SYSTEMIC

Fact sheet

Recovery of nutrients and resources from digestate

2021

Extract from D 3.4 Market research in Europe -2021

Market opportunities for advanced bio-refinery products from digestate

Recovered nutrient fertilisers for organic farming

The European Green Deal is a roadmap to make the European economy sustainable. It includes targets for 2030 to reduce nutrient losses by at least 50%, while ensuring that there is no deterioration in soil fertility. This will reduce the use of fertilisers by at least 20% by 2030.
Additionally, the Commission will persue the objective of at least 25% of the EU's agricultural land under organic farming by 2030 (European Commission 2020).
Increasing organic farming practices will contribute to the reduction of artificial fertilisers use, because mineral nitrogen fertilisers are not allowed in organic farming (European Commission 2018).
On the other hand, the Commission will also work with Member States to extend recycling of organic waste into renewable fertilisers (European Commission 2020).

This poses the question if these recycled, renewable fertilisers would be applicable in organic farming.

Principles of organic farming

An important principle in organic farming is to maximally use natural resources which are internal to the system. This means that external inputs (feed, fertilisers, soil improvers, bio-stimulants, pesticides) and non-renewable resources are restricted. Plants should preferably be fed through the soil eco-system and not through soluble fertilisers added to the soil. Therefore, waste products and by-products of plant and animal origin from the farm can be re-used as nutrient inputs into cultivation (European Commission 2007).

Therefore, external fertilisers are allowed in organic farming, if no other appropriate management practices and methods exist.

In Europe, the import of external inputs such as fertilisers into organic farms is currently regulated by the Council Regulation (EC) No 2018/848 (European Commission 2018), which is interpreted and put into practice by the national governments (Table 1).

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Table 1 Mentions of digestate on Annex I of Regulation (EC) No 889/2008.

	Name	Description, compositional requirements, conditions for use
A	Composted or fermented mixture of household waste	Product obtained from source separated household waste, which has been submitted to composting or to anaerobic fermentation for biogas production Only vegetable and animal household waste Only when produced in a closed and monitored collection system, accepted by the Member State
A	Composted or fermented mixture of vegetable matter	Product obtained from mixtures of vegetable matter, which have been submitted to composting or to anaerobic fermentation for biogas production
B	Biogas digestate containing animal by-products co-digested with material of plant or animal origin as listed in this Annex	Animal by-products (including by-products of wild animals) of category 3 and digestive tract content of category 2 (categories 2 and 3 as defined in Regulation (EC) No 1069/2009 of the European Parliament and of the Council (1)) must not be from factory farming origin. The Processes have to be in accordance with Commission Regulation (EU) No 142/2011. Not to be applied to edible parts of the crop

A: authorised under Regulation (EEC) No 2092/91 and carried over by Article 16(3)(c) of Regulation (EC) No 834/2007

B: authorised under Regulation (EC) No 834/2007

Each Member State can file a product for consideration, amendment or withdrawal from the list by providing a dossier to the European Commission containing argumentation and reasons for inclusion on the list.

Nutrient balance in organic farming

Like in conventional farming, the organic farming sector has been specializing and expanding, accompanied by increased production levels (Eurostat, ORG_CROPAR). However, when increasing the number of organic farms, the principles of organic farming of closing the loops for nutrients and resources, seem to hit the boundaries of production (Kirchmann, Ryan, and Bergström 2008). Several studies indicate that a lack of adequate nutrient supply is one of the major constraints of yields in organic farming (Askegaard et al. 2011; Berry et al. 2003; Lockeretz et al. 1980; Möller et al. 2006; Röös et al. 2018; Ryan, Derrick, and Dann 2004).

Nitrogen forms the foundation of proteins and is an important factor determining crop production and growth. Since mineral N fertilisers are not allowed, organic farming is depended on the mineralisation of N from organic matter and the breakdown of organic fertilisers. N deficiency is cited as the major yield limiting factor in organic farming, except from pastures with grazing cattle i.e. systems with also a large proportion of N_2 fixing forage crops (Clark et al. 1999; Kirchmann et al. 2007).

