Nutri2Cycle

D7.5 Practice abstracts of ongoing work - midterm update

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1. Table of contents

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2. Follow-up to first EIP abstracts

As a H2020 multi-actor innovation project Nutri2Cycle is committed to ensuring a continuous exchange of knowledge with interested stakeholders through different channels and this throughout all stages of the project and well beyond project-ending. A specific tool for this purpose are practice abstracts, a common format set by the agricultural European Innovation Partnership (EIP-AGRI) to share and spread project activities and outcomes to a broad range of actors related to sustainable agriculture within EU.

In the first reporting period (M1-M18) the consortium developed 11 practice abstracts, presenting the major research lines that will be managed within Nutri2Cycle and the early research results (see deliverable D7.4). This particular follow-up deliverable compiles the next 16 practice abstracts that were developed in the period M18-M36, focusing on operational experiences and practical guidelines. The table below summarizes the total of practice abstracts as generated by the project, together with their their publication status on the EIP-AGRI website and intended target audience.

PA title	Status	Target audience
Reducing EU's dependence on protein import (e.g. soy bean) by local production of novel animal feeds from agro-residues	Submitted	All stakeholders
Substituting primary resources by biobased products for a more sustainable European agriculture	Submitted	All stakeholders
Solutions for more nutrient efficient plant production as investigated by the H2020-NUTRI2CYCLE project	Submitted	All stakeholders
Innovative solutions for optimized nutrient & GHG in animal husbandry	Submitted	All stakeholders
Enhanced recycling of (organic) carbon within European agricultural systems	Submitted	All stakeholders
Short term N-effect of recycling-derived fertilisers focusing on crop yield and N losses to the environment	Submitted	Arable land farmers, advisors, researchers, policy makers
Nitrogen and phosphorus recovery from pig manure via struvite crystallization and design of struvite based tailor-made fertilizers	Submitted	Animal husbandry, (pig) farmers, researchers
Use of an inoculate of microbiota and enzymatic precursors to reduce ammonia emissions and optimize nutrients use efficiency	Submitted	Animal husbandry farmers, researchers
A study case on the use of digestate as bio fertilizer: characterization and environmental assessment	Submitted	Biogas operators, arable land farmers, researchers, policy makers
Closing the loops at farm scale : using livestock manure to fertilize feeding crops on agroforestry plots	Submitted	Farmers in general yet with interest toward mixed farming systems in particular
Substituting mineral inputs with organic inputs in organic viticulture	Submitted	Viticulture farmers

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Partial substitution of mineral fertilizers by animal manures in an apple orchard	Submitted	Animal husbandry farmers,
Enhanced manure recycling by producing manure-based fertilizers	Submitted	Animal husbandry, arable farmers, researchers
Use of digestate in orchards	Submitted	Arable farmers
Lemna minor cultivation for treating swine manure and providing micronutrients for animal feed	Submitted	Animal husbandry, pig farmers, policy makers
Poultry and chicken manure management - practical considerations in Polish conditions	Submitted	Poultry farmers
Short term N-effect of recycling-derived fertilisers focusing on crop yield and N losses to the environment – 2nd year	Submitted	Animal husbandry, pig farmers, researchers
Using digestate, precision agriculture and no-tillage to increase soil quality and organic matter stocking in soil	Submitted	Arable farmers, policy makers
Producing bio-fertilisers from pig manure through different separations stages	Submitted	Animal husbandry farmers, biogas operators, policy makers
Are consumers willing to pay a premium price for sustainable food?	Submitted	All stakeholders, policy makers, consumers
Refining bio-based fertiliser has limited effect on potato yield	Submitted	Animal husbandry farmers, advisors
Precision farming and optimised application: under-root application of liquid manure for maize and other row crops	Submitted	Arable land farmers, advisors
Upcycling of food grade animal bone by-products for recovery and reuse of concentrated BioPhosphate products with BIO-NPK-C formulations	Submitted	Fertiliser companies, arable farmers, policy makers
Poultry manure derived biochar as a sorbent for removal of various contaminants	Submitted	Poultry farmers, researchers
Fertilizing products from poultry manure	Submitted	Poultry farmers, researchers
Energy recovery from poultry manure	Submitted	Biogas operators
Using soil electrical conductivity and NDVI to identify distinct fertilizing areas in a vineyard	Submitted	Arable farmers, researchers

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3. Compilation of practice abstracts

Practice abstract 12

Short title (in English): Partial substitution of mineral fertilizers by animal manures in an apple orchard

Short summary for practitioners (in English)

The excessive use of mineral fertilizers seen in the last few decades has contributed to an increase in environmental impacts, such as water contamination, soil erosion and resource depletion. To maintain crop productivity high but its impacts low, it is vital to promote the recycling of nutrients and to increase resource use efficiency. The present work's aim is the substitution of the conventional mineral fertilizers with manures and slurries, thus taking avail of livestock production wastes and hopefully maintain crop productivity but with less impacts. As such, it is important to study the effects of organic (manures and slurries) versus mineral fertilization. In our trials, cattle manure, poultry manure, cattle slurry, and acidified cattle slurry were applied to soil in an apple orchard, with the purpose of evaluating fruit production and quality, greenhouse gas (GHG) emissions and soil nutrient content. Regarding fruit production, there were no significant differences between the mineral and the organic treatments, indicating that the organic materials did not injure crop productivity as one would expect due to their characteristic slow mineralization rate, however, leaf analysis has shown that the organic treatments presented higher content of phosphorus, potassium, and boron, indicating that the plants were able to obtain nutrients from the manures and slurries. However, the organic treatments produced more GHG, although it is worthy to note that acidified cattle slurry has significantly reduced CH4 emissions when compared to raw cattle slurry, hence reducing the environmental impacts associated with slurry application. More results are expected, as the trials are still on-going, nonetheless the outcomes seem promising. Replacement of mineral fertilizer by manure in orchards fertilization is an excellent tool to improve the soil quality but also to decrease the carbon footprint of apple production. Furthermore, the use of manure might be beneficial for maintenance of soil cover.

Short title (native languange): Substituição parcial da fertilização mineral por estrumes e chorumes num pomar de macieira

Short summary for practitioners (native language)

O uso excessivo de fertilizantes minerais visto nas últimas décadas tem contribuído para o aumento dos impactos ambientais, como a contaminação de água, erosão do solo e esgotamento de recursos. Para manter a produtividade alta, mas os impactos baixos, é vital promover a reciclagem de nutrientes e aumentar a eficiência do uso de recursos. O objetivo do presente trabalho é a substituição dos fertilizantes minerais convencionais por estrumes e chorumes na fertilização de pomares de macieira, aproveitando-se dessa forma os resíduos da produção pecuária mantendo-se a produtividade da cultura e reduzindo os impactos ambientais associados. Como tal, é importante estudar os efeitos da fertilização orgânica (estrumes e chorumes) versus mineral. Os nossos ensaios utilizarão estrume bovino, estrume de aves, chorume bovino e chorume bovino acidificado, com o objetivo de avaliar a

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produção e o desempenho da cultura, as emissões de gases com efeito estufa (GEE) e o teor de nutrientes no solo. Em relação à produção de frutos, não houve alterações significativas entre tratamentos, indicando que os materiais orgânicos não prejudicaram a produtividade da cultura como seria de esperar devido à característica taxa de mineralização lenta, no entanto, a análise foliar mostrou que os tratamentos orgânicos apresentaram maior conteúdo de fósforo, potássio e boro, indicando que as plantas foram capazes de utilizar os nutrientes nestes tratamentos. No entanto, os tratamentos orgânicos produziram mais GEE, embora o chorume bovino acidificado tenha diminuído significativamente as emissões de CH4 quando comparado ao chorume bovino bruto, reduzindo assim os impactos ambientais associados à aplicação de chorumes. Esperam-se mais resultados, pois os ensaios ainda estão a decorrer, mas os primeiros resultados parecem promissores. A substituição de fertilizantes minerais por estrume ou chorume na fertilização de pomares é uma excelente ferramenta para melhorar a qualidade do solo, mas também para diminuir a pegada de carbono da produção de maçã. Além disso, o uso de estrumes e chorumes pode ser benéfico para a manutenção do coberto vegetal na entrelinha.

