e.g. environmental conditions); however, the experimental setup allowed the comparative evaluation of treatment effects. Management operations that involve slurry disturbance must be carefully planned in order to limit gaseous emissions, particularly those of NH_3. Mechanical separation, in addition to being a treatment for improving manure handling, was proved to be a good mitigation option for greenhouse gases emissions when expressed in terms of CO_2 equivalent.

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TC-O_10 Reduction of gaseous emission from slurry storage tanks by different covering materials

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Objectives

Gaseous losses from manure management are of increasing public concerns. Covering slurry storage tanks is one of the possible solutions for the reduction of ammonia emission. Nevertheless, floating covers might increase GHG emission. The research objectives were to assess the abatement of ammonia and GHG gases of four different covering materials, as well as their economic sustainability and influence on slurry handling.

Methodology

Four covering materials (Leca® balls, Hexa Cover Tile®, Floating Joint Elements and a Membrane for biogas recovery) were placed over the surface of a 250m3 storage tank filled with pig slurry. A portion of the tank was left uncovered and used as control. Ammonia and GHG losses were afterwards measured by means of a set of Wind Tunnels [1] and a set of Funnel systems [2] over a period of 180 days. Along the trials, the environmental and slurry temperatures were continuously recorded by means of data loggers (Hobo Onset). At the end of the experiment, operative and economic evaluations were carried out, based on the behavior of the covering materials along the trial period.

Results

All the covering systems showed to be effective in reducing ammonia emission. The Hexa Covers Tiles® and Leca® balls showed approximately a 80% reduction, whereas the 99% of ammonia losses were abated by using the Floating Joint Elements. No ammonia nor greenhouse emission were recorded from the slurry surface covered by the membrane for biogas recovery. The other floating covering materials (Leca balls, Hexa covers and Joint Elements) were less effective on GHG abatement (-48%, -38% and -77% methane emission respectively compared to the control). N_2O losses were significantly reduced by all systems but by Hexa Covers and Leca. From the surfaces covered by these materials +7% and +8% NO_2 emissions were recorded respectively. Besides Leca balls, all the covering systems showed to be persistent over time, thus suggesting the possibility to re-use the covering material several times. The membrane for biogas recovery showed to be the easiest system to install, maintain and handle.

Conclusion

Considering the gaseous losses abatement efficiency, investment costs and handling easiness, the slurry tank covered with the membrane for biogas recovery resulted to be the most suitable system. Besides the environmental benefits, it also enables the energetic valorization of the recovered methane, thus increasing the economic sustainability of this solution (payback time shorter than 4 years).

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TC-O_11 Influence of surface processes on gaseous emissions from manure slurry – Surface oxidation and pH gradient

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Objectives

Abatement of gaseous emissions from manure slurry requires knowledge about factors influencing the release of ammonia (NH_3), greenhouse gases, and odorants on a detailed level. Surface pH plays a crucial role for the release of many compounds that are either basic (e.g. NH_3) or acidic (e.g. H_2S or acetic acid) and has been suggested to be different from bulk pH [1], although measurements with high spatial resolution in real manure slurry has not been reported. In addition, chemical or microbial surface oxidation by oxygen penetrating few µm to mm into the slurry surface [2] may reduce emissions of compounds that are easily oxidized. In this work, a unique combination of pH micro-sensors and online mass spectrometry has been used for the first time to investigate these processes. Furthermore, the effects of slurry stirring on surface pH and on emissions are reported.

Methodology

The experiments were performed in a 2 liter reactor containing 1 liter of pig manure slurry. Headspace was continuously flushed with air. A pH micro-sensor positioned in a micro-manipulator was used to carry out measurements of pH gradient in increments of 250 µm in the top 0-100 mm of slurry. Emissions were measured by proton-transfer-reaction mass spectrometry (PTR-MS) supplemented by photo-acoustic detection. Measurements were done under stagnant conditions as well as under slurry stirring. The effect of surface oxidation was investigated by exchanging air with N_2 in the headspace.

Results

A strong pH gradient was observed to develop within few hours of slurry storage. The gradient reached a level of ~1 pH unit over a depth of less than 10 mm and as expected [1] pH was higher near the surface, which is ascribed to differential release rate of CO_2 and NH_3. During stirring of the manure, surface pH approaches bulk pH and becomes more acidic. This is accompanied with reduced emission of NH_3 and increased emissions of acidic components (H_2S, CO_2 and carboxylic acids). However, emissions of H_2S and CO_2 were increased far beyond what can be explained by decreased surface pH, which is ascribed to reduced liquid-side resistance to the flux during stirring in the case of relatively poorly soluble compounds. The same was observed for methanethiol, which is not affected by pH.
The presence of oxygen in the headspace strongly reduced emissions of H_2S and methanethiol compared to anoxic conditions. This is a clear demonstration of surface oxidation of these compounds even if O_2 only penetrates little into the slurry surface. Other compounds and pH were not affected by the headspace composition.

Conclusion

The compound flux from the surface of manure slurry is affected by the pH gradient in the upper mm, including the effect of stirring on this gradient. Stirring leads to reduced surface pH and lower emissions of NH_3. Surface oxidation of H_2S and methanethiol is evidenced by strongly increased flux in the absence of oxygen in the headspace.

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TC-O_12 Bio-acidification of manure – By supplying manure with 2-3% sugar or cellulose

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Objectives

Ammonia emissions from manure can be decreased with 70% by lowering the pH to 5.5 with sulfuric acid in-house [1]. However, it is prohibited for organic farmers, may cause inhibition in biogas plants and an excessive soil-S, and handling is hazardous. An alternative is in-situ production of lactic acid [2] and acetic acid. However, the quantities of bacterial and substrate supplement must be clarified.

Methodology

Twenty-seven treatments were run for 4-6 weeks in 0.2 L cattle manure batches with vertical shaking at 20-25 °C with continual or initial additions. And treatments were stored at 20-25 °C subsequently. Treatments included 10, 30, 50 and 100 g of glucose or cellulose or 30 or 50 g of lactic acid per kg manure. Some of the treatments were supplemented with 10^8-10^{11} CFU per kg manure of three types of lactic acid producing bacteria and /or β-gluconase. The stoichiometric requirement of lactic acid and substrate was estimated by performing titration of the slurry with hydrochloric acid to a pH of 5.5.

Results

The intent was to convert carbohydrate into lactic acid by the indigenous lactic acid producing bacteria. Indeed successful pH reductions of cattle manure were observed.

Adding supplementary lactic acid producing bacteria did not affect the slurry pH.

Glucose supplements of 30-100 g per kg manure, corresponding to 3-10 times the stoichiometric requirements for homo-fermentative conversation to lactic acid, all decreased the pH to 4.2-4.4. Lactic acid was observed present. The numbers of lactic acid producing bacteria increased with three orders of magnitude over the period. Residual glucose was observed in the end of the incubations in the treatments. Thus the lactic acid producing bacteria produced lactic acid, but only until the pH had dropped to a certain level.

Cellulose supplement at 3-10 times the stoichiometric requirement per kg manure all decreased the pH to 5.4-5.7. High acetic acid and propionic acid levels were present. The amount of lactic acid producing bacteria was not elevated. No effect of adding β-gluconase was observed. Thus primarily acetogenic bacteria were indicated to produce acids, and the manure's indigenous content of hydrolytic exoenzymes appeared to cause a sufficient hydrolysis rate.

Conclusion

A successful treatment would thus be addition of a sugar, cellulose or hemicellulose rich agricultural by-product in an amount equal to 20-30 g monomeric carbohydrate per kg manure. No bacterial and likely no enzyme supplement should be added. The carbohydrates could be added directly in the slurry channels. Compared to sulfuric acid-acidification, bio-acidification may thus equally reduce NH_3 emission.

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TC-O_13 Proposal of a composting model to predict and manage gaseous emissions and quality of compost

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Objectives

Composting is commonly used to treat solid organic residues and to recycle them as an amendment for agricultural soils. An environmental limit of the composting process is linked to the gaseous emissions (GHG and NH_3) released by this biological treatment. The objective of this study was to propose a numerical model predicting gaseous emissions and the final compost quality in order to optimize composting management practices.

Methodology

Based on previous work by Tremier et al. [1], Denes et al. [2] and Oudart [3], a numerical model formed of four coupled modules (a biodegradation module describing organic matter fractions and microbial kinetics, a mass transfers and a heat transfers modules and finally a nitrogen module describing the dynamics of nitrogenous forms) was designed. Composting pilot experiments were performed with solid manure and digested solid manure mixed or not with woody bulking agent to confirm modelling hypothesis and to calibrate the numerical model.

Results

Composting pilot experiments highlighted different behaviors for solid manure and digested solid manure. As awaited, raw solid manure demonstrated to be more biodegraded than the digested one with a higher heat release. The presence of bulking agent did not significantly change the carbon biodegradation dynamics. For all trials, CH_4 was detected concomitantly to the highest oxygen uptake rates and represented 5 % of the total carbon degraded. Nitrogenous emissions differed depending on the treated mixtures. Composting of solid manure without bulking agent emitted mainly ammonia (8% of the initial N content) and less N_2O (2.2 % of the initial N content), whereas ammonia emissions were largely decreased with bulking agent (a large part of ammonia nitrogen was trapped in the bulking agent). In this last case, more organic nitrogen was biodegraded and the transformation of nitrogen forms to N_2 was enhanced. Digested manure emitted mainly N_2O (9.7 % of the initial N content).
The developed model was tested on the experimental results for solid manure without bulking agent. It was able to describe the intensity and the extent of the carbon degradation. Modelling of the N dynamics has still to be calibrated.

Conclusion

Composting experiments proved that gaseous emissions along treatment can largely differ depending on the quality of the treated substrate and on the treatment conditions. It confirms that the best way to optimize composting management will be the use of numerical models. Our model has still to be calibrated, especially concerning nitrogen dynamics but promise to be a very interesting tool to understand and predict composting behaviors and supply environmental data.

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TC-O_14 Gaseous emissions from slurry storage – Influence of temperature and potential mitigation methods

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Objectives

The objectives of this study were to assess the influence of storage temperature on methane (CH_4) and ammonia (NH_3) emissions from pig and cattle slurry storage and to assess the potential of two mitigation techniques – namely a clay granule floating cover and acidification, to effectively reduce both NH_3 and CH_4 emissions.

Methodology

The experiment was conducted using 6 pilot-scale slurry tanks (c. 1 m^3) with specially adapted lids for gaseous emission measurement. A total of 6 experiments were conducted, each of 2 months duration, covering 2 slurry types (pig, cattle), 3 temperature regimes (winter, summer, spring/autumn) and 2 potential mitigation practices (floating cover, acidification). Lids were left in place for the duration of each experiment with a constant airflow through the headspace which was monitored for CH_4, NH_3 and CO_2 concentrations.

Results

Methane emissions were similar to those reported elsewhere [1] and were strongly influenced by temperature, with very low methane conversion factors in the colder months (c. 1%), substantially below current default IPCC values for the UK. There was no significant effect of the floating clay granule cover on cumulative CH4 emissions, as there was presumably no methanotrophic activity, but emissions were significantly reduced by between 60 and 90% by slurry acidification, agreeing with the results of Petersen et al. [2]. Ammonia emissions were also influenced by temperature, with greater emissions in warmer months. Cumulative emissions varied between 10 and 50% of initial slurry ammoniacal N. Both treatments gave significant reductions in NH3 emission, with average reduction efficiencies of c. 70 and 75% for covering and acidification, respectively. The pH of the acidified slurries increased during the storage period, depending on the initial quantity added, with an associated increase in NH3 flux.

Conclusion

Temperature has a significant influence on CH_4 and NH_3 emissions from slurry storage and appropriate UK-specific emission factors should be derived for use in the national emission inventories. Slurry acidification is an effective method to reduce both CH_4 and NH_3 emissions. A floating clay granule layer reduced NH_3 emissions but not CH_4 emissions. Further work to assess effectiveness over longer storage duration is required and to investigate the possibility of enhancing methanotrophic activity in floating layers on slurry storage.

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TC-O_15 Ammonia emissions factor modelling of naturally ventilated dairy housings using on-farm measurements, climate data and nitrogen levels

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Objectives

The aim of this study was to determine NH_3 emissions for the most common future dairying situation in Switzerland and to derive a year-round emission factor as a contribution to emission inventories. This paper is focused on nitrogen input in feed and nitrogen output in milk, urine and slurry.

Methodology

We performed measurements on six dairy loose housings with natural ventilation, solid floors and an outdoor exercise area using a tracer ratio method [1]. A large set of accompanying parameters such as descriptive farm data, climate data, aisle/exercise-area soiling, and nitrogen input, output and utilization was recorded to characterise each measuring situation and to deduce relevant influencing variables. A calculation based on our measurements, typical wind speeds, milk urea contents from commercial dairy farms and air temperatures from two altitude levels over a five-year period was used to calculate yearly averaged emission factors.

Results

The farms differed in herd size (20 – 74 cows), live weight of the animals (average herd: 669 - 871 kg), feed ration, and milk yield (average herd: 18.6 - 30.6 kg cow^{-1} d^{-1}). The tank milk urea level between the farms and measuring periods varied from 13 to 31 mg dl^{-1}. The urea content of the tank milk was correlated with total nitrogen content of the urine.
From a linear mixed-effects model the outside temperature ($p < 0.001$), the wind speed in the housing ($p < 0.001$) and the urea content of tank milk ($p = 0.0446$) emerged as significant variables influencing NH_3 emissions. The tank milk urea level - as a reliable indicator of nitrogen utilization and the nitrogen level for the whole herd [2] - appeared to be useful to understand fluctuations within and between farms. For the model-based calculation milk urea levels on an individual animal basis from the monthly milk recording issued by the Swiss Brown Cattle Breeders' Federation, the Swiss Fleckvieh Cattle Breeders' Federation and the Swiss Holstein Cattle Breeders' Association were used. The average calendar year levels varied from 22 to 29 mg dl^{-1}. While during the winter the nitrogen level was lower, in the summer feeding period the milk urea content reached maximum values.
The calculated NH_3 emission factors ranged between 22 and 25 g $LU \cdot d^{-1}$, depending on altitude level and wind speed. The detailed database of temperatures and milk urea levels from practical farms enables to take into account typical patterns during the course of the year.

Conclusion

The measurement concept as well as the tracer ratio method have proven their worth in practical use in naturally ventilated dairy housings with an outdoor exercise area, and are transferable to other housing systems for cattle and further livestock categories. Using the model-based calculation approach it was possible to determine regionally differentiated NH_3 emission factors based on widely available underlying data of high temporal and spatial resolution, thereby showing differences in climatic conditions and nitrogen levels.

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TC-O_16 Assessment of the through-flow patterns in naturally ventilated dairy barns – Three methods, one complex approach

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Objectives

One of our main objectives is to better characterize the emission source “dairy barn”. The highly variable through-flow patterns of naturally ventilated barns determine the air exchange rate and are crucial for the transport of pollutants, humidity and heat. Understanding the flow processes in detail and relating those to typical emission rates is essential.

Methodology

We develop and validate numeric models to simulate the through-flow depending on the boundary conditions. Typical areas of high and low wind speed in the animal occupied zone are identified. For model validation, a three-column approach (field measurements, experiments in a boundary layer wind tunnel and numeric simulations with different software tools) is continuously refined. The wind field and gas concentrations are measured simultaneously under conditions of practice.

Results

Field measurements that map the nature are only samples since the boundary conditions are fast and ever changing and the number of possible sensors is limited. The through-flow processes of naturally ventilated barns are highly complex and turbulent. Even for symmetric buildings the flow is spatially heterogeneous and not stationary. The observed patterns depend strongly on the inflow and the building design (e.g. size and position of openings) [1]. However in most of the cases, the building design cannot be changed to study the effect on the flow in detail. Thus, it is sensible to complement field data with data from modelling and simulation. Those, however, require a validation of their results.

Studies in the boundary layer wind tunnel and various numerical simulations with an orthogonal inflow revealed a meandering flow which is implied by the field data as well [2]. In the front half of the barn high wind speed values occur in the animal occupied and the emission active zone while wind speed in the back half of the barn is typically much lower. Close to the roof a reverse flow is observed.

Conclusion

Combining field measurements, physical modeling in a boundary layer wind tunnel and numerical simulations yields maximal information output to determine typical through-flow patterns in naturally ventilated barns. Physical and numerical modeling is essential to obtain sufficiently high resolved data and to study the influence of boundary conditions. Field measurements are crucial to validate the models and assess the flow patterns regarding their effect on emission rates.

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TC-O_17 Influence of deep litter on gaseous emissions and microbial composition in a dairy farm

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Objectives

A deep litter system was implemented in a dairy farm, resulting in clear benefits for animal health and wealth, organic matter needs for bedding, and on the subsequent management of manure. While dairy cattle farms are a major source of greenhouse gases (GHG) and ammonia (NH3), data on the influence of the bedding structure on such emissions is scarce. The present work was aimed at characterizing the gaseous emissions that are associated to deep litter.

Methodology

The farm "El Trèvol" (Vilobí d'Onyar, Spain) encompassed 5 similar barns (65-85 cows each); 3 barns were handled with deep litter and 2 were conventional management controls. Deep litter consisted in the daily bed mixing and addition of a thin layer of sawdust, while control beds were replaced weekly. Emission rates of CO2, CH4, N2O, and NH3 were determined [2] and bed samples taken for chemical and microbial characterization by molecular techniques (qPCR and microbiome NGS) [1]. Measurements were carried out at spring, summer and winter for including weather variability.

Results

The average temperature of the bed ranged from a minim of 13°C during the winter to a maximum of 45°C in the summer. These temperatures were well below 60°C that is common during the termophilic phase of a standard composting process, being the differences between deep litter and controls not significant. Gaseous emission were generally lower during the cold season and emission rates (measured in g m-2 d-2) for deep litter ranged 440–824 for CO2, 3.5–17.5 for CH4, 0.3–1.5 for N2O, and 2.9–3.12 for NH3. This values were in average a 40%, 46%, and 80% lower for CO2, CH4, and NH3, respectively, than those measured in the traditional management control (differences were significant at $\alpha<0.05$). Instead, the emission rate of N2O in deep litter and control did not differ significantly. Average GHG emission rates in deep litter correlated strongly with the bed temperature ($r2\geq0.99$), which points to the importance of the microbial aerobic, anoxic and anaerobic activity resulting in the emission of CO2, N2O and CH4, respectively. Molecular microbial counts also revealed a positive interrelation between representatives of the Eubacteria and methanogenic Archaea with CO2 and CH4 emissions, respectively. Interestingly, such temperature/emission correlation was not observed in the control. Concerning the emission rate of NH3, it correlated poorly with the bed temperature ($r2<0.6$) and was significantly lower in barns managed with deep litter than in the controls.

Conclusion

The reported deep litter emissions are comparable to those determined previously in a Danish dairy farm (with deep litter) [3] but, more importantly, they were generally lower than those of conventional bed management, especially for NH3. Microbial community structure and GHG emission rates were also related to bed temperature, but environmental conditions rather than metabolism appear to be the main contributor to the bed heating and, ultimately, to the emission of GHG.

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TC-O_18 Reduction of ammonia emission from broiler houses by use of a heat exchange system

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Objectives

A heat exchange system is a system that utilizes the thermal energy of the air leaving a housing system to heat and dry incoming air by a countercurrent heat exchange system. The aim of the study was to investigate how the use of a heat exchange system effects the emission of ammonia from broiler houses.

Methodology

The ammonia effect of a Agro Clima Unit (ACU) heat exchange system developed for broiler houses was tested by simultaneous measurement of the ammonia emission from 30.000 broilers housed in a mechanically ventilated broiler house attached the ACU unit (case), and 30.000 broilers housed in a similar housing system without the ACU unit (control). The ammonia emission was continuously measured in three production cycles each lasting approximately 30 days. The emission was quantified by continuous measurements of air exchange and ammonia concentration of in- and outflowing air. The air exchange of the housing systems was continuously measured by air anemometers situated in the ventilation ducts. The ammonia concentration of incoming and outgoing air was continuously quantified by photo-acustic multigas analyser system (INNOVA, 1412, Denmark).

Results

In the first part of each production cycle, the ventilation of the case section was performed exclusively by the ACU system. When the ventilation requirement was increased later in the production cycle, the ventilation was performed by both the ACU system and roof ventilation. The highest ammonia abatement effect was found when the majority of the ventilation was performed by the ACU system.

The measured ammonia emission from the broiler houses in the three production cycles was reduced by between 33 and 49 percent when the broiler house was ventilated by use of the ACU heat exchange system. The use of the ACU system reduced the average ammonia emission from the three studied periods from 5.3 to 3.0 g NH_3 per broiler, which equals an average reduction of 41 per cent.

Conclusion

The ammonia emission from broiler houses with and without an ACU heat exchange system was measured for three broiler production cycles. The use of the ACU heat exchange system was found to reduce the ammonia emission from broiler houses by 41 %.

TC-O_19 Greenhouse gas and ammonia emissions from different dairy production systems in Germany

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Objectives

Dairy production is predicted to strongly increase in Europe, as milk quotas are going to be abolished. This will also affect the greenhouse gas and ammonia emissions. Therefore it is necessary to identify low emission production systems and mitigation options. Their effects on the whole process chain and their applicability into regional settings need to be considered. Therefore, dairy farms representing the existing range in production systems have been modelled and emissions of NH_3 and GHG have been calculated.

Methodology

Five dairy farms with an average milk yield between 5 200 and 11 850 kg ECM (cow a)$^{-1}$, representing the existing range of production intensities in Germany, were modelled. An approach was applied, that integrates the compartments feed production (emissions from soil and cultivation), enteric fermentation and excretion, housing systems and manure management. Nutrient and product-flows between these compartments were considered and resulting GHG and NH_3 emissions calculated. The output of one compartment is depending on the input from other compartments or inflows from outside the system.

Results

GHG emissions range between 0.8 and 1.9 kg CO_2e (allocation 100 % to milk). About half of the GHG emissions are caused by field activities. The second most important source is enteric fermentation, which contributes between 34 and 40 % to overall GHG emissions. The specific GHG emissions are mainly related to average milk yield per cow. High shares of grass and maize pellets in the feed ration increase GHG emissions due to the high energy demand to produce this forage. Depending on the housing system and manure management (manure removal intervals, storage type, and storage time) significant differences in emissions of GHG and detrimental nitrogen compound from barn and storage can occur. Transport of feed that cannot be grown in the vicinity of the farm only marginally contributes to the total emissions. Even transport distances of 250 km for the whole feed increase overall emissions marginally.

Depending on the housing system and manure management (manure removal intervals, storage type and storage time) significant differences in emissions of GHG and, especially, NH_3 from barn and storage are observed between the different farm models. NH_3 emissions range between 6.7 and 11.3 g NH_3 (kg ECM)$^{-1}$. Differences are mainly caused by differences in manure management, but also by milk yield per cow.
If GHG emissions are allocated between milk and beef according to the IDF methodology (IDF 2010), systems with high amounts of produced beef showed higher reductions in GHG emissions for milk compared to those with less beef. Reductions range between 12 and 30 % per kg ECM.

Conclusion

The most promising measure to reduce GHG and NH_3 emissions is a well-balanced nitrogen management. In dairy farms the enteric fermentation and manure management most significantly contributes to GHG emissions. Since these emissions mainly depend on the number of animals, product related emissions decrease with increasing milk yield. Considering beef yield reduces the effect of milk yield on overall emission.

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TC-O_20 Excretion of volatile solids by livestock to calculate methane production from manure

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Objectives

Methane emission from manure management is estimated from the excretion of volatile solids (VS) by livestock, the potential methane production (Bo) and the Methane Conversion Factor (MCF) [1]. The Netherlands have revised the method to estimate excretion of VS based on data of intake, digestibility of organic matter and excretion of Total Ammoniacal Nitrogen (TAN). A comparison was made with the IPCC Tier 2 method.

Methodology

The excretion of VS in manure is the sum of VS excreted with feces (VS_F) and urine (VS_U) of which the latter is defined as urea or uric acid and thus relates to TAN. Excretion of TAN was calculated from feed intake, diet composition, digestibility of N and N retained in milk and body tissues as was done for the Dutch monitoring program on the emission of ammonia for the calculation of TAN excretion [2]. The excretion of VS_F was calculated with data on intake of organic matter and the digestibility (DOM). VS excretion based on TAN and OMD were compared with the IPCC Tier 2 method, which calculates VS from Gross Energy, ash intake, digestibility of energy and excretion of urinary energy [3].

Results

Table. Excretion of Volatile solids in manure (VS, kg/yr per animal) by Dutch livestock based on the IPCC Tier 2 method (IPCC) using the suggested range of DE% and the revised Dutch method based on excretion of Total Ammoniacal Nitrogen and digestible organic matter digestibility (TAN+DOM)

	IPCC	TAN+DOM
Dairy cows	1764 – 2981[a]	1712
Young stock < 1 yr	389 – 657[a]	396
Young stock > 1 yr	751 – 1269[a]	783
Fattening pigs	96 – 165[b]	110
Sows and piglets	447 – 634[c]	319
Broilers	3.62 – 6.25[d]	7.98
Layers	8.29 – 12.82[c]	8.54

[a] range DE 55-75%; [b] range 80-90%; [c] range DE 70-80%;[d] range DE 85-93%

Conclusion

The Dutch methodology to estimate TAN extended with data of OM intake- and digestibility, provides a good and useful framework for estimation of VS for methane emissions from manure management. It proves to be more accurate for the Dutch situation than the IPCC method. However, further research is needed to assess the sensitivity of the estimation for variation in input data.

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TC-O_21 Animal delivery of a nitrification inhibitor via feeds to urine patches

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Objectives

In grazed pastures, urine patches are the main source of nitrate leaching and nitrous oxide loss to the environment. The nitrification inhibitor dicyandiamide (DCD) can reduce these losses. We investigated the efficacy of feeding cows with DCD (mixed with supplementary feeds) to achieve targeted delivery of DCD to urine patches only (as an alternative to broadcast application).