On the other hand, P and K balances of organic systems generally indicate a net loss of these nutrients through harvested products, (Fagerberg, Salomon, and Jonsson 1996; Kaffka and Koepf 1989; Reimer et al. 2020), unless sufficient volumes of approved organic manures are purchased (Ryan and Angus 2003).

Unfortunately, no comprehensive dataset is available on which kinds of inputs are actually used in organic farming in the Member States. However, for Flanders, Belgium (Reubens and Willekens 2012) describe that in 2009, there was not enough organic manure to supply for all nutrients needed in organic farming. Therefore, the Flemish organic farming sector was estimated to be depended for 30% on external, conventional animal manure. This underlies the demand of the organic sector for (external) nutrient input.

On the other hand, poultry manure is net exported out of the Flemish organic sector and send through acknowledged manure transporters or manure processors to organic arable land abroad: mainly France or Germany (Reubens and Willekens 2012). This has to do with a shortage of available organic land for this type of manure. This is due to the fact that organic poultry farming cannot make use of land related animal husbandry principles (i.e. chickens don't drop their manure directly on the soil that needs to be fertilised). Also, stringent phosphorus limits make poultry manure unattractive for arable farmers because of its variability in composition and low N/P ratio.

This creates a paradox: certain types of organic manure don't supply the nutrients in the right ratio's, hence they are processed or exported. This stimulates the intensification of the sector and makes it rightly sensitive to social criticism. On the other hand, are the amounts of organic manure or digestate are not available in high enough quantity to meet the demand of the crops.

Despite the fact that approved external organic nutrient sources tend to have a lower nutrient utilisation efficiency than inorganic artificial fertilisers (Mattsson and Kjellquist 1992), there is an increasing trend in some countries to apply products such as meat meal, bone meal and wastes derived from the food industry (Kirchmann et al. 2008).

All these external, organic farming approved fertilisers involve an indirect nutrient transfer from conventional to organic farming and create a reliance on production systems fertilised with inorganic fertilisers (Berry et al. 2003; Kirchmann et al. 2008).

Recovered nutrients in organic farming?

Recovered P fertilisers

An ideal organic fertiliser has a high organic matter content, slowly available nutrients and high N/P ratio (Smit, Prins, and Hoop 2000). Some of the recovered nutrient products, like struvite or renewable calcined phosphate, could be suited for this.

Struvite is a slow release P fertiliser and can be used to satisfy plant needs for phosphorus. A struvite dossier was filed back in 2011 by the UK and together with the calcined ashes dossier filed in 2014 by Austria (AshDec) evaluated by EGTOP (Expert Group for Technical advice in Organic Production). They formulated their official advice to DG AGRI in their 2016 report (EGTOP 2016) stating that struvite is in line with the organic fertiliser principeles. DG AGRI concluded that they would add these products to the list (Annex I of Regulation (EC) No 889/2008) when the Fertilising Product Regulation(EC) 2003/2003 was amended and implemented. This will happen when the STRUBIAS ANNEX is implemented in the Fertilising Products Regulation (2019/2009) and this enters into force in 26 June 2022.

Novel fertilisers obtained by stripping of ammonia

In general, organic farming prohibits the use of highly soluble mineral N fertilisers as it is clashing with the principle of feeding the soil life and not the plants.