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Practice abstract 13

Short title (native language): Enhanced manure recycling by producing manure-based fertilizers

Short summary for practitioners (in English)

The production of a manure-based fertilizer will proportionate a more sustainable agriculture practice through the valorisation of animal manure in a circular economy. Hence by adding an organic material to the soil the carbon soil reserve should increase and thereby improve its fertility and productivity. The production of a manure-based fertilizer will allow a better control of the nutrients flow, since it will ensure a decrease in the nutrient losses associated with the raw manures, such as ammonia emissions or nitrate leaching. Also, one of the difficulties in applying manure is the nutrients' concentration that are unbalanced for the crop's necessities, so in that case, this production aims to produce a fertilizer based on the mixture of manures, treated or not, that will have a known ratio of N:P. In that line, two scenarios are possible, one at farm scale where the farm manure can be amended with a small amount of mineral fertilizer to achieve the desired N:P ratios, and a second scenario where, at a central plant, different manures will be blended between them also to reach the intended N:P ratios. In both scenarios, the intention is to use mineral fertilizers as a complement and not as the main nutrients sources. The manure-based fertilizer will allow to close the nutrient cycle since the solution proposed here intended to reduce the known environmental impacts of manure application to the soil and, by reducing nutrients losses, the agronomic results should be comparable to the mineral fertilizers. The results obtained in this project showed at farm scale, it is possible to improve the agronomic value of manure by using some simple treatment as separation or by using some additives. It is to believe that such improvement might contribute to a wider use of manure as substitute of mineral fertilizers.

Short title (native language): Produção de fertizante orgânico com base em efluentes Pecuários

Short summary for practitioners (native language)

A produção de fertilizante orgânico com base em efluentes pecuários, irá proporcionar práticas agrícolas mais sustentáveis, pela valorização de efluentes pecuários numa filosofia de economia circular. Não obstante, a adição de material orgânico ao solo irá aumentar a sua reserva de carbono e por conseguinte melhorar a fertilidade e produtividade do mesmo. A produção do fertilizante orgânico irá permitir um melhor controlo dos fluxos de nutrientes, visto garantir uma diminuta perda de nutrientes associada aos efluentes em bruto, tais como as emissões de amoníaco ou a lixivição de nitratos. Por outro lado, uma das dificuldades em aplicar efluentes pecuários é a sua concentração de nutrientes, que é desproporcional face às necessidades das culturas, pelo que este trabalho terá o intuito de produzir um fertilizante através da mistura de efluentes pecuários, com ou sem tratamento, que terão um rácio de N:P conhecido. Neste sentido, criaram-se dois cenários, o primeiro atuando ao nível da exploração onde ao efluente da mesma será adicionada uma pequena quantidade de adubo para perfazer os rácios requeridos, enquanto no segundo criou-se uma central de processamento onde ocorrerá a mistura dos efluentes entre si para obter igualmente os referidos rácios. Em ambos os cenários, a intenção é que a fertilização mineral passe a ser um complemento. A produção do fertilizante orgânico irá permitir fechar o ciclo de nutrientes visto que a solução proposta pertende reduzir os impactos ambientes associados à aplicação de efluentes em bruto e pela redução da perda de nutrientes é expetável uma performance agronómica similar à aplicação de fertilizantes minerais.

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Os resultados obtidos neste projeto mostraram que é possível, à escala da exploração, melhorar o valor agronômico dos estrumes e chorumes usando alguns tratamentos simples como a separação ou usando alguns aditivos. Acredita-se que tal melhoria possa contribuir para uma utilização mais ampla dos estrumes e chorumes como substitutos de fertilizantes minerais.

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Practice abstract 14

Short title (in English): Use of digestate in orchards

Short summary for practitioners (in English)

The Nutri2Cycle project will assess the current Nitrogen (N), Phosphorus (P) and Carbon (C) flows looking into existing management techniques in different farms across Europe and analysing their related environmental problems. One of such technologies is the application of digestate in orchards. If taking into consideration that the vast majority of Croatian farmers don't apply digestate in agricultural production, one could conclude that digestate application can be considered as an innovative solution. Application of digestate in large scale orchards may have been applied across EU already, but it is considered to be an innovative management solution in Croatia. Furthermore, when digestate is applied it is usually for the energy crop production and not in long-term plantations. The underlying working principle refers to the application of digestate in raspberry plantation in the beginning of the project. In the phase of soil preparation, a combination of $Ca(OH)_2$ in concentration of 1,00 t/ha, thick fraction of digestate in concentration of 50,00 t/ha and cattle manure in concentration of 33,00 t/ha was used. Also, next to organic fertilizers, 30 grams/plant of mineral fertilizer (NPK 7-20-30) was also applied. When investigating existing research databases, there were no specific research found on application of digestate in raspberry plantation. Use of digestate contributes to the Nitrogen and Carbon cycles in agriculture. It can also increase soil biodiversity, while reducing erosion, leaching and water pollution Numerous research findings indicate that digestate from agricultural biogas plants cannot only be a good fertilizer but also an effective mean to close the carbon cycle in the soil for a more sustainable agriculture. To conclude, digestate in Croatia is often neglected in application. When deciding, farmers should take into account important benefits that digestate has for crops, such as presence of high amounts of easily accessible plant nutrients, improved physical structure of soil, reduced ammonia emissions, and the appearance of unpleasant odours. Considering these aspects, farmers now have a new and significant role in society, as both, crop and energy producers and waste processors.

Short title (native language): Primjena digestata u voćarstvu

Short summary for practitioners (native language)

Projekt Nutri2Cycle će osigurati važna dostignuća za održivo i učinkovito upravljanje prirodnim resursima. Također, predmetni projekt analizira trenutne tokove dušika (N), fosfora (P) i ugljika (C), odnosno postojeće tehnologije njihovog upravljanja na poljoprivrednim gospodarstvima. Jedna od takvih tehnologija je i primjena digestata u voćarstvu. Ako se uzme u obzir da velika većina hrvatskih poljoprivrednika ne primjenjuje digestat u poljoprivrednoj proizvodnji, moglo bi se zaključiti da se primjena digestata smatra inovativnim rješenjem u poljoprivredi. Primjena digestata u voćnjacima velikih površina možda je već i zastupljena u cijeloj EU, ali u Hrvatskoj se smatra inovativnim rješenjem. Nadalje, kada se primjenjuje digestat, njegova primjena je učestalija u proizvodnji energetskih usjeva, za razliku od primjene u dugogodišnjim nasadima. Temeljni princip rada odnosi se na primjenu digestata u nasadu malina na početku projekta. U fazi pripreme tla kombinacija $Ca(OH)_2$ u koncentraciji 1,00 t/ha, kruti digestat u koncentraciji 50,00 t/ha i goveđi gnoj u koncentraciji 33,00 t/ha je korišten. Također, uz organska gnojiva primijenjeno je i 30 grama/biljci mineralnog gnojiva (NPK 7-20-30).

