Recommendations

FOR OPERATORS

on sustainable nutrient management for biogas production and digestate management

SUSTAINABLE BIOGAS

Interreg Central Baltic

EUROPEAN UNION
European Regional Development Fund

Fertilizers used in agriculture, including slurry, litter manure and plant post-fermentation residues contain valuable nitrogen and phosphorus compounds that are easily ingested by plants, but excessive usage may cause pollution of surface water and ground water with water-soluble nitrates and phosphorus compounds.

Also, leakages from biogas plants' raw material storages, for instance, slurry and silage effluent, can cause point-source pollution in watercourses in the vicinity of biogas plants.

The most visible consequence of excessive accumulation of nutrients in watercourses is eutrophication.

In anaerobic digestion

of manure and other organic biomasses the nutrients remain in the digestate.

Due to its stability against decomposition during storage and spreading, it is more environmentally friendly in comparison with manure and silage effluent.

Although during digestate formation process, majority of organic substances are transferred to less active compounds, it shall be considered that when spreading digestate into soils with typical flushing water flow, there a is risk of the passage of certain chemical compounds, including nitrogen and phosphorus compounds, which can create environment pollution and reduce agricultural efficiency *(LULST, 1999)*.

STORAGE OF DRY RAW MATERIAL

To prevent nutrients from leaching into the soil and surrounding water bodies due to environmental conditions (for instance, heavy rains) and mass pressure, the raw materials shall only be stored on waterproof cover, which is resistant for impact of the raw material and possible mechanical damages during filling or emptying processes.

Operators shall do regular visual monitoring of silage effluent collection system.

After each self-monitoring measure, the operator shall write down the condition of silage effluent collection system. Emptying of silage effluent storages shall be carried out in accordance with the developed internal control guidelines and the measures shall be done in accordance with the permit conditions.

For biogas plants where technically possible, it is recommended to mix the silage effluent with slurry, but not more than **5 %** of digester volume at a time, or to store the silage effluent in digestate storage up to **15 %** of digestate storage volume *(I.Kavanagha et.al., 2021).*

Particular attention shall be paid to

silage storage, considering its low pH level and high content of nutrient that shall not get into environment. Operator shall ensure an efficient silage effluent collection system complying with individual production practice and shall ensure that no environmental pollution occurs.

When storing raw material and digestate, the storage areas shall be covered

so that they are not exposed to wind and rain and that also odour emissions are reduced, especially if raw materials are stored for longer time.

Cross-channels of silage effluent runoff collection with sufficient width shall be maintained clean all the time so that sewage water can flow through them to collector wells and no leakages occur in the surrounding environment.

DIGESTATE STORAGE

Volume of digestate storage tanks is a significant part of nutrient management. Inadequate storage capacity may cause problems, for instance, in situation when due to manufacturing volume increase, digestate storage is filled up before it is allowed to spread the digestate on the field.

Also, in the spring inappropriate climate conditions such as frozen soil or heavy rain that prevent the spreading of digestate may cause overflow risks for digestate storage.

Large digestate storages and additional storage facilities provide the operator with options of storing reserves where the stored digestate may be used according to the plant needs throughout the entire vegetation period.

It is recommended

to use artificial gas-tight coverage, for instance, with valves for digestate storage ventilation to control possible emissions from the digestate storages and to use technological methods of gas collection and repeated usage (for instance, scrubber system for nitrogen fertilizer recovery).

ADDITIONAL DIGESTATE STORAGE

It is recommended to construct smaller stationary additional storage facilities as reserve storage places for storing of additional digestate, for instance:

- during winter season, when the main digestate storage is full, the additional storage for digestate can eliminate overflow from the main digestate storage;
- additional storage close to the fields, where the digestate is spread, is practical – when machinery has to fill up the digestate spreading tank, this additional storage may be connected to the station via pipelines, so that freight transport carriages are less used;

Recommendation:

to plan construction of additional storage site near spreading fields, where also liquid (separated) fraction of digestate may be stored if needed, using it as additional fertilizer to the growing plants.

RAW MATERIAL AND DIGESTATE FILLING PROCESS, TRANSPORTATION

Leakage of raw material during filling process is not admissible.