Methodology

Three groups of cows (n=5) were fed daily one of three treatments (3 kg of grass silage GS, maize silage MS or barley concentrate BC) that was manually mixed with DCD (30 g/cow). Cows were rotated through the treatments in a Latin square design. Cows were pre-conditioned with their feeds and DCD, then brought out to graze. Urine patches were sampled, soil extracted with KCl, DCD analysed by HPLC, and concentrations were converted into DCD equivalent application rates [1] and loadings per patch.

Results

DCD concentration in urine excreted by DCD-fed cows ranged between 264 mg/L and 2517 mg/L (mean=1460, SE=123, n=26). There were significant positive correlations between DCD concentration and urea-N (R^2 = 0.38, P < 0.001) and between DCD concentration and total N (TN) concentration (R^2 = 0.38, P < 0.001) in urine. Thus, the highest DCD excretion coincided with urine patches with the highest TN levels. Following grazing, the mean equivalent DCD application rates in the three feeding treatments varied between 25 and 40 kg ha^{-1} (no significant treatment effect, P > 0.05), i.e. above the 10 kg DCD ha^{-1} rate recommended in New Zealand. The mean DCD loading per urine patch (i.e. the equivalent rate × patch area) showed less variation as values ranged between 1.6 and 2.5 g of DCD per patch. Values were higher in treatment BC than MS and GS, but there was no significant treatment effect (P > 0.05).

Conclusion

This experiment shows that incorporating DCD with any of the three feeds should be similarly effective at delivering high DCD rates to urine patches where high TN levels can lead to large N losses. DCD could easily be incorporated into animal feeds and would reduce costs (compared with DCD blanket application) as well as decreasing N losses to air and water.

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Disclaimer:

DCD has been withdrawn from use on farms in New Zealand and its use is now restricted to research. Protocols to ensure that DCD use in research does not enter the food chain are supported by soil and plant testing for DCD residues

TC-O_22 Development of system to reduce ammonia emission and leaching of nitrate from slurry application

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Objectives

Development of a system to reduce both ammonia emission and leaching of nitrate from slurry during application to fields.

Methodology

Initiated by BioCover A/S, a group of companies were assembled (Agrodan, A P Gyllevognen, Kemira Denmark, Agro Business Park) and universities (Aahus university and Agrotech) and committed to a joint development project – Nutrients on demand – with support from the Danish ministry for development and innovation.
The group defined and created a demand specification for incorporation of an ammonia injection system in a slurry tanker with the purpose of being able to adjust the nutrient values in the slurry and with a desk research evaluation of its environmental effect. Following a successful evaluation, the system was jointly developed to a pilot scale system and used in commercial slurry application.

Results

Based on the Danish SyreN system for acidification (sulphuric acid) to change ammonia (gas) to ammonium (salt) during application of slurry, an ammonia pressure tank was added to the system.
The combined system, now under the name of SyreN+, adjusts the amount of ammonium nitrogen in slurry during application through addition of anhydrous ammonia during the filling of the slurry tanker. The added ammonia is changed to ammonium in the slurry, resulting in a sharp increase in pH value to app. 9. At the same time, app 5 l / Ha nitrogen inhibitor is added to the slurry. During application, sulphuric acid is added to change pH value to 6.0.
The effect is creating balanced NPKS nutrient values in slurry, an up to 70% reduction in ammonia emission and binding the nitrogen as ammonium in the soil, reducing leaching of nitrogen to aquatic environment. Further, a reduction in co2 emission through a reduced traffic on fields and in the fertilizer value chain through using industry raw materials direct at the end user level.
Software was developed to allow the user to quantify amounts of nutrients to be used and to identify the economy in using the system to optimise the effectiveness of organic fertilizers.

Conclusion

Successful demonstration of commercial scale system to reduce both ammonia emission through acidification and reduction in leaching of nitrate through injection of anhydrous ammonia combined with nitrogen inhibitor and balancing of nutrient contends of slurry is possible.

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TC-O_23 GHG emissions from temperate paddy fields under different straw and water managements

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Objectives

Straw management is a key factor affecting soil sustainability in rice cropping systems. Rice straw is a potential source for energy production. Straw and water management techniques strongly impact on greenhouse gas (GHG) emissions from paddy fields through changes in soil redox conditions and DOC availability regulating both CH_4 and N_2O production and release. Three experiments were set to explore the implications of alternative straw and water management techniques on CH_4 and N_2O emissions from paddy cultivation during crop growth and in intercropping periods.

Methodology

Methane and N_2O emissions from temperate rice-cropped soil were measured applying the closed-chamber technique [1] on a series of three experiments set within the Italian rice district (Pavia and Vercelli, NW Italy) in the period 2012-2014. Three different residue management techniques (autumn or spring straw incorporation to soil, straw removal) and as many options for water management (continuous flooding, dry seeding and delayed flooding, rotational irrigation) were explored.

Results

Under continuous flooding conditions, autumn incorporation of straw reduced CH_4 emissions with respect to spring incorporation, achieving yearly cumulative losses equal to those produced in system with straw removal. Nevertheless removed straw could be addressed to a virtuous use of its C for energy production and not emitted in form of CO_2 during the inter-cropping period as it is for autumn incorporation, but on the other side it can be less effective in maintaining a proper SOC level.

Reducing conditions, due to flooding, boosted CH_4 fluxes, leading to the highest emissions in treatments seeded in water and flooded for the most part of cropping cycle [2]. Delaying flooding of approximately one month not only postponed the starting point for CH_4 emissions but, when present, significantly reduced their intensity, since incorporated straw was subjected to a period of aerobic decay before flooding. Rotational irrigation on one side prevented any CH_4 loss guaranteeing oxic conditions for the whole cropping system, but on the other side induced high N_2O emissions, otherwise arrested during flooding for complete denitrification. Such blocking-effect of water on N_2O emissions is the more effective the earlier is the flooding after fertilization. When combining fluxes in the GWP indicator, CH_4 is more influential than N_2O and continuous flooding resulted more dangerous for climate change than the alternative water management options.

Conclusion

The best straw practice for containing GHG losses was the spring incorporation associated with dry seeding and delayed flooding. Straw removal (for energy production) was effective in reducing field emissions of CH_4.

Continuous flooding, although preventing N_2O fluxes, was the water management option showing the worst performance in terms of GHGs emissions, by reason of elevated CH_4 losses.

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TC-O_24 Life cycle assessment of a combined manure system optimized for phosphorous utilization

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Objectives

As part of an ongoing effort in identifying improved systems for future management of manure, an environmentally-optimized system was designed with focus on increased utilization of phosphorus in manure. The optimized system comprises a combination of techniques (in-house source-separation, biogas production from the source-separated solid and untreated manure, separation of the digestate and thereby obtaining a phosphorus-rich organic fertilizer, which can be transported to agricultural areas with phosphorous deficiency). The objective was to evaluate the environmental consequences of the optimized system.

Methodology

The evaluation of the environmental impacts of the manure management system was based on the consequential Life Cycle Assessment (LCA) approach [1]. Data represents Danish conditions, e.g. manure composition and management, crop cultivation, legislation, separation and biogas technology. The optimized system was compared to the typical manure system found in Denmark today (in-house storage, outdoor storage and application to field). The LCA was carried out for manure from fattening pigs.

Results

The results of the Life Cycle Assessment, comparing the optimized system to the typical manure system in Denmark today showed that:

- The optimized system reduces greenhouse gases by 25-50% (50% when biogas substitutes fossil fuels; lower if the biogas substitutes a mixture of fossil fuels and renewable resources in the future).
- The optimized system cuts ammonia emissions by 23-30%.
- The separation of digestate leads to important savings of mineral phosphorous fertilizer. In the optimized system, 57% of the phosphorous can be transported to agricultural areas with phosphorous deficiency.
- The energy consumption for transporting the phosphorous-rich solid fraction was insignificant for the overall results, implying that transportation distance would not hinder the environmental benefits of the overall system.
- There was no significant difference regarding nitrate leaching.

The results confirm the importance of considering manure management techniques in a whole system perspective, rather than evaluating the techniques isolated from the context of the system.

One key limitation was to assess the fate of phosphorus at the field, due to the lack of precise models on phosphorous losses from agricultural soils and on the long- term consequences of application of various amounts of organic phosphorous to fields.

Conclusion

Introducing an optimized system for manure management in Denmark, comprising of a combination of techniques (source-separation, biogas production followed by separation of the digestate) could lead to significant reduction of the consumption of mineral P fertilizers in Denmark and reduce the total greenhouse gases as well as ammonia emissions from the management of pig manure. One key limitation was to assess the phosphorus fate in both systems, due to the lack of detailed models.

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Thematic Area TC – Advances in emission prevention (Poster presentations)

Trees, processed photograph

TC-P_01 In-house distribution of ammonia and greenhouse gas concentrations in a laying hen facility

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Objectives

Gaseous losses and air quality are areas of concern in laying hen facilities [1]. Standard method for estimating gas losses requires measuring them at exhaust fans. However, the composition of the exhaust air may be different from the inside air composition. It was aimed to assessing the spatial variability of ammonia (NH_3) and greenhouse gas (GHG) concentrations in a laying hen facility.

Methodology

The study was conducted in a commercial laying hen building adapted to Directive 1999/74/EC with 53,000 hens. Ammonia, nitrous oxide (N_2O), methane (CH_4) and carbon dioxide (CO_2) concentrations were continuously monitored from February to September 2014 by a photoacoustic analyser (INNOVA 1412). Twelve sampling tubes were distributed into the exhaust fans, inside the laying hen cages, on manure belts and in the corridors. Ventilation rates were continuously monitored.

Results

Results showed that NH_3 concentration was significantly higher on manure belts ($P < 0.05$). Mean NH_3 concentration on these sites was 3.9 mg NH_3 m^{-3}. Threshold limit value for animal welfare (25 ppm) was not reached during the experimental period. Ammonia concentration at exhaust fans was overall 23% lower than those observed on the belts. However, a seasonality effect was observed between both sampling sites ($P < 0.05$). Ammonia concentration at fans was 34 % lower in warm season while the difference was 20% in the coldest months. Carbon dioxide emissions were significantly higher either inside the laying hen cages or in the corridors ($P < 0.05$). Carbon dioxide concentration averaged around 2,200 mg CO_2 m^{-3} in both areas. Carbon dioxide concentrations were also below the threshold limit estimated for animal welfare (3,000 ppm). Carbon dioxide concentration was 17% lower at exhaust fans, significantly affected by the difference observed in the coldest season (21%). Methane and N_2O losses did not differ among the selected sampling sites ($P > 0.05$) and averaged 3.7 and 0.57 mg m^{-3}, respectively.

Conclusion

Ammonia and carbon dioxide distribution is variable inside the laying hen facilities. Gaseous sampling locations must be consciously analysed if it is aimed at assessing the air quality in terms of animal welfare or estimating the gaseous losses at farm level. Seasonality must be necessarily considered in this kind of studies.

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TC-P_02 The effect of slurry composition on methane and ammonia emissions from fattening pig slurry – A review of three nutrition assays

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Objectives

This study is aimed to review the effects of pig slurry composition on the biochemical CH_4 potential (B_0) and NH_3 emission potential, using the information collected in three nutrition assays.

Methodology

A total of 84 animals were used to test the effect of 13 different diets. These included different types and sources of fibre, different sources of protein, and different inclusion levels of fat and fibre. Faeces, urine and slurry production and composition were determined, as well as B_0 and potential NH_3 emissions, both measured *in vitro* during 100 and 11 days respectively. Correlations and multiple linear regression analysis were conducted.

Results

B_0 ranged between 256 and 430 g CH_4 per gram of VS, while NH_3 emissions ranged from 1.12 to 2.55 gNH_3-N/kg slurry, in both cases emissions and were conditioned by the type of diet. Faeces and slurry pH were positively and strongly correlated with B_0 ($r=0.72$ and $r=0.62$, respectively, $p<0.05$), but no effect was found on NH_3 emissions. Nitrogen content of faeces was positively correlated with B_0 and NH_3 emissions (0.61, $p<0.05$ and 0.60, $p<0.05$ respectively). In this regard, it was also found that NH_3 emissions were negatively correlated ($r<-0.6$, $p<0.05$) with the Faeces:Urine N excretion ratio. The following significant regression models were obtained: B_0 (mL/g VS)= -458+119.4*pH ($r^2=0.52$) and NH_3 (gNH_3-N/kg slurry) = -0.922 + 0.18*TKN (g/kg DM) – 0.71 Faeces-N:Urine-N ratio ($r^2=0.67$).

Conclusion

Although no relevant relationships were found between effluent composition and potential emissions, the type of diet was a critical factor. The inclusion of different types and amounts of fibre and fat changed potential emission per animal in a two-fold range because of changes in B_0 of slurry and the amount of excreta produced. Regarding NH_3, modifying nitrogen sources in diet resulted in the most effective strategy to reduce NH_3 emissions from slurry

TC-P_03 Potential for biogas production from anaerobic fermentation of vinasse in Iran

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Objectives

Currently disposing vinasse in Iran has become an environmental problem for the plants. Vinasse evaporates in the storage lagoons, producing a lot of emissions. The aim of this study was to evaluate potential of vinasse in biogas produced by anaerobic digestion process in Iran.

Methodology

This research is a case study based on published data in literature. It was conducted on the basis of theoretical data to calculate the potential for methane production. The sources consulted for the preparation of this paper were Iranian government organizations and producers of sugar cane and ethylic alcohol.

Results

Iran is one of the producers of ethylic alcohol from sugar cane in Middle East. The potential of ethylic alcohol from sugar cane in 2012 was 110 m^3 /day. The production of 1 liter of alcohol discharges 10 liters of vinasse and with digestion of 1 m^3 of vinasse approximately 14,6 m^3 of biogas is produced. Chemical oxygen demand (COD) of vinasse before the digestion is 29000 mg/L but after the digestion is 9000mg/L. In bio gas there is approximately 55% of methane (CH_4).

Conclusion

Studies show that Iran can produce approximately 2650000m^3/year of methane by anaerobic digestion process of vinasse and the treated effluent from digester will be used as an important source (liquid bio fertilizer) for agriculture, in addition, treatment of vinasse will reduce environmental risks in nature.

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TC-P_04 Flux chamber measurements of ammonia emission from organic beddings in bedded pack dairy barns

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Objectives

Bedded pack dairy barns are an alternative for loose housing systems with cubicles as lying area and concrete floors as walking areas. Typically, Dutch farmers use either compost or wooden chips as bedding material. The compost originates from processed municipal organic wastes, the chips are often by-products of wood processing. Objective of this study was to get insight into the differences of ammonia emissions between the two bedding materials.

Methodology

At nine farms, the ammonia emission from the bedding was measured several times using an open flux chamber. Ventilation was set at a constant value of 30% of the maximum capacity resulting in an average air velocity across the emitting surface of 0,57 m/s. Both incoming and outgoing air were sampled during the last 15 minute of a 30 minute period at which the flux chamber was placed on the bedding. Air samples were led with a restricted flow (~1000 ml/min) through two glass impingers placed in serial and both put in a acid solution. The ammonia emission was calculated from the average ammonia concentration difference between ingoing and outgoing air and the ventilation rate in the sampling device.

Results

The results of ammonia emission measurements are presented in the table below. Average ammonia emission from wooden chips bedding was calculated to be 186,3 mg/m^2/h and from compost bedding at 409,1 mg/m^2/h. Flux chamber measurements of ammonia emission from a concrete slatted floors with slurry pits resulted in 1200 mg/m^2/h[1]. A typical cubicle barn offers 4 m^2 emitting area per cow.

Farm	Material	m^2/cow	n	NH_3 emission (mg/m^2/h)	SE	NH_3 emission (mg/cow/h)
1	Wooden chips (WC)	12,5	16	154,2	83,8	1927,8
2	Wooden chips (WC)	15,0	9	163,8	38,4	2457,0
3	Wooden chips (WC)	15,0	9	207,6	39,7	3114,6
4	Wooden chips (WC)	16,0	16	346,5	65,7	5544,4
5	Wooden chips (WC)	8,5	7	59,6	28,0	506,2
6	Compost (C)	18,0	10	356,2	105,7	6411,7
7	Compost (C)	22,0	10	837,8	152,7	18430,8
8	Compost (C)	9,5	5	319,1	80,1	3031,4
9	Compost (C)	12,5	10	123,2	63,2	2711,0

Conclusion

Ammonia emission per m^2 from a compost bedding is more than two times higher than from a wooden chips bedding. It is argued that the difference lies primarily with the different composting conditions. Both values are less than one third of earlier measured emissions from farms using a concrete slatted floor. Differences in available area lead to higher ammonia emissions per cow.

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TC-P_05 Impact of cattle-slurry treatment by separation and acidification on gaseous emissions after soil application

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Objectives

The aim of the present work was to assess the efficiency of cattle slurry treatment by acidification and/or solid liquid separation to mitigate ammonia (NH_3) and greenhouse gases (GHG) emissions following surface application to a sandy loam soil.

Methodology

Untreated slurry (S) was treated by centrifugation to obtain a liquid fraction (LF). One half of S and LF was then acidified to pH 5.5 by addition of concentrated sulphuric acid leading to an acidified slurry (AS) and liquid fraction (ALF). These materials were then applied to a sandy loam soil at a rate equivalent to 240 kg N ha^{-1} and an aerobic incubation was performed during 92 days at 25ºC in 2L kilner jars. The treatments considered were: 1. soil only (Control); 2. Surface application of S (S-S); 3. Surface application of S followed by soil incorporation (S-I); 4. Surface application of AS (AS-S); 5. Surface application of LF (LF-S); 6. Surface application of ALF (ALF-S). NH_3 emissions were measured using acid traps while methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) were measured using the close chamber technique followed by quantification by gas chromatography as described by Fangueiro et al. [1].

Results

Significant NH_3 emissions were observed in S-S and S-I treatments during the first 48 hours following soil application while in the other treatments NH_3 emissions remained residual. N_2O emissions in amended treatments peaked first on days 10-14 and then on days 28-30. It is to refer that the higher N_2O emissions rates were observed in S-I and AS-S on the first peak and in LF-S and ALF-S for the second peak. The higher cumulated N_2O emission was observed in the ALF-S treatment and the lower in the AS-S (excluding the Control). More than 30% of the applied N was released as NH_3 and N_2O in the S-S treatment against 12% in S-I and AS-S and 3% in LF-S and ALF-S. Methane emissions were only observed in S-I and S-S treatments during the first 4 days following soil application. Regarding CO_2 emissions, higher losses were observed in S amended soil relative to LF amended soil. Furthermore, CO_2 emissions were significantly lower in ALF-S than in LF-S while no significant differences were observed between S-S and AS-S treatments. More than 60 % of the applied C was released as CO_2 in the LF-S treatment whereas in all the other amended treatments, less than 35% of the applied C was released.

Conclusion

In the present study, soil application of LF rather than untreated slurry appears as the most efficient solution to minimise N and C losses to air. Furthermore, a combined treatment - separation + acidification - did not bring any benefit relative to NH_3 and N_2O emissions since similar results were observed in LF-S and ALF-S treatments. However, our results showed that slurry acidification is a good solution to minimise N and C losses to air from amended soil. Soil application of AS rather than LF might be motivated by the lower costs associated to acidification compared to solid-liquid separation.

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TC-P_06 Greenhouse gas emissions and crop yields under different organic fertilizers and irrigation treatments in a Mediterranean maize field

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Objectives

In this experiment, we aimed to assess the effect of different organic amendments (pig urine (PU); pig urine with the nitrification inhibitor 3,4 dimethylpyrazolephosphate (DMPP, PUI); compost from the solid phase of pig slurry (PC)) compared to urea (U); and two different irrigation systems (sprinkler and drip) on greenhouse gas (GHG) emissions, crop yield and Nitrogen Use Efficiency (NUE) in a maize (*Zea mays* L.) crop.

Methodology

The study was carried out in "El Encín" field station (Madrid, Spain). All the irrigation and fertilizer treatments were assigned in a three-replicated completely randomized design. A control with no N fertilization was also included, while the rest of the plots were fertilized with 180 kg N ha-1. Maize was seeded on 7th May 2014 (resulting in a plant population of 7.5 plants m-2) and harvested on 24th October 2014. Greenhouse gas emissions were sampled by the static closed chambers method, and quantified by gas cromatography.

Results

Only PUI significantly decreased nitrous oxide (N_2O) cumulative emissions compared to the synthetic fertilizer (U). Nitrous oxide fluxes were higher in sprinkler than in drip irrigated plots. By contrast, U and sprinkler were the treatments that resulted in highest methane (CH_4) uptake in fertilization and irrigation factors, respectively. Cumulative respiration rates were greater in PC and sprinkler irrigation plots. Urea led to higher biomass yield than all organic treatments, although grain yield was not significantly different in U and PUI plots. Drip irrigation resulted in greater biomass production in C, PU and U treatments. Nitrogen Use Efficiency decreased in the order: U > PUI = PU > COM. When considering the Yield-Scaled N_2O emissions ratio (g N-N_2O kg^{-1} N uptake or mg N_2O kg^{-1} grain), COM and PUI showed the highest and lowest values, respectively. Drip irrigation also minimized cumulative N_2O fluxes per kilogram of N uptake or grain yielded.

Conclusion

Management strategies as combining organic fertilizers (PU) with nitrification inhibitors (DMPP) and drip irrigation may provide the best balance among GHG mitigation [1],[2], obtaining similar grain yields to those of U and reducing environmental impacts arising from a wrong management of animal residues while abating farm costs associated with the use of synthetic fertilizers; and favoring and improvement of physical, chemical and biological fertility of soils [3], which is crucial in semi-arid soils.

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TC-P_07 OptiBarn – Optimized animal specific barn climatisation facing temperature rise and increased climate variability

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Objectives

The OptiBarn aim is to develop region-specific, sustainable adaptation strategies for dairy housing, focusing on an optimized climatisation of naturally ventilated buildings to adapt to climate change. Appropriate construction methods and management of the buildings can improve thermal control for increased productivity and welfare of animals and reduce emissions from livestock buildings.

Methodology

Indicators for an optimisation of livestock buildings under climate change will be developed in OptiBarn by: (i) Barn-specific assessment of the influence of outdoor climate on the indoor conditions, (ii) Region-specific risk analysis on how often extreme weather situations will occur, (iii) Monitoring animal-individual stress responses to the indoor conditions, (iv) Development of engineering solutions. (v) Modelling tools to assess environmental and economic effects of adaptation alternatives.

Results

OptiBarn was recently granted in the framework of the FACCE-ERANET+ initiative “Climate Smart Agriculture”. This paper informs on the early project state. An interdisciplinary team investigates region-specific, sustainable adaptation strategies for dairy housing. Field measurements, lab experiments, physical and numerical modeling are compiled to combine the advantages of the different methods and evaluate the results. The integration of companies and stakeholders from the start of the project shall ensure input from commercial farms to the project design and a rapid dissemination and uptake of proposed adaptation options.

First studies indicate that even for symmetric buildings the air flow field inside the barn is spatially heterogeneous and not stationary [1]. The observed patterns depend on the size and position of openings [2] and on the outdoor climate, particularly on the wind. Simultaneous measurements of temperature and gas concentrations (ammonia and methane) suggest that high temperatures inside the barn result in a significant increase of emission rates. High relative humidity and low wind speed close to the emission active areas are expected to decrease ammonia emissions.

Conclusion

The development of smart ventilation concepts for naturally ventilated barns is essential for emission reduction and animal welfare. An in-depth study on the effects of outdoor conditions and building design on the climate inside the barn is required. An interdisciplinary approach and continuous validation under commercial conditions are essential for a holistic view on dairy husbandry systems.

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TC-P_08 Solid manure and its liquid fraction – Quantities and nutrient contents derived from balancing models

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Objectives

Mass amounts and contents of solid manure and its liquid fraction are important for nutrient balances and emission inventories and for planning of stables, logistics and storage space capacities. These farm fertilizers are usually inhomogeneous so that accurate determination of its mass and contents is complex. An alternative to measuring or thumb numbers are balancing models based on practical animal feed and performance data.

Methodology

Focus of the proposed mass balance computational model is the separation of mass amounts in faeces and urine. For mammals, the excretions faeces and urine must be determined separately, taking into account the amount of bedding material and their absorption potential for urine as well as rotting losses (OM), gaseous losses (NH_3). The amounts of seepage from stable manure and usual operational water inflows to the liquid fraction are also taken into account. For calculating the mass amount of faeces and urine the digestibility coefficients of the energy containing organic raw nutrients (crude protein, crude fat, crude fiber, nitrogen free substances) are required. These figures are derived from feed value tables. Digestibility coefficients are components of the energy calculation of a feed calculation and are determined sufficiently exact in a variety of feeding trials or can be derived by estimating equations. For poultry, faeces and urine are excreted together. The amounts of poultry manure are calculated with the digestibility of organic matter in the feed and the excreted crude ash (ash in the feed minus ash in animal product) taking into account the amount of bedding material as well as rotting and gaseous losses.
For different animal categories and production methods the calculations are performed for solid manure and its liquid fraction, respectively. Based on animal performance and feeding data the mass amount of rotted solid manure and its liquid fraction are derived. The amount of nutrients per animal place and unit of time and the content values per mass are calculated. The calculated quantities and contents are expected average values. Water additives e.g. milking parlour water, courtyard drain must be added as unaccounted amounts to the liquid fraction.

Results and conclusions

Mass amounts and contents of solid manure and its liquid fraction can be accurately calculated with a mass balance approach based on feed, digestibility parameters and animal performance. Deviations are given by changes in the input parameters in the following areas: amount and composition of feed intake; nutrient and mineral content of the feed; admixtures of bedding material and feed residues; other bedding materials (assumed: wheat straw); and different decomposition rates during storage.

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TC-P_09 Use of a feed additive based on biochar for mitigation of ammonia emissions from weaned piglets and broilers

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Objectives

Biochar (BC) is a product based on pyrolysis of biomass [1]. It was suggested that the use of BC might contribute to the mitigation of ammonia emissions from livestock production [2]. The aims of the present study were to investigate whether the addition of a commercial additive based on BC to the feed contributes to the mitigation of ammonia emissions from weaned piglets and broilers.