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Tijekom istraživanja postojećih baza podataka, nisu pronađena značajna istraživanja o samoj primjeni digestata u voćarstvu. Korištenje digestata doprinosi ciklusima dušika i ugljika u poljoprivredi. Također, primjena digestata doprinosi povećanju biološke raznolikosti tla, istovremeno smanjujući eroziju, ispiranje i zagađenje vode. Nadalje, istraživanja pokazuju da digestat iz poljoprivrednih bioplinskih postrojenja može biti i gnojivo, ali imati i značaj u zatvaranju ciklusa ugljika u tlu radi održivije poljoprivrede. Može se zaključiti da je digestat u Hrvatskoj često zanemaren u primjeni. Poljoprivrednici bi trebali razmotriti najvažnije prednosti, koje uključuju prisutnost velikih količina lako dostupnih biljnih hranjivih tvari, poboljšanu fizičku strukturu tla, smanjenu emisiju amonijaka i pojavu neugodnih mirisa. Uzimajući u obzir gore navedeno, poljoprivrednici stječu novu i važnu ulogu u društvu, kao proizvođači energije i prerađivači otpada.

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Practice abstract 15

Short title (in English): *Lemna minor* cultivation for treating swine manure and providing micronutrients for animal feed

Short summary for practitioners (in English)

Treatment and nutrient recovery of waste streams have an essential role in improving the sustainability of conventional agriculture. *Lemna minor*, small floating-flowering aquatic plants known as duckweed, has been shown to grow on wastewaters and subsequently produce a protein-rich feed ingredient suitable for pig production, offering a possible solution for addressing both the protein scarcity and local nutrient abundancy. In this study, the potential of *Lemna minor* to valorise agricultural wastewater into a protein-rich feed component to meet the growing demand for animal feed protein and reduce the excess of nutrients in certain European regions was investigated. Three pilot-scale systems were fed with a mixture of the liquid fraction and the biological effluent of a swine manure treatment system diluted with rainwater in order that the weekly N and P addition was equal to the N and P removal by the system. The study shows that a duckweed lagoon can be used as an extra polishing step after swine manure treatment, converting the manure into dischargeable water instead of spreading it on arable land. Based on the N and P removal, it is estimated that one hectare of duckweed can remove the residual N and P of the biological effluent produced by 2805 swines. However, the side streams contain also K, Cl, S, Ca, Mg, and Na. It was found that these are inadequately removed from the system and will accumulate over time. By extrapolation, it was found that after 9 years K will be the first element to reach toxic concentrations for duckweed. This means that an operator should replenish the growing medium before this time. Furthermore, it should be avoided that potential harmful elements like the heavy metals As, Cd, and Pb would accumulate over time in the growing medium and subsequently taken up by the plant reaching toxic concentrations for animal consumption. It was observed that As, Cd, and Pb content were below the limits of the feed Directive 2002/32/EC in the duckweed grown on the tested medium are the elements even decreased over time. This is evidence for policy makers to consider the use of agricultural side streams like the biological effluent of the pig manure treatment system as a nutrient source for duckweed cultivation which is intended for animal consumption, if other safety risks are also validated in a similar way. In contrast, the plant is even a source of Mn, Zn, and Fe which are beneficial elements for swine's metabolisms.

Short title (native language): De kweek van *Lemna minor* om varkensmest te verwerken en te dienen als bron van micronutriënten in varkensvoeder

Short summary for practitioners (native language)

Het potentieel van Lemna minor om landbouwkundige zijstromen in eiwitrijk voeder om te zetten werd onderzocht om tegemoet te komen aan de groeiende vraag naar eiwitrijke diervoeders en het overschot aan nutriënten in sommige regio's in Europa te verwerken. Daarvoor werden er drie opstellingen gevoed met een verdund mengsel van vloeibare fractie en biologisch effluent van varkensmest zodat de wekelijkse toevoeging van N en P gelijk staat aan de verwijderingscapaciteit dat het systeem heeft. De studie toont aan dat een eendenkroosvijver gebruikt kan worden als een laatste omzettingstap van biologisch effluent tot loosbaar water, waardoor het niet meer hoeft uitgereden

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worden op landbouwgrond. Het wordt geschat dat een hectare eendenkroos de mest van 2805 varkens kan verwerken. Echter, naast N en P bevatten de stromen ook K, Cl, S, Ca, Mg, en Na. Bij een continue toediening werd vastgesteld dat de verwijderingscapaciteit van het systeem lager is dan de toediening, waardoor de elementen accumuleren na verloop van tijd. K is het eerste element die concentraties zal bereiken die hoger zijn dan de toxische grens voor eendenkroosgroei. Een kweker zal dus minstens om de 9 jaar het water moeten verversen. Bovendien moet vermeden worden dat toxische elementen zoals As, Cd, en Pb accumuleren tot toxische concentraties. In de studie werd geobserveerd dat deze elementen dalen over tijd en steeds onder de voorgeschreven limieten staan (uit Europese richtlijn 2002/32/EC). Dit kan ondersteunend bewijs zijn voor beleidsmakers om het gebruik van eendenkroos in diervoeders toe te laten nadat ze bemest zijn met reststromen uit de varkensmestverwerking. Dit als ook aanwijzingen zijn dat er geen andere gezondheidsrisico's bestaan die hier niet werden onderzocht. Bovendien blijkt dat het eendenkroos ook een bron is van Mn, Zn, en Fe, waardoor het gunstig kan zijn voor het metabolisme van het varken.

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Practice abstract 16

Short title (in English): Poultry and chicken manure management - practical considerations in Polish conditions

Short summary for practitioners (in English)

Management of poultry and chicken manure is a challenge not only in Poland but globally. Due to the concentration of large poultry farms, it is more important to use such a management methods that will reduce the negative impact on the environment, and at the same time will be consistent with the principles of circular economy and economically justified. It is also important to take into account the carbon footprint and legislation in force in a given country, as well as the European Green Deal strategy. Currently, poultry and chicken manure are most often used as an organic fertilizer in agriculture. However, due to the environmental nuisance and periodicity of application, new technologies are considered as a source of energy and fertilizers. The most advanced methods of energy recovery include methane fermentation, but in Poland manure or chicken manure is used only in a few agricultural biogas plants, only in the process of co-fermentation with other substrates. This is due to high investment costs and the optimization process that requires specialist knowledge. More widespread is drying and granulating of chicken / poultry manure itself or prior mixing with various other substrates (dolomite, opoka-rock, coal), which are placed on the market after being certified as eco-fertilizers. The most important criterion for selecting a technology for farmers is the cost of the investment and the benefits that would be obtained from the selected technology. Additional important factors in the final choice are incentives and technical support, environmental regulations and level of education. The size of the farm is also important as there must be consistency between the quantity of the waste stream and the processing technology. On the other hand, external investors take into account the net profit as the most important criterion, and for the local government an important aspect is the acceptance or not of the local community. Poultry farm owners who plan to handle and manage poultry manure onsite can use the help from specilized consulting companies or scientific consultants who can help with the selection of a poultry manure processing technology and the development of a case-specific solution.

Short title (native language): Zagospodarowanie pomiotu i obornika kurzego – uwarunkowania praktyczne w warunkach polskich

Short summary for practitioners (native language)

Zagospodarowanie pomiotu i obornika kurzego stanowi wyzwanie nie tylko w Polsce ale i na świece. Z uwagi na koncentrację dużych ferm drobiarskich coraz istotniejszy jest taki sposób zagospodarowania, który ograniczy negatywny wpływ na środowisko, a jednocześnie będzie zgodny z zasadami GOZ i ekonomicznie uzasadniony. Nie bez znaczenia jest także uwzględnienie śladu węglowego i prawodawstwa obowiązującego w danym kraju a także strategii Europejskiego Zielonego Ładu. Obecnie najczęściej obornik i pomiot wykorzystywane są jako nawóz organiczny w rolnictwie. Jednak ze względu na uciążliwość środowiskową i okresowość stosowania, rozpatrywane są nowe technologie jako źródło energii oraz nawozów. Do najbardziej zaawansowanych metod odzysku energii należy fermentacja metanowa, jednak w Polsce obornik czy pomiot kurzy wykorzystywany jest zaledwie w kilku biogazowaniach rolniczych, wyłącznie w procesie kofermentacji z innymi substratami.