In case of both solid and liquid raw material spill or leakage, the material must be collected immediately and fed into the biogas digester.

To prevent leakage from digester during emptying process, there shall be a leak-proof connection to prevent uncontrolled leaking of liquid digestate in the environment.

It is recommended

to make an underground polyethylene pipeline and pumping station for the transfer of raw material to the additional digestate storage situated further away. Such type of infrastructure reduces odour emissions and possible nutrient leakages to the environment.

Usage of pipeline system in different processes

related to biogas production and digestate management reduces the need to use vehicle transport and it can be considered as a more environmentally friendly solution that reduces consumption of fossil resources (fuel). Pipeline system will also protect country's road infrastructure from depreciation. With such pipeline systems the digestate can be technically transported to place up to 8 km away. Thus, it is possible also to establish digestate storage in the areas with less population density to reduce number of claims for disturbing odours.

If it is possible, pumps shall be used for transportation of liquid raw material, e.g., slurry, from their origin place (barn) to biogas plant without intermediate tank or other infrastructure, which essentially reduces emission of nitrogen, ammonia and odours in the air.

DIGESTATE SEPARATION

For more efficient use of produced digestate in the soil and to facilitate pumping,

It would be recommended

at first to separate solid fraction from liquid fraction by using, for example, screw-press or centrifuge separation equipment. Separation reduces the relative transport costs of the phosphorus-containing dry fraction by reducing the mass transported.

DIGESTATE USAGE

In addition to use as an organic fertilizer digestate has other options for application.

Just like technical compost it is possible to use digestate for areal improvement projects, landscape relief formation, in road construction for renewal of green zone, as finishing coverage for organic part formation in landfills and elsewhere.

Different regulation applies to different use.

The digestate which cannot be used in agriculture due to the presence of pollutants, can be quite well used in industrial sector, where materials have lower environment requirements.

Usage of dry digestate as barn litter is not recommended, as under impact of liquids, dry digestate causes high and comparatively fast point-source of nutrient release at product usage sites.

Depending on how activities with digestate are organized, there are four basic ways:

1. even spreading on field surface;
2. spreading simultaneously with incorporation in the soil;
3. injection in soil;
4. incorporation in rows with pipes on the soil (ribbonlike incorporation). Liquid fraction of digestate that can be used in this method is fast absorbed by soil and thus ammonia emissions are minimal.

From nutrient management point of view,

if comparing simple spreading with spreading with immediate incorporation in the soil, then spreading with immediate incorporation is more efficient, because when digestate mixes with the soil, possibility of nutrient leakage significantly reduces. Unification of these activities reduces soil compaction due to heaviness of technical equipment.

From nutrient management point of view, the situation when fertilizer is spread but is not incorporated, causes risk of nutrient leaching.

In terms of nutrient leakage and ammonia emission, it is better to use immediate incorporation or injection into the soil. If choosing the second, the following factors should be considered:

1. injection equipment provides also closing of the made furrows;
2. input shall not be done too deep (deeper than 15 cm) to avoid pollution of groundwater in areas with high ground water level (the location of each field in relief shall be taken into account);
3. time of application;
4. planned/existent plants on the field (if this method is suitable for plant needs);
5. amount of dose shall be observed – is it possible to spread the desired amount.

It is recommended

to use precise agricultural methods for digestate incorporation to minimize concentration of point-source pollution in places, where risks of organic matter leakage are increased.

ENVIRONMENTAL FACTORS

It is not recommended to spread digestate on frozen, snowy, or wet soil and it is already forbidden in many EU countries.

Digestate spreading under inappropriate conditions may stimulate its run-off into water courses thus contributing to eutrophication, also nutrients are lost from the digestate causing potential economical loss to farmers.

To limit discomfort for inhabitants, emissions of volatile organic compounds and odours, digestate spreading is not desirable in hot weather conditions.

In Latvia, for instance, it is not recommended to transport and spread digestate, if air temperature exceeds **25°C**.

ECOLOGICAL FACTORS

> **It is important to observe protection zones in digestate spreading. For instance, in the "Protection Zone Law" in Latvia it is stated that digestate may not be spread closer than 10 meters from surface water objects (it is area of protection zone).**

Protection zones are usually stated for water drills (bacteriological and chemical). It is forbidden to spread digestate or other fertilizers in bacteriological protection zone.