Methodology

Parameters related to animal performance and health of weaned piglets and broilers fed diets without (C) and with 2% (piglets) and 3% (broilers) of an additive based on BC (BC), were investigated. Ammonia (NH3) emissions produced from the piglet slurry and the broiler manure from both treatments C and BC were measured in wind tunnels. Additionally, NH3-emissions were measured accordingly after storage of piglet slurry without (C) and with addition of biochar (BC).

Results

Parameters such as feed intake, daily weight gain, feed conversion, slaughter weight and mortality differed only numerically (no significant differences) between C and BC for both weaned piglets and broilers. Health parameters such as diarrhea frequency were not influenced by the treatments.
NH3 emitted by piglet slurry and broiler manure in wind tunnels were comparable for C and BC treatments. The development of the emission curves differed. Lower emissions at the first day after application were measured for the BC treatment compared to C. However, higher emissions towards the end of the measuring period counterbalanced the cumulative emissions. When BC was added to the control slurry during storage, it did not influence the emission level either.

Conclusion

The addition of a commercial additive based on BC did not influence performance and health parameters of weaned piglets and broilers. Moreover, no influence on ammonia emissions from piglet slurry and broiler manure in wind tunnels could be detected. This contrasts to results published elsewhere [3]. However, additional studies under more realistic conditions are required for a conclusive evaluation of the potential of BC regarding emission mitigation in livestock production.

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TC-P_10 Identification of odorous compounds in air following land spreading of animal slurry

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Objectives

Odorant emissions following land spreading of animal slurry cause nuisance for local surroundings and can hamper further expansion of animal production locally. Studies of odorous emissions following land spreading of animal slurry are currently scarce, especially on full-scale applications. Here, results from 2 field studies are reported and discussed with the following objectives:

- The influence of dynamic flow rate on the odorant concentrations and emissions.
- The difference of emission patterns for different types of slurry applications.
- The duration of gaseous emissions.
- The dominated odorants after slurry applications.

Methodology

In the first study, emissions from full-scale land spreading of: 1) cattle 2) pig 3) mink and 4) anaerobic digested (mixed) slurry where examined. The second study was carried out in spring 2015 where the effect of acidification of pig slurry on odorous emissions was evaluated.
In both experiments dynamic chambers are used to supply a constant flow flushing soil surface and to simulate the wind effects on gaseous emissions. The dynamic chambers were designed on the basis of CFD modeling ensuring that the wind profile with in the chamber was relatively uniform. Measured VOC emissions included carboxylic acids, aldehydes, alcohols, ketones, phenols, indoles and organic sulfur compounds. A time resolved, high sensitivity Proton-Transfer-Reaction Mass Spectrometry (PTR-MS) was employed for capturing the fast change of VOC and H_2S emissions after the land spreading of manure slurry.

Results

Results from the first experiment indicated that H_2S and organic sulfur compounds had little contribution to the total emissions for all types of slurry. The flow rate dependence test revealed that the odorant concentrations were not significantly dependent on air flow rate applied. Significant difference in emissions following land spreading of the different slurry types was identified. Odorants usually gave another emission peak the next day afternoon especially for carboxylic acids.

Conclusion

The following conclusions can be drawn in this study:

- The influence of air flow rate on the odorant concentrations is insignificant.
- Sulfur compounds contribute less significantly after a few minutes of slurry application.
- Cattle slurry gave higher ammonia emission.
- Pig slurry and mink slurry gave higher emissions of carboxylic acids and phenols.
- Acidification significantly reduced ammonia emission.
- The dominated odorants after slurry applications include: 4-methylphenol, carboxylic acids, skatole, trimethylamine and sulfur compounds

TC-P_11 A French inventory of solid manure (cattle, pig, poultry) stored in temporary field heaps

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Objectives

The objectives of the present work was (i) to estimate the quantity of solid manure likely to be stored in temporary field and (ii) to establish the farmer practices when storing the solid manure on field.

Methodology

The quantity of solid manure likely to be stored in temporary field heap was estimated at the French national level with the use of an appropriate set of statistical and technical data which allowed multiplying the quantity of manure produced by animal with the number of head of the different categories of animal according to the housing type and the housed or rearing period. A questionnaire was sent to the national livestock and technical organizations in order to obtain information on farmer practices relating to field storage.

Results

The French national amount of solid manure likely to be stored in temporary field heaps from cattle, pig, and poultry was estimated around 55 million tons. 93.6% of this quantity is produced by cattle (51.5 million tons) with 70% of very compact manure from loose housing on deep litter, 17% are compact manure from tied-stall and 13% are very compact manure from loose housing with lying area with straw. Solid manure and droppings from poultry are estimated about 1.9 million tons and 0.8 million tons, respectively. Solid manure comes mainly from of broiler production (48%) and turkey production (30.6%). Droppings are produced at 82.1% by standard laying hens for human consumption. Solid manure from pig farms is estimated less than 0.8 million tons produced at 65% by fattening pigs, 25% by sows and 10% by weaning pigs. The results show also that some regions have to deal with temporary field heap storage of the three livestock sectors while other regions manage mainly cattle manure. The very limited responses to the questionnaire on farmer practices relating to field storage do not allow drawing conclusions. Instead, the questionnaire returns reflect the expected diversity of storage practices in the field in terms of management before field storage, months of field storage and stockpiling of manure (dimensions and form).

Conclusion

The estimation of the French national amount of solid manure likely to be stored in temporary field heaps (55 millions of tons) show that the main source is cattle farms (94% of the quantity) followed by the poultry and pig farms. A distribution of the manure according to the animal species and the type of building allows specifying the different solid manures likely to be stored in temporary field in the different geographical regions. These results should be very useful if a mapping and a characterization of the different manure must be necessary in evaluating the significant threat of the temporary field heaps storage to water quality according to the Nitrate Directive regulations.

TC-P_12 Environmental benefits of amending cow slurry with the nitrification inhibitor dicyandiamide

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Objectives

Cattle slurry is a source of nutrients that can also cause contamination after field application. This research investigated i) DCD stability in cattle slurry (5% dry matter) stored under anaerobic conditions and ii) DCD amended anaerobic cattle slurry as a new effective and practical mitigation measure to reduce greenhouse gas (GHG) emissions from grassland application.

Methodology

DCD stability in slurry was studied at 15°C under two treatments (slurry, slurry+DCD) × five sampling times (up to 41 days) × four replicates. DCD concentration was measured by HPLC analysis [1]. GHG emission in grassland was studied under three treatments (control, slurry, slurry+DCD) × fifteen sampling times (up to 35 days) × three replicates. Nitrous oxide (N_2O) and methane (CH_4) emissions were measured using the static gas chamber method and GC analysis.

Results

DCD concentration in the slurry+DCD treatment of the incubation study remained stable, close to the initial concentration (444 mg L^{-1}). Its variation with time was not significant (P = 0.3). Similarly, DCD in the slurry that was incubated for six months and later applied to grassland plots did not show any sign of degradation. The slurry treatment in grassland resulted in a sharp increase in the N_2O-N flux for about three weeks post-application. In contrast, the slurry+DCD treatment did not cause any large N_2O-N peak. The net cumulative N_2O-N emission (i.e. corrected for control values) was significantly higher (P = 0.008) in the slurry (793 g ha^{-1}) than in the slurry+DCD treatment (95 g ha^{-1}), similarly to other studies [2]. Daily CH_4-C fluxes were elevated in the two slurry±DCD treatments on the day of application only, after what values returned to control levels. The net cumulative CH_4-C emission was higher in the slurry (1634 g ha^{-1}) than in the slurry+DCD treatment (942 g ha^{-1}), although this difference was only significant at the 0.1 significance level.

Conclusion

DCD incubated in anaerobic cattle slurry for up to six months did not degrade and effectively reduced N_2O emissions from landspread slurry by 88% in grassland during autumn, when there is a higher risk of high N_2O emission. The results indicate that DCD can be mixed directly in slurry tanks any time before landspreading is planned. This finding opens up opportunities for the addition of DCD to organic farmyard wastes during storage as an effective GHG migration measure following landspreading.

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TC-P_13 Can earthworms reduce greenhouse gas emissions from composting of urban waste?

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Objectives

Many studies have been conducted to reduce nitrogen losses and greenhouse gas (GHG) emissions from composting. Nevertheless, the effectiveness of earthworms to reduce GHG emissions is not clearly understood. Therefore, the objectives of the study were: (i) to quantify GHG emissions from conventional composting and vermicomposting of urban waste (ii) to determine the effect of different vermicompost parameters (i.e earthworm density, carbon to nitrogen ratio of starting material, labile C content and moisture) on greenhouse gas emissions.

Methodology

Urban waste was collected and mixed with wheat straw and cattle manure at different ratios to produce the starting materials with various carbon to nitrogen ratios. Accordingly, four mixtures were prepared. Conventional compost and vermicompost were then prepared from these mixtures in 50 litres reactors for 45 days. Temperature was measured from each reactor every 2 hours using data logger. The gas samples were collected every day for the first two weeks and twice a week until the end of the experiment using chamber technique [1]. The gas samples were taken from 0, 20, 40, 60 and 80 minutes during each sampling date, and the fluxes were calculated from the increase of gas concentration inside the chamber assuming a linear change in gas concentration during the sampling time [1].

Results

The study demonstrated that use of earthworms significantly ($P<0.05$) reduced N_2O emissions when the composting materials have low carbon to nitrogen ratio. However, a significant difference in N_2O emission was not observed between the two composting methods when the materials have high carbon to nitrogen ratio. The CO_2 emission was significantly ($P<0.01$) higher in earthworm composting than conventional composting. The peaks for N_2O and CH_4 emissions were observed within the first week during conventional composting while the N_2O peak was observed after two/three weeks during vermicomposting. Our result showed a non-significant effect of earthworm density on N_2O and CH_4 emissions. Nevertheless, high earthworm abundance increased CO_2 emission significantly ($P<0.05$). Moisture content and labile C content also influenced N_2O and CH_4 emissions from vermicomposting. We also found that nitrogen losses were significantly ($P<0.0001$) decreased from vermicompost compared with conventional compost regardless the starting materials.

Conclusion

Vermicomposting is an effective method to reduce N losses and greenhouse gas emission from composting. Although earthworms increase CO_2 emission significantly, vermicomposting could be still considered as effective method to reduce greenhouse gas emissions because CO_2 is less potent gas, and it is an indicator of biological activity. Furthermore, we demonstrated that carbon to nitrogen ratio of the starting material, earthworm density, labile C content and moisture significantly influence N losses and greenhouse gas emissions from vermicompost.

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TC-P_14 Evaluation of reduction effect by different kind of soil injection in bare soil

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Objectives

Shallow closed slot injection of slurry in bare soil is an effective method to reduce ammonia emission from land spreading of animal slurry (Moseley et al., 1998; Nyord et al., 2010). In Denmark, injection of slurry in bare soil is traditionally done by a robust spring tine mounted with an attached slurry hose, placing the slurry in the slot created by the tine. However, on areas with huge amounts of crop residues on the soil surface, e.g. maize stubble and residues from catch crops, the risk of residues building up in front of the tines is high. Samson Agro (Vestermarksvej 25, DK-8800, Viborg, Denmark) has developed a new injector system based on disc coulter tines, which cuts the crop residues and covers the applied slurry effectively without mixing the slurry with the soil.

In corporation with Samson Agro a series of trials were conducted in autumn 2014. The aim of the trials was to examine the optimal setting of the discs compared to the slurry hoses in order to get the maximum reduction of ammonia emission.

Methodology

Field trials were carried out at Aarhus University, Research Centre Foulum on loamy sand. The soil surface was covered by cereal stubbles. Slurry was applied with a commercial slurry trailer from Samson Agro equipped with a new developed disc injector with the discs mounted in two rows. The following four treatments were compared:

1. Surface application, no incorporation (reference)
2. Slurry injected right after the discs at the first row where slurry was placed in the slit
3. Slurry placed randomly on the soil surface in front of the discs at the front row
4. Slurry placed exactly between the discs on the soil surface in front of the discs at the front row

Ammonia emission was measured 72 hours after application using wind tunnels (two replications per treatment). Ammonia was measured by impingers (gas washing bottles), which were changed after 1, 4, 8, 24, 48 and 72 hours following slurry application. The trail was made first time in the beginning of November 2014 and repeated two week later.

Results

Ammonia emissions following surface application are measured at relatively low level in this trial. Here it should be taken into consideration that the air temperature generally was low in the measuring periods. Ammonia loss is approximately halved by injection, when slurry is placed in front of the discs, in comparison with trail hose application. Slurry placed behind the discs during injection, reduces ammonia losses even greater to about 84 % of the loss following trail hose application. There is no statistically significant difference at the 95% level, between the three injection methods. However, the trend is clear: slurry placed behind the discs reduces ammonia loss more than placement in front of the discs. The explanation is probably that the slurry placed in front of the discs will be placed throughout the entire volume of the worked soil, leaving a proportion of the slurry on the soil surface or in the very top soil. From this ammonia can evaporate especially in a dynamic chamber setup with no precipitation in the measuring period possible, due to the covering of the emission area.

Conclusion

Soil injection of cattle slurry was found to be very effective to reduce ammonia emission compared to surface application. The most effective injection method seems to be placement of the slurry right behind the discs (84 % reduction compared to surface application). However, no significant difference was found I comparison with the two treatments were slurry was placed in front of the discs (55 and 45 % reduction compared to surface application).

TC-P_15 Animal feeding strategies to abate nitrous oxid and ammonia emission from surface applied slurry to a grassland soil

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Objectives

The main objective of this study was to evaluate the effect of five different feeds, in terms of protein content, on the emissions of ammonia (NH_3), nitrous oxide (N_2O) and carbon dioxide (CO_2) from a grassland soil fertilized with pig slurries.

Methodology

A greenhouse experiment was carried out in which five types of pig slurry (Table) were surface-applied in a randomized complete plot design with three replicates to a grassland (*Lollium perenne*) soil (*Calcic Haploxerepts*), previously collected from the field, air dried and sieved (2 mm). This soil has a clayey loam texture (28% clay, 17% silt, and 55% sand) in the upper horizon (0-28 cm). A soil with no fertilizer applied was used as a control. Samples of GHG were taken following the procedure of Abalos et al. (2013) from a closed static chamber (7.96 l). Concentrations of GHG were determined by gas chromatography. Ammonia emissions were measured by a dynamic chamber connected to a chemiluminescence analyser.

Treatment	N applied (kg N ha^{-1})	Total N (g kg^{-1})	Ammonium N (g kg^{-1})	pH
PSControl	100	9.91	5.32	8.89
Ga 7.5	100	7.97	3.75	8.38
Ga 15	100	9.72	4.35	8.2
Pn 7.5	100	8.71	4.53	7.93
Pn 15	100	7.84	3.41	8.08

Table: N applied, N content and pH of applied slurries. "PSControl" refers to a slurry coming from pigs fed with barley (40%), wheat (45%) and soybean (10.30%); "Ga" refers to slurries produced by pigs fed with a mixture of "Garrofa" a by-product of the Carob tree (*Ceratonia siliqua*) (7 5 and 15% for Ga7.5 and Ga15, respectively); wheat (45%); barley (28.17 and 16 34% for Ga7.5 and Ga15, respectively) and soybean (13.21 and 16.12% for Ga7.5 and Ga15, respectively). "Pn" refers to slurries produced by pigs fed with a mixture of orange pulp (7.5 and 15% for Pn7.5 and Pn15, respectively); wheat (45%); barley (30.09 and 20.19%, respectively) and soybean (12.18 and 14.06% for Pn7.5 and Pn15, respectively).

Results

Application of slurries increased N_2O emission in all cases compared to the control (from 98.2% to 96% for PSControl and Pn7.5, respectively). The type of pig slurry had an effect on these emissions. Incorporation of by-products in the animals' diet decreased N_2O emissions from applied slurry by 36.6 and 55.6% for Ga and Pn, respectively. This was probably related to the higher NH_4^+-N of PSControl (Table 1). Application of slurries enhanced soil respiration (i.e. CO_2 fluxes) in all cases (64% on average), being this increase lower for PSControl (34.6%), possibly due to a reduction of plant biomass as a result of foliar damage following slurry application.

Conclusion

Partial substitution of soybean and barley by "garrofa" and orange pulp in the diet of pigs reduced NH_3 and N_2O from slurry application under controlled conditions. These preliminary results may show the potential of alternative feeding strategies for the reduction of environmental problems associated with agriculture and for decreasing the external dependency of N imports for feeding animals in Spain. Further research under real conditions is needed to confirm these results.

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TC-P_16 Ammonia emissions following crop-based and manure-based digestate applied to maize, with or without a nitrification inhibitor

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Objectives

To quantify ammonia emissions and crop available nitrogen supply from crop (maize)-based digestate and manure (cattle slurry)-based digestate, applied to maize, with or without the nitrification inhibitor Dicyandiamide (DCD).

Methodology

Two replicated field experiments were undertaken in spring 2014, in climatic regions and soil types typical of maize growing in the UK: Fakenham (in Norfolk) and Gleadthorpe (in Nottingham). Organic materials were applied either pre-maize establishment or top-dressed to the growing crop. Ammonia emissions were measured for 7 days, using wind tunnels, following the application of either: 1) cattle slurry, 2) manure-based digestate, 3) crop (maize)-based digestate (separated liquor at Fakenham and whole digestate at Gleadthorpe) 4) separated fibre from crop (maize)-based digestate and 5) separated liquor from crop (maize)-based digestate with DCD (10 kg ha^{-1}). At harvest maize yields and nitrogen (N)-offtakes were measured from every plot. The crop nitrogen response was assessed by applying ammonium nitrate (AN) fertilizer at 6 rates, ranging from 0 to 200 kg N ha^{-1} and fitting yield response curves. Estimates of the N use efficiency, of the organic materials, were derived from the yield response curves.

Results

At Fakenham, ammonia emissions following the application of cattle slurry were *c.*15% of total N applied. Following the application of manure-based digestate and separated liquor of crop-based digestate, ammonia emissions were greater, ranging from *c.*45-50% and *c.*30-50% of the total N-applied, respectively. Ammonia emissions following the application of separated fibre from crop-based digestate, were much lower i.e. 1% of total N applied; reflecting the low readily available nitrogen content (*c.*5 kg NH_4-N ha^{-1}) of this material.

At Gleadthorpe, ammonia emissions from cattle slurry, manure-based digestate and separated liquor from crop-based digestate, were similar, ranging from *c.*15-20%, *c.*30% and *c.*35-45% of the total N-applied, respectively. In contrast to Fakenham, ammonia emissions following the application of separated fibre from crop-based digestate were greater at *c.*25% of total N-applied, this could be explained by the higher readily available nitrogen content (*c.*120 kg NH_4-N ha^{-1}) of this material. There were no consistent differences in NUE between the organic materials applied. However, there was a trend for higher NUE when organic materials were applied pre-maize establishment (mean *c.*40%) compared to top-dressing (mean *c.*30%). At both sites, there were no differences in ammonia emissions following the application of liquid crop-based digestate treated with or without DCD.

TC-P_17 Limiting nutrient losses and improving product quality during storage of cattle manure by composting and ensiling

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Objectives

Storage of cattle farmyard manure (CFM) on the field might cause nutrient leaching [1]. Therefore, Flemish farmers are not allowed to store manure (i) on the field between 15/11 and 15/01, and (ii) longer than 1 month during the rest of the year. It is evaluated whether composting and ensiling can reduce nutrient losses, and optimize the quality of CFM as fertilizer and soil improver.

Methodology

Storage experiments were conducted during April-June 2014. Four CFM treatments consisting of the same volume (24 m³) were compared: (1) untreated storage on the field, (2) composting on the field (2 times turned and covered with a semipermeable fabrics cover), (3) composting on a concrete floor (2 times turned and covered) and (4) ensiling on a concrete floor. During the experiment, mineral N enrichment in the soil for the field treatments, gaseous emissions and product quality were monitored.

Results

Composting CFM resulted in a more homogeneous product with a lower volume compared to the untreated CFM. However, the differences in product quality between untreated storage and composting on the field were small. We observed a lower amount of NH_4^+-N in the 0-30 cm soil layer under the compost pile compared to the untreated pile, possibly due to more leaching and mineralization under the untreated pile. Further research is being conducted to confirm those results.
The composted pile on the concrete floor was wetter than the one on the field, likely because of absorption of run-off water. This resulted in a better composting process and a trend toward higher gaseous emissions. However, little differences in product quality between composting on the field and on the concrete floor were observed.
Ensiling CFM on a concrete floor resulted in a lower temperature compared to composting, due to a limited organic matter decomposition. The losses of organic matter, dry matter and nitrogen were smaller during ensiling the CFM. The silage end-product had a higher NH_4^+-N and moisture content and was more heterogenic than the compost. High CH_4-emissions were noticed when opening the silage.

Conclusion

Composting CFM resulted in less mineral N leaching from the pile to the soil underneath compared to untreated storage. The composted CFM is more easy to transport and spread than the untreated and ensiled CFM. Ensiling the CFM resulted in a product in which organic matter and nutrients were better conserved during composting. Differences in product stability are currently assessed by an incubation test in which N-mineralization is measured in soil amended with the different products.

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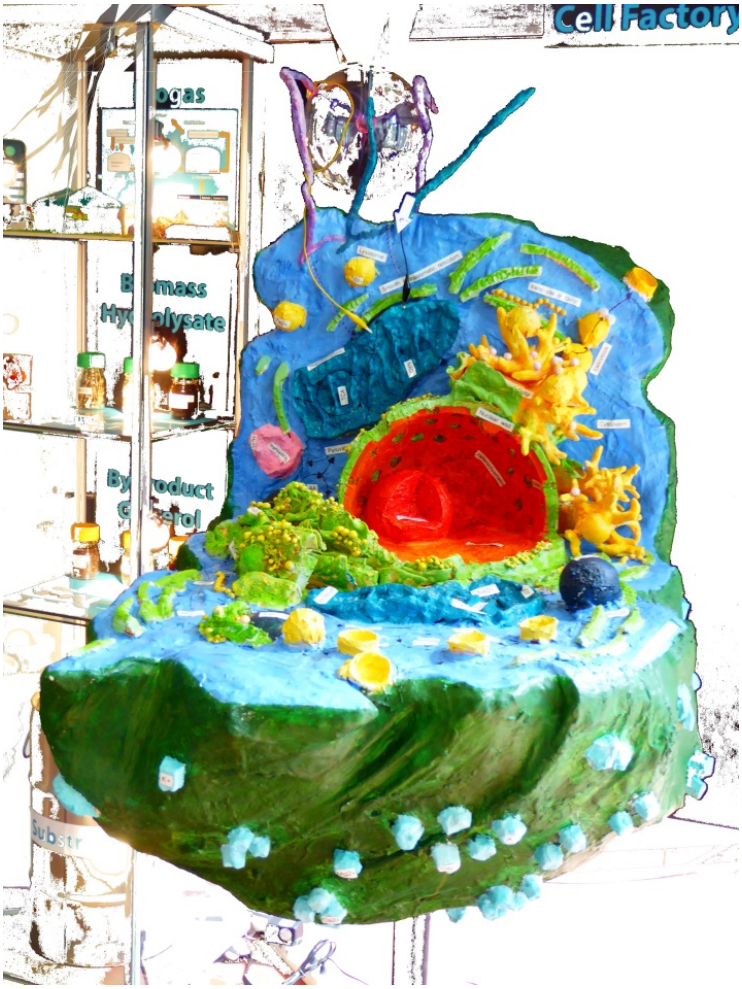
Thematic Area TD – The bioresource challenge
(Oral presentations)



Cell factory, processed photograph, Institute of Bioprocess and Biosystems Engineering, TUHH

TD-K Bioresource utilization in context with regional development

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Objectives

Bio-resources are becoming increasingly contested as food demand as well as pressure to provide energy and materials from them is growing. A rational utilization of bio-resources is however a pre-condition for a successful bio-economy in Europe which in turn is a crucial element for achieving sustainable development. The paper will provide insight into rational bio-resource utilization in a regional context.

Methodology

Bio-resources are an important way to convert natural income in the form of solar radiation into material goods. The basic production factor for this conversion is fertile land. All uses of bio-resources therefore compete for this limited factor, requiring highest possible efficiency in their use. Natural endowment of land, logistic requirements as well as economic and cultural factors in their utilization makes bio-resources inherently contextual goods. The paper summarises an European discourse among eseia-experts on this topic.

Results

The utilization of bio-resources must therefore be seen in the context of regional development. Optimising the value chain of bio-resources by providing more societal benefit while remaining still within the limits of ecological sustainability regarding fertility of land and co-evolution of man and nature requires innovative approaches to material flow management, technological conversion of non-conventional raw materials and new services and business models based on bio-resources. This will contribute to a re-industrialisation of rural regions and a thorough re-orientation of the relation between urban and rural regions.

Conclusion

Based on the analysis of services of bio-resources in a bio-based economy, their particular properties and the characteristics of current state technologies the paper develops systemic approaches to utilise bio-resources within the framework of sustainable regional development.

TD-O_01 Co-digestion of manure and organic residues in the Netherlands

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Objectives

The aim of this study is to assess the environmental, economical, health, societal, and legislative aspects of co-digestion of livestock manure with organic residues in the Netherlands [1].

Methodology

The assessment was based on a literature review, analysis of statistical and administrative data, evaluation of permits of co-digesters and discussion sessions with stakeholders.

Results

There are 100 co-digesters in the Netherlands and this number has been stable during the last years. About 3 percent of the total amount of cattle and pig slurry manure is digested annually. Currently, some 155 organic residues have been 'approved' for co-digestion and are listed in the Fertilizer Act. About half of these products have been evaluated in terms of biogas production and contents of heavy metals and organic pollutants, using a protocol. Possible contamination of the other permitted products should be evaluated by farmers. In 2011, the most used organic residues were silage maize (19%), food residues (14%), glycerin (10%), and residues of processed cereals (10%). Without digestion, most of these residues would have be used as animal feed ingredient, compost or fertilizer. Evidently, co-digestion is not necessary for recycling of these organic residues. Controls showed that about 25% of the co-digesters used organic residues that were not permitted. These residues were sometimes contaminated with heavy metals.

