Closing nutrient cycles in organic farming

Nearly 100 stakeholders from organic farming organisations, organic and mineral fertiliser companies, compost producers, research and regulators discussed the possible use of recycled nutrient and recycled organic carbon products in organic agriculture.

The meeting was co-organised by **ESPP** (European Sustainable Phosphorus Platform) and **IFOAM EU (International Federation of Organic Agriculture Movements –EU Group).**

The meeting was opened by **Chris Atkinson, IFOAM EU Council Member and UK Soil Association**, who explained why closing nutrient cycles is necessary for organic farming, in particular recycling phosphorus.

The **definition of "organic farming"** adopted by *IFOAM* in 2005 specifies that organic agriculture relies on the health of soils, ecological processes, biodiversity and cycles adapted to local conditions and avoids the use of inputs with adverse effects *www.ifoam.bio/fr/organic-landmarks/definition-organic-agriculture*. This definition refers to the health of soils, ecological processes, biodiversity and cycles adapted to local conditions.

Phosphorus, unlike nitrogen or carbon, cannot be replenished by the plant-soil system, and phosphorus leaving a farm in crops or animal products must be replaced. This was already recognised in the Soil Association (UK organic farming association) *report* "A rock or a hard place" (2011, see SCOPE Newsletter *n°77*).

At present, the use of ground phosphate rock is authorised in organic farming, but this is not an effective fertiliser except in acidic soils, and also poses issues of non-sustainability of supply. Manure, food waste and food industry by-products are today authorised in organic farming, but **do not fulfill phosphorus demand**, because of exclusion of sources from intensive agriculture or relatively low phosphorus content. Sewage sludge was authorised for use in organic farming in the UK by the Soil Association in the 1960's, and similarly in the USA, but is today excluded by EU and US organic standards, because of concerns about contaminants.

For Chris Atkinson, in order to close nutrient cycles in organic farming in the short term, **fertiliser products recovered from sewage sludge and with low contaminant levels should be authorised in organic farming**. In the longer term, separative sewerage systems (eco-sanitation) should offer nutrient sources with lower contaminant levels, and the EU Organic Farming Regulation should be amended to authorise the use of sanitised sewage sludge subject to quality criteria.

Kurt Möller, Universität Hohenheim, Germany, and "Improve-P" *project* (CORE ORGANIC II funded, Improved Phosphorus Resource efficiency in Organic agriculture Via recycling and Enhanced biological mobilization) also underlined the clear need to enable use of recycled phosphorus as input to organic farming.

See Improve-P video tutorial
www.youtube.com/watch?v=LBKmgw5LjLA

Nearly 40% of organic farm soils surveyed in Improve-P were below optimal phosphorus status (in Austria, Swizerland, Germany, Norway, UK, and Denmark), especially in arable organic farming, with mean annual phosphorus balances of -4 kgP/ha (-11 kgP/ha/y for arable).

Fertiliser value of recycled nutrient materials

Dr. Möller presented collated data from a wide range of sources regarding phosphorus crop availability for different recycled nutrient materials (from literature and from *Improve-P* studies). Phosphate rock shows plant availability highly dependent on soil pH, with **near zero fertiliser value of phosphate rock** on most European soils (pH 6 or higher). Struvite shows good phosphorus availability, independent of soil pH, but with variable results suggesting that some materials may not in fact be struvite but mixtures of other phosphate salts. Manures, biological P-removal sewage sludge and compost show phosphorus plant availability comparable to water-soluble mineral fertilisers, whereas digestates and chemical P-removal sewage sludge show lower phosphorus availability.

Else Bünemann-König, FiBL, see below also presented test data showing the near zero fertiliser value of phosphate rock on most soils, and only 40% phosphorus plant availability even on acid soils.

Overall sustainability considerations

Improve-P looked at Life Cycle Analysis of different phosphorus sources, concluding that the most overall sustainable route for sewage nutrients is managed spreading of appropriately treated sludge on farmland. Recovery of nutrients from sewage has an environmental and energy cost, but still has an **LCA generally better than phosphate rock**. The LCA of mineral phosphate fertilisers (which are not authorised in organic farming) is not significantly different from that of phosphate rock.