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Związane jest to z wysokimi kosztami inwestycyjnymi i wymagającym specjalistycznej wiedzy procesem optymalizacji. Bardziej rozpowszechnione jest suszenie i granulowanie samego obornika/pomiotu lub uprzednie mieszanie z różnymi innymi substratami (dolomit, opoka, węgiel), które po uzyskaniu certyfikatu eko-nawozów są wprowadzane na rynek. Najważniejszym kryterium wyboru technologii dla właścicieli ferm jest koszt inwestycji oraz korzyści, jakie uzyskaliby dzięki wybranej technologii. Ważnymi czynnikami ostatecznego wyboru są także zachęty i wsparcie techniczne, przepisy środowiskowe i poziom wykształcenia. Ważna jest także wielkość gospodarstwa, ponieważ musi istnieć spójność między ilością strumienia odpadów a technologią przetwarzania. Z kolei zewnętrzni inwestorzy jako najważniejsze kryterium uwzględniają zysk netto, a dla samorządu lokalnego ważnym aspektem jest akceptacja lub nie miejscowej społeczności. Właściciele ferm kurzych, którzy chcą we własnym zakresie zagospodarowywać pomiot kurzy mogą zwrócić się do wyspecjalizowanych firm doradczych bądź konsultantów naukowych, którzy z kolei pomogą w wyborze odpowiedniej technologii i opracowaniu rozwiązania dla danego przypadku.

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Practice abstract 17

Short title (in English): Short term N-effect of recycling-derived fertilisers focusing on crop yield and N losses to the environment – 2nd year

Short summary for practitioners (in English)

Large surpluses of on-farm nitrogen (N) and phosphorus (P) are processed or exported out of Flanders while tonnes of synthetic N-fertilisers are purchased and used for crop production. The use of recycling-derived fertilisers (RDFs) from manure can counter this situation. Currently, RDFs derived from animal manure still need to comply with the legal application constraints of animal manure and are thus not often used. That is why five RDFs (ammonium nitrate, ammonium sulphate, digestate from co-digestion of pig manure, liquid fraction of digestate and pig urine) are compared with mineral fertiliser CAN, pig manure and a blank treatment in a 3-year field trial focusing on short term N-effects of the RDFs. The main goal of the trial is to establish a clear relationship between the amount of N applied by RDF and dry matter production for each applied RDF. During the second year of the field trial (crop: spinach), weather conditions had a significant impact: the trial period was extremely dry, with only 12 l/m² of rain received between sowing and harvest. Therefore water shortage was an important factor influencing the growth of spinach. Hence, local differences in soil fertility appeared causing N availability as no longer the only decisive factor for crop growth and causing extra variability in the field trial, parallelly with a sandstorm that damaged many young plants. Therefore, no differences in fresh and dry yield were observed between RDFs, except ammonium nitrate which had significantly lower yield. This is probably also due to soil treatment because the applied N via ammonium nitrate had to be directly in contact with the root zone in harmful dry conditions. Residual nitrate was lower than legal limits for all RDFs except pig urine at 70% N dose.

Short title (native language): Korte stikstof termijneffect van herwonnen meststoffen met focus op gewasopbrengst en stikstofverliezen naar het milieu - 2e jaar

Short summary for practitioners (native language)

Het mestoverschot in Vlaanderen wordt verwerkt en geëxporteerd, terwijl kunstmest wordt aangekocht om in de gewasbehoefte te voorzien. Nochtans kan het gebruik van herwonnen meststoffen dit oplossen. Echter moeten deze voldoen aan de wettelijke toepassingsvereisten van dierlijke mest waardoor het gebruik laag is. Daarom worden de korte stikstof termijneffecten van vijf herwonnen meststoffen (ammoniumnitraat, -sulfaat, digestaat, dunne fractie van digestaat en varkensurine) vergeleken met KAS kunstmest, varkensmest en een blanco behandeling in een driejarige veldproef. Het doel van de proef is om een verband te leggen tussen de hoeveelheid N die wordt aangebracht en de drogestofproductie. Tijdens het tweede jaar van de velproef (gewas: spinazie) hadden de weersomstandigheden een grote invloed: de proefperiode was extreem droog, met slechts 12 l/m² regen tussen zaaien en oogsten. Watertekort was daarom een belangrijke factor. Dit veroorzaakte lokale verschillen in bodemvruchtbaarheid waardoor N-beschikbaarheid niet langer de bepalende factor was voor de gewasgroei. Bovendien was er door de droogte en een zandstorm extra variabiliteit. Er werden daarom geen verschillen in verse en droge opbrengst waargenomen tussen de herwonnen meststoffen, behalve een significant lagere opbrengst bij ammoniumnitraat. Dit effect heeft wellicht te maken met de bodembewerkingen, aangezien de toegediende N via ammoniumnitraat reeds van bij het begin van de teelt in de bewortelde zone aanwezig moet zijn. Hierdoor kwamen de kiemplantjes direct in contact met de meststoffen in stresserende, droge omstandigheden. Het nitraatresidu was voor alle meststoffen lager dan het wettelijk maximum, behalve voor varkensurine 70%.

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Practice abstract 18

Short title (in English): Using digestate, precision agriculture and no-tillage to increase soil quality and organic matter stocking in soil

Short summary for practitioners (in English):

Due to the increase of the population and the improvement of life quality for large groups of people worldwide, the food need and the production of wastes is increasing consequently. Higher food production will require a higher quantity of fertilizers, while waste disposal (mainly sewage sludge) can be expensive, energy consuming and environmentally hazardous. The system encompasses a plant performing anaerobic digestion on sewage sludge. Anaerobic digestion is a biological process, conducted without air that stabilizes the substrate, makes the nutrients more available for plants, and increases the product's health safety while producing biogas. The digestate can partly substitute chemical fertilizers in a very efficient way. Moreover, this plant has a "stripping system" that can extract ammonia to increase the plant's digestion efficiency and produce ammonium sulphate, which can be used as valuable fertilizer or sold for industrial uses. Results are not complete yet, because tests are still in progress, but we can already share some comments:

I. In a full-scale field experiment, rice yields were similar using chemical fertilizers vs digestate + ammonium sulphate, showing the excellent quality of this solution for fertilization (experiment now running for two years out of three).
II. Analyses on rice grain showed similar composition for chemical fertilizers and for digestate + ammonium sulphate fertilization.
III. Using digestate + ammonium sulphate, we expect an increase of soil quality, intended as organic matter quantity and stability.
IV. Nitrate leaching in digestate + ammonium sulphate fertilization resulted very low, similar with chemical treatment and the untreated.

The Digestate + Ammonium sulphate combination is a suitable fertilizer, safe, and with performance substantially equal to traditional chemical fertilizers. Nevertheless, such equivalent performance cannot be reached if other practices are not assured in its production and use (i.e. digestate highly stabilized and injected in soil). Besides, the parallel electric energy production (through biogas combustion) and the safe sewage sludge disposal make this technology very efficient. Finally, based on the provisional data, it has a positive effect on soil in the long run, increasing the amount and stability of organic matter, while the concentrations of pollutants (both organic and inorganic) are similar to that of a traditional fertilized field.