The energy generated from biogas from manure co-digestion amounted to 4100 TJ in 2012, which is 0.2% of the total energy production and 4% of the total production of renewable energy in the Netherlands. Co-digestion is currently not economically feasible without subsidies, because of the low prices of fossil energy sources and the high prices of organic residues. The total subsidy for energy generation by co-digestion in 2010-2013 ranged from 55 to 60 million Euro per year. The effects of co-digestion on emissions of greenhouse gases, ammonia and nitrate on national level is small (< 1% of total). The total amount of phosphorus in organic residues added to the animal manure is about 1.5 % of the total amount of phosphorus in manure produced annually.

Some co-digesters have caused nuisance to the neighbourhood, because of bad odour and noise. There are discussion in the society about health risk because of release of toxic gases (e.g. H_2S) and risks of explosions. However, no severe accidents with co-digestion have occurred in the Netherlands. The enforcement and controls of co-digestions are complex, because many institutions and ministries are involved and many aspects have to be covered.

Conclusion

Co-digestion of manures with organic residues contributes to energy generation, reduction in greenhouse gas emissions and recycling of organic residues, but the contributions to the totals are relatively small in the Netherlands. Co-digestion is not economic feasible currently, without subsidies. There is a need for more efficient enforcement and controls, better communication and education to decrease risks of co-digestion for the environment, health and safety and to increase the acceptance by the society.

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TD-O_02 Perspective and conversion routes for bioproduction of bulk chemicals and fuels from organic wastes and green electricity

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Objectives

To deal with the global challenges of limited fossil resources, climate change and environmental pollution bio-economy has been identified globally as a strategic development goal. In this regard, many industrial countries and regions have set very ambiguous targets: e.g. within the EU 25 to 30% of all chemicals and other industrial products should be bio-based by 2030. To this end, new concepts of bioproduction are desperately needed. This work presents a new perspective for a sustainable bio-economy [1].

Methodology

The major limitations of present bioproduction systems are analyzed, especially regarding substrate availability, product yield and processing costs. Against these background and facts a new strategy toward a sustainable and feasible bio-economy is proposed which takes advantages of the latest developments in biology, renewable energy technologies and electro-biotechnology. The components of the strategy are discussed in more details, especially regarding the resources and technologies.

Results

The following facts are of particular importance in developing a sustainable bioproduction system for bio-economy:

- CO_2 as the final product of each use cascade of organic material could basically be recycled into products following the example of nature and could thus be used as a carbon source,
- electrical energy from renewable sources (like wind or solar) is available already at low costs; due to the fluctuating characteristic of the wind speed and solar radiation this green electricity is available to a certain extend as a surplus when high shares of such energy sources are used within the electricity supply system and no large scale storage systems are technically available at low costs, and
- organic waste material from agri-, horti- and aquaculture, from households and from industry can often be used most efficiently by anaerobic fermentation providing bio-methane which could be used easily and highly efficient within the existing energy system. Adding the fact that methane from fossil sources (i.e. natural gas) is a widely used feedstock, a so-called “Methane Bio-engineering” is emerging [2].

We therefore propose the concept E&G^{2}C with the central idea to first convert organic wastes into a widely usable product – biogas (CO_2 +CH_4) – which is then used as a clean and uniform substrate for the synthesis of bulk-chemicals and/or fuels, especially by using green electricity from wind and solar. Possible technological routes are assessed.

Conclusion

The concept E&G2C has the potential to overcome major limitations of known bioproduction systems. Biogas as a substrate of biosynthesis has many unique advantages including sustainability, efficiency and flexibility. And the use of electricity for biosynthesis with biogas represents an ideal system for efficient bio-electrochemical conversion.

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TD-O_03 Bioconversion of renewable feedstocks and agri-food residues into lactic acid

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Objectives

Besides the quantity and availability of raw materials together with their properties and quality the feedstock costs are very important for the production of bulk chemicals like lactic acid. Especially for biotechnological processes, in which the carbon of various substrates should be converted into microbial products, there is an increasing interest in the use of cheap raw materials.

Methodology

Renewable feedstocks (crops, lignocellulosics, green biomass, residues etc.) are already being used as raw materials for the production of bio-based products. However, these feedstocks cannot be used normally for fermentation directly because the fermentable sugars are bound in the structure especially as cellulose and hemicellulose. They have to undergo a pre-treatment to release these sugar components.

Results

Investigations dealt with the optimization of different process steps (e. g. disintegration and hydrolysis of biomass, filtration, sterilization, fermentation, downstream processing etc.) and were performed subsequently in form of coupled process sequences. In this context different fermentation regimes were tested for the development of an innovative and environmental benign lactic acid production.

Special detoxification steps can help to improve the fermentability and conversion efficiency of complex biomass hydrolysates. According to the difficulties mentioned in the mobilization of fermentable sugars a range of other, easy accessible substrates are suitable for subsequent fermentation processes (such as residues from fruit and vegetable processing, by-products from starch and sugar factories or from the baking industry).

Depending on the further processing of the lactic acid the separation of impurities after fermentation is a major process cost too. Therefore an optimization is necessary to find a balance between the substitution of expensive nutrients and the limitation of interfering or undesirable components of natural raw materials.

Conclusion

The entire processing chain has been implemented: from the feedstock, the pre-treatment/hydrolysis for releasing C5 and C6 sugars, the fermentation to lactic acid and the downstream processing of fermentation broth to generate marketable lactic acid of high enantiopurity and quality. Exploitation of L(+)- and D(-) lactic acid for the production of biopolymers is one of the recent applications.

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TD-O_04 Bioresource utilization as a challenge of coordination

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Objectives

Bio-resources are a-typical goods from an economic point of view. Economics distinguishes between private and public goods and suggests respectively markets and hierarchies as best fitting coordination mechanisms (Williamson (1985). However, given their contested nature, bio-resources can also be considered as common pool resource (Ostrom, 2005) with self-governance as mode of coordination. But self-governance is not an easy task given the numerous societal twists and debates on bio-resource utilization projects. The paper aims to contribute to the knowledge on mitigating contested bio-resource utilization in practice.

Methodology

The paper is basically theoretical in focus. Drawing on institutional economic literature and the literature on bio-resource utilization, the paper explores the nature of bio-resources as an economic good and modes of coordination. Drawing on the IAD framework of Elinor Ostrom, the analysis will concentrate on bio-resources as common pool resource (a commons problem). The ways suggested by the IAD framework to cope with property, value and interest conflicts, will be analyzed and illustrated by 3 bio-resource utilization settings: manure digestion, biomass incineration for space heating and fast pyrolysis.

Results

The paper argues that bio-resources incorporate severe value conflicts and inherent property and use rights conflicts. The implications of this as well as the need of new modes of coordination to deal with the conflicts, is not sufficiently recognized in practice. It will be argued that coordination of bio-resource utilization from a commons perspective implies, localized settings where stakeholders jointly decide about bio-resource projects, but only after they have agreed on the rules how to reach decisions, how to communicate and what should be considered as effective and acceptable outcome. Effective coordination, therefore, means also incorporating decision making about the rules and procedures structuring local settings for bio-resource utilization.

Conclusion

Value and interest conflicts quite often frustrate the implementation of bio-resource utilization projects. Considering bio-resources as a common pool resource opens new perspectives to cope with these conflicts. Part of the solution is to make decision making about rules and procedures part of the coordination of bio-resource utilization.

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TD-O_05 Residual grass an overlooked bioresource – Environmental consequences of various conversion pathways

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Objectives

Recovery of biogas from organic residues is an acknowledged cost-effective mitigation technology for greenhouse gases [1]. Although agricultural residues have been widely studied [1-2], grass residues received little attention, remaining generally underutilized throughout Europe. The aim of this study is to assess the environmental consequences related to diverse uses of this substrate.

Methodology

A consequential life cycle assessment with detailed mass and energy balances was carried out for five management scenarios of meadow grass, otherwise left un-harvested. These include: i) biogas production (considering various pre-treatments); ii) composting; iii) animal feeding; iv) integrated generation of solid fuel and biogas (IFBB) and v) green biorefinery (combined production of protein, fibres and biogas). Indirect land use changes implications as well as the digestate fate were included.

Results

Four impact categories were considered: global warming, acidification, nitrogen- and phosphorus losses to freshwater. Except composting (330 kg CO_2 eq. t^{-1} grass), all scenarios led to an improvement of the global warming potential (GWP_{100}), in comparison to the no-harvest situation. Compared to grass mono-digestion (-130 kg CO_2 eq. t^{-1} grass; scenario i), the IFBB system allowed an additional 50% GWP_{100} reduction, while the biorefinery led to twice the savings, and the animal feeding scenario to more than four times the savings of mono-digestion. For the latter two, it reflects the benefits from protein substitution (here soybean meal), and thus of reducing the pressure on land in sensitive ecosystems. For all impact categories, composting led to increased environmental impacts, in comparison to the no-harvest situation. This reflects the important loss of nitrogen and carbon during the composting process. Except composting, losses of nitrogen and phosphorus to freshwater were negligible for all scenarios. Acidification was increased for all scenarios but feeding, reflecting the production of ammonia during digestate handling. This, however, could be minimized through careful pH control.

Conclusion

Except composting, all management scenarios led to increased environmental benefits in comparison to today's no-harvest situation, for all impact categories assessed. Alternatives allow to recover a maximum of protein (animal feeding, green biorefinery) generated the greatest benefits, essentially due to the avoided land use changes this creates. The green biorefinery concept, allows to recover substantial energy and protein, was shown as a promising avenue for managing residual grass.

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TD-O_06 Influence of food waste characteristics on treatability through anaerobic digestion

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Objectives

The objectives of this communication are to describe the behaviour of food waste (FW) through anaerobic digestion (AD) as a function of basic characteristics of FW, to determinate the influence of their variations in AD, according to collection source and typology, and to evidence the link of these variations with FW biodegradability.

Methodology

A bibliographical compilation of FW characteristics data was proposed and a statistical study was performed to identify the variations of FW characteristics based on collection source variations and their influence on AD. Then AD strengths and technical obstacles related to FW characteristics were analysed. To confirm literature data, an experimental determination of the characteristics of local FW was realised and a study of correlations of characteristics and biodegradability was performed.

Results

FW demonstrate to have very favourable characteristics for AD as shown by the mean BMP of 460 mLCH4/gVS. But the initial pH (5.1), the total ammonia concentration (731.4 mg/L), the carbohydrates contents (36.4%DM) and C/N ratio (18.5) may generate instabilities. The main risks for AD related to FW type are: 1) the high ammonia concentration in FW mixed with green waste might reduce more than 50% of the methane yield by acidification, 2) the high cellulose content from the organic fraction of municipal solid waste might be degrade incompletely, and 3) the low C/N ratio of FW collected during summer might cause nutritional deficits. Experimental characterisation confirms the statistical analyse, with higher values only for hemicellulose (18.3 %DM), K (13.8 mg/kg DM) and Na (6.1 mg/kg DM). Finally, biodegradation analysis shows: 1) biogas production is positively linked with pH, COD and the C content, 2) dry matter and soluble particles non-easily biodegradables are positively linked with methane rate, and 3) cellulose is correlated negatively with biogas production but positively with methane ratio while carbohydrates have the opposite behaviour.

Conclusion

FW characteristics show high influence on treatability through anaerobic digestion. Characteristics as pH, COD, C, N, ammonia concentration, carbohydrates and cellulose content demonstrate influence on AD. The identified risk factors and biodegradation correlations must be studied more in detail to design most adapted pre-treatments or special configurations to avoid instabilities or inhibitions and to enhance methane production.

TD-O_07 Design of microalgae process for nutrient extraction from digestate through laboratory tests and modelling

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Background and objectives

The improvement of the efficiency of nutrients from livestock manure is facing to a number of issues associated with (1) the heterogeneity of manure and poor knowledge of their characteristics, (2) the important volatility of nitrogen (NH_3) and (3) the intensive production of manures in specific areas and the difficulty to export such product due their low value and high dilution. In this context, the culture of microalgae using the nutrients from digestate and combined with anaerobic digestion through the use of CO_2 and excess energy from biogas burning could be an opportunity to address these issues by concentrating nutrients in the microalgae biomass. Some previous researches studying such process indicate an algae productivity varying from 2 to 360 $mg.L^{-1}.d^{-1}$ and a N removal rate between 1 and 45 $mgN.\ L^{-1}.d^{-1}$ using slurry or digestate. However, no clear result was found concerning the influence of the parameters and the processes involved explaining such variations. Thus, the aim of this study was to understand and quantify the algae productivity and the processes involved in N removal according to the parameters applied in order to be able to design such a process.

Methodology

The impacts of parameters on microalgae productivity and nitrogen removal was studied under controlled condition at laboratory scale. The experimental set up consists of six 2.5L tubular reactors. A complex phytoplanctonic ecosystem dominated by *Scenedesmus sp.* and *Chlorella sp.* was used for all experiments. The parameters studied were (1) the color/turbidity of the influent, (2) the light provided, (3) the N/P ratio of the influent, (4) the level of CO_2 addition and (5) the solid retention time (SRT) of microalgae in the bioreactor. All results obtained allowed to adapt and calibrate models from literature (as Contois and Monod kinetics) and finally, the model developed using Scilab software was used to design a real-scale treatment system.

Results

Concerning the effect of color/turbidity defined on the basis of optical density at 680 nm (from 0.2 to 1.3) and light (from 50 to 250 µmolE.m-2.s-1), maximum algae productivity varied between 0.3 and 139 mg.L-1.d-1 and associated N removal up to 8.5 mgN.L-1.d-1 was observed. These results also showed the limitation of the growth of ammonia-oxidizing bacteria by microalgae growth and the advantage of Chlorella in limited light medium as regards to Scenedesmus. Productivity and N removal was modelled using a Contois kinetic for light leading to a maximum growth rate of 0.74d-1. N/P ratio of the influent from 3 to 75 gN.gP-1 were studied and highlighted no effect of this ratio on microalgae productivity and an adaptation of the N:P microalgae from 10 to 30 gN.gP-1 according to the N:P medium. Results also indicated the internal phosphorus storage performed by microalgae leading to a limitation of nitrification in poor P medium. The impact of phosphorus on microalgae growth was modelled using Droop model. The impact of carbon dioxide (CO2) was also studied and modelled and the results showed a limitation of microalgae growth when total inorganic carbon in the medium fall below 10-15 mgC.L-1. Finally, the study of the effect of SRT showed the importance of nitrification-denitrification processes on N removal for semi-continuous systems with rates comprised between 100 to 200% of N assimilation by microalgae.

Conclusion

From these results, a model was developed and used to simulate a high rate algal pond at real-scale. As an example, a surface of 0.8 ha and a recirculation from microalgae separators back to the reactor equal to 50 times the influent flow rate was determined for the treatment of digestate from a commercial farm producing about 4000 pigs per year.

TD-O_08 Ecological evaluation of biogas from catch crops with Sustainable Process Index (SPI)

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Objectives

In many places agricultural energy production from biomass can result in competing situations between food and energy. Furthermore a one-sided use of land such as pure monocultures can not only lead to heavy pressures on soil and environment but also much more cropping potential could be revealed if some farming techniques are changed. Future challenges in bio resource management will have to sustain intact arable land and food production without losing economic feasibility. Further development of conventional farming processes can bring economic and ecological benefits [1].

Results

During the projects Synenergy 1 and 2 possible contributions to tackle these issues were tested. On different test areas throughout Austria additionally to the typical growing period of the main crops maize and wheat different mixtures of catch crops were sown in the time gaps between. Beneficial effects for soil, water, erosion and weed management could be measured and further processing of the catch crops in bio fermentation processes and the cycled use of biogas manure as fertilizer back on field reduces amounts of conventionally used external fertilizer.
The total agricultural production process chains on the test areas from soil cultivation and seeding to harvest of the main crops and catch crops were evaluated with Sustainable Process Index (SPI) [2]. Measured data by project partners who did research about catch crops on the testing areas including biogas potential, changes in humus system, erosion, N_2O emissions and NO_3 washout was ecologically evaluated in SPI [3].
The comparison of ecologically evaluated conventional with biogas driven processes shows a potential to reduce ecological pressure by up to 60 %.

Conclusion

Substitution of fossil fuels with biogas from biomass from field without touching the main crop for energy purposes can have several benefits. Producing energy from catch crops means no additional competition of land use, it can be a chance to better guarantee food security and however energy can be provided from biomass on the same area where food and fodder is grown.

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TD-O_09 Needs for production of grain protein crops in Europe and possibilities for more bio-based green economy including nitrogen use

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Objectives

At the moment the EU has a 70% deficit in protein rich grains, which are mostly imported like soya bean and soybean meal. The biggest proportion is used as a feed for increased meat production with amplified imports of soya beans that increased from 1961 to 2013 from 2,7 to 37 M t (15% of world soybean production), respectively [1, 3]. In case of Slovenia the situation is more critical, the existing own production of protein feeds cover just 2,8% needs, and share of fields under grain legumes is around 0,25%, import of soya bean and meal are about 97,5% [1, 3]. The aim of paper is to introduce of protein feed crops into crop rotation, especially soya bean and pea.

Methodology

An review of protein supply in EU countries, such as export, import and production data for Slovenia are analyzed, including potential importance of N symbiosis on the fields, exchange of functional biodiversity on the fields, inputs of N with organic manures and costs for N fertilizers.

Results

Analysis of Slovenian protein supply chain potential is based on existing production of oil crops (cca. 5.000 ha seed rape (nowadays used only for biodiesel exported to Austria and Italy) and 5.000 ha oil pumpkins), which cakes can give (15.000 t with 34% and 4.000 t with 60% crude protein, respectively) in total 7.500 t crude proteins. After consumption this feed represents quality organic manure (in total approximately 145 t N i.e. 478 t 27% N-CAN i.e. 5560 bags of CAN i.e. 76.728 EUR) that could be used for incorporation in soils, which will reduce use of mineral N fertilizers, increase water infiltration, etc. Even the total balance of N for soybean production is negative, in case of Danube Soya scenario on 17.500 or 35.000 ha fields with grain legumes approx. 14.000 or 28.000 t of symbiotic N could be assimilated, instead of buying 250.550 or 560.000 bags of CAN in the sum of 1.062 or 2.128 M EUR, respectively. As additional value of symbiotic N used by intercrops (for example 10% of cereals, 4000 ha x 60 kg N) 2400 t of N matches 48.000 bags of CAN i.e. 662.400 EUR. However, changed natural system can reduce N mineral inputs in total to 2.13 M EUR and increase functional biodiversity for 1/4 [2]. Imported soya and soya meal (mainly from Brazil) into EU is produced on 18 M ha. In case of different scenarios of self production in EU (in total 10, 20, 30,...%) similar trends of green bio-based economy and decreasing costs could be achieved at the field production level.

Conclusion

To conclude, increasing production of grain legumes can be important additional self-sufficiency measure for creating greener bio-based economy, while increased functional biodiversity on the fields, more natural symbioses N instead of using artificial N fertilizers, saving of energy and cost for artificial N fertilizers are expected.

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TD-O_10 Effect of source segregation and conventional separation of pig excreta on biogas yield of solids

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Objectives

Our objectives were to compare the source segregation with four conventional separations (screw press, centrifugation, flocculation and combined flocculation with centrifugation) of pig excreta by using same and known input. We compared the characteristics and degradability of the solids and the liquids and evaluated the volumetric methane yield of the solids (m^3 CH_4/ton substrate).

Methodology

Fresh source segregated solid (SSS) and liquid (LSS) were collected from the conveyor belt system (Aanink and Ogink 2011 [1]) of fattening pig farm in Sterksel, The Netherlands. Slurry (S) was created by mixing a fixed ratio of the solid and liquid with water. Separation efficiencies E(x) for *x* (wet weight, dry matter (DM), organic matter (OM), soluble COD (sCOD), and nutrient content) were compared between methods. The specific biochemical methane yield (BMP) of the solids was determined in batch test following VDI 9630 standard. The hydrolysis rate constant k_h of the solids were determined according to Sanders 2001 [2].

Results

E(OM) of screw press (34.3%) and centrifugation (84.2%) were lower than E(OM) of flocculation (93.4%), flocculation combined with centrifugation (92.7%) and source segregation (95.5%). The solids from source segregation (SSS) and screw press (SSP) had highest OM content (22% and 24%, respectively) whereas the solids from centrifugation, flocculation and combined flocculation with centrifugation had lower OM content (19%, 16% and 18%, respectively). The BMP were 304±4.6-338±8.9 ml/gOM for the solids and 362-708 ml/gOM for the liquids. In this study, the BMP of the solids were significantly higher compared to the reported values for solids from commercial separators (158±76 to 247±25 ml/gOM) in Ole Thygesen et al. 2014 [3]. SSS showed faster degradation rate k_h (0.106 d^{-1}) than other solids (0.058-0.085 d^{-1}). The volumetric methane yield of a solid (m^3 CH_4 per ton substrate) was significantly higher for SSS (73.2±1.9) and SSP (71.5±1.1) than SC (61.8±2.3), SF (53.0±1.1), SFC (60.2±1.7) and S (23.9±0.8). This means with same reactor volume, digesting solid from source segregation and screw press would produce higher volume of methane (i.e., higher m^3 CH_4 /m^3 reactor/day).

Conclusion

Separation efficiencies (E(OM)) of flocculation and flocculation combined centrifugation are similar to source segregation. The specific methane yields of the solids in term of ml/gOM did not vary much but SSS showed fastest hydrolysis rate, requiring less retention time in continuous reactor. The volumetric methane yield of SSS and SSP are much higher than other solids, however E(OM) of screw press was very low (34.3%).

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TD-O_11 Biogas production from large-scale retail trade wastes – Preliminary assessments related to Piedmont reality

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Objectives

In Italy more than 800 anaerobic digestion plants are currently fed with large quantities of energy crops. Several studies demonstrated that the environmental sustainability of this technology relies on the use of by-products as input biomasses [1]. The objective of this research was to assess the regional availability of organic waste from the large-scale retail trade as feedstock for AD plants.

Methodology

A survey on the amount and type of organic leftovers produced by representative supermarkets of Piedmont region was carried out. The products were grouped into animal (meat, milk..) and non animal (fruit, bread..) derived-leftovers. Both categories were represented by expired and unsold products. For the selected biomasses the BMP was measured according to VDI 4630 (2006) methodology [2], or estimated according to an average organic matter composition and bibliographic data [3], [4], [5]. A potential regional methane yield was afterward estimated.

Results

Based on our evaluation, in Piedmont region, the annual availability of organic leftovers from the large-scale retail trade is of about 37 kt. More than the 60% is represented by non-animal expired products (60% bread and 40% fruit and vegetables) that are highly variable both in terms of quantity and quality due to seasonality of the production. The animal derived byproducts is mostly represented by unsold meat (51%), milk and milk-derived products (25%) and fish (24%). According to the produced leftovers, their organic matter composition and specific methane yield, approximately 10,600x10^3 Nm^3 of methane can be produced per year on a regional basis. 83% of the overall production might be achieved by the anaerobic digestion of unsold bread only, given its high availability (approximately 14.500t per year) and organic matter content. Despite the 9600t of available fruit and vegetable leftovers and their high specific methane yield (up to 450 and 280 m^3 $CH_4 \cdot t\ SV^{-1}$ respectively), their contribution to the potential regional methane production is relatively low (≈3%) due to their high water content. Expired animal-based products (dairy-mix, fish and meat) account for the remaining 14% of the overall producible methane.

Conclusion

Approximately one supermarket every 3000 inhabitants is available on the regional territory and a significant amount of methane could be produced by the anaerobic digestion of the yearly produced organic leftovers. By its energetic valorization through CHPs it might be possible to produce approximately 43$GWh_{el.}$ and 45$GWh_{th.}$ on a yearly basis. Nevertheless the use of such by products is still limited by the normative in force.

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TD-O_12 New tool for improving management of biogas digesters – A heat transfer- and biogas production model for anaerobic digestion

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Objectives

Accurate prediction of anaerobic digester temperature in relation to management and design plays a key role in designing and optimizing digester performance. Our objective was to develop a flexible and accurate model for predicting temperature and biogas production that can be used to design new digesters and select designs for a specific environment.

Methodology

A heat transfer and biogas production model was developed based on [1], with significant changes. It uses a finite-difference, one-dimensional approach with fixed time-step (1 hour) evaluation of heat transfers and a Contois model for prediction of biogas production. Heat sources and sinks include solar radiation, soil and external heating. Model evaluation was carried out for both temperature and biogas production using datasets from Vietnam, Denmark, Norway and USA.

Results

We developed a graphical version of the model that can be used for different digester designs under varying configuration and climate conditions. The model is simple to use and requires few input data: air temperature, digester geometry, feed type, feeding rate, and longitude, latitude and altitude of the site.

The model was able to accurately predict biogas production and slurry temperature for a small 7 m^3 digester in Hanoi, Vietnam. For most dates predicted slurry temperature was within 2-3 degrees Celsius of measured values. Additional evaluation with other datasets is ongoing.

To demonstrate the utility of the model for management and design, it was used to evaluate the effect of adding insulation to a large tank digester. Additionally, it was applied to a covered lagoon design.

Conclusion

A simple heat transfer and biogas production model can be a powerful management tool for improving performance of digesters. This is especially important for remote rural areas where winter periods can lead to psychrophilic conditions of anaerobic digestion, inhibiting biogas production. Our model can be applied to a wide range of digester designs, from small digesters with solar or no heating common in Latin America, to large tank digesters common in Europe.

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TD-O_13 A Flemish case study of possible synergies between high quality green compost and green energy

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Objectives

SYNECO investigated if and how the Flemish green composters can contribute to green energy without jeopardizing the compost quality. The results aim to help transform the composting sector to a more synergetic and economically viable player.

Methodology

Through an inventory of green waste, calculation of mass balances and biogaspotential-tests SYNECO defines an optimal input-distribution for green energy vs materials recycling. By analyzing end products (compost and biomass) of referential and experimental compost piles and the critical process factors the necessary adaptations of the composting process are mapped in case of a changed input composition. An online decision support-tool for maximizing net cash flow is presented.