Improve-P studies on contaminants in sewage sludge and other organic materials (e.g. composts) suggest that risks of accumulation in soil are low at appropriate application rates, whereas the risk of accumulation of cadmium from use of phosphate rock is higher (but still not susceptible to reach risk levels). This confirms the *assessment* in Norway (Erikson et al. *2009* Norway, ISBN 978-82-8082-337-3) concluding a low accumulation risk for most organic contaminants.

Koen Desimpelaere, EIP-AGRI Service Point, presented the conclusions EIP-AGRI *Focus Group* on Recycled Nutrients. The Group's conclusions are published and are summarised in SCOPE Newsletter *n°124*, including recommendations for research needs and for possible Operational Groups under Rural Development funding. Of particular relevance for organic farming are the identified need for research into organic contaminants, societal acceptance and LCA methodologies. Participants are also referred to the conclusions of the *Focus Group* on organic arable farming. See for more information: *https://ec.europa.eu/eip/agriculture/en/focus-groups/nutrient-recycling* *https://ec.europa.eu/eip/agriculture/en/focus-groups/organic-farming-optimising-arable-yields*

Organic farmers' acceptance

Else Bünemann-König, Research Institute of Organic Agriculture (FiBL), summarized Improve-P project studies on organic farmer acceptance of recycled fertilisers (see also Loes et al. 2016 in SCOPE Newsletter *n°122* and Loes et al. 2017 *https://doi.org/10.1007/s13165-016-0165-3*). Organic farmers (in seven countries surveyed) were generally positive towards use of recycled nutrient materials, for example nearly 2/3 considering acceptable use of sewage sludge, biowaste or manure from conventional farms. There are however considerable differences between countries in attitudes to reuse of sewage sludge.

Eric Gall (IFOAM EU) confirmed that surveys of organic farmers in the **SUSTAINGAS** project showed their positive acceptance of digestates from wastes and residues, with a preference for using small scale – locally sourced materials.

Discussion of organic farming criteria for recycled nutrients

The EU's "Expert Group for Technical Advice on Organic Production" (EGTOP) gave in *2016* (see ESPP eNews *n°4*) a **positive opinion on the authorisation of sewage-recovered struvite and calcined phosphates as phosphate fertilisers for organic farming in Europe**, subject to their authorisation under the revised EU Fertilisers Regulation. This is therefore dependent on the STRUBIAS process (see ESPP eNews *n°15*).

It was discussed that recycled nutrient products in organic farming **must respect the overall organic principles**, and not copy the development of conventional farming. Dependence on external suppliers poses issues and local recycling loops would be preferable, yet the specialisation of organic farmers is a reality. Farmer to farmer cooperation and management of organic wastes at regional level is a critical issue to be tackled.

Participants underlined the **need for dialogue** to define criteria for what nutrient materials are acceptable in organic farming, taking into account nutrient source/inputs, LCA and sustainability of processing, contaminants.

- To what extent is the use of chemicals in the nutrient recovery process acceptable (e.g. potassium hydroxide)?
- Must recycled nutrients be recovered from 100% organic sources?
- The accent should be on improving sewage quality upstream by avoiding contaminant inputs
- What is the effect on crop nutritional value of the use of organic or recycled nutrient materials? – this is an important purchasing criteria for many organic produce customers.
- Need to involve crop breeding and seed companies: genetics interact with nutrient uptake and use
- Better understand the roles of organic matter and humic acid in recycled nutrient materials (and in soil) in improving nutrient uptake

- Need for long term studies to assess the fate over time of carbon input to soil in materials such as compost or digestate, and how organic farming practices can contribute to long-term carbon retention in soil

Chris Atkinson noted that the definition of organic farming criteria in the USA is a public consultation process, but regrets that it is essentially a "closed" system in the EU. However, the **current revision of the *EU Organic Farming Regulation*** does open opportunities for change.

Else Bünemann-König, FiBL, indicated that this organization is currently working to make a European Organic Farming Input List (*www.betriebsmittelliste.de/en/bml-info/manufacturers.html*) to cover fertiliser materials, composts, etc. This will first be presented at the *BIOFACH* fair in Nuremberg in February 2018. This will list company products which are positively evaluated for use in organic farming by *FiBL*. This list will be further extended to cover struvite and ash-based products, but only after these are added into the EU Organic Farming Regulation (see above).