Short title (native language): Utilizzo di digestato, agricoltura di precisione e minima lavorazione per aumentare la qualità del suolo e lo stoccaggio di sostanza organica

Short summary for practitioners (native language):

A causa dell'aumento della popolazione e del miglioramento della qualità della vita per alcune fasce di popolazione, il fabbisogno alimentare e la produzione di rifiuti sono in aumento. Una maggiore produzione alimentare richiederà una maggiore quantità di fertilizzanti, mentre lo smaltimento dei rifiuti (principalmente fanghi di depurazione) è costoso, richiede grandi quantità di energia ed è pericoloso per l'ambiente. L'impianto in questione processa fanghi di depurazione tramite digestione anaerobica. Quest'ultima è un processo biologico, condotto in assenza di aria, che stabilizza il

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substrato, rende più disponibili i nutrienti per le piante e aumenta la sicurezza sanitaria del prodotto, producendo biogas. Il digestato così prodotto può sostituire in parte i fertilizzanti chimici in modo molto efficiente. Inoltre, questo impianto dispone di un "sistema di strippaggio" in grado di estrarre ammoniaca, così da aumentare l'efficienza dell'impianto e produrre solfato di ammonio, che viene utilizzato come fertilizzante o può essere venduto per usi industriali. Visto che i lavori sono ancora in corso i risultati non sono definitivi, ma possiamo già condividere alcuni commenti:

I. In un esperimento in pieno campo, le rese del riso sono state simili utilizzando fertilizzanti chimici e digestato + solfato di ammonio, a dimostrazione dell'eccellente qualità di questa soluzione per la fertilizzazione (esperimento ora in corso da due anni su tre).

II. Le analisi sul chicco di riso hanno mostrato una composizione simile per la fertilizzazione chimica e per digestato + solfato di ammonio.

III. Utilizzando digestato + solfato di ammonio ci aspettiamo un miglioramento della qualità del suolo, inteso come quantità e stabilità di sostanza organica.

IV. La lisciviazione dei nitrati nella fertilizzazione con digestato + solfato di ammonio è risultata molto bassa, simile al trattamento chimico e al non trattato.

La combinazione digestato + solfato ammonico è un fertilizzante idoneo, sicuro e con prestazioni sostanzialmente pari ai tradizionali fertilizzanti chimici. Tuttavia, tali prestazioni positive non possono essere raggiunte se non sono assicurate altre pratiche nella sua produzione e utilizzo (es. digestato altamente stabilizzato e iniettato nel suolo). Inoltre, la produzione elettrica (attraverso la combustione del biogas) e lo smaltimento sicuro dei fanghi di depurazione rendono questa tecnologia molto efficiente. Infine, dai dati provvisori, ha un effetto positivo sul suolo nel lungo periodo, aumentando la quantità e la stabilità della sostanza organica, mentre la concentrazione degli inquinanti (sia organici sia inorganici) è simile ad un campo fertilizzato tradizionalmente.

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Practice abstract 19

Short title (in English): Producing bio-fertilisers from pig manure through different separations stages

Short summary for practitioners (in English)

Intensive livestock activity in Lombardy (northern Italy) and in other regions in Europe (like Denmark; Catalonia, Spain; Flanders, Belgium; Netherlands) is causing several environmental issues. The nitrates directive limits the amount of manure that can be used in fields (depending on if the area is considered vulnerable or not). The possibility to export some fractions of the effluent can increase the number of livestock heads without jeopardising the environment. The plant separates the effluent in a solid fraction, which will be composted and a liquid fraction. The latter is further separate thanks to reverse osmosis (super tight filtrations) in clean water and a concentrate that can be exported from the farm as RENURE (it could be considered a chemical fertiliser instead of livestock effluent). Results are not complete yet because tests are still in progress, but we can already share some comments:

I. "Clean" water, more than half of the input volume, fit all the parameters to be disposed in superficial water bodies (rivers or lakes) or used for irrigation,

II. about one-sixth of the input volume is recovered as solid fraction that can be composted

III. The liquid concentrate has high concentration of ready-to-use nutrients for plants.

Moreover, a real scale field experiment is set (on corn) to demonstrate that fertilisation with concentrate is AT LEAST as good as a chemical fertilisation (urea).

Short title (native language): Produzione di bio fertilizzanti da effluenti suinicoli attraverso successive separazioni

Short summary for practitioners (native language)

L'intensa attività zootecnica in Lombardia e in altre regioni d'Europa (come Danimarca, Catalogna, Spagna, Belgio, Paesi Bassi) sta causando diversi problemi ambientali. La direttiva nitrati pone un limite alla quantità di letame che può essere messo in campo (a seconda che l'area sia considerata vulnerabile o meno). La possibilità di esportare alcune frazioni dell'effluente può aumentare il numero di capi di bestiame senza compromettere l'ambiente. L'impianto separa le deiezioni in una frazione solida, che verrà compostata, e in una frazione liquida. Quest'ultimo è ulteriormente separato grazie all'osmosi inversa (una filtrazione estremamente fine) in acqua pulita e un concentrato che può essere esportato dall'azienda come RENURE (può essere considerato un fertilizzante chimico e non come effluenti zootecnici). I risultati non sono ancora completi perché i test sono ancora in corso, ma possiamo già condividere alcuni commenti:

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I. L'acqua “pulita”, più della metà del volume in ingresso, soddisfa tutti i parametri per essere smaltita in corpi idrici superficiali (fiumi o laghi) o utilizzata per l'irrigazione.

II. Circa un sesto del volume in ingresso viene recuperato come frazione solida compostabile.

III. Il concentrato ha un'alta concentrazione di nutrienti pronti all'uso per le piante.

Inoltre, è stato impostato un esperimento di campo in scala reale (sul mais) per dimostrare che la fertilizzazione con concentrato è ALMENO efficace quanto la fertilizzazione chimica (urea).

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Practice abstract 20

Short title (in English): Are consumers willing to pay a premium price for sustainable food?

Short summary for practitioners (in English)

Understanding consumer behaviour, perception and acceptance of eco-friendly and sustainable food products is one of the key objectives for the Nutri2Cycle project with the aim of bridging the current environmental informational gap between producers and consumers. As a first step towards achieving this goal, techniques of meta-analysis were applied to studies on the relationship between sustainable agricultural products and consumers' willingness to pay (WTP). The data obtained from over 100 papers screened in the analysis showed that the percentage difference in the WTP estimated ranged from 2% to 92%. The overall WTP valuation was calculated as 33%, that is, consumers are willing to pay about a 33% more for sustainable attributes in food products. This WTP depended significantly on variations of the consumers' region (the highest WTP was located in Asia, 65%) as well as the food categories (cereal & bread provided the highest WTP, 60%). Moreover, the results showed the presence of different sustainable claims was not a significant factor and it did not influence the WTP significantly which means that consumers have knowledge about what sustainable food product is but should become more familiar with them to learn to distinguish between the different sustainable claims and their meanings. There are currently a wide range of Ecolabels in the market, with significant differences in scope, indicators, verification processes or claims affecting the overall effectivity of Ecolabels. The farmers can indeed benefit from striving towards a label - as consumers are willing to pay more – however, the labelling landscape is too scattered. Therefore, unification of the Ecolabelling schemes is required and the European ecolabelling landscape need a continuous updating that allows an easy decision-making process for consumers and stakeholders involved.

Short title (native language): Están los consumidores dispuestos a pagar más por los alimentos sostenibles?

Short summary for practitioners (native language)

Comprender cuál es la percepción del consumidor por los alimentos etiquetados como sostenibles y/o respetuosos con el medio ambiente es uno de los objetivos clave del proyecto Nutri2Cycle, contribuyendo a cerrar la brecha de información ambiental que existe actualmente entre productores y consumidores. El primer paso para ello ha sido la aplicación de técnicas de metaanálisis a una amplia variedad de estudios publicados sobre los criterios que definen su compra. Los datos obtenidos en los más de 100 artículos examinados mostraron que la diferencia porcentual en la disposición de pago oscilaba entre el 2% y el 92%, situándose la media en un 33%, lo que significa que los consumidores estarían dispuestos a pagar alrededor de un 33% más por alimentos calificados como sostenibles. Esta variación dependía significativamente de la región del consumidor (la más alta se encontró en Asia, 65%), y de la categoría de alimentos (la más alta fue para los cereales y el pan, 60%). Los resultados mostraron también que la presencia de etiquetas ambientales no era un factor significativo en la compra. La principal conclusión a extraer es por tanto que los consumidores sí saben qué es un alimento sostenible (ya que están dispuestos a pagar más por ellos) pero necesitan familiarizarse con

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los distintos tipos de ecoetiquetado, puesto que, en la actualidad, existen una gran variedad de ecoetiquetas con importantes diferencias en cuanto a alcance, significado etc. De hecho, los agricultores podrían beneficiarse del trabajo por conseguir una etiqueta, ya que los consumidores estarían dispuestos a pagar más. Sin embargo, actualmente el marco del etiquetado no está muy definido. Esto afecta directamente a su efectividad y por esta razón es necesario unificar los actuales esquemas de ecoetiquetado, con el objetivo último de permitir un proceso de toma de decisiones mucho más sencillo para consumidores y productores.