Results

The green waste received by composting sites consist on average of 1/4th bulky material. Or, including overflow, a yearly share of 1/3rd in the set-up material. On the other hand 1/5th bulky material is to be considered as a threshold for maintaining a sufficiently high level of organic matter (OM) in compost. Wet as well as dry fermenting of various subfractions of green waste lead to similar and low biogas yields on average inferior to 50 Nm³/T. Experimenting with removal of green-waste-fractions before composting lead to similar compost-qualities except, occasionally, low levels of OM (<16%). A higher frequency of turning is beneficial to compost-maturity and dry matter-level (compost/biomass), and facilitates a shorter compost-duration, but too frequent turning will endanger hygienisation. Biomass extracted before (white biomass) and after (black biomass) composting shows similar caloric potential-averages between 5,3 and 9,3 Mj/kg but, for black biomass, a tendency to higher alkali-elements. Fractions of at least '>20mm' (lower ash, higher OM), additional drying and purifying of biomass are essential to improving biomass-acceptability.

Conclusion

For green composting Vlaco considers min. 20% bulky material at set-up as a rule of thumb. Biomethanization of subfractions is disregarded as a synergetic option while extracting fractions white/black biomass is defendable especially during november-april although OM-levels in compost need to be continually monitored. In may-october extraction of biomass-fractions is not advised. This will theoretically yield higher net cash flows mainly due to the possibility of more input/gate fees.

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TD-O_14 Environmental infrastructural investments in peri-urban areas – How to overcome nimbyism in case of waste to energy biogas plants

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Objectives

The research focuses on location procedures for infrastructural investments with the environmental added value, however, inhibited by social acceptance NIMBY (not in my backyard) effects (e.g. AD of MSW). Despite obvious benefits (organic recycling process, biogas production and local employment), sitting issues limit realisation of new facilities. A decrease of the quality of life especially in the rural-urban fringes due to possibility of odour imissions, intensification of traffic as well as loss of property value are main inhibitors.

Methodology

The sitting process should represent not only elements traditionally represented in a feasibility study- i.e. multicriteria evaluation of technological, organizational and economic issues – social and spatial criteria should be prioritised. The research presents the experiences of chosen plant operators of the MSW anaerobic digestion. The key element of the research is the elaboration of a multicriteria analysis (with the inclusion of organisational, legal, economic, technological, social and spatial planning issues) is to be elaborated for sitting of such investments in Poland. An AHP method in combination with GIS tools is be used. Also as a tool for NIMBY mediation among local stakeholders a German odour dispersion tool AustalView was applied to determine the optimal distances to sensitive areas [2].

Results

The case study analysis of 10 AD facilities in Europe [1] has identified basic types of AD (using OFMSW) locations: 1) urban areas AD units: onsite MBT fuelled by the organic fraction selected mechanically from mixed municipal solid waste, 2) rural-urban fringe: AD plants fuelled by selected at source biowaste,3) rural areas: agricultural AD plants fuelled by selected at source biowaste in cofermentation in agricultural AD, as an additive to with agricultural substrates. Due to logistic constraints and urban planning considerations the analysis was focused on suburban areas, of mainly medium and large cities. The starting point for further consideration is the state of the art; including organizational and legal framework in the Polish reality. Based on lessons learned from the analysis of existing facilities located in Europe conditions for the location of this type of waste treatment facilities were defined, in particular emphasizing economic, environmental and social aspects. As a result criteria for the location of AD facilities were formulated, taking into account: local conditions, organizational, legal (in particular planning) issues as well as technical and practical aspects. The research focused on optimal distances showed that 500 m is usually a sufficient compromise but in the urban or rural-urban fringe areas such distance prohibits the local development especially of residential areas therefore a spatial planning compromise must be found with the help of expertise tools.

Conclusion

The application of proposed criteria in the a multicriteria decision support tool M-BIST (Municipal Biogas Investment Support Tool) will result in the identification of the best locations for AD facilities for OFMSW under specific conditions in Poland. Apparently the results of the M-BIST project could be transferred for the use in other locations (other countries), especially in countries with similar GDP and a similar state of the art in waste management system.

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TD-O_15 Ensiling as pretreatment to improve the anaerobic biodegradability of catch crops

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Objectives

The main objective of this research was to assess the effect of ensiling on the anaerobic biodegradability (AB) of three catch crops (CC), in order to use them as co-substrates in manure-based biogas plants while maximizing biogas production.

Methodology

Biochemical methane potential (BMP) tests of three CC (*Lolium spp., Brassica napus and Avena strigosa*) were carried out at 37 ºC. 1.2 L-glass vials were filled with 0.5 L of a mixture of inoculum (5 gVSS/L), silage and fresh CC as substrates (5 gCOD/L) and deionized water. The mixture was supplemented with macro/micronutrients and bicarbonate. A control vial without substrate was included to assess the residual methane (CH_4) potential of the inoculum. The test lasted an average of 30 days.

Results

The anaerobic biodegradability obtained after the BMP tests was 48%, 43% and 37% for *Lolium, Avena* and *Brassica*, respectively. However, CH_4 production per hectare of *Brassica* and *Avena* was significantly higher (803 and 740 Nm^3_{CH4}/ha, respectively) than those obtained for *Lolium* (471 Nm^3_{CH4}/ha), in spite of its higher anaerobic biodegradability. Besides, CH_4 yield in terms of volatile solids (VS) added was 300.76, 271.08 and 198.67 NL_{CH4}/kg_{VS} for *Brassica*, *Avena* and *Lolium*, respectively. Molinuevo-Salces et al. [1] obtained higher methane yields for the CC studied and its variability was lower (412, 395 and 405 NL_{CH4}/kg_{VS} for *Lolium, Avena* and *Brassica*, respectively), which indicates the heterogeneity of CC samples and the influence of environmental and seasonal conditions as well as the harvest time on the anaerobic digestion performance.

On the other hand, the effect of ensiling on the anaerobic biodegradability of the CC is being assessed. For *Lolium spp*., the results confirm that ensiling favours the hydrolysis process and thus, the biodegradability increased by more than 40% in comparison with fresh *Lolium spp*.

Conclusion

Silage catch crops could be a good option as co-substrates for the anaerobic digestion of manure. The anaerobic biodegradability could be improved by 40% but taking into account the methane production per hectare of CC, *Brassica napus* would be the best option to increase biogas production in manure-based biogas plants while maximizing biogas production

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TD-O_16 Anaerobic co-digestion of pig manure and organic waste materials as affected by different hydraulic retention time

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Objectives

The aim of the study was to study the effect of hydraulic retention time (HRT) on biogas production of co-digestion of pig manure and organic waste materials in continuous stirred tank reactors (CSTR) and to evaluate transformation of organic fractions affected by different HRTs. The results were used to develop a model that predicts the washout hydraulic retention time, maximum rate of biogas production and biogas yield.

Methodology

Mesophilic anaerobic digestions were performed using pilot scale continuous stirred reactors of 20 liter at three HRTs of 20, 30 and 45 days. Input feedstock was made up of pig manure (75%) with slaughterhouse waste (2.5%), food processing waste (11.25%) and brewery waste (11.25%) as co-substrates. Volatile Fatty Acids (VFAs) in substrates and digestates, and methane (CH_4) content and biogas production were monitored. Substrates and digestates were characterized to study organic fractions transformation. Biochemical methane potential (BMP) was measured according to the German standard method (VDI 4630). Recalcitrant organic fractions were measured according to Van Soest characterization. Kinetic analysis of transformation was performed using linear relationship between input organic fractions flow versus HRT.

Results

The CH_4 production was modeled using linear relationship between HRT and CH_4 yield from the anaerobic digestion of the feedstock. According to the model, maximum CH_4 yield at long HRT corresponding to low organic loading rate is 548 NL(CH_4) kg^{-1}(VS) of input substrate. The VFA concentration was stable at the three HRT and pH of digestate was 8.
The measured BMP was 297, 821, 605 and 577 NL(CH_4) kg^{-1}(VS) for pig manure, slaughterhouse waste, food processing waste and brewery waste respectively, and using these data give an calculated BMP of the input feedstock at 513 NL(CH_4) kg^{-1}(VS), which is very close to the CH_4 yield of 500 NL(CH_4) kg^{-1}(VS) predicted by the model at a HRT of 60 days HRT.
The transformation of refractory fractions to assess their degradation in the CSTR will be reflected in the final manuscript.
Biogas production affected by changing HRT was modeled predicting critical hydraulic retention time at 6 days and maximum rate of methane production at HRT of 12 days.

Conclusion

This study shows that model can be developed for predicting maximum CH_4 yield and maximum rate of methane production as affected by hydraulic retention time by use of fitting the linear relationship between HRT or organic loading rate and CH_4 yield for anaerobic digestion. With this model the critical hydraulic retention time was estimated to be 6 days and maximum rate of CH_4production was at a hydraulic retention time of 12 days.

TD-O_17 Promoting pig slurry low-cost methanization by understanding the microbiology of anaerobic digestion at low-temperature

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Objectives

Psychrophilic methanization is used all over the world as a simple, robust and cheap way to produce green energy from animal waste and prevent GHG emissions (. One limitation is the long time required for microbial communities to adapt to low temperatures. We applied several strategies to test the impact of temperature on methanogen microbial communities and optimize process start-up on swine slurry: selection of inocula adapted to 35°C or 13°C, brutal and gradual shift of the communities from 35°C to 5°C.

Methodology

Three swine slurries (fresh or stored), 1 fresh cow manure and 1 mesophilic swine slurry digestate were tested as inoculum for methanization of swine slurry at 13°C in 2L bottles for 8 months. Biomass from the best acclimated bottle was then used for BMP tests incubated at 35, 25, 15 and 5°C to study the impact of brutal temperature changes on methanogenesis. Comparison was done with a mesophilic biomass incubated in the same conditions. Finally, the adaptation of a mesophilic biomass to a gradual temperature change from 35 to 15°C (reduction of 0.3°C/ day) was tested in 2L reactors. Methane production and microbial community dynamics were monitored respectively by AMPTS and 16S rDNA qPCR, fingerprints and pyrosequencing.

Results

All slurry inocula, but the swine slurry digestate, adapted to low temperature and produced biogas after 20 days. Kinetics and production yield were different but low. The best inoculum was swine slurry coming from a 2 months storage tank. After 200 days at 13°C, this inoculum produced 125 L CH_4/kg COD_{added} with a COD loading rate of 2.4 kg/m^3 day. It is 68% of the substrate BMP.
When incubated directly from 13°C to 35, 25, 15 and 5°C, this adapted inoculum remained active at all temperatures but 5°C. Methane production at 15°C was about 1.3 times lower than at 25 and 35°C.
In comparison, a mesophilic community used as control could not adapt to produce methane when it was shifted rapidly from 35°C to 15°C. Nevertheless, this mesophilic community did adapt when it was slowly shifted from 35 to 15°C, biogas production decreasing accordingly.
Dynamics of the archaea community showed both archaeal populations shifts within the community and that a group of archaea kept its activity at decreasing temperature. Dynamics of the bacterial community has been analyzed by pyrosequencing and interpretation is underway.

Conclusion

Using different slurry inocula and a simple selection procedure we were able to adapt a microbial community to anaerobic digestion of swine slurry at low temperature (13°C) within 200 days. Because of its ability to produce methane at temperatures above 20°C, this microbial community is actually a mesophilic community adapted to low temperature and not a true psychrophilic community. Adaptation of the community required both microbial populations shifts and microorganisms metabolic adaptation.

TD-O_18 Interstage treatment for increasing methane production from recalcitrant biomass

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Objectives

The goal of this work was to increase the conversion efficiency of recalcitrant biomass to methane during anaerobic treatment. Pre-treatment has received more attention, but inter-stage treatment may be more effective. Our objective was to determine the effect of thermal and biological inter-stage treatments on biogas production from typical biogas plant substrates.

Methodology

Thermal and aerobic biological inter-stage treatments were applied to mixtures of pig manure and food processing waste that had previously been anaerobically digested for ≥ 4 months in batch mode. Inter-stage thermophilic aerobic digestion (TAD) was applied to wastewater sludge and manure. Methane production and COD removal were used to quantify degradation extent and rates. A kinetic model using pools with different degradation rates was developed to quantify effects of inter-stage treatment.

Results

At the end of the first digestion, daily biogas production had dropped to ≤ 0.4% of cumulative production, showing that the original feed was highly recalcitrant. Inter-stage thermal treatment (70°C for 10 h) of this material increased methane production by as much as three-fold, but increases in total production (including the first digestion stage) were ≤ 5%.Other studies have shown larger effects of thermal inter-stage treatment on sewage sludge [1, 2]. Ongoing experiments with TAD will show how to apply a more complete inter-stage treatment using both heat and a thermophilic aerobic microbial community to increase degradability of recalcitrant biomass and thus biogas production.

Conclusion

Inter-stage thermal treatment of highly recalcitrant organic matter shows a positive effect on biogas production. Aerobic inter-stage treatment exploits differences between aerobic and anaerobic microorganisms to enhance biodegradability of recalcitrant biomass. Furthermore, because easily digestible organic matter is fully used for methane production and not lost during a pre-treatment, inter-stage treatment is a promising way to increase biogas production from a fixed amount of biomass.

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TD-O_19 Quality fertilizer for apple and vine-growing from dry anaerobic digestion of biowaste

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Objectives

The work presents one best practice of integration between an industrial plant (anaerobic digestion of biowaste and composting of digestate) and agriculture (apple and vine-growing) as final user of the high quality fertilizer produced. Two years of monitoring of the processes, the final product and information of the stakeholders involved are all necessary steps for a successful initiative.

Methodology

The waste plant is located in Trentino province (Northern Italy) and was started in 2012 for the treatment of 25750 tons/y of biowaste. The dry anaerobic digestion (AD) is carried out in 2 horizontal mixed reactors for 25 days at 51°C. The digestate is sent to the aerobic composting process after addition of yard waste to balance the C/N ratio of the starting mixture. The biogas produced feeds 1 MW engine for CHP; 12.000 tons/y of good quality compost (D.Lgs 75/2010) are sold to local farmers.

Results

A plan for the operational management of both the biological processes was elaborated (with local authority) to monitoring and improve the process evolution [1]. The mean values of FOS/TAC (ratio of organic acid and alkalinity) of the substrate (about 27,15% TS; 56,15% VS) were defined at 0,45 for input point and 0,34 for output point; this indicates a good feeding of the system and a quick answer from the microbial community showed by the specific amount of biogas produced: 203 m^3/ton of food waste. The composting of digestate (about 26% TS; 54% VS) is key step to produce a soil conditioner available for local agriculture. The intensively cultivated soils are showing complex phenomena which seem to be connected to the soil fertility and organic matter content [2]. The quality compost produced, supported by low respiration rates (about 540 $mgO_2\,kgVS^{-1}\,h^{-1}$), the presence of humic substances (7,6% of TS), a good macro and micro-nutrients content (1,9% TS total N; 1,75% TS organic N; 152 mg/kg TS Zn; 67 mg/kg TS Cu) and safe from the environmental quality (heavy metal) is suitable for application in the new orchards and in the maintenance of the soil fertility.

Conclusion

The energy exploitation of biowaste by means of AD is a high efficiency process but the full closure of the chain can be gained only when it is ensured the proper recovery of organic matter for the agriculture. The monitoring of both the biological processes are basic to guarantee good amount of biomethane, but also high quality compost. The proper use and market of the compost is possible even thanks to a correct and constant information of users on how and when it has to be applied.

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TD-O_20 Biogas for the future – Trade-offs between economy and climate

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Objectives

This study is part of a broader endeavour to determine, at the regional level, the possible role of biogas, in the perspective of current and future energy systems (2035 horizon).Through a case study for the Funen region (Denmark), it aimed to identify the economic and environmental consequences of various biogas uses and the dependency of these upon the substrate used for producing the biogas.

Methodology

A consequential carbon footprint was carried out for three biogas use scenarios: Direct use in combined heat and power (CHP) production, upgrade by removing the carbon dioxide (CO_2), and upgrade by addition of hydrogen to transform the CO_2 into methane. The evaluation of the economic aspects was performed through a socioeconomic analysis taking into account the relevant taxes and subsidies. These assessments were performed considering nine different substrates to produce the biogas, including wheat straw, deep litter and a variety of manure types.

Results

The environmental analyses confirmed earlier findings [1-2] showing that biogas production based on agricultural residues results in a reduction of greenhouse gas emissions. It further highlighted that this climate benefit is very dependent on how the biogas is used and how the remaining energy system is designed. Using biogas directly for CHP production leads to a climate benefit only when the district heating system can utilise all produced heat throughout the year, and when the substituted electricity in the power grid is associated with large emissions of greenhouse gases. Upgrading biogas to natural gas quality through CO_2 removal generates larger climate benefits as the gas can then be stored and substitute fossil fuels anywhere in the energy system. Converting the biogas CO_2 to methane gave rise to even larger climate benefits, but only providing that the hydrogen used for the conversion was produced from renewable resources.
The socioeconomic analysis showed that, under current conditions, it is economically feasible to use biogas directly for CHP production or for upgrade through CO_2 removal. This is primarily due to the subsidies given to both electricity and synthetic natural gas (SNG) produced from biogas. Subsidies are not yet given to SNG produced from biogas and hydrogen. Further, the results showed the technology to be too expensive for this conversion pathway to generate a profit.

Conclusion

Biogas produced from agricultural residues is beneficial to the climate but its utilization should be considered in the context of the overall energy system. In an energy system where an increasing share of the electricity originates from renewable resources with a low climate impact, the benefit of biogas is not as high for direct heat and power production as it is for conversion into a storable fuel such as SNG. This supports the claim of other studies, e.g. [3]. An inverse correlation between climate impacts and economic feasibility from different biogas utilization was found, reflecting the need for an optimized framework in the perspective of future biogas production and integration in the energy system.

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Thematic Area TD – The bioresource challenge
(Poster presentations)

Macroalgae, processed photograph

TD-P_01 Environmental assessment of the agronomical recovery of post-treatment digestates

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Objectives

The environmental assessment of digestate (residue from anaerobic digestion) post-treatment pathways is seen from a new perspective: it is no longer a residue management but an agronomical pathway which is environmentally assessed. LCA is used to compare the post-treatment pathways of four types of digestates.

Methodology

Pathways are compared in terms of the agronomical value of the produced and spread products. The fertilizer value is based on the amount of available nitrogen for plants and the amendante value is based on the amount of organic matter that remains to the soil. A functional unit based on "to provide X mass of available nitrogen and Y mass of organic matter to the soil, from an annual production of Z mass of raw digestate" has been deployed to the various pathways (farm, territorial, biowaste) applied to each one of the digestates.

Results

For a given nitrogen fertilization and a given amendante value, adding available nitrogen via mineral fertilizing or organic matter via peat spreading has a low influence on the scenario hierarchy. Moreover, emissions that follow spreading are the main causes of the impacts of the pathways. This is not true regarding the resource depletion category, which is mainly due to the reagents production (for centrifugation and gas treatment).

When a raw digestate direct spreading is compared to the spreading of both solid and liquid phases, establishing or not a raw digestate post-treatment does not discriminate the pathways concerning digestates issued from farm biogas plants. The results are more contrasted for the post-treatment of digestates from territorial pathways, when the spreading of both solid and liquid phases is compared to the spreading of a dried product and the liquid products issued from ultrafiltration and reverse osmosis. The environmental assessment is also balanced in the comparison of the spreading of the solid phase towards the spreading of a digestate biowaste compost.

Conclusion

LCA has shown its limits here as an evaluation tool for agricultural product-providing-pathways, due to the poor grasp of impacts and the benefits of spreading such products on agricultural soils via LCA. This study approaches the aim of a digestate post-treatment via the agronomical view. More investigations should be done on this interest to better reflect the environmental benefits of post-treatment. Authors would like to thank the project partners for having provided the data used in the LCAs.

TD-P_02 High-tech water-and nutrient-recycling – The blackwater-loop

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Objectives

This paper presents the results of the operation of a full-scale pilot plant of the black water loop process that is operated at the main railway station in Hamburg since 2013.
The system is maximally conserving our renewable water resources. Potential recyclables are almost fully recovered: by-products of the process are compost, two fertilizer raw materials and optionally biogas.

Methodology

The operation of the pilot-plant is monitored by several online sensors (liquid-levels, water-flows, air-flows, pH, electric conductivity, pressures, temperatures, energy consumption). Also the quality of the water in the different stages is measured (TS, VS, TN, TOC). The data are analyzed and discussed. Investment and maintenance costs for operation are calculated and compared.

Results

The black water loop process can be operated stable and safely and thus presents a robust technology for wastewater-treatment. The quality of the processed water for flushing is clear and not to distinguish visually from tap-water, so the toilet-users do not realize a difference to normal flush-toilets.
With the integration of a new solid-liquid-separator (patent pending) the safe running of the plant is further enhanced.
Specially adapted microorganisms in the high-performance biological fixed-bed reactor reach efficiencies for nitrification at extremely low ph-values below 5 not reported in literature before.
High energy-demand is a draw-back, but here optimization is possible. In certain conditions where water-prices are high the black water loop is economically viable.

Conclusion

The Black water loop is a technology that enables the reuse of the water and nutrients. It is one step towards the complete water-autarky of a building. With the integration of the “grey water loop process” (loop processing of greywater via a groundwater passage), safe water self-sufficient buildings become possible. Domestic wastewater can be physically eliminated – and with that all the potential threats for public health and the environment caused by fecal contamination and micro-pollutants.

TD-P_03 Process simulation of biological degradation processes in waste management

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Objectives

Extensive scientific works exist which deal with the treatment or utilization of waste. The knowledge has gotten essentially to an empirical scale and many more laboratory experiments, measurements and analysis are needed. To summarize this knowledge by using a computer software for model simulation so as make it usable for other applications was the aim of this work.

Methodology

The essential aerobic and anaerobic microbiological, chemical and biochemical processes and as well as the physical effects were considered provided that these can be generalized. Process interests were integrated in both input and output parameters. LabVIEW 7.0 (graphical programming language) of National Instruments for the programming of this simulation software allows expansions and integrations of further special questions up to integration of tasks of technology of measurement and control engineering.

Results

A simulation model was built which gives the complex relationships of the microbiologically treated materials that contains carbohydrates, proteins and/or fats. The developed software also help to find process optimization steps for both the aerobic treatment (e. g. composting) and the anaerobic biogas production (fermentation) or conditions for changing milieu parameters (e. g. ventilated landfill and aerobic/anaerobic process).
The question about the status of the nutrients carbon, nitrogen and sulfur in the different phases can be shown with this process simulation software for the most different attitudes and modes. A comparison of the simulation values with empirical values showed that the results are proportional and the development and value range are very similar.
Important materials and surcharge materials are integrated and can be added arbitrarily in different ways.
Applications for this software are e. g. optimizations of resource uses, control of the whereabouts of nutrients, and emission forecasting.
The program helps to operate and plan waste plant systems and is usable for treatment optimizations. Also the software is usable for forecasts and for education.

Conclusion

The essential aerobic and anaerobic microbiological, chemical and biochemical processes but also physical effects are summarized in a simulation model. The simulation of one-step processes in batch operation, two-step processes, and the quasi-continuous batch operation is possible in this software. Inserting individual substrate and inserting common substrate from a database (not included) are taken into consideration.

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TD-P_04 Biogas and fertilizer from lawn silage and lawn silage juice

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Objectives

Lawn cuttings are generated as residues in large amounts in public areas and private gardens. Actually, they are commonly inefficiently used or disposed. The utilization potential of that as tertiary bioresource is investigated. The anticipated products are biogas and fertilizers. Since lawn cuttings are not available the whole year the influence of ensilage of lawn cuttings on the biogas potential is investigated. Original lawn cuttings and press juice prepared from lawn cuttings are compared with silage from lawn cuttings and silage press juice.

Methodology

An overview of silage preparation options applied in practice is given. Possibilities for preparation of silage in small laboratory scale are shown. Preparation experiments were carried out with lawn cuttings from various private and public areas. Two different silage samples are further investigated regarding pre-treatment for the biogas process - cutted silage and silage press juice. The cutting is carried out with a macerator and juice preparation by means of a screw press. The various fresh, ensilaged and pre-treated samples are characterized chemically and the biogas potentials are measured. The results are compared with agricultural grass silage.

Results

The preparation of silage from agricultural grassland is frequently applied, but not in case for lawn cuttings from public areas. These bioresources differ in many aspects, e.g. with respect to harvested amounts and times as well as chemical composition. It could be shown, that it is also possible to prepare silage from public lawn cuttings successfully. The process can be carried out also in small scale with the advantage that low harvested amounts can be used. Emissions are low because the silage utilization takes place shortly after opening the silage bags. The biogas batch tests showed that the specific biogas potential of the silage range between 300 and 400 nl/kgoDM. This is in similar range like agricultural grass silage. The specific biogas potential of the press juices was higher for both, the agricultural grass silage and the lawn cutting silage. The grass silage juice from farmland reaches values up to 500 nl/kgoDM. The specific biogas potential from the private lawn silage juice is even higher with up to 900 nl/kgoDM.
Also the nutrient potential of the substrates is investigated. The juice contain between 1000 to 1700 mg/l phosphorous, for the silage phosphorous values range from 800 to 1400 mg/kg. The nitrogen content of the silage varies between 5000 to 7000 mg/kg fresh matter and 3000 to 5000 mg/l for the juice. After digestion the potential of nutrients is still in the digestate and makes it attractive as fertilizer. [1] [2]

Conclusion

The work shows that lawn cuttings from public area can be stored as silage. Both, silage and silage juice provide good biogas yields and have a considerable nutrient potential. This makes lawn cuttings from public areas an interesting bioresource for biogas and fertilizer generation, which is available the whole year.
Biogas production, based on organic matter, is higher for press juice compared to cutted silage; based on fresh matter, the silage biogas potential is much higher. Which variant is suitable is case-specific and depends on fermentation plant and feeding system.

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TD-P_05 Multi-composting as a tool to produce compost from olive mill waste as a substitute for growing strawberries in the United Kingdom

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Objectives

Trials were conducted to compare the yield and quality of fruit produced when waste from olive mill production was composted multiple times in combination with poultry manure. The combinations used different ratios of olive mill waste (OMW) compost with regular peat-free compost as a base. Studies trialling OMW compost on horticulture crops has proven to be successful or compared similarly [1, 2]

Methodology

Strawberry plants were transplanted into pots with compost; compost variations included: 10% OMW compost with 90% standard compost (SC), 25% OMW with 75% SC and 50% OMW with 50% SC. There were 2 types of OMW compost, one composted twice with poultry manure (OMW2), and one 3 times (OMW3). Strawberries were harvested after 55 days growth and on 10 more occasions. Ten strawberries per replicate were measured for weight, width, firmness and sugars; all fruits were weighed and counted.