Organic contaminants and safety of recycled nutrients

Hannah Rigby, Imperial College London, presented studies carried out for the UK Food Standards Agency investigating uptake of organic contaminants present in sewage sludge biosolids and other recycled wastes by grazing animals and by crops. Upper rates of exposure were studied, including mixing biosolids (at 5% dry weight) into feed of lactating cows to simulate ingestion of contaminated foliage or of biosolids from the soil surface by grazing cattle. In this 5% biosolids treatment, organic contaminants were detected in milk at elevated concentrations in comparison to the control, in particular polychlorinated alkanes, and others such as brominated and chlorinated dioxins and furans, brominated flame retardants, and polychlorinated naphthalenes. However, **surface application of biosolids to pasture is rarely practiced, and no-grazing periods and methods of biosolids application minimise ingestion of biosolids from the soil surface by grazing cattle.**

In tests with crop application, **there was no organic contaminant uptake above control levels to wheat grain in a field investigation** after one application of biosolids and other recycled waste materials.

Further studies are needed to provide adequate data for risk assessment of repeated applications of biosolids, but the overall conclusion is that no immediate risk to human health was apparent.

Marissa de Boer, University of Amsterdam and SusPhos presented uptake of pharmaceuticals in nutrient recovery from pharmaceutical-spiked urine and transfer to tomato crops. Nutrient recovery was by struvite precipitation (phosphorus recovery) and by zeolite and biochar (ammonia adsorption). The pharmaceuticals spiked were carbamazepine, diclofenac, ibuprofen, propranolol, sulfamenthoxazole. **Struvite precipitation takes up very low levels of pharmaceuticals**, but the zeolite adsorption processes take up higher levels. Even for these, transfer to the tomatoes was extremely low, with only carbamazepine being detectable – at levels such that it would be necessary to consume **over a tonne of dried tomatoes per day** to pose a health risk. Nonetheless, further work is needed to assess possible impacts of the contaminants on soil ecology.

Discussion on contaminants

The following issues were raised by participants concerning contaminants:

- Risk of accumulation of contaminants with repeated application of recycled nutrient products?
- Possible long term effects of low levels of contaminants, or of combinations of different organic contaminants
- Detection methods for organic contaminants in organic materials?
- Impacts of organic contaminants on soil ecology, soil organism and micro-organism community
- In particular, possible impacts of micro-plastics on soil ecology
- Risk of development of antiobiotic resistant micro-organisms in soil if exposed to pharmaceutical contaminants? Is this a relevant health risk?
- Data can never be complete on organic contaminants (large number of pharmaceuticals and of consumer

chemicals, and of their breakdown metabolites), but it is nonetheless important to develop further data to support risk assessment

- The possible risks of organic contaminants must be balanced against the positive LCA of using organic materials (such as treated sewage sludge) on soil compared to incineration
- It should be remembered that most pharmaceuticals are water soluble (mainly not transferred to sewage sludge but to aquatic discharge) and most are adsorbed onto sludge/soil particles and so may be inactivated

Case studies of recycled nutrients in practice

Michel Raaphorst, TIMAC Agro, and also himself an organic farmer, presented the use of **modified struvite as a precision starter fertiliser for maize** in the Netherlands. The product offers added value in phosphorus and/or nitrogen depleted soils, and in organic or low-input crop systems. Specifically developed processing, including dosing of nutrient complements and biostimulants, and delivery as a micro-dose to the root zone at the start of the maize growth period is shown to lead to increase yields. It is identified that this is because **the plant is incited to develop an efficient root structure, also helpful for plant wind resistance and water uptake**. Trials have shown that for maize in the Netherlands, for a range of different genotypes, and also for lettuce and potatoes, precision application of manure is less effective than processed struvite, and that the initial micro-application of struvite phosphorus enables better nitrogen uptake over the maize growth cycle. It is noted that such added value products will often **need to be tailor made for different crops or different climates and soil conditions**. The Netherlands soils generally have sufficient phosphorus for crops, but it is not sufficiently rapidly available for optimal plant development.

Mike Daly, Ostara, explained progress towards regulatory acceptance of sewage-recovered struvite as an organic fertiliser. **Ostara submitted in 2015, via the UK authorities (DEFRA), sewage-recovered struvite to EGTOP for consideration for addition to the EU Organic Farming Regulation** (Annex 1 of EC 889/2008). Following the EGTOP positive opinion in *2016* (see ESPP eNews *n°4*), recovered struvite is expected to be authorised for organic farming once the revised EU Fertilisers Regulation and STRUBIAS are adopted (2019?).