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Practice abstract 21

Short title (in English): Refining bio-based fertiliser has limited effect on potato yield

Short summary for practitioners (in English):
Processing manure can contribute to closing carbon (C) and nutrient loops, but this will only succeed when the products resulting from manure processing (also called bio-based fertiliser) are being accepted by arable farmers as a replacement for mineral fertilisers. This not only depends on the performance of these bio-based fertilisers compared to mineral fertiliser, but also on the costs and benefits. In this study, the effect of refining bio-based fertilisers was tested on potato yield. The less refined, and therefore cheaper, product (thin fraction of the digestate) as well as the refined product (ammoniumsulphate) showed a high nitrogen fertiliser replacement value (81% and 73% respectively). This means that both products are suited as a replacement for mineral N fertiliser. In the field, the different products showed limited differences in plant growth and yield which confirms the safe use of these products for potato growing. The fields that received only bio-based fertiliser showed similar results, but bio-based fertilisers will not be used as a replacement for animal manure in practice in the Netherlands due to the higher costs. Although this study concludes that both products are suitable as a replacement for mineral N fertiliser, only the refined product will potentially be used because it has the status of anorganic fertiliser.

Short title (native language): Het verfijnen van mestproducten heeft gering effect op aardappeloogst

Short summary for practitioners (native language):
Het verwerken van mest kan bijdragen aan het sluiten van koolstof (C) -en nutriënten kringlopen, maar dat lukt alleen als de producten die door mestverwerking verkregen worden (ook wel bio-gebaseerde meststoffen genoemd) als kunstmestvervanger geaccepteerd worden door akkerbouwers. Dit hangt niet alleen af van de prestatie van deze bio-gebaseerde meststoffen ten opzichte van kunstmest, maar ook van de kosten -en baten. In deze studie werd het effect van verfijning van bio-gebaseerde mestproducten getest op aardappeloogst. Zowel het minder verfijnde, en dus goedkopere, product (dunne fractie van het digestaat) als het verfijnde product (ammoniumsulfaat) gaven een hoge stikstofkunstmest vervangingswaarde (81% en 73% respectievelijk). Dit betekent dat beide producten geschikt zijn om stikstofkunstmest te vervangen. In het veld toonden de geteste mestproducten weinig verschil in plantengroei en opbrengst. Dit bevestigt dat de bio-gebaseerde mestproducten veilig gebruikt kunnen worden voor de aardappelteelt. De velden die alleen bio-gebaseerde meststof ontvingen toonde vergelijkbare resultaten, maar vanwege de hogere kosten zullen deze meststoffen in de praktijk in Nederland niet snel gebruikt worden ter vervanging van dierlijke mest. Alhoewel deze studie concludeert dat beide producten stikstofkunstmest kunnen vervangen, zal in de praktijk waarschijnlijk alleen het verfijnde product gebruikt worden omdat het de status van anorganisch meststof heeft.

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Practice abstract 22

Short title (in English): Precision farming and optimised application: under-root application of liquid manure for maize and other row crops

Short summary for practitioners (in English)

In combination with precision farming, in under-root fertilization of maize seeds (or similar row crops), mineral fertilizers can be replaced by liquid organic fertilizers, such as liquid manure or biogas residue. This is the first precise application technology for liquid organic fertilizers for early under-root fertilization of maize, and potentially other row crops. In order to replace mineral fertilizer banded below seeds, a precise placement of manure close to the seeds (in the seeding lines and in a precise soil depth) is necessary. The new technology consists of a precise application technique of liquid organic fertilizer in terms of positioning, making use of GPS information, and in terms of dosage. Application of under-root fertilization can be carried out before or after sowing, even simultaneously. The preliminary conclusions are: (a) liquid manure for under-root fertilizer application instead of application of mineral P (and N) fertilizers has advantages with regard to the on-farm nutrient management; (b) in soils rich in P due to prior intensive manure application, under-root fertilization with liquid manure would reduce the P demand in form of mineral fertilizers; (c) in poor soils, this technique can increase particularly the P use efficiency; (d) N and P surplus thus can be reduced by reducing mineral fertilizer application around seeding; (e) results also show that under-root application of liquid manure can be combined with the strip-till technique; this combination makes it possible to make advantage of mulch sowing, which protects soils against erosion; (f) results showed that under-root application of liquid manure did not negatively affect yields and quality of silage maize.

Short title (native language): Präzisionslandwirtschaft und optimierte Düngerausbringung: Unterfußdüngung von Mais (oder ähnlichen Reihenkulturen) mit organischen Flüssigdüngern

Short summary for practitioners (native language)

Mit der Unterfußdüngung von Mais (oder ähnlichen Reihenkulturen) kann in Kombination mit Maßnahmen der Präzisionslandwirtschaft Mineraldünger durch flüssige organische Dünger wie Gülle oder Biogasgärreste ersetzt werden. Es handelt sich um eine Neuentwicklung für die frühe Unterfußdüngung von Mais und ggf. andere Reihenkulturen mit organischen Flüssigdüngern. Um den i.d.R. unter Fuß ausgebrachten Mineraldünger adäquat ersetzen zu können, ist eine ebenso präzise Ausbringung der Gülle hinsichtlich der Positionierung (in den Saatlinien und in einer bestimmten Bodentiefe) unter Nutzung GPS-Informationen und hinsichtlich der Dosierung erforderlich, wobei die Applikation vor oder nach der Aussaat erfolgen kann. Die vorläufigen Schlussfolgerungen bezüglich der Unterfußdüngung bei Mais sind: (a) Die Verwendung von Gülle zur Unterfußdüngung anstelle von mineralischen P- (und N-) Düngern hat Vorteile im Hinblick auf das Nährstoffmanagement in den landwirtschaftlichen Betrieben; (b) in Böden mit hohem P-Gehalt aufgrund vorheriger intensiver Gülleausbringung würde die Unterfußdüngung mit Gülle den P-Bedarf in Form von Mineraldünger

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reduzieren; (c) in armen Böden kann diese Technik insbesondere die P-Nutzungseffizienz erhöhen; (d) N- und P-Überschüsse können durch die Reduzierung der Mineraldüngerausbringung vor oder kurz nach der Aussaat reduziert werden; (e) die Unterfußdüngung kann mit dem Strip Till-Verfahren kombiniert werden, wodurch auch gleichzeitig die Vorteile einer erosionsmindernen Mulchsaat nutzbar sind; (f) die Ergebnisse zeigen, dass die Unterfußdüngung mit Gülle keinen negativen Einfluss auf die Erträge und die Qualität von Silomais besitzen.