Results

Statistical analysis of the data from the trials was completed and data were subjected to multivariate analysis and the Least Significant Difference (LSD) and Tukey's test were used at a significance level of $p<0.05$. The results from the statistical analysis show that none of the different treatments from either OMW product are significantly different from each other or the control for weight. There is no significant difference between the number of marketable or discarded fruits produced when analysed using both Tukey's test and the test for LSD. The tests for fruit firmness and sugar content showed significant differences between some treatments. The results of the penetrometer test showed that in Tukey's test the control was a significantly higher value than treatments with 25% OMW3 and 50% OMW2. Treatment 3 (50% OMW3) was also significantly higher than the 50% OMW2 treatment.

Conclusion

There is no statistical difference between any of the compost treatments and the control for weight or width of fruit, or numbers of strawberries produced. These trials demonstrate that under these conditions, compost produced from chicken manure and OMW can compare similarly when assessed against fruits grown in traditional peat-free compost. The compost variations did show differences in fruit quality for both flesh firmness and sugar content.

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TD-P_06 Wastewater treatment plant of the future – Energy storage in interaction with technical infrastructure between the poles of energy generation and consumption ("ESiTI")

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Background

Municipal wastewater treatment requires a considerable input of energy. However, at the same time, wastewater contains energy in the form of heat and chemically bound energy, both utilizable within the wastewater treatment process. In municipal wastewater treatment plants, energy consumption and generation are usually subject to separately optimized processes and are separated in space and time, as well.

By crosslinking energy consumption and generation the subsystem "wastewater treatment plant" can become an efficient energy storage. Furthermore, by interacting with technical infrastructure facilities, e.g. power providing companies or large-scale energy consuming resp. generating enterprises (industry, waste incineration plants, etc.) new potentials of efficient energy utilization and generation can be identified.

Due to its potential regarding energy storage and generation, sewage sludge treatment is an important component of this system. In the frame of the joint project, the system of sewage sludge treatment is to be further developed, targeting at an intelligent and flexible energy concept, in which the different forms of energy, i.e. electricity, heat, cooling energy, chemically bound energy (sewage sludge, gas) and work are to be brought together. In this context, energy and mass balancing are highly relevant, i.e. regarding the expansion of the system's boundaries by including the chemically bound energy of sewage sludge resp. co-substrate.

Objectives

The objective is to develop a manual-based planning tool as well as tools for real-life application, whilst considering technical, ecological, economic and social aspects for operating future wastewater treatment plants in interaction with infrastructure facilities. Target is the identification of the sewage sludge treatment plant as energy systems provider, with the focus on sewage sludge digestion as energy consumer, storage and producer, and providing maximum flexibility of energy flows.

Results from the investigations to be carried out in the scopes "system", "technology", "ecology" and "economy and society" using the example of the city of science Darmstadt, are brought together via the planning tool that also enables the evaluation from different perspectives. The planning tool forms the transfer for application by mapping key figures and decision trees.

Methodology

The joint project includes five major fields of activity: The system analysis evaluates the potential of the wastewater treatment plant to become an energy systems provider through the identification and visualization of dynamic energy flows (electricity, heat, cooling energy as well as potential storage media such as sewage sludge, substrates, biogas). The technology work package strives for the development of a sewage sludge treatment process as functional module of a flexible energy system as to the combination and optimization of different steps of sludge treatment (digestion, thermal pressure hydrolysis, thermal treatment processes). These technical aspects are framed by an ecological assessment of the process variants as well as a multi-criteria evaluation, into which further economic, ecological and social costs and benefits are incorporated. These four activities serve as a basis for the transfer work package which contains the development of a planning tool for the integration of the wastewater treatment plant into an energy network system.

TD-P_07 Nutrients removal capacity of the green microalgae isolated from wastewater treatment plant in Hamburg

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Objectives

This research aims to inspect the nutrients removal capacity and the potentials of the microalgae to produce biomass in the wastewater for treatment and bioenergy production. The main objectives are to isolate and identify the green microalgae from wastewater and furthermore, to grow the isolated algae in the wastewater and monitor the growth rate, assimilation of the nutrients to determine the most productive strain.

Methodology

Wastewater samples (including sludge) were collected from Seevetal wastewater treatment plant (WWTP) to inoculate the artificial medium BG11 [1]. The algae plaques were transferred using methods of dilution-spread, dilution-spray and micromanipulation (with capillary) to isolate the algae and separate each distinct strain from other strain and other biological contaminations.
To eliminate the influence of the bacterial activity, municipal wastewater (from Seevetal) was autoclaved and filtered through glass microfiber filters. The nutrients in the wastewater were measured before inoculation and wastewater was introduced to airlift bioreactors (300 ml) in triplicates in light intensity of 720 µmol m^{-2} s^{-1}. The reactors were inoculated with the isolated algae and the batch cultivation continued for 12 days. Total nitrogen (TN) and non-purgeable organic carbon (NPOC) were measured using Shimadzu TOC/V auto-analyzer. Chemical oxygen demand (COD), Total phosphorus (TP), Phosphate (PO_4-P) and ammonium (NH_4-N) were measured using Hach-Lange standard cuvettes and DR3900 spectrophotometer. Biomass growth, pH were investigated throughout the experiment on days 0,1,3,5,8 and 12.

Results

Based the on microscopic photos, 7 distinct algae strains are distinguished. The genera of the isolated algae are Chlorella, Desmodesmus, Tribonema and Stigeoclonium. Due to the very small cell sizes (<10 µm), identification of the algae species using DNA sequencing is carrying out. Growth of 6 most productive strains is investigated in the wastewater. The nutrients removal also was impressive when we achieved up to 99% phosphorus removal on Day 3 and up to 96% ammonium removal on day 5 of the experiment with both Desmodesmus sp.(1) and Chlorella sp.(1). The highest attained biomass concentration was about 1.6 g/l in Desmodesmus sp.(1) and Chlorella sp.(1) as well. There was no significant correlation was found between COD and NPOC removal and the biomass growth. The nutrients removal and biomass growth in Tribonema sp. was delayed because of the morphology of this specie which is very sensitive to shear stresses.
Our results coincide with those of Cabanelas et al. (2013) and Ji et al. (2013) [2,3].

Conclusion

This experiment has shown that the native microalgae in the wastewater have a high nutrients removal potential. Two species which are recognized as Desmodesmus sp.(1) and Chlorella sp.(1) in our experiment have demonstrated a high biomass productivity and nutrients removal.

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TD-P_08 LIFE + MANEV – Evaluation of manure management systems and treatment technologies in Europe

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Objectives

Aiming to unify the knowledge in manure management and the experience in technologies available in the market, the LIFE+ MANEV project (LIFE09 ENV/ES/000453) emerged within the frame of the European Programme LIFE+.
The objective is to demonstrate that the technology combined with a proper management can reduce the environmental affection and improve the sustainability of the livestock sector.

Methodology

Every project partner has monitored scenarios with manure treatment plants at different scales. The facilities are located in some of the regions with higher livestock density in Europe.
The evaluations followed the guidelines predefined in a Common Protocol aimed at obtaining comparable data and to assess the same parameters using the same methodology. The criteria considered were environment, economic, energy and agronomy, as well as social, sanitary and legal aspects.

Results

13 treatment facilities have been monitored at farm scale or in centralized management systems in 8 different areas of Europe. The field work, data collection and final assessment have been carried out following the guidelines previously defined in a Common Evaluation and Monitoring Protocol.
The treatment technologies assessed include separation techniques, energetic and agronomic valorisation of the manure, nutrient recover and removal and tertiary treatments such as constructed wetlands and reverse osmosis.
The results obtained in the monitoring work have been used to validate the software tool developed in the project (MANEV tool) that globally assesses different manure management systems in a certain scenario. It is freely available in the webpage of the project (www.lifemanev.eu) in English and other European Community languages.
A general view of the different options of treatment technologies for the manure management has been acquired during the development of the project. This knowledge has been transferred to the different stakeholders involved in this activity.

Conclusion

LIFE+ MANEV has gathered the treatment technologies knowledge in different parts of Europe with the aim of exchanging and transferring those experiences and improving environment and sustainability of the livestock sector.
The results of this project let asses and compare different management systems adapted to specifics scenarios providing a global point of view of the consequences of their implementation.

Thematic Area TE – Sustainable regions
(Oral presentations)

Christiane Lüdtke: Art from Tetrapak

TE-K New paradigms on how to achieve zero food waste in future cities – Optimising food use by waste reduction and valorisation

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Objectives

Cities currently manage uneaten food and other food system based biomass quite inefficiently. The organic compound, although highly valuable, in most cases is not recycled and not returned to the soil of farm areas. Objectives of our work are to identify research questions in order to foster and accompany 1) food waste prevention and 2) optimization of the uses of food waste material and resources (energy, water etc.), specific to different urban settings in different regions worldwide (covering both industrialized and unindustrialized areas). A selection of city case studies at hand, urban flows of food system based biomass are quantified

Methodology

Twenty experts related to disciplines like industrial ecology, urban metabolism, urban farming, aquaculture systems, waste recovery and processing techniques, law, ethics, system innovation and foresight studies are organized as a working group following a foresight study approach. A literature review, expert interviews and 5 workshops are being conducted between September 2014 and May 2015.

Results

Expert interviews and literature review have shown that innovative approaches in urban food waste management are being experimented in a couple of cities worldwide (in countries like Canada, USA, UK, France, and Senegal for example). Food system actors involved are as different as business and catering companies as well as civil society, NGOs and municipalities. Food waste prevention strategies mainly use communication and awareness raising tools, whereas valorization of food waste mainly aims at energy recovery so far. However, coherent concepts and strategies are currently missing in most case studies, though single initiatives on food waste prevention and valorization are abundant and using manifold tools (regulation, technology, social innovation etc.). Interaction between both strategies and possible intervention needs to be better understood in order to optimize food use in cities.
Further work will be done by the expert group early 2015.

Conclusion

Research is needed to accompany cities' zero food waste strategies. This study is the first one to place research on food losses and waste into an urban context. However, with a growing population in cities worldwide and increasing pressure and competition on uses of biomass, successful strategies on achieving zero food waste cities are mandatory with respect to future generations.

TE-O_01 Appropriateness and potential of large-scale composting initiatives in developing and transitional municipalities

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Objectives

Composting is an attractive first option for developing municipalities to upgrade local collect-to-landfill waste management schemes[1]. Their intensive urbanization trends and high generation rate of organic wastes imply that composting may be a beneficial option to recover nutrients and stabilized organic matter (humus) for agricultural use[2]. This critical review (i) describes the current relevance and potential of composting in a developing context and (ii) identifies and assesses the key factors that define its resilience.

Methodology

The multidisciplinary assessment included the following criteria: (i) financial & economic, (ii) institutional & management, (iii) operational & technical, (iv) environmental & resource recovery, and (v) social & public health-related aspects. The studied geographical areas were (i) China, (ii) India, (iii) South-East Asia, (iv) the Middle-East, (v) Sub-Saharan Africa and (vi) South America. Information was collected from scientific literature and practical documentation on existing initiatives. The main factors influencing appropriateness and resilience were classified according to type, objectivity, quality and global relevance.

Results

Globally, the operational sustainability of composting initiatives appears to be very low. Lack of experience with composting initiatives often leads to technical overdesigning of the feedstock load and the conversion process. The policy frameworks intended to support the initiatives often prove inadequate. In the least developed countries this often leads to the neglecting of composting initiatives in favor of direct landfilling. In quickly emerging waste sectors (e.g. in China), the fast spreading of incinerators proves to be a key reason of composting initiative failures. Lack of proper mechanisms to regulate potential uptake markets is indicated to lead to an unbalanced competition between compost products and more embedded alternatives as artificial fertilizers or animal manures. Unrealistic expectations from the produced compost quality and the related low sales are key economic reasons for suboptimal operations. The analysis suggests that even if larger uptake markets are achieved, the introduction of a gate fee and a landfill tax are still unavoidable in order to maintain economically viable initiatives.

Conclusion

Despite the obvious need to recycle the increasing flux of urban organic wastes to agricultural soils, composting initiatives in developing countries often cope with numerous challenges. The review shows that (i) the mismatch between local infrastructure and the chosen technical sophistication, (ii) the underdeveloped policy framework and (iii) the restricted compost demand are the key areas to improve to achieve sustainable implementations. The identified objective criteria can be applied to support an efficient, resilience-based evaluation of planned initiatives.

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TE-O_02 Farmers attitudes and potential barriers to the use of new organic fertilizers

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Objectives

Many regions of Europe have a surplus of nitrogen and phosphorous in soil. To reduce nutrient input to agricultural soils, more treatment or transport of organic wastes (e.g. manure, urban waste, or organic industrial waste) is needed. To increase farmers' acceptance of treated organic wastes, it is important to understand farmers' attitudes towards their use.

Methodology

Farmers are surveyed in five EU countries that have areas of soil nitrogen and phosphorous saturation (Spain, Portugal, Italy, Denmark, and the Netherlands). The survey consists of 24 questions and has been translated into five languages. Cross-country farmer surveys require flexibility, and so the data collection is conducted using a mixed-methods approach: online, and with face-to-face interviews at agricultural events or through contacts via farmer associations.

Results

Data collection will be ongoing in each country until spring 2015. At the conference we will present the final results of the survey. We will describe the amount and type of organic fertilizers that farmers currently use or plan to use in the near future (whether treated or untreated manures, urban wastes, composts, mineral concentrates, or others). We will describe the attitudes of farmers towards the use of treated organic wastes in agriculture, particularly in terms of perceived barriers to their use, and the most desirable properties of treated organic wastes that make them attractive for field application. We will compare these results between the five surveyed countries and also between different farm land uses. Finally, we will describe experiences from our methodological approach and recommendations for future multi-national farmer surveys.

Conclusion

The survey will provide unique information and insight of the attitudes of EU farmers towards organic fertilizers and their use. Surveying farmers in different countries with multiple languages is a complex task and requires a high degree of co-ordination with local partners. Multiple data collection methods (e.g. via the Internet, or face-to-face surveys at agricultural fairs) are essential to ensure a wide representation of farmers' views.

TE-O_03 Management of wetland areas – Tradition & innovation for sustainable land use and network between rural and urban areas

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Objectives

Wetland areas are important for grassland management, soil protection, carbon storage, water regulation, biodiversity. Management with conventional equipment is hardly possible because of sometimes highly water-saturated soils. Work-horses can be an innovative approach for preservation of cultural landscape and strengthening the relation between rural and urban areas through various services.

Methodology

Interpretation of local history of land use
Analyses of natural and cultural environment
Pilot tests of horse mowing, technical development (modern equipment) and innovation
Monitoring the change of biodiversity in relation to method
Evaluation and testing of traditional methods of land use for sustainable management with innovative approaches
Analyses for demand and supply for additional services, second income, local recreation
Benefits for regional added value and socio-ecological approach

Results

The use of workhorses supports small scale grassland farming to protect cultural landscape
Awareness creation for ecological sustainable landscape management practices
Minimal noise, no emissions, no fossil fuels, insects and birds can easily escape
Moving of wet land areas is possible under difficult conditions and has low impact on wet soils
Maintaining high biodiversity of wet meadows, keeping cultural landscapes open, prevention of forest and scrub encroachment
Low cost of technical equipment, Potential for technical evaluation and optimization
Pasture management with slopes up to 30% is possible
Using the hey for innovative products, as litter for stables
Promoting new income possibilities for local farmers
Apart from mowing there are versatile uses of horses: thinning of forests, clearing of bushes or dwarf shrubs, cultivation of potatoes, transport services, leisure activities and other tourist activities, hippo-therapy, disposal of waste, environmentally friendly transport system
A special funding in the Austrian Environmental Programme was implemented.

Conclusion

Today's management is mainly based on agricultural subsidies. With the ongoing structural change in agriculture new strategies and innovative solutions are needed for future sustainable management. The local population and regional famers as well as media and tourism take great interest in the method. The multiple use of horse power is a new chance for sustainable ecological agriculture in rural areas and other services also in urban areas.

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TE-O_04 Practical experiences in Flanders towards a rural-urban sustainable biomass policy

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Objectives

Flanders has a long tradition of using biomass for food, feed and wood industry, as well as 25 years of separate collection and recycling of biowaste in rural and urban areas. Stakeholders of the different governments and industries asked for a clear sustainable policy for the destination of biomass (residues) in Flanders during the next 5 years.

Methodology

We made an analysis of the supply and destination of biomass in Flanders in 2013 and the forecast for 2020. We evaluated the local and some surrounding and EU-strategies and political regulatory measures which encourage the bio-economy by linking rural and urban biomass (residues) and which enable compromise solutions between stakeholders with conflicting interests.

Results

A practical overview is made of the production, actual and potential use and instruments for a more level playing field for the use of local and imported biomass (residues). 98% of the residues from the food industry find their way to food, feed, cosmetics, compost; a lot of challenges are waiting for the anaerobic digestion plants in Flanders because of the high standards for discharging on surface water and the phosphate restrictions for using digestate on land. Different examples show the local potential of specific use of treated digestate. Depending on the price of artificial fertilizer at the moment, new opportunities for struvite and other recycled nutrients are waiting in the future. The composting plants for bio waste are looking for predigestion of the bio waste in order to combine the production of energy and good compost quality. The paper industry has converted to self-supply of energy by producing green power and heat by incinerating own biomass waste, together with wood waste from e.g. rural areas or RDF. Next to investing in pilot and full scale plants, a lot of research is done in universities, research institutions and private companies for the biorefinery of more difficult biomass streams, like lignocellulose crops and biomass waste to develop compounds for biochemical (1).
One year of intersectoral debate lead to an action plan towards a rural-urban sustainable biomass policy at the end of 2014 (2). The action plan 2015-2020 is focussing on three biomass cycles : 1. from agriculture to food and consumer, 2. biomass from the management of green and rural areas and 3. wood (waste) from industry and households. Some of the case studies will be presented on the conference.

Conclusion

It's a big challenge for the rural and urban biomass and biowaste sector to contribute to a more sustainable bio economy on a cost effective way. This means that maximally creating economic added value and foreseen in the demand of biobased energy will probably don't match together. The success is depending on the implementation of new policy supported by a mix of different instruments e.g. realistic goals for consumers and industry, support for a quality based chain management, biorefinery facilities, green support for producing electricity of biogas and using biogas for transport from digestion. and for producing electricity of incineration of not recyclable biowaste. The Flemish action plan shows that compromises are possible between stakeholders with conflicting interests.

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TE-O_05 Integration of sanitation infrastructure with agriculture in peri-urban communities of South Africa

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Objectives

To meet the sanitation guidelines for South Africa, which guarantees each person a minimum water and sanitation access (SERI, 2011); the eThekwini Municipality has deployed Community Ablution Blocks (CAB) as an alternative to Ventilated Improved Pit Latrines (VIP) toilets in the Peril-Urban settlement areas of Durban. The Decentralized Wastewater Treatment Systems (DEWATS) combined with the CABs are being used for effluent (grey and blackwater) treatment. Community agriculture areas are planned to make use of the high plant nutrient content in the treated wastewater from DEWATS systems. This would allow the communities to have a higher quality of sanitation as provided by the CABs, reduced municipal maintenance costs and the potential to contribute to improved livelihoods, employment creation and food security for the community through urban agriculture. This concept is being investigated at the Newlands Permaculture Centre experimental site in Durban where a DEWATS system has been installed. The studies are focusing on processes that would ensure the safe use of effluent as well as understanding effluent movement through different soil types, root uptake mechanisms and the effect on crop growth, yield and the environment. The specific objectives were to assess Swiss chard yields, nutrient uptake and to determine the area required for irrigation with effluent on different soils. The study also assessed the DEWATS effluent chemical properties.

Methods

The water consumption patterns of CABs in the eThekwini municipality has been extensively investigated in the past (Crous et al., 2013). The DEWATS effluent used for irrigation was characterized for N, P and K (Foxon et al., 2013). The pot experiment was done to investigate nutrient uptake and yield of Swiss chard irrigated with DEWATS effluent on three contrasting soils at different fertilizer rates and crop water requirements. A field experiment was done to investigate N and P leaching using the Wetting Front Detectors (WFDs). Land area required for irrigating with DEWATS effluent was estimated based on quantity of effluent used.

Results

Irrigation with DEWATS effluent increased Swiss chard yield on acidic soil ($P<0.01$). There was no significant leaching of N ($P<0.05$) and P ($P<0.001$) in soil irrigated with DEWATS effluent.

Conclusion

A single DEWATS can irrigate 2335 m^2 of Swiss chard while meeting water and N requirements. This system can potentially remove nutrients (N and P) in a manner that will prevent pollution of water resources while benefiting farmers living in peri urban informal settlements.

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TE-O_06 Planning the sustainable use of agricultural bioresources as fuel for city busses – Example case Turku, Finland

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Objectives

The objective of the research was to plan sustainable biomethane production from energy crops for busses in city of Turku. The aim was that the produced biomethane would reduce the environmental effect of city traffic and digestate is used as fertilizer in sustainable way in surrounding areas. The objective was that the biogas plant and fields in surrounding area form a closed cycle of nutrients and that this example case brings tools for future biogas plant planning.

Methodology

In Turku, about 3 Mm^3 of biomethane is produced per year from waste materials. Needed amount of methane for city busses is about 5.6 Mm^3. Basis for the study was that extra 2.6 Mm^3 of methane could be produced from energy crops. Case study area was called Topinoja and it was selected as a request of city of Turku, as there is a biogas plant processing biowaste and sludge in the same area and the area is logistically potential area for biomethane distribution. Grass was selected as raw material as methane potential of grass silage is good, years of crop failure are rare and production costs compared to energy content of product are reasonable. Also, cultivation, harvest and preservation of grass are known and all technical solutions are available (compared to e.g. maize production in Nordic countries) [1]. It was assumed that cultivation will follow EU nitrate regulation and terms of Environmental Support of Agriculture (e.g. taking phosphorus status of the field in Turku area into account). For field location information and distance calculations, geographic information system (GIS) was used.

Results

Phosphorus status of the fields, crop yield, amount of harvested nutrients and allowed fertilization of grass and nurse crop of establishment year were taken into account when calculating the amount of fields needed for sustainable crop production. When 10 % margin was added (for e.g. annual variation) it was concluded that field area of 1800 hectares is needed for 2.6 Mm^3 methane production. According to the legislation and terms of Environmental Support of Agriculture the 1800 ha is needed to return the digestate while 1100 ha would be sufficient for grass cultivation. 280 ha are needed for sward establishment using barley as nurse crop. The needed 1800 ha area can be obtained within 9 km radius from Topinoja biogas plants if presumed that all field plots above 1.5 ha in size are available for biomass production. With increasing distance, the field area increases rapidly enabling energy crop cultivation along with food and feed cultivation. If 20 % of the farmers of surrounding area are producing grass for biomethane production and/or using digestate to fertilize their fields, the needed 1800 hectare field would be located less than 15.4 km radius from biogas plant.

Conclusion

When planning a biogas plant which utilizes field biomasses, the amount of nutrients in digestate and the allowed/needed fertilization of the crops needs to be taken into account in order to obtain closed nutrient cycle. In Turku case, the needed field area for digestate distribution is larger than the area needed for biomass production. In conclusion, 2.6 Mm^3 of biomethane can be produced on the target area based on closed nutrient cycle and grass silage as raw material and the bioenergy production can be done along with food and feed production.

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TE-O_07 SMART-3S and CST system for zero waste low-rise and high-rise urban settlement – A concept

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Objectives

The SMART-3S (Short Simple and Save) and The CST (*Cat-Shit* Technology) systems are prepared to solve waste management problems within densely populated urban area. Challenged by the lack of green/open space and also different human daily life behavior, the ideas were taken from nature, with less influence of the modernized technology.

Methodology

The SMART-3S and The CST are different technology with similar concept: an in-house technology. The SMART-3S serves high-rise settlement and located in each sink in each flat. This technology uses shredder machine to blend the organic waste, excluded from hard material such as bones, thick fruit skins and hard seed to cover the knife of the shredder, thus create slurry. From these sinks all slurry are collected in a communal-tank. The digestate, which is produced from the slurry, will be emptied from time to time and can be used as a fertilizer [1].

The CST serves low-rise settlement and buried in the mini garden. It uses big drums with several holes keep open for aeration (Drum diameter = 0.03-0.04 m, 1 m length). All the organic waste, excluded from fish, meats, and dairy products to prevent flies and fewer odors, are put inside the drum and covered with waste every 0.02 m depth just like a normal cat after defecated. In this way CST also called as mini-sanitary landfill. As a result the material inside the drum will turn in to compost and ready to be used for planting [1].

Results

Urban area faces many environmental problems including un-covered waste generation at the landfill, lack of green/open space. Urban people spent so many working hours out side the house. In this way The SMART-3S and CST are proved to make life a way better and simpler. These systems emphasize less contact with waste but also benefiting from the products. As it is a communal waste treatment and happens at home, the product is less contaminated. The treatment happened before the waste is mixed with any other non-organic material, moreover hazardous waste/material.

The CST prevents the organic waste to be treated outside the house. It cuts some budget for transportation, which related to the carbon emissions from the vehicles. This system is simple and low budget. One should fill the drum with organic waste and soil and to re-empty the tank once the compost is finished. It triggers people to do urban farming, thus addressing water scarcity and food sovereignty.

Conclusion

Urban people need solutions to manage their waste from home, under a simple technology, less-space and directly benefiting their life [2]. Waste management at source guaranty the products of these systems are less contaminated. They cut-off some additional budget and costs. The SMART-3S and CST adjust urban people's life, while promoting waste separation at source and waste-as-resources principles so the result is highly efficient.