Ostara struvite has been assessed in the **UK Arable LINK project** (Southampton University, field trials, see SCOPE Newsletter *n°125*) showing that as wheat plants grow so struvite disappears from the soil – the nutrients are released when the plant needs them. The plants develop five times higher root volume than with triple super phosphate application. Further trials are underway in the Nurec4Org project (see below) and with Manitoba University Canada (looking at impacts at soil health and biology).

Viooltje Lebuf, Fertikal, is one of Europe's larger organic (as in carbon containing) fertiliser producers, processing fertilisers and soil improvers from local secondary resources and selling in Europe and to export (see SCOPE Newsletter *n°118*). Today, around 5% of the company's production of pellets is certified for organic farming but none of the company's compost.

Prices for organic farming certified input raw materials can be five times higher, so that certification is a significant economic question.

The company faces a number of **challenges and contradictions in obtaining organic farming certification for its products**:

- Simple solid-liquid separation of pig or cow manure seems to be considered as "processing" which excludes from organic certification
- Chicken manure can be certified if the chickens are "free range" … but then this status is lost if the chickens are enclosed because of bird 'flu or cold weather – whereas Fertikal needs reliable status raw material
- It is not clear which poultry stables are considered "free range" for organic certification, and which are not
- Use of organic farm manures as inputs is not possible, because the organic farmer must demonstrate that their manure production goes to an organic farm (incompatible with commercial processing and distribution)

- Meat and bone meal, on the other hand, is acceptable for organic certification, even if from factory farming

Contradictory regulation for recycling nutrients to organic farming

Other participants confirm that currently there is **confusion and incoherence in regulations defining from which materials and how nutrients can be recycled to organic farming:**

- (UK) meat and bone meal ash can be considered as "too processed" to be organic, despite the incineration being obligatory to ensure safety – as well as ensuring elimination of organic contaminants
- (Germany) any trace of catering biowaste excludes from organic, whereas separately collected household biowaste is accepted (despite being generally being of comparable quality to catering biowaste)
- (Germany) the number of animals for the definition of excluded intensive livestock (manure not acceptable for organic farming) concerns the number of animals covered by the manure contract, not the number actually present on the farm (may be different)

Gerald Dunst, Sonnenerde Austria, presented a local success story (150 farmers) using biochar produced from crop residues as a soil improver. Here, **soil organic matter has increased from 3% to 7%** on average, considered to result in reductions in soil erosion and nutrient losses, lower fertiliser and pesticide use and better soil water retention. He considers that nitrogen is the limiting factor for soil organic carbon, because soil organic material is 10% nitrogen w/w. He underlines the **contradiction that biochar is not authorised as an input for organic farming**, whereas it is authorised on cheese (E153), in animal feed (where it can reduce contaminant toxicity) and is sold in Germany as a fertiliser.

Irmgard Leifert, European Compost Network, indicated that high-quality compost is an important source for nutrients, including phosphorus, and for organic matter recycling in arable organic farming production. Compost from separately collected household food wastes is already authorised for input to organic farming (Annex 1 of EC 889/2008).

A pre-condition for the acceptance of compost and digestate by the organic farming association is that compost and digestate have passed an external control by an acknowledged quality assurance system. **Dr Leifert presented the basic requirements and specific standards given by EU legislation, the Research Institute for Organic Farming (FiBL-Germany) and the national organic farming associations (e.g. Bioland /Naturland, Germany) and the Quality assurance (RAL-Germany, ECN-QAS).** In 2017, around 29% of the RAL - quality certified composting and digestion facilities achieved an FiBl-recognition. About 50.000 tonnes of RAL-quality assured compost produced from biowaste and greenwaste fullfilling the FiBl and Bioland/Naturland criteria were sold to organic farmers in Germany in 2017.

Compost application can fulfil a large part of the nutrient needs for arable crop rotation. For example, with permitted 20 tonnes compost dry matter/ha/3 years, for a compost containing - amongst others – about 0.2 % P (in dry matter), about 40 kgP/ha/3 years (14 kgP/ha/y) are applied. The fertiliser efficiency of phosphorus in compost is relatively high, so 100% can be credited to crop utilisation in the nutrient balance.