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Practice abstract 23

Short title (in English): Upcycling of food grade animal bone by-products for recovery and reuse of concentrated BioPhosphate products with BIO-NPK-C formulations

Short summary for practitioners (in English)

The main aim of the deep-technology and product development driven BioPhosphate research (2002-2022) is to replace mineral fertilisers, most importantly the Cadmium and Uranium contaminated mineral and soft rock phosphate fertilizers, closing the CNP loops/reducing GHG emissions at less cost. High material core temperature, innovative zero emission pyrolysis (3R) applied to recover 35% P2O5 concentrated Phosphorus from pressure sterilized food grade cattle bone byproducts, which is than controlled release BIO-NPK-C compound biofertilizer formulated as of organic farmer user demands. The average dose is 300-500 kg/ha. The outcome of BioPhosphate research so far is TRL8, where the technology has been experimented in deployment conditions (i.e. real world) and proven its functioning in its final form with compliance with industrial/enviro standards of the addressed markets (EU, UK, USA, AU, JP). The BioPhosphate BIO-NPK-C compound biofertilizer products MS Authority permitted in 2020, fully meet the new 2022 EC Fertiliser criteria in several product functional categories and prepared for REACH certification (ongoing). As a result so far the BioPhosphate research so far already removed most technical/market risks, while majority of the underlying scientific/engineering problems being solved. The last research action is in progress, e.g. TRL9 first full industrial replication model deployed at 20,800 t/y capacity that is the ultimate evidence that research is successfully completed. TheBIO-NPK-C compound BioPhosphate biofertilizer is safer, better and less costly versus any market competitive product in the agri sector.

Short title (native language): Upcycling of food grade animal bone by-products for recovery and reuse of concentrated BioPhosphate products with BIO-NPK-C formulations

Short summary for practitioners (native language)

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Practice abstract 24

Short title (in English): Poultry manure derived biochar as a sorbent for removal of various contaminants

Short summary for practitioners (in English)

Extensive agriculture results in increasing amounts of phosphorous compounds in soils mostly due to the use of mineral fertilizers. In consequence, this biogen is transferred to water, and in turn can cause eutrophication of water reservoirs. Phosphorus fertilizers contain some heavy metals which can lead to soil contamination due to improper fertilization. What is more, excessive acidification of soils can contribute to mobility of heavy metals already present in soils. One of the potential solutions to mitigate and/or prevent from these threats is introducing to soils substances with suitable sorption properties such as biochars. The overall goal of this research was to evaluate the sorption properties of biochars produced from poultry manure. The obtained results demonstrated that sorption of phosphorus was above 95% of the applied dose. At the same time biochar produced from poultry manure at 425 °C showed not only high sorption capacity but also demonstrated desorption of phosphorus at around 21%. This biochar property could be of importance when it comes to agricultural soils where excessive phosphorus fertilization could be a threat. Such sorbent could also function as phosphorus storage. The research confirmed high efficiency (above 99%) of biochars to remove heavy metals ions, even at high concentrations in solutions (1000 mg L-1). Alkaline character of these biochars is also important. The application of obtained biochars to soils could prevent from excessive acidification of soils. In conclusion, the obtained poultry manure derived biochars can be valuable additives to soil, and thus prevent from improper fertilizing practices by immobilizing excessive amounts of phosphorus and at the same time limiting the mobility of selected contaminants such as heavy metals.

Short title (native language): Wykorzystanie biowęgla z pomiotu kurzego do usuwania zanieczyszczeń obecnych w glebach

Short summary for practitioners (native language)

Intensywna produkcja rolna związana jest z wprowadzaniem do gleb dużych ilości związków fosforu obecnych w nawozach mineralnych. Migracja tego biogenu do wód, jest jedną z przyczyn eutrofizacji zbiorników wodnych. Obecne w nawozach fosforowych, pewne ilości metali ciężkich, przy niewłaściwym nawożeniu, mogą być źródłem zanieczyszczenia gleb. Ponadto nadmierne zakwaszanie gleb może powodować mobilność metali ciężkich obecnych w glebach. Jednym ze sposobów eliminacji tych zagrożeń jest wprowadzanie do gleb substancji o dobrych własnościach sorpcyjnych, np. biowęgla. Przedmiotem badań była ocena zdolności sorpcyjnych biowęgla wyprodukowanego z pomiotu kurzego. Badania wykazały, że zdolność do sorpcji fosforu jest na poziomie powyżej 95% zadanej dawki. Jednocześnie biowęgiel wytworzony w temperaturze 425 °C charakteryzował się nie tylko dużą pojemnością sorpcyjną, ale również zdolnością do desorpcji fosforu na poziomie 21%. Ta cecha biowęgla jest szczególnie przydatna w obszarach rolniczych, gdzie nadmierne stosowanie nawozów fosforowych jest zagrożeniem, a jednocześnie sorbent może być rezerwuarem tego

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biogenu. Przeprowadzone badania potwierdziły również wysoką skuteczność (powyżej 99% zawartości początkowej) biowęgli w usuwaniu jonów metali ciężkich, nawet przy ich dużej koncentracji w roztworze (1000 mg L-1). Istotny jest również alkaliczny charakter tych sorbentów. Stosowanie biowęgli w uprawach może przeciwdziałać nadmiernemu zakwaszeniu gleb. Zatem wytworzone sorbenty są dobrym dodatkiem glebowym, mogącym przeciwdziałać złym praktykom nawozowym poprzez unieruchomienie nadmiernej ilości fosforu przy jednoczesnym ograniczeniu mobilności innych zanieczyszczeń, np. metali ciężkich.

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Practice abstract 25

Short title (in English): Fertilizing products from poultry manure

Short summary for practitioners (in English)

Due to chemical composition and properties poultry manure is considered a valuable substrate to obtain fertilizing products such as composts and biochars. Compost from poultry manure compared to poultry manure when applied to fields does not contribute to excessive gaseous emissions including ammonia or carbon dioxide. It is microbiologically safe, and thus does not pose any threat to the environment. Biochars produced through pyrolysis of poultry manure can be used in composting as a supplementary material in composting mixtures to limit nitrogen loss during composting. Poultry derived biochar can be also used as an additive to mature composts or as a soil enhancer directly introduced to soils. The main goal of this research is to convert poultry manure into composts such as nitrogen losses can be limited during the process and to evaluate the obtained composts, composts mixed with poultry manure derived biochar and poultry manure derived biochar itself for fertilization of soils with low organic matter. So far, the results show that the obtained compost from poultry manure fulfils the requirements for fertilizers. It is microbiologically safe (free from pathogens), contains 73% of organic matter, 41.7% of carbon, 1.8% of nitrogen, 8.1% of phosphorous, C/N of 22 and pH of 9.2. Currently, the pot experiments with selected growing media amended with poultry manure composts, biochars and their mixtures are in progress. They are aimed to evaluate the effect of poultry manure derived fertilizing products on soil properties and growth of selected plants.

Short title (native language): Produkty nawozowe z pomiotu kurzego

Short summary for practitioners (native language)

Z uwagi na skład i właściwości pomiot kurzy stanowi wartościowy substrat do otrzymywania różnych produktów nawozowych takich jak komposty czy biowęgle. Kompost z pomiotu kurzego w porównaniu do świeżego pomiotu kurzego nie wydziela do atmosfery dużych ilości gazów tj. amoniak czy dwutlenek węgla. Jest również stabilny mikrobiologicznie, dzięki czemu nie stanowi zagrożenia dla środowiska. Biowęgiel otrzymane w wyniku pirolizy pomiotu kurzego mogą być wykorzystane w procesie kompostowania jako dodatek do mieszanek kompostowych, który będzie ograniczał straty azotu podczas samego procesu. Może być również wykorzystany jako dodatek do dojrzałych kompostów lub jako polepszacz glebowy wprowadzany bezpośrednio do gleb. Głównym celem badań jest uzyskanie kompostów z pomiotu kurzego przy jednoczesnym ograniczeniu strat azotu podczas samego procesu kompostowania oraz ocena kompostów z pomiotu kurzego oraz ich mieszanek z biowęglem otrzymanym z pomiotu kurzego do nawożenia gleb ubogich w materię organiczną. W wyniku przeprowadzonych badań otrzymano kompost z pomiotu kurzego, który spełniał wymagania dla nawozów. Był bezpieczny pod względem sanitarnym (wolny od jaj pasożytów i bezpieczny mikrobiologicznie), zawierał 73% materii organicznej, 41.7% węgla, 1.8% azotu, 8.1% fosforu, stosunek węgla do azotu to 22, a pH 9.2. Obecnie prowadzone są doświadczenia wazonowe z wybranymi podłożami wzrostowymi, które pozwolą na określenie wpływu dodatku kompostów z pomiotu

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kurzego, ich mieszanek z biowęglem i biowęgla z pomiotu kurzego na właściwości gleb i wzrost wybranych roślin.