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TE-O_08 Scenarios for a low carbon society – Agricultural waste

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Objectives

This study focuses on agri wastes as a source of greenhouse gas (GHG) emissions within the agricultural sector to

- Understand emission patterns and emission factors associated with agri-wastes
- Identify effective mitigation options to treat and utilize agri-wastes
- Improve GHG emission and mitigation interaction in existing parameterization of assessment models to develop low carbon scenarios

Methodology

Scope: European Union (EU) countries for current and future projections
Data sources: IPCC reports, Country emissions fact sheets, EU reports and IIASA databases
Models used: IIASA's Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model; and additional energy or agronomic models
Approach: Optimization approach incorporating emission controls and their costs driven by environmental targets to identify emission reduction strategy (ies) to mitigate GHG emissions from agri-wastes.

Expected Results

- Emission patterns of agri-wastes for short-, mid- and long term projections
- Emission factors for GHG emission sources from agri-wastes
- A portfolio of mitigation options to treat and utilize agri-wastes along with their emissions reduction potential and costs
- Assessment of linkages, systematic changes and feasibility of implementing mitigation technologies to utilize agri-wastes in rural-urban settings
- Development of an integrated assessment model for effective agri-waste utilization, accounting for emission patterns, emission factors and emission controls and associated costs
- Application of the model to generate mitigation strategy (ies) to reduce GHG emissions from agri-wastes along with the capability to conduct various scenario analyses

Conclusion

The agricultural sector is a source of food and is indispensable to society. However, it is a major source of GHG emissions (~10–12 $GtCO_2$ eq./yr). International agreements to reduce agricultural emissions have not been effective, in part due to missing concepts of realistic "low- carbon" situations. This study quantifies and characterizes GHG emissions from agri-wastes and identifies economically viable low-carbon mitigation strategies which would be helpful for farmers, crop advisors and policy makers struggling in a sector that itself is highly vulnerable to climate impacts.

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TE-O_09 Urban farming to grow a greener future

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Objectives

In 2050 the world population is estimated to grow up to 9.1 billion demanding for a 70% raise in food production [1]. In a world increasingly urbanized and characterized by a scarceness of green spaces and natural resources, cities have been playing, along the recent years, an important role in the conservation and increment of productive areas by implementing crop production within urban limits, and using organic materials as fertilizers. Although in Europe this is a new tendency, in other continents urban farming represents a major source for population subsistence, namely in southern Asia, in Latin America and in Africa, where it stands with economic importance since the early 90's [2]. This concept has been evolving to Northern America, to Europe and to Australia with contrasting objectives of pleasure and recreation, socialization and social inclusion, education, aesthetics, environment and therapy [3]. The major objective was to understand the main motivations that lead the new gardeners of the capital to invest in Urban farms, specifically in three pilot areas developed by the Lisbon City Hall.

Methodology

Three pilot municipal Urban Farms located in three different Lisbon neighborhoods were implemented by the City Hall and studied (Granja, Campolide and Telheiras). To evaluate the link between townsmen residents and farming motivations, 5 pillars were chosen to inquire the farmers installed at the referred 3 urban farms: (i) characterization of the farmer; (ii) former relation with rural areas; (iii) dedication to the urban farm; (iv) characterization of the farm; (v) motivation and opinions of the farmer. From a total of 80 farmers, 49 were inquired about the mentioned topics.

Results

This study on the Urban farms in Portugal revealed the existence of four different types of farms, depending on their characteristics: social, recreational, educational and business farms. Given the current economic situation it is not surprising that social typology is the predominant thus contributing to the users life quality improvement. Amongst the respondents, 61% are men and 39% women. 94% of the farmers are 45 years old or more, being 47% above 60 years old. Basic education is predominant in the farmers from social typology urban farms, while the farmers from recreational farms are predominantly highly educated (79%). However, 84% of the farmers are employed. Their relation to the rural context is strong, as 67% of the respondents have a former family or personal relation to farming activity and 82% visits rural areas frequently and only 8% do not visit their farm on a daily basis. An average 71% of the farmers consume their vegetables and have thus altered their consumption habits accordingly. Main motivation for urban farming within the enquired population is the search for better quality products where only organic materials are used for fertilization and the products are closer to organic products.

Conclusion

The main typology for urban farms in Lisbon is social type, where the farmers are predominantly men over 45 years old, with a great percentage of retired farmers. Urban farming is not related to unemployment, but with the need to alter consumption habits towards the use of organic products and zero use of fertilizers. The majority of urban farmers have or had a previous link to rural areas or/and farmer's history in the family.

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TE-O_10 Waste recycling through integrated farming system – An Assam agriculture experience

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Objectives

1. To analyse the possibilities of recycling the agricultural waste in the Integrated Farming System model to sustain agricultural productivity.
2. Improving economic viability through zero waste strategies or optimization of waste minimization.
3. To present a zero waste model focussing essentially on using available scarce resources and waste recycling more efficiently, effectively and sustainably for natural resources.

Methodology

Assuming a family having 5 members with 10,000 m^2 cultivated area, an Integrated Farming System (IFS) model was developed to meet their annual food requirement as far as possible and to present a zero waste model after conducting field experiment under All India Coordinated Research Project on Integrated Farming System at Assam Agricultural University, Jorhat, Assam, India from 2010-11 to 2013-14. The data presented here relates to the year 2013-14.
In this system, animals reared for milk were fed on agricultural (crop) waste and the voids in turn were used as manure for crops grown in the system, in fishery unit, for Vermicomposting and for Liquid manure production. As the system is a rainfed one Fish ponds were considered as Water Harvesting Structure and the rain water harvested there was utilised in the *Rabi* crops just before harvesting of fish during the 2nd week of January. Besides this, de-siltation was carried out after every two years and the fertile seed were used in the Horticultural crops.
Components: Field crops (Cereals, pulses, oilseeds), horticultural crops (fruits and vegetables), fodder crops, livestock (2 milk cows and 1 calf), apiary (5 beehives), Vermicompost unit (8.41 m^3, Liquid manure production unit (1.79 m^3), biogas unit (2 m^3).
Vermicompost unit: Cow dung and crop residues/bio wastes were used in the ratio 2:3. Crop residues/ bio-wastes include dried water hyacinth, vegetable waste, straw, and waste obtained at the time of winnowing of rice.
Liquid manure unit: Every day output of cow dung and urine mixture was channelized to a 4 chambered tank and liquid manure were produced through the process of sedimentation.
Biogas unit: Initially 2000 kg cow dung along with required amount of water were poured in the Bio-gas plant and kept for fermentation for a period of 45 days when release of gases were observed and after that 55 kg cow dung per day was used to continue the release of gases and gases were utilized as fuel.

Results

6220 kg total bio-waste obtained in the IFS area were used as animal feed and as a raw material for vermicomposting. Total quantity of organic manure received from livestock components (2 milch cow and 1 calf) of Integrated Farming System (IFS) was 23119 kg cow dung and 14235 litre cow urine, which were used as raw materials for liquid manure production, vermicomposting and biogas production besides using directly in fish pond and crop components. About 4866.67 litre liquid manure, 506 kg vermicompost and 511 m^3 bio-gas were produced annually in the system and were used as inputs for other farm components. Net return from the system as a whole was observed to be Rs.1,26,828.00 with a B:C ratio of 1.68 and a total employment generation of 391 mandays per year in the system.

Conclusion

Thus, the IFS model developed would provide an excellent opportunity for organic waste recycling besides reducing farmer's dependency on external market purchased inputs leading to improved farm income in one way and also improving environmental quality in other by reducing the pollution.

TE-O_11 Analyzing consumer-related nitrogen flows – A case study on food and material use in Austria

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Objectives

The objective of this study is to quantify flows of nitrogen (N) contained in human-made goods and compounds, using Austria in 2010 as an example. The aim is to extend the boundaries of conventional nitrogen budgets towards the consumer sphere by considering frequently neglected flows such as N in non-food industrial products or N related to gardens and green spaces.

Methodology

Based on the principles of material flow analysis and using Austria in 2010 as an example, this study quantifies the following N flows: N in food and agricultural products, N in non-food industrial products (synthetic & natural polymers, wood & paper products, waste), N related to pets, gardens and green spaces. The analysis covers only the nitrogen contained directly in the respective products, and considers flows that account for more than 100g N per inhabitant and year as relevant.

Results

As expected, the most relevant N inflows to the consumer sphere stem from food supply (52% of the total inflows of 127 000 tonnes N), but material products do also play a role (28%). Compost and fertilizer application in gardens and public green spaces accounts for 12%, and pet food for 7%. N outflows (92 789 tonnes N in total) can largely be attributed to human excretion and food waste (54% and 13%, respectively), followed by garden waste (16%), waste from pets (10%) and material waste (7%). However, there is a gap between inflows and outflows, resulting in a surplus of roughly 34 000 tonnes N. Possibly some flows have been overlooked in this analysis, and/or N accumulates in the form of durable consumer goods. Over the last five decades, both food and material consumption have increased distinctly.

In particular, considering the current trends of urban gardening, flows related to private (urban) gardens and public green spaces are of growing relevance. Although generally not covered comprehensively in statistics, there are indications that urban gardening systems cause N aggregation due to high N application rates [1].

Conclusion

Focusing on the apparent knowledge gap of flows involving material products, this study indicates ways to contribute to more complete consumer related nitrogen budgets in the future. A better understanding of these flows is needed to shape future policies with regard to nitrogen-efficient consumption. In particular, nitrogen flows related to private gardens, urban gardening and public green spaces and their interconnections with conventional agriculture are worth a more in-depth analysis.

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TE-O_12 Food and phosphorus security – Bridging the global-local and the rural-urban gaps

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Objectives

To assess to what extent households, industry and local authorities can contribute to reduce, re-use and recycle P-rich waste products to agriculture. The purpose is to improve global food security and to enhance sustainability of nutrient resources in waste products. Thereby preventing of cross planetary resources boundaries [1].

Methodology

Life-cycle thinking is applied using an extended waste-hierarchy comprising solid and liquid wastes. Step 1 is to reduce (a) waste generation, and to (b) minimise harmful contents in products and flows to make P mining almost redundant. P-rich solid (e.g. biowaste) and liquid (e.g. urine) waste can be reused (Step 2) more or less as they are. Step 3 concerns P-rich liquid and solid waste that can be recycled into new products (including biogas production). The conventional solid waste hierarchy comprises two more steps: incineration and landfilling. These are not included here, since the EU parliament has already decided that only waste that cannot be reused or recycled should be incinerated, and landfilling is only for residues after exhausting the previous steps.

Results

The three steps applied to non-agricultural waste is likely to increase the recovery of P from a few percentage points to 90 %. This, in turn, would save some 60 % of presently mined P each year. 28 % is saved by shifting to other resources than P (17%) and by decreasing food losses (11%). Another 32 % is saved by reusing/recycling food P, taking into account that half of presently mined P is lost in the food chain up to the consumption stage. P in biodegradable paper, board and wood waste is not included, since these flows are already recycled to a large extent for non-agricultural purposes. Garden waste is not considered due to a lack of reliable data, but could easily be composted and recycled. Savings at farm level and by dietary changes would add further reduction of mined P. Food security is ensured and in addition sustainable levels of harmful emissions from food production, consumption and nutrient waste management are achieved [2]. Thus, extraction of nutrient resources is deferred and so is the transgression of planetary resources boundaries.

Conclusion

Now is a window of unprecedented opportunity to design urban infrastructure to facilitate the exchange of nutrients in organic waste and food production in short closed loops between urban and rural areas. Since houses and infrastructure for an additional 5.5 billion new urban residents have not yet been built or planned, the change can start immediately and gradually include existing buildings when these are to be retrofitted anyway. The necessary changes in infrastructure to achieve the above results can be accomplished by the end of this century. It is a win-win situation, providing simultaneous food security and reduced harmful emissions to air, water and soil.

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TE-O_13 Encouraging local organic cycles in urban Europe with a collaborative tool

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Objectives

Many solutions for sustainable organic cycles in cities and towns are possible. Yet, their implementation often remains to be seen. A new collaborative tool shall help to make different solutions more accessible and to overcome existing barriers.

Methodology

The first step is the collation of known solutions for local organic cycles in cities and towns. This includes a look back into history. Next, barriers for their implementation are identified. These include the environment, economy and policies, and community and individual preferences. Then, the relations between the diverse solutions and barriers are evaluated. The resulting structure is then implemented into a collaborative online-platform.

Results

The created online-platform is a wiki with databank capabilities (based on Semantic Mediawiki), which provides registered users with forms for structured data input and update. This allows the supplement of data not available from statistics offices and other central data providers. The geographical structure of the tool is based on standards used by Eurostat (NUTS). Basic geoinformation capabilities allow quick visual estimates of biomass potentials and their use for specific settlements or whole regions. Local specifics, like city ordinances or implemented solutions can be entered and retrieved by local stakeholders or used for the networking between regions. Beside the information use at the local and regional level, policy advisors and scientific research could profit from the collated data as well.

Conclusion

Action requires knowledge; about alternatives, about problems, and about solutions. The presented tool is a transdisciplinary approach to structure and to provide this knowledge and therefore to encourage action for sustainable organic cycles in the towns and cities of Europe.

TE-O_14 Software tool for a global evaluation of different manure management systems focused on specifics scenarios – MANEV TOOL

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Objectives

MANEV is a free software tool aimed at the supporting for the election of an appropriate manure management system that better fits into every agricultural scenario. A comparative assessment of the different alternatives available nowadays is carried out bearing in mind the different points of view: environmental, economic, energetic, agronomic, social, sanitary and legal.

Methodology

The tool carries out the evaluation of the different technological solution in every scenario based on the algorithms developed by every partner integrated in the project according to their know-how and the data available on scientific papers, official reports from international organisms and experimental data.
The results has been tested and verified with the data obtained from the monitoring of treatment plants at large scale in real scenarios from 8 different areas in Europe.

Results

The MANEV tool, developed within the frame of the LIFE+ MANEV Project (LIFE09 ENV/ES/000453), is available on the web page www.lifemanev.eu in English, Spanish, Italian, Polish, French and German.
The compliance with the regulations at different scale, the obtaining of added value end-products, the environmental protection, the health and sanitary guarantees and the sustainability of the agricultural sector as well as the development and commercialisations of proper treatment technologies are the main aspects this work is focused on.
The treatment technologies available for the evaluation include separation techniques, energetic and agronomic valorisation of the manure, nutrient recover and removal and tertiary treatments such as constructed wetlands and reverse osmosis.
The software tool is aimed at the stakeholders involved in the manure management. A help assistance will orientate the user into the options that better satisfy the necessities of the scenario. An expert user will be able to design and simulate their own management system to be evaluated.

Conclusion

MANEV is a sound and consistent web tool that unifies the knowledge and experience of the different treatment technologies and the criteria used for their evaluation focused on the environmental protection and the sustainability of the livestock sector in Europe.
The software tool provides to the user a global assessment of a manure management system and/or a comparative analysis of more than one in order to orientate him to the technological solution that better fulfil his necessities.

TE-O_15 Availability and use of urban areas green cuttings for methane production through anaerobic digestion

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Objectives

In recent years, as a consequence of the national financial crisis, several municipalities, including the city of Torino (Piemonte Region - Northwestern Italy), had to abate their management costs. Among these costs, significant budget reductions involves the conservation and maintaining of green spaces (e.g. public parks, flower beds etc.). Nevertheless, the green cuttings might be valorized as feedstock for anaerobic digestion plants. The objective of this study was to assess the yearly availability of such biomasses and their suitability for biogas production as a way to increase Municipality's revenue.

Methodology

The green areas of Torino were quantified according to the data provided by the Municipality and classified into five categories: i) public gardens, ii) parks, iii) sport fields iv) public buildings and v) traffic islands. The amount of green biomass produced by each category was afterwards estimated according to the adopted management technique (e.g. fertilization, irrigation, cut frequency...) Samples of green cuts were collected, analyzed for their total solids (TS), volatile solids (VS) and fibers composition. Their BMP was then measured in 2,5 liters batch fermenters according to the VDI 4630 (2006) methodology [1].

Results

The City of Turin has approximately 2101 ha of urban green areas. The 80% of these surfaces are represented by public parks and gardens, whereas the remaining 20% by green areas belonging to public buildings, sport fields and traffic islands. Parks and gardens grasses are cut on average 4-6 times per year, whereas the 5% only of green spaces are cut more the 12 times a year. The average TS content of the collected samples was 22% and their measured BMP was 220Nm^3 per ton of total solids. According to the municipal green surfaces, their average biomass production and physical characteristics, approximately 10.000t of TS are yearly available on the municipal territory. By the anaerobic digestion of the whole green biomass produced, it might be possible to produce 2.100x10^3 m^3 of methane per year and, thus, to feed a 1MWel. installed power A.D. plant.

Conclusion

By the energetic valorization of the biomass derived from green urban areas it would be possible to produce approximately 8GWh per year of electric energy, corresponding to a yearly income of approximately 2,2Mio € for the municipality. Nevertheless, it must be pointed out that this type of biomass can be contaminated by inorganic pollutants that might be properly removed prior to anaerobic digestion.

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TE-O_16 Addressing the nexus of sanitation and energy towards increased living conditions in rural areas in Kyrgyzstan

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Objectives

This study was conducted to investigate the opportunities for upscaling sustainable local-made technologies for more comfort and better hygiene conditions in rural areas of Kyrgyzstan. The results are relevant for decision and policy makers, local administration and stakeholders.
The population of the Kyrgyz Republic remains largely rural with 64 % of its population residing in rural areas. Rural inhabitants face many problems in daily life: lack of safe sanitation, WASH related diseases, energy poverty (lack of heating, light and fuel) and low nutritional status. The project *Home Comfort*, which gained support from the EU, has created local capacity for improved rural living standards through sustainable energy and sanitation innovations.

Methodology

The innovative technologies included:

- Urine diverting dry toilets (UDDT) for comfortable and safe sanitation and production of fertilizers
- Solar water heaters (SWH) for hot water by solar energy
- Energy efficient stoves (EES), which allow people to save on wood and coal

For this study, a survey with questions about the current situation and the demand for innovative technologies was conducted among 407 rural residents in Issyk Kul and Naryn oblast. Additionally, interviews have been held with householders and project managers, and guest books at demonstration centres were reviewed.

Results and conclusions

The technologies have been successfully adapted and implemented, and they are appreciated by the villagers, especially by women. The combination of UDDT and solar water heaters made it possible to implement full bathrooms with a similar standard than in the cities.
The EES and SWH have good economic pay-offs compared to the traditional ways of heating or bathing. In fact, the savings they generate are respectively € 800 and € 1400 over a period of 10 years.
The results show that villagers, who often face challenges in their daily routines, are ready to take risks to improve their comfort and security. This is confirmed by the high number of self-financed replications of the technologies.
About 60% of the respondents (24% women) indicated to be willing to take a microcredit for one of the technologies. 6 to 11% of the respondents are willing to invest the full cost of the technologies, and 23 to 30% half of it. Yet, some barriers have been identified since some people are not able to invest the full amount of an innovation. Increased availability of microcredit with low interest rates, enabling political frameworks and additional capacity building are needed to overcome these barriers.

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TE-O_17 Resources recovery and economic aspects in the application of terra preta sanitation system in Arba Minch, Ethiopia

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Objectives

The objective of the study was to evaluate the application of terra preta sanitation [1] system in a case study settlement in Arba Minch, Ethiopia which consists of 1250 households. The system was assessed for its potential in terms of recovering nutrients and organic matter contained in human waste. Moreover, the economic feasibility of implementing the system was evaluated.

Methodology

Terra preta sanitation system was planned for the case study area consisting of two pathways for treatment and processing human waste: direct vermicomposting [2] and anaerobic digestion with subsequent vermicomposting of digested slurry. Material flow analysis was used to evaluate mass and nutrient flows and simplified economic evaluation based on lifecycle cost analysis of the sanitation system was used to assess the potential of the system to provide low-cost sanitation alternative.

Results

The results of material flow analysis show that nutrient and organic matter rich vermicompost can be produced by the application of terra preta sanitation system which can potentially cover the nitrogen fertilizer demand of 820 hectare agricultural area belonging to local state farm. The high organic matter and nutrient content of the vermicompost was associated with the conservation effect of the lactic acid fermentation process [3] which was considered to be applied as human waste collection method in terra preta sanitation toilet and also the high efficiency of vermicomposting process in conserving the nutrients available in the organic waste mixture. Potential production of biogas energy from human waste collected in terra preta sanitation toilet combined with other organic wastes was found to have significant implication for the local population as it can completely replace firewood and charcoal which are the currently used cooking energy sources. The results of economic evaluation showed that terra preta sanitation system can be applied in the case study area with net benefit considering the monetary values of the recovered resources in the form of fertilizer, soil conditioner and energy.

Conclusion

The findings suggest that the terra preta sanitation system enables the provision of economically self-sufficient sanitation service boosting local agricultural production through utilization of safely treated final sanitation products.

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TE-O_18 Treatment of deinking sludge from wastepaper recycling by anaerobic digestion

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Objectives

The use of recovered paper in paper production has increased steadily and has established itself as an important resource in many countries [1]. However, a more sustainable and economical handling of the large amount of deinking sludge produced during this process is still required. Deinking sludge is the wastewater stream from the deinking operation in a wastepaper recycling process. The goal of this study is to investigate the possibility to produce biogas form the deinking sludge.

Methodology

Biogas potential, methane yield and organic degradability under anaerobic conditions were studied for dewatered deinking sludge. A one Liter reactor test system operating in batch mode and also a two liter reactor test system operating in a semi continuous mode was used. Both were operated under mesophilic conditions. Essential trace elements (cobalt, nickel, molybdenum and selenium [2]) were added in some of the experiments and their influence was investigated.

Results

The Total solid content of raw and dewatered deinking sludge were 4% and 14% respectively and the organic matter content (basically lignocellulosic fibers and fines) were 34% and 30% of dry matter respectively in average. The large amount of the remaining inorganics consists e.g. Calcium carbonate which is used as filler in paper making. The maximum measured degradability of organics was 35%.

Maximum Methane yield of 173 mLN/g VS (substrate) was observed for the batch treatment and 223 mLN/g VS (substrate) for the semi continuous treatment. Improvement in methane yield of 42% was observed with the supplementation of a mixture of trace elements (TEs) when compared to the control (without TEs) in the semi-continuous experiments. The study showed that microorganisms need an adaptation time for the deinking sludge and for the trace elements which leads to improve activity and hence increase in methane yield.

Conclusion

Result showed that the deinking sludge investigated in this study is a bioresource with potential for biogas production. The biogas could be used for heat generation since heat demand in the waste paper recycling process is large and hence the additional heat source could be of economic benefit. The maximum measured percentage of organic degradability (35%) also shows that some amount of the organic fraction in the deinking sludge can be removed by anaerobic treatment. Adaptation of pretreatment operation such as enzymatic hydrolysis to breakdown large amount of the lignocellulosic material, consideration of nitrogen deficiency and long-term studies to explore the microbial adaptation to substrate and supplemented TEs are further optimization steps.

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TE-O_19 Energy production and resource recovery on sewage plants in Austria

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Objectives

Taking renewable energy production into consideration, waste water treatment plans were almost unattended in Austria till now. As investigations on real world case studies have shown, sewage plants can not only treat waste water, there is also a high potential for the efficient use of so fare wastes heat and other resources.

Methodology

Process Network Synthesis (PNS) is the main tool in this study optimising the waste water energy system. Based on the p-graph methodology [1] the programme estimates an economical optimal energy network taking all possible energy producing technologies and available resources into account. Furthermore an ecological evaluation of these calculated scenarios will be done be using the Sustainable Process Index (SPI) methodology [2]. These ecological footprint calculations will be done be SPIonWeb a free online tool available at: spionweb.tugraz.at.

Results

The internal energy requirements could be covered by the plant itself and even external at neighbouring infrastructures under certain conditions. First results show that especially the in-house heat demand on a plant could be covered by various technologies. For example heat exchangers and heat pumps using the warm waste water as source seem as having a high potential. Even amounts of the internal electrical energy demands could be covered by the waste water treatment plants itself. Moreover including local stakeholder helped to evaluate the potentials of the produced resources like heat, electricity and biogas and integrate them into the energy network of the plant and the surroundings.

Conclusion

The results of the PNS and SPI calculations for optimal energy producing technologies in an economic and ecological way on an Austrian sewage plant will be discussed. Additionally the different approaches for diverse case studies in terms of size and geographical surrounding will be explained.

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TE-O_20 Estimation of design values for greywater treatment units

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Objectives

New sanitation systems are based on the separate collection and treatment of different wastewater flows. For the design of treatment units and the assessment of environmental impacts, the knowledge of loads and concentrations is fundamental. For new sanitation systems the data basis on the characteristics of greywater is very weak. Therefore several sampling campaigns were carried out to characterise greywater and improve the available data basis.

Methodology

Goal of this study is the characterisation of greywater and improving the base of data on the one hand and the estimation of design values for greywater treatment units on the basis of five sampling campaigns conducted in different greywater systems. The sampling campaigns were carried out by the Bauhaus-Universität Weimar in Berlin “Block 6” and the ecological housing estate Lübeck “Flintenbreite”. During the sampling campaigns in Berlin “Block 6” and Lübeck Flintenbreite” a new flow proportional sampling-method was tested, which allows separate assessment of the liquid and the solid phase of the greywater flow. The collected data were analysed in terms of the organic pollution COD and BOD_5 and nutrients (N, P).

Results

The composition of Greywater composition varies widely depending on factors such as drinking water source, quality of water supply, water use, household activities, socio-economic, cultural factors and the country [1][2]. Literature reviews on greywater composition show a great variability in terms of volumes, concentrations and loads. The Results of the sampling campaigns in „Block 6“ and Lübeck “Flintenbreite” show on average higher concentrations for the organic parameters with about 470 – 490 mg/l for the BOD_5 and 780 – 820 mg/l for the COD. For TSS and VSS concentrations of 75 – 85 mg/l and about 60 mg/l respectively can be determined. The concentrations of total Nitrogen (TN) and total Phosphorus (TP) were in a similar range like other values found in the literature. The concentration of TN was about 15 mg/l and total Phosphorus TP was in a range from 4 – 7 mg/l. The Loads per capita and day for BOD_5 and COD showed ranges of 25 – 36 g/(c*d) and 44 – 67 g/(c*d) and were slightly higher than the literature values. During the sampling campaigns TP- loads around 0,4 g/(c*d) were found. The nitrogen load were in a range of 1,0 – 1,3 g/(c*d).