Carlotta Hoffmann, Bioland (a German organic farmers' organisation) underlined that **phosphorus deficiency in organic farming can lead to reduced nitrogen fixation**, whereas plant nitrogen fixation is the principal nitrogen supply for organic farming. A first survey in Germany shows that around 40% of organic farmland is today at low phosphorus status. Studies with German organic farmers show general acceptance of the use of recycled nutrients, with key concerns being contaminants and product nutrient efficiency.

Through the Nurec4org (recycled nutrients for organic farming) *project* **dialogue is engaged between producers of recycled nutrient products, organic farmers and consumers**. To date, this confirms the importance of contaminants and nutrient efficiency of products, and also indicates the need to assess the environmental and energy impacts of the recycling chain to ensure respect of organic farming principles. Further actions engaged within Nurec4org will include building consumer – public awareness and pot trials of recycled nutrient products.

Nurec4org organic farmers workshop

A stakeholder workshop of German organic farmers and representatives, organised by the nurec4org project and DBU (German Federal Environment Foundation), 16th November 2017, Frankfurt, identified key criteria for acceptability of recycled phosphate products in organic agriculture:

- **Regulatory authorisation for organic farming**
- **Fertiliser efficiency**: nutrient plant availability, low nutrient losses to the environment
- Low **contaminant** levels and safety
- **Environmental performance** of production process, e.g. energy consumption and greenhouse gas emissions compared to mineral fertiliser production
- **Cost**
- **Transparency**: Life Cycle Analysis, data on production

Discussion and conclusions

Bram Moeskops, IFOAM EU, noted that this meeting helped to put the issue of closing nutrient cycles higher on the agenda of the organic movement. Recycled phosphorus products can be part of the solution to organic farming's phosphorus deficit considering that nutrient cycles should be closed as locally as possible, including at regional level. It is important to avoid economic dependence of farmers on input suppliers. The meeting showed the **need to identify criteria for acceptance of recycled nutrient products in organic farming**. This discussion is more advanced in some countries than in others, and needs to be taken up at the European level, maybe with appropriate support or recognition by the European Commission.

Ludwig Hermann, ESPP President, summarised the meeting with the following conclusions:

- **Organic farming needs recycled phosphorus**. Specialisation of organic farming results in a phosphorus deficit in non-livestock organic farms. Phosphate rock is not a good phosphorus source: largely not crop-available and posing contaminant and sustainability issues (non renewable resource)
- **Organic farmers are generally positive to acceptance of recycled nutrient products**, but with concerns which need to be addressed (contaminants, nutrient efficiency, overall sustainability, supply dependence …)
- **Organic farming offers potential added value** for producers of recycled nutrient products, and so positive economic value for the nutrient circular economy
- **The current regulatory context is complex, contradictory, incoherent** (between Member States, e.g. on definitions of "processing" or "intensive" sourced manures), for recycled products in organic farming in Europe
- There is a **window of opportunity to integrate recycled nutrient products into organic farming regulation in Europe,** with the revision of the EU Organic Farming Regulation, the new Fertilisers Regulation, STRUBIAS, and an overall positive policy maker approach through the Circular Economy
- **Both societal dialogue and scientific data are needed**. Dialogue should involve organic farmers, organic food companies and supermarkets, consumers, recyclers, agronomists. Data is needed on contaminants and safety, to support risk assessments, and on environmental / LCA aspects.
- **Success stories and positive information already exist**: field tests of products, use by farmers, R&D/implementation projects, positive positions of supermarkets.

Future actions

- **Develop recommendations for outline criteria for acceptance of recycled nutrient products in organic farming**, covering contaminants and product quality, nutrient efficiency, sources of input materials, environmental/LCA aspects, supply/system. This should bring together the organic movement, other stakeholders and science as possible basis for future decisions on candidate products.
- In the short term, incite Member States to **submit further recycled products to EGTOP for consideration,** maybe starting with available sources and products (manure recovered nutrients, STRUBIAS products: biochars, phosphate salts, ashes).
- For this, **identify specific candidate recycled nutrient products available today**, for which data is available and producer(s) ready to put onto the market
- In the longer term, **work on systems approaches**, such as separative sewage (eco-sanitation)

Conference slides, programme, etc.
www.phosphorusplatform.eu/activities/conference/meeting-archive/1602-meeting-eu-organic-agriculture

See also, Möller et al., "Improved Phosphorus Recycling in Organic Farming: Navigating Between Constraints", Advances in Agronomy 2017 https://doi.org/10.1016/bs.agron.2017.10.004