However, a request for inclusion on the list was filed for scrubber salts of NH3-stripping-scrubbing, since N is often a limiting nutrient for crops. EGTOP concluded in their 2018 report that two principles conflict in this case:

1) The recycling of wastes and by-products of plant and animal origin is explicitly welcome (see Art 5(c) of Reg. 834/2007). Catching otherwise 'lost' minerals and recycling them is in line with the organic principles. Also, the catching of nitrogen can be an on-farm process.
2) On the other hand, there is a requirement that mineral fertilisers must be of low solubility (see Art. 4(b)(iii) of Reg. 834/2007). If such fertilisers were allowed, the Group is concerned that the current approach of organic crop nutrition which is primarily based on biological aspects of soil fertility would be replaced by a conventional, intensive approach focussing on nutrient supply. Additionally, the nutritional quality of crops can be decreased by high values of nitrate in the harvested crop. They stress that for cultivation of terrestrial crops, there are numerous alternatives in organic farming practices to achieve N supply. The products obtained are highly soluble and have a potential risk of nitrogen leaching, when applied in farming.

If such N fertiliser from scrubbing would be approved, it would also quickly add more administrative and technical questions:

How to define the minimum C/N ratio when these products are mixed with other organic products?
How can inspection verify that this minimum ratio is respected?
How long does the stripped nitrogen need to remain in the compost, to be transformed into low solubility organic forms?
And is this practically feasible?
Can the stripped nitrogen be sold to another organic farm?

As for the production of such N fertilisers, biological methods should be preferred to chemical methods, even if the use of certain chemicals can be acceptable, if no alternatives are available. If chemical air scrubbers with sulfuric acids are used, substantial amounts of sulphate are produced, which is not an authorized fertiliser.

Therefore, the EGTOP did not recommend including stripped nitrogen in Annex I, but welcomed research activities which lead to an acceptable mode of application of stripped nitrogen, in line with organic farming principles (EGTOP 2018).
In Denmark, the authorities did not consider it necessary to consult EGTOP and accepted the process of nitrogen stripping. They considered the processing as purely mechanical, and thus not altering the product it comes from, namely digestate. Several companies are now considering dossiers for acceptance of similar products (FiBl and SEGES, RELACS webinar, 2021).

N stripped digestate

Soil phosphate saturation in certain regions (**Fout! Verwijzingsbron niet gevonden.**) will only be resolved in the long term. In the meantime, it will become increasingly difficult to use (digested) animal manure or co-digestate with high P content. Certain fertilisers with recovered nutrients(e.g. N stripped LF of digestate) could then ensure that fertilisation could be done with lower concentrations of phosphate. No dossier on such treated organic products has been filed yet.

One could also argue that by producing such a product, part of the carbon is also lost, since it is present in the solid fraction, together with the phosphate. The product therefore also contains highly soluble mineral nutrients, which is not desirable for improving the soil.

Technologies for nutrient recovery

Many technologies used to recover nutrients and organic matter from digestate use chemicals like acids or alkali (e.g. evaporation, NH_3-stripping-scrubbing, membrane filtration) or technological additives (e.g. flocculants, coagulants for enhanced separation). EGTOP concluded in their advice (EGTOP 2016) that the use of acids and alkali should be authorised only after case by case evaluation. Technological additives should in EGTOP's opinion not normally be present in organic fertilisers and should only be used when there is a clearly demonstrated need.

Discussion

Standpoint of organic farming organisations

At first sight, recycling of resources and nutrients as bio-based fertilisers is very much in line with the philosophy and foundation of organic farming, even more because the choice and supply of fertilisers for organic farming can be limited in some regions.

However, at the same time, the organic sector is greatly concerned about the integrity of their products, and therefore organic farmers, food processors and retailers may have some reservations against recycled products, due to concerns about contaminants, and consumer perceptions of the organic brand (Jensen et al. 2016).

The opinion of organic sectors in different member states varies on the degree in which also conventional manure should be banned from organic growing (e.g. Denmark vs. Norway). They all agree that they want to avoid that organic farming becomes a “dumping place” for excess nutrients from conventional farming. Digestate from source-separated organic waste, and struvite from sewage, are considered as interesting options for recycling of nutrients (personal communication, 2020).