Conclusion

The compilation of greywater data demonstrates that the concentrations of greywater from households in a similar range than for domestic wastewater for organic parameters, but differ completely in the nutrients concentrations. Specific loads of COD and BOD_5 show that half of the organic load can be found in greywater, the nutrients-load is significantly smaller than in mixed sewage. Reliable capita specific loads are the basis for the design of treatment facilities for greywater.

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TE-O_21 Interfacing urban water management and agriculture – Transformation steps towards new alternative sanitation systems

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Objectives

Wastewater systems in rural areas do not yet meet the state of the technology. Additionally instable conditions such as demographic change or increasing energy prices occur [1]. This paper discusses value-added concepts by implementing New Alternative Sanitation Systems (NASS) in cooperation with agriculture. Thus the symbiotic system can enhance the energetic potential of both sections based on organic residues.

Methodology

In the context of the research project TWIST++ wastewater systems for two villages in Thuringia were conceptualized. These villages are supplied with a sewage system but do not hold a treatment plant. Part of our work is to identify transition approaches towards state of the technology. Thus NASS will not be implemented directly but gradually over a long time. Furthermore the determined concepts include cooperation with agriculture. Therefore appropriate partners in agriculture are identified. After specifying the concept fitting organizational models are designed.

Results

The reuse orientated concepts include a separation of black- and greywater. Together with organic residues from agriculture the blackwater is fermented in a biogas plant. The remaining greywater will either be drained to a central treatment plant or treated directly at each property. The on-site treatment has the advantage of possible drain water heat recovery.

To minimize the pitfall of sunk costs and problems of acceptance, transition steps were determined. Initially a vacuum sewage system is built. In further steps tube-in-tube reconstructions to separate grey- and blackwater and vacuum toilets are installed inside the houses. Subsequently a biogas plant can be built. There a mixture of blackwater, not yet separated wastewater and organic residues from agriculture are fermented. The integrative and regenerative energy generation und fertilizer production accomplishes an interconnection of urban feedstock supply and rural bioresource production.

Regarding to this interdisciplinary cooperation we exemplary investigated how organizational and institutional general regulations, which constrain the implementation of our approach, can be adjusted.

Conclusion

Water infrastructure in rural areas is impacted substantially by instable general conditions. The purpose of ensuring of public services by flexible and transferable approaches can be achieved with New Alternative Sanitation Systems [2]. Nevertheless a gradually implementation helps to establish successfully the proposed concept. Using the case of two Thuringian small villages, this paper presents ideas how similar concepts can be adapted in further regions to establish more flexible water infrastructure systems. An obvious trait of designed solutions is the near entanglement with agricultural framework conditions.

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Thematic Area TE – Sustainable regions
(Poster presentations)

Wood, processed photograph

TE-P_01 Agriculture as a mean of sustainable resettlements – A proposal of symbiotic agricultural and micro-economic projects for internal displaced persons (IDPs) in Darfur, Sudan

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Objectives

The objective of this project is to suggest a possible and convenient solution for sustainable repatriation and integration of the internal displaced persons IDP's living in camps around Nyala city south Darfur Sudan, by establishing sustainable water supplies and promoting a sustainable economy. As result of comprehensive analyses of the existing voluntary return programs performance.

Methodology

Data was collected from different governmental and nongovernmental bodies such as research and groundwater, water environment and sanitation program, UNHCR, and UNMID. It was validated through interviews with the head officers of the main wash, urban and rural planning players in the state, followed by statistical analyses to illustrate the current situation. System analysis approaches were used to define the root objective, and means. Plus, a causal map, and system diagram.

Results

Eight initiatives were formed to conduct a smooth and sustainable voluntary repatriation; by both governmental and humanitarian bodies. The previous initiatives addressing the issue followed a "donor approach" by attempting to provide readymade solutions / services (e.g. Building schools, facilitating return trip, and raise awareness). The initiatives failed to provide sustainable economic systems to the returnees, because the budgets of the returns programs 2012 is around 70.9 million, resulting on an output of only 81,000 returnees out of 1.7 million of IDP's. Major difficulties facing voluntary repatriation process are security, access to basic services, food insecurity, and lack of employment. This research claims that innovative symbiotic agriculture projects that integrates the urban lifestyle, and the rural means of production will be most suitable and convenient solution for IDP's; provides such services education, health, transport and sustain the main term of agricultural production, and lively stock. Furthermore, the water scarcity in the region is a good promoter for using green solutions such as water recycling, and rain water harvesting on agricultural activities.

Conclusion

The data used in this research was collected from a field study conducted by the researcher during a one month period volunteering job in the water environment and sanitation program, the main service provider for IDP camps. The data had been gathered, and validated, the observation remarks gathered from the IDP's. The data analysis illustrated the need for small and realistic agriculture projects which creates a small socio-economy that can lead to a sustainable repatriation and integration of the IDP's.

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TE-P_02 Sustainable urban rural proposal in Malinalco, Mexico – Case study

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Objective.

Designing a Rural-Urban Sustainable Development of six small businesses using Technologies Appropriates and human and natural resources of the region.

Observations.

Malinalco is a rural urban town whit population of about 10,000 inhabitants and 110 km. by road from Mexico City. There is a monolithic pyramid built by the Aztecs. Its main activity is tourism, only on weekends. There are particular business of raising and selling fish and twenty bakeries. Malinalco is semi tropical climate so it can be grown coffee. The closest coffee producer to Mexico City is 350 km. far away.

Case study description.

It proposes training in appropriate technology some people so they can build, produce and market different products to improve their diets and have economic and social benefit technologies.
Make a grain coffee process by the dry way using solar energy in this process wastewater is not generated.
Build a galley with local materials to raise chickens and feeding them with mixture of regional plants and sell the meat and eggs. Make another galley breeding rabbits and feed them with mix of regional plants. They can market the meat and skins. Manure can be used to make compost. Build a fish hatchery and feeding them with plants in the region. It can be sell the fish and take advantage of heads, tails, and bones for balanced feed. Build greenhouses to grow vegetables that can be marketed and with waste prepare balanced feed for chickens and rabbits food.
The battered tomato is difficult to market so it can mix with potatoes and make nutritional biscuits because the tomato contains minerals and potato carbohydrates.
The excreta of animals can be used in a process of anaerobic digestion and methane used as fuel for bakery oven.
All these economic activities can be located in one spot for easy intera-operation between them.

Conclusion

Each one of productive activities can be handled by groups of people who learn technologies to produce the products and get them to avoid technological dependence, besides their diet can be better by eating meat, fish, vegetables and biscuits while improving their income .

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TE-P_03 Systemic approach applied to a Mexican rural area, in order to improve the quality of life and economic well-being of people

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Objectives

Promote economic diversification combining traditional agricultural skills and new technical know-how.
Support and develop agro-food systems, thus contributing to sustainable, inclusive and economic growth in rural regions.

Case-study description

The project is located in Ahuacuotzingo, a Mexican rural area, State of Guerrero chosen because of its particular features related to food, both production and consumption. Take action on these aspects has environmental, social, economic and health consequences.
The area is characterized by low population and enterprise density, high unemployment and emigration, especially to the United States. This situation generates a radical change in food consumption and lifestyles, and a loss of material culture and know-how, because some people try to imitate other cultures losing totally its own know-how.

Observation

The population of this rural area, rather isolated, reveals to be intimately and intensely linked to the territory and to have a strong sense of belonging and aggregation. In addition, the farmers of the cooperative Ahuehuetla, with which we are working, they are very motivated for a substantial change towards sustainable rural development.
The Systemic project started from the analysis of the activities of six farmers in order to identify the materials and energy flows, and the main critical aspects.
The second step is the flows design according to the intention of tending to zero waste. The objective is to reach the satisfaction of the agro-food demand of the people of Ahuacuotzingo by intervening on production but also changing dietary habits. The project aims to produce healthy, local and clean food, linked to the rural Mexican tradition. Also educational and social aspects are important: the Ahuehuetla cooperative owns a community space (Cavideco), where it is possible to make and sell food, as well as being a meeting point for seminars and workshops. Cavideco could be the link between the cooperative and the population, so that both can benefit from the systemic project.

Methodology

The methodology applied in this project is the Systemic Design Approach, because it plans open systems with a strong reduction in the waste production and with benefits for the whole community: from a better environmental quality to the creation of new job placements. The first guide-line of this approach is that the waste (output) of a system must become resources (input) of another system. In this way the system generates for itself resources, content and meaning, by updating and developing independently.

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TE-P_04 Unemployed young people and periurban agriculture – Case of Madrid

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Objectives

Agriculture is losing importance around urban area of Madrid from decades ago. Periurban familyfarming has been one of the main harmed. However, currently, unemployed young people consider agriculture as a professional option, as a result of socioeconomic crisis. This research systematizes and analyses young people´s discourses about agriculture, barriers and stimuli that they find it to work in this area.

Methodology

Universe: Unemployed young people (less than 40 years) and young farmers living in Las Vegas region, the best agrarian periurban area of Madrid. This area includes 21 towns.
Qualitative methodology: 21 interviews to key players; 6 focus groups to stakeholders included in the universe. Structural sample consider next variables: agrarian family tradition, sex, age.

Results

Unemployed rural and periurbanyoung people (UYP) need an alternative employment opportunities. Currently, Madrid cannot offer enough jobs so little towns need find occupation for their young people. Madrid is a huge market with a lot of kind of consumers. They buy agrarian products from all around Spain; however Madrid is surrounded for neglected meadows. Historically, these meadows offereda broad variety of commodities, from staple food produce to cash crops.
Do UYP consider agriculture as a professional alternative? What kind of barriers and stimuli do they find?
Firstly they talk about economic barriers (initial investment, access to land, difficulty of negotiating with large distributors). Basically, they consider agriculture is not profitable and hard work. However if we continue listening their discourses we can find the most important barrier. Social perception of agriculture is very poor and farmers wish their children do not work in agriculture: “study and work outside agriculture”.
However, current socioeconomic context is knocking down this barrier. Some UYP are considering agriculture like alternative. Innovation and tradition work together and we can find some entrepreneur in these meadows. They demand information, training, advisory services, initial public support…in short, they are demanding extension services. A new kind or revitalizing extension services is necessary.

Conclusion

Periurban agriculture is emerging like professional alternative in Madrid. Socioeconomic context obliges to get over psicosocial barriers and some UYPs are starting agrarian project in this periurban area. They need a revitalized extension services to support them.

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TE-P_05 Ecological restoration approaches for degraded forrests in landscape scale – Functional roles of corridors

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Objective

The ecological status the water catchment around a city is often the key to water and food security. The main objective of this study is to apply a new methodology, that complements the availability of data and status of degraded forests, to reduce forest fragmentation by emphasize on roles of corridors.

Methodology

The method outlined here follows the conceptual "corridor" functionality for defragmenting in Shafarud watershed, which is located in in the northern part of Iran, with approximately 39,800 hectares of forest.
Data collection is conducted through the extracted satellite images from *Indian Remote Sensing (IRS)* including land use, roads, and river maps. For computing fragmentation, all of these maps are overlaid in Shafarud landscape. Priorities of restoration are evaluated by taking into account paths' shape, surface area (i.e. more than 1 hectare is recognized as a patch in this study), distance to river, and distance to roads. As acknowledged, a row of stepping-stones is a non-continuous way to connect two patches [1, 2], which can greatly increase species' mobility and ability to disperse in a fragmented landscape [3]**.** Thus, we recognize stepping stones as the corridors of patches in this survey.

Results

About 56 patches (i.e. natural and man-made), with a total area of 228 hectares, are identified for establishing corridors in Shafarud watershed. The whole area has about 683 patches with a surface area of 36,200 hectares. According to the defined restoration priority, around 109 hectares with priority of 1 (i.e. highest rank) are recognized as a suitable option for establishing the corridors, rather than 51 hectares with priority of 2 (i.e. moderate state), and 68 hectares with priority of 3 (i.e. worst state). Because of connections which are provided by the corridors, different species can move easily between the fragmented forests and this will prevent the isolation of species. Thus, our proposed approach develops natural functions inherent in the forest landscapes. And on top of this, biodiversity of the region could be maintained.

Conclusion

Maintaining the integrity and sustainability of an ecosystem are crucial issues in a regional development plan. Regarding the integrated environmental model, forest is considered as a valuable and important part of an ecological structure. Ecological restoration in degraded forests is achievable by connecting fragmented forest through suitable corridors. Several environmental issues could be attained in the region by creation of vegetational corridors namely preventing soil erosion, controlling floods, and preserving biodiversity. Thus, the resilience of cities can be improved.

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TE-P_06 Biosolid recycling in agriculture – A case study, Cairo sludge disposal study

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Objective

The Cairo Sludge Disposal Study is being funded within the Mediterranean Environmental Technical Assistance Programme (METAP) through the European Investment Bank (EIB). The study is a demonstration programme to show how the problems of sludge disposal from large rapidly developing cities, such as Cairo, can be solved through the establishment of a practical system for the safe reuse of sludge in agriculture.

Case study description

27 field trials were undertaken, most continuing over the three years and including six seasons of arable crops. The total trials area extended to 200 fd(83ha). The data from all of these trials were summarized and interpreted, and the findings used in the development of focused agricultural advice in the extension and farmers' guides, and to support the scientific basis for the strategic sludge management plan.

Observations

The field trials programme demonstrated the effectiveness of solar-dried raw and digested sewage sludges as fertilizers and soil conditioners for arable crop production on alluvial clay soils of the Nile delta, and sandy soils on reclaimed land. The main factors influencing crop responses to the applied sludges were:rapid and slow N release characteristics of the sludge; Improved fertility of soil from cumulative applications of sludge; Crop requirement for, and sensitivity to, N; Soil type; and Irrigation method. Sewage sludge is also effective as a fertilizer and soil conditioner for fruiting tree crops on reclaimed land. Composted sludge is particularly effective at improving production of fruit, but raw and digested sludges were equally as effective as FYM at increasing yields. The suggested recommended rate of sludge application to fruiting trees is 15 - 20 kg per tree. Extensive chemical analysis of field and fruit crops from the trials (25,000 individual plant tissue analyses were reported by the Study) did not reveal any significant relationships between heavy metal additions from sludge to soil and the concentrations present in plant tissues, which were in the normal ranges reported for crop plants in Egypt . Heavy metals accumulate in soil only very slowly when repeated applications of sludge are made, and it may take many decades or centuries to reach concentrations that could cause toxicity to plants or animals or man eating the crops. The potential risks are small due to the relatively low concentrations in Cairo sludges.

Conclusion

In overall assessment of the practical situation in Egypt and from a scientific perspective, the use of sewage sludge in agriculture is justified and would appear to be the most sensible and sustainable solution to the management of sludge produced from great cities.

TE-P_07 Methodology for geo-based bioresource inventory shown on a case study of the town of Beočin, Serbia

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Objectives

When comparing the big centralized energy systems, with the local energy communities, the latter have more advantages in becoming self-sustainable, with closed energy and material loops. Therefore the objectives of this work were to show that classifying urban and suburban bioresources in selected communities can show substantial energy potential, making these communities more resource-independent. This energy potential can be locally utilized, e.g. in an urban biogas digester, which can be coupled with the current natural gas district heating system.

Case Study Description

To show the methodology for a GIS-Based bioresource inventory, an appropriate community with a good bioresource potential was selected. The town of Beočin in Serbia has already good predispositions in terms of resource potential and infrastructure (e.g. district heating). Within the town, an evaluation of spread and the utilization of the bio residues was made. The bioresources considered were the biodegradable fraction of the municipal waste, the public park maintenance residues, and private lawn cuttings (private green waste). In the case study, it was first determined how much can specific bioresources yield. The urban biomass yields in respect to area, and applicable to the GIS processing were taken from [1] and [2], respectively. Finally, the CO_2 savings and primary energy substitution as well as the management of the digestate were determined.

Results

The urban area of the town of Beočin was processed in ArcGIS, mapping the individual households with respective lots, as well as lots of public surfaces (parks, meadows, woodland). This resulted in the GIS-inventory results of the public green areas, consisted of several meadows and a park amounts up to about 1.72 mio. m^2, which then have around 1204 t/a grass yield. The private green areas in the urban area amounts up to 2.15 mio. m^2, which totals up to 3655 t/a green waste yield. The total weight of these resources are 5699 t, the organic dry matter is around 14%. The primary energy is around 1718,000 kWh, a biogas plant of around 75 kW_{el} and around 118 kW_{th} can be constructed. Since the bioresources must be delivered to the biogas plant, yearly 212 truck tours are needed. The CHP plant could prevent 597.5 CO_2/a of emissions. The bioenergy can substitute around 2% of electrical energy, and about 8% of the heat energy consumed. The amount of digestate is calculated at 5030 t/a, and the amount of needed land for application is 140 ha.

Conclusion

As it is seen, the results show that there are substantial, in this case practically unused, amounts of bioresources within the urban communities, which can be identified and dimensioned using GIS processing. The results shown however were compiled based on several theoretical assumptions, so they may vary from case to case or from season to season. Still, the good side of this type of GIS-inventories is once the model of the inventory is made, it can be easily upgraded or modified in order to achieve a greater precision. The quality of the results is here analogue to the input details.

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TE-P_08 The effect of long term storage of dogs´ excrements with "Enviro" lime on the survival of helminth eggs

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Objectives

Regarding the spread of helminthoses, domestic animals (dogs, cats) are of great importance because they live in a close contact with man. Through faeces of infected animals the germs of parasitozoonoses spread into the environment. The most serious problem is the sanitation of the faeces. The aim of the study was to monitor the effect of long-term aerobic storage (73 days) of dogs´ excrements with or without "Enviro" lime on the survival of model helminth eggs under laboratory conditions.

Methodology

Dogs´ excrements mixed with hay in the ratio of 1:5 and mixed with "Enviro" lime in a concentration of 20 $g.kg^{-1}$ and 70 $g.kg^{-1}$ mxture were used in the experiment. The "artificial contamination of organic wastes" with unembryonated *Ascaris suum* eggs was used approach to make sure that there was a sufficient number of positive samples in our observations. Eggs were inoculated at a dose of 1000 eggs per carrier into polyurethane carriers and introduced into the wastes. The methods used for monitoring physical and chemical properties of organic wastes corresponded to the STN 465 735. The C content was calculated according to the content of OM by the method of Navarro et al. (1993), and the C:N ratio was calculated. Samples were collected after 0, 1, 2, 3, 7, 8, 9, 10, 14 and 73 days of the storage. Three samples were taken and analysed at the given sampling intervals.

Results

An application of "Enviro" lime to the mixed dogs' excrements at a concentration of 20 g.kg-1 of organic wastes, resulted in a devitalisation of 65.65 ± 2.84 % and at a concentration of 70 g.kg-1 77.05 ± 2.36 % of model unembryonated A. eggs within 24 hours. A. suum eggs were totally devitalised as early as within 8 days in dogs' excrements after application of "Enviro" lime at a concentration of 70 g.kg-1 and within 21 days after application of lime at a concentration of 20 g.kg-1. 87.23±3.21 % of eggs were devitalised in the control without lime in the end of experiment.

Conclusion

The issues of safe sanitation and waste management are highly topical as it has been universally acknowledged that the majority of endoparasitic germs is able to cause infection in animals and humans even a year or two later. For the sanitation of dogs' excrements, the use of "Enviro" lime, is very suitable.

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Acknowledgement

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TE-P_09 Integrated management of water resources with an innovative aquaponic system under greenhouse conditions in Spain

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Objectives

The objective of this study is to design, develop and validate a prototype of aquaponic system under greenhouse conditions which is a combined production system of tomatoes and tenchs with a sustainable and integrated management of re-used wastewater as a water resource for the crop and potable water for the canals where tench fishes are being fattened.

Methodology

This prototype has been provided with five canals to fatten tench and with ten lines of a hydroponic pure system (NGS®). Fifty tench young fishes have been fattened in each canal during a period of time of twelve months. Three different strategies of water management have been evaluated during the first tomato cropping season; and one strategy has been used to validate it during a second tomato cropping season.

Results

The treated wastewater of cities can be used to produce vegetable crops in semiarid areas such as the province of Almeria, in which the annual rainfall is lower than 300 mm. The recirculation of the nutrient solution prepared with this re-used wastewater in a pure hydroponic system to grow a tomato crop with “nude roots” has produced high yields and it has reduced the amount of water required to grow this crop. The use of hanging growing canals to develop a tomato crop has enabled the combination of two production system under the same greenhouse structure: tomato crop production and fish fatten. The re-used of effluents produced in the canals to the NGS system provides the tomato plant a source of nutrients rich in ammonium, nitrates, phosphates and organic substances, reducing the amount of mineral fertilizers and water that must be used periodically to prepare the nutrient solution of this closed hydroponic system. The species of fish selected (*Tinca tinca*) has good business skills and has the same thermal requirements that the tomato crop. The necessary fatten cycle of tench species to reach a weight of 200 gr can last twelve months, and it is completely compatible with the cropping season of a tomato crop.

Conclusion

This innovative aquaponic system is a model of sustainable production system in which urban sewage water and effluents from canals for fatten tench fishes are re-used to growth a tomato crop, reducing the use of inputs (water, fertilizers and organic materials) and increasing the benefits obtained per area unit.

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TE-P_10 Changes in farming production strategies with wastewater in Sacaba Valley, Bolivia

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Objectives

This study identifies farming production strategies with wastewater in Sacaba Valley to contribute to assessment of their risks. It has two objectives. The first one was to identify characteristics of production with wastewater. The second one was to know the changes shown in such characteristics during the last ten years to identify the factors that caused these changes.

Methodology

It consisted in transect walks alongside the river that receives wastewater, on-farm enquires to 19 farmers, semi-structured interviews, field observation and revision of secondary information. Identified production strategies and practices have allowed classifying plots according to intensity, type of crops and agricultural practices in production systems. Comparing former and current characteristics have served as a basis to identify main factors that originated such changes.

Results

Three production systems have been identified: a) horticultural semi-intensive, b) forage semi-intensive and c) horticultural intensive. Two main changes have been identified in production strategies on these systems: the search for alternative sources of water –which has resulted in one type of on-site treatment by filtration– and change of produced crops. These changes have been triggered by six main factors, four of which have already been mentioned by Raschid-Sally et al (2004) –i.e. reliable flow availability, farm size, village conformity, market access– and two are news: social pressure and organization level of farmers.

Conclusion

Understanding of the main factors that explain the situation of production systems can be achieved during the process of risk assessment, and information that they provide may be useful as a part of a long term planning for sustainable use of wastewater. On the other hand, it is a need to get reliable data about the resulting risk of identified production practices, strategies and the on-site treatment.

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TE-P_11 The water-energy-food-nexus and international trade – Australia's water trade offs through energy and virtual water exports

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Objectives

Australia is facing water scarcity as a continent with limited water resources and thirsty industries. Two of the economical pillars are agriculture and mining, which are in this case competing for water. A case for close synergetic links of the water-energy-food nexus spiraling into water scarcity used to develop a new nexus framework by focusing on international trade as one of the driving forces.

Methodology

Trade data specifically on agricultural goods and energy carriers were used in combination with water footprinting [1] data to generate estimations of the competing sectors for water resources. This got cross referenced with estimations on water resources. A discourse analysis on these conflicts helped to identify sectors driving water-energy-food nexus synergies to develop a more detailed new nexus framework for future analysis.

Results

The synergetic links between resource cycles amplify the already critical situation with international trade as one of the major motors. Conflicting interests between water and energy got most visible in Australia's movements against uranium, coal and most recently gas mining through hydraulic fracturing. At the same time a case for conflicting discourses resulting in a growing one on sustainable resource usage as a precondition for a fast developing organic farming industry during the last decades as one way of using synergies between resource cycles.

Conclusion

Therefore, resource cycles as a nexus connected are heavily influenced by the forces of globalization [2] and hegemonic struggles on quantities and ways of resource exploitation. More dimensions have to be included into the nexus framework to make the anthropogenic link more visible and analyzable.

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TE-P_12 Volunteers to translate waste prevention policy to citizens

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Objectives

Flanders (northern part of Belgium) is one of the best students in the field of separate collection of waste. This also counts for the organic fraction. A large amount of organic residues are processed by the people, at home or in their gardens. The Flemish government wants (cfr. the so called Materials Decree) to further increase the number of home processors and the quality of home processing of these organic materials. To put this into practice, Flanders follows a very specific and unique approach.

Methodology

In Flanders, Vlaco npo supports and implements the policy of biowaste. Vlaco is a membership organisation with representation of both the Flemish government (OVAM and intermunicipal waste associations) and the private sector (private waste treatment companies). All the Vlaco activities support the sustainable material cycle of biowaste.

The 'Biocycling at home' unit of Vlaco focuses on raising an environmental awareness concerning bio-organic materials. All individuals are to be sensitized and convinced in a different way. On the longer term 'Biocycling' (or 'Kringlopen', a verb in dutch) must evolve in a 'way of life'. A 2-fold awareness approach has proven its success.
First approach: the Vlaco-unit has trained several thousands of volunteers the past 15 years. These volunteers (so called Biocycle Volunteers / Master Composters) assist the Municipality by promoting the 'Biocycle at Home'. They communicate about different techniques to achieve the biocycle of:

- Food waste
- Lawn
- Prunings
- Home composting and compost use
- Chicken keeping
- Perennials
- …

The second approach 'goes' directly to the public by organizing courses, campaigns, distributing brochures, posters … , communicating by several types of (social, internet or paper) media, and through intermunicipal waste associations and the local environmental services.

Results

Research shows that this approach makes sense. About 52 % of the inhabitants composts at home, and more than 75 % applies one or another biocycling technique to process organic waste at home. The unique co-operation model with authorities on different levels, a network of well trained teachers and trained volunteers who sensitize citizens was and still is successful.
The last years, we see that citizens still want to engage themselves and like to co-operate in organisations, but they want to do it in a more noncommittal and trend-sensitive way. Social media and direct action are playing an important role in this.

Conclusion

The 2-fold policy followed clearly has a positive result, but integrating the experience and knowledge of our original volunteers in the new ways of communicating and community creating, is the challenge for the future, and at the same time it is also the assurance that the biocycle message is alive and meaningful!

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