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Practice abstract 26

Short title (in English): Energy recovery from poultry manure

Short summary for practitioners (in English)

Poultry manure, due to the high content of organic substances, are an attractive raw material for biogas production, however, mono-digestion in their case may be difficult due to the low C/N ratio. Therefore, it seems reasonable to optimize the substrate, obtained by creating a homogeneous mixture of manure with other organic waste and their co-digestion. For this reason, in our study we tested the possibility of anaerobic co-digestion of poultry manure with sewage sludge. The proposed solution, seems to be very interesting option, because it leads to an enhanced production of biogas (>40%), as well as volatile solids removal (>20%). In this context, the implementation of this solution in WWTPs provides an unique opportunity for these facilities to improve their energy self-sufficiency as well as profitability which are possible by enhancing energy recovery from sludge as well as full utilisation of the existing infrastructure (oversized digesters) and hence creates a new place for the treatment of the poultry manure. Moreover, considering the solution at the investment planning stage may significantly impact the disposal capacity per volume unit of the digester, thereby affecting investment costs. However, the implementation of this solution in the wastewater treatment plant is still a big challenge and needs further studies including the identification of optimal digesting conditions, information about substrate pumping, infrastructure for WWTP (e.g. efficiency co-generation devices, energy consumption in activated sludge system, inhibition thresholds and processing properties). Other challenging task for future research is: 1) the identification of the microbial community structure which can vary in response to the changing environmental conditions such as: OLR, HRT; 2) optimization of feedstock composition.

Short title (native language): Odzysk energii z pomiotu kurzego

Short summary for practitioners (native language)

Pomiot kurzy, ze względu na wysoką zawartość substancji organicznych, jest atrakcyjnym surowcem do produkcji biogazu, jednak jego monofermentacja może być utrudniona ze względu na niski iloraz C/N. Dlatego też, zasadna wydaje się optymalizacja wsadu poprzez stworzenie jednorodnej mieszaniny obornika z innymi odpadami organicznymi i ich wspólne przetwarzanie (kofermentacja). Z tego powodu, w naszych badaniach sprawdziliśmy możliwość beztlenowej kofermentacji obornika drobiowego z osadami ściekowymi. Zaproponowane rozwiązanie wydaje się być bardzo interesującą opcją, ponieważ prowadzi do zwiększenia produkcji biogazu (>40%), jak również stopnia przefermentowania (>20%). W tym kontekście, wdrożenie tego rozwiązania w oczyszczalniach ścieków stwarza unikalną szansę dla tych obiektów na poprawę samowystarczalności energetycznej oraz rentowności, które są możliwe dzięki zwiększeniu odzysku energii z osadów, jak również pełnemu wykorzystaniu istniejącej infrastruktury (przewymiarowane komory fermentacyjne), a tym samym stwarza nowe miejsce dla przetwarzania pomiotu kurzego. Ponadto, uwzględnienie tego rozwiązania na etapie planowania inwestycji może znacząco wpłynąć na wydajność utylizacji w przeliczeniu na

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jednostkę objętości komory fermentacyjnej, a tym samym na koszty inwestycji. Jednakże wdrożenie tego rozwiązania w oczyszczalni ścieków jest nadal dużym wyzwaniem i wymaga dalszych badań obejmujących określenie optymalnych warunków fermentacji, informacji na temat pompowania substratów, infrastruktury dla oczyszczalni ścieków (np. sprawności urządzeń kogeneracyjnych, zużycia energii w komorach osadu czynnego, progów inhibicji oraz parametrów procesu). Innymi wyzwaniami dla prowadzonych badań są: 1) identyfikacja struktury zbiorowiska mikroorganizmów, która może zmieniać się w odpowiedzi na zmieniające się warunki środowiskowe, takie jak: OLR, HRT; 2) optymalizacja składu substratów.

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Practice abstract 27

Short title (in English): Using soil electrical conductivity and NDVI to idenitify distinct fertilizing areas in a vineyard

Short summary for practitioners (in English)

The intensification of agriculture has greatly enhanced crop productivity, much needed with the present population growth, but its potential environmental impact also increased. Precision agriculture has potential to tackle this challenge and the present work is framed within that context, as it intends to study the spatial variability of soils in order to precisely apply organic fertilizers. For this, three distinct zones were defined in a 6.77 ha vineyard based on high and low values of 1) apparent soil electrical conductivity (ECap), measured using an indirect sensor (Geonics EM38®), and 2) normalized difference vegetation index (NDVI), obtained from satellite images. Soil samples from each zones were then collected and chemically analysed. Most of the selected soil chemical properties, such as nutrients concentration, varied significantly among zones, showing a potential for differential application of fertilizers. Regarding soil mineralogy, significant differences were also observed between zones, as zones defined with high ECap showed higher percentage of clay and lower percentage of sand, with the opposite also true. Another reassuring but expectable outcome was the fact that zones with high NDVI presented the highest concentration of soil nitrogen and phosphorus. Both indicators are non-destructive, cost less and require less labour and, as seen, has showed efficiency in the delineation of distinct zones and in providing information about soil properties. With this information, the farmer knows which areas lack or have an excess of a specific nutrient and manage soil and crop fertilization in accordance, thus applying only the necessary amount or providing higher amounts in the poorer areas, resulting in a more evenly production.

Short title (native language): Uso da condutividade elétrica aparente do solo e de NDVI para o delineamento de zonas de gestão numa vinha

Short summary for practitioners (native language)

A intensificação da agricultura aumentou consideravelmente a produtividade das culturas, contudo, o impacto associado também aumentou. A Agricultura de Precisão tem potencial para enfrentar este desafio e o presente trabalho insere-se neste contexto, visto que pretende estudar a variabilidade espacial do solo de forma a aplicar com precisão os fatores de produção, nomeadamente fertilizantes. Assim, numa vinha de 6,77 ha foram definidas três zonas distintas, com base em valores altos e baixos de 1) condutividade elétrica aparente do solo (ECap), medida através de um sensor (Geonics EM38®), e 2) índice de vegetação por diferença normalizada (NDVI), obtido a partir de imagens de satélite. Amostras de solo dessas zonas foram então colhidas e analisadas. A maioria das propriedades químicas do solo estudadas, como a concentração de nutrientes, variou significativamente entre zonas, evidenciando potencial para a aplicação diferenciada de fertilizantes. Em relação à mineralogia do solo, foram também observadas diferenças significativas entre zonas, onde zonas definidas com alto ECap apresentaram maior percentagem de argila no solo e menor percentagem de areia, e o contrário também se observou. Outro resultado otimista, mas expectável, foi o fato de as zonas com

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alto NDVI apresentarem as maiores concentrações de azoto e fósforo no solo. Ambos os indicadores são não-destrutivos, mais económicos e requerem menos mão de obra e foram eficazes no delineamento de zonas distintas e no fornecimento de informações sobre as propriedades do solo. Dessa forma, o agricultor consegue aplicar fertilizantes de acordo com a carência ou excesso de nutrientes de um dado local, aplicando apenas o necessário ou reforçando as áreas mais pobres, o que resulta numa produção mais homogénea.

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