The organic sector acknowledges that it cannot close the nutrient cycles 100% (cfr. nutrient deficits because of harvesting of agricultural production). One could argue if this is the case for nitrogen, but it is seen particularly in the use of micro-element fertilisers and potassium. Local recycling could provide access to nutrients that would otherwise be imported (Dionet Greece, 2021).

Organic farming organisations are also worried that opening the door for recovered nutrients would make them abandon the land-related principle of organic farming, which would risk setting up a separate circuit for organic fertilisers. This way organic fertilisation could be gradually reduced to a chemical issue: after all, does it make a qualitative difference whether an organic farmer uses digestate from organic inputs or from non-organic (contentious) inputs?(BioForum Vlaanderen 2019)

Additionally, if organic farming would increasingly rely on the use of such recycled rapid fertilisation forms, organic farmers who continue to effectively opt for ecological fertilisation

methods with slow fertilisers could become competitively disadvantaged within the organic label (BioForum Vlaanderen 2019).
The basic principles of organic farming start from the minimization of external inputs. Investing in the technological recycling of nutrients makes agriculture more dependent on inputs and technology, which necessitates further scaling up and specialization to keep everything financially feasible (BioForum Vlaanderen 2019).

The organic sector is generally of the opinion that nutrient recycling is an end-of-pipe technical solution that does not address the underlying problem and is not in accordance with the basic principles of organic farming (BioForum Vlaanderen 2019, Ecozept, 2021).

Is the organic farming sector ready for 2030?

Unless there are changes in regulations, the organic farmers will continue to rely on the import of nutrients from conventional production. If a large proportion of conventional farms is converted to organic farming (cfr. European Green Deal targets), the amounts of recyclable wastes produced would not be sufficient for high-yielding corps since they will be spread over a much larger area. It is also questionable if transfer of nutrients from natural systems would be enough to cover crops needs, resulting in decline in soil fertility (Kirchmann et al. 2008).

To sustain food production after complete adoption of organic farming, mixed animal-arable organic systems would require an increase of land area of 33%, while pure arable systems would require doubling in area (Kirchmann et al. 2008). Only a 20% conversion to organic farming would be possible without increasing land use by more than 5%, without other food system changes.
The needed nitrogen supply could only be met if cropping intensities were increased and fallow land and intercropping were to be systematically used for legume production, which may not be possible because of e.g. water supply and feasibility of legume production in intercropping in some regions (Muller et al. 2017)

It seems a bit contradictory to imply an intensification to an agricultural sector which is not focused on maximizing yield, but rather on being land-related resilient, and giving great attention to animal welfare and eco-system.

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Circular solutions for biowaste

Organic farming alone as a dominant system will not provide a better long-term outcome in the search of sustainable forms of crop production than conventional alternatives. The real challenge will be intensifying this sector and including a synergy with the conventional agricultural sector. For this trade-offs and compromises will have to be made in both sectors to ultimately create a flexible approach where cropping systems are designed to meet specific environmental, economic and social goals unencumbered by dogmatic constraints (Kirchmann et al. 2008).

Although many arguments can be given to underline that recycled nutrient products are not in accordance with the basic principles of organic farming, they can have their place in future farming systems, which will have to optimally combine the best of both organic and conventional farming.
For example, an adequate farm- specific mixture of different external inputs, including recovered nutrient products, in combination with biological nitrogen fixation, which fits the nutrient requirements of the farm, might be a suitable solution.

Anyhow, further research on the safe application and regional availability of recycled fertilisers in the context of organic and conventional farming systems is necessary to find solutions for the future.

The H2020 project RELACS will create some interesting deliverables, working further on the above-mentioned themes:

- An overview on the current use of and needs for external nutrient inputs in five European regions with contrasting agroecological and socioeconomic conditions;
- A publication on the short-term and longer term benefits of recycled fertilisers with respect to soil quality
- European roadmap on contentious fertilisers (manure from conventional agriculture, recycled nutrients)

An overview of and provide overall recommendation of recycling technologies suitable for organic agriculture

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