Regarding the use of fertilizers

in nitrate sensitive areas in Latvia, for example, the maximum nitrogen level allowed for cultivated plants are defined in the legislative regulation. For these areas a plant fertilization plan shall be drawn and coordinated with supervising authority.

We must always pay attention to the slope of the field and the closeness of the watercourses.

The use of digestate in places where the field has considerable terrain changes compared to common relief that could promote nutrient leaching into rivers, ditches or any other water bodies shall not happen. This must be included in national legislation and permits.

OTHER APPLICATIONS

The depletion of soil organic matter and the increase in soil acidity are becoming more common in the Baltic Sea region. This affects the fertility of the soil and therefore liming is required.

To improve digestate quality and start to use it wider in agriculture and forest management, the scientists of Latvia University of Life Sciences and Technologies together with partners have started development of new technology, planning to mix wood ash with digestate and obtain product with high added value that is suitable for liming.

By adding wood ash to dehydrated digestate

it is possible to increase Ca content in product and it gives characteristics of liming material to the product as well to enrich it with K, P and microelements. It can significantly reduce usage of chemical fertilizers in agriculture *(LULST, 2019).*

This is only one example how digestate value may be improved by changes of its content.

EXAMPLES OF GOOD PRACTICE IN BIOGAS PLANTS:

- Raw material is stored on waterproof basis that is chemically and mechanically durable against impact of heavy technique, and it has properly functioning, sufficiently wide draining-canals, located on an open perimeter and along tanks for silage effluent collection and pumping to digester or digestate storage;
- Silage storage is constructed with a slope and the silage effluent collection system in the furthest side of storage unloading, where a cavity in basis is established for discharge collection and drainage into the tank;
- Raw materials are fed to the digester using the pipeline system and sealed connection points that prevents emission of ammonia and other substances, as well as to reduce spillage and liquid leakage;
- Biogas operator provides appropriate number of days for the digestion of raw material (HRT – Hydraulic retention time), so that after the digestate has been removed from the digester as little methane is released as possible. This is required for a good economical result, so both the content of raw materials' C:N ratio and granulometric content must be considered;
- Improved biomass management in digestion process reduces loss of nutrient. Example: improved pre-processing, providing optimal size of raw material particles and optimal C:N ratio 25:1-35:1; improved anaerobic digestion methods; chemical recovery of nutrients, for instance, by adding sulphuric acid for ammonia binding; and gas recovery with scrubbers or other methods. Preventive methods for loss reduction – digestate treatment with air to stop the digestion process before transfer into storage tank etc.;
- It is suggested to separate digestate from nitrogen gas compounds after digestion. It is possible to obtain clean ammonia fertilizer and reduce nitrogen emissions from storage sites in that way. NH_3 recovery technology is required when drying the digestate;

- Oxygen proof barrier ensures minimal nutrient loss, particularly from silage. Full gas-proof barrier provides its retention in the result of which it may be collected and used repeatedly (for instance ammonia may be collected by water scrubbers);
- Minimal ammonia emission in the environment and thus minimal ammonia nitrogen loss is ensured by suitable equipment and incorporation methods used for digestate incorporation, for instance, immediate incorporation of digestate in the soil, use of ribbon-type incorporation between plant rows for liquid fraction and by acidification of digestate;
- To prevent phosphorus over-fertilization in the vicinity of the biogas plant, it is suggested to separate the liquid digestate to increase the phosphorus content of the solid fraction and to transfer and spread the solid fraction in the areas, where transportation of liquid fraction is not economically justified.

EMERGENCIES

In case of emergency that does not comply with normal operating principles, the operators shall act as follows:

1. to ensure the operation of the plant in an emergency without endangering the surrounding environment and employees. In case of power disruption, it must be possible to shift to spare energy sources, transfer spare gas to gas storage tanks or gas burning torch, which must be located at the plant;
2. inform senior employees about the emergency for operative consequence management (management, electricians, gas specialists and environment, labour safety specialists);
3. monitor and manage plant operations according to the options of emergency;
4. in case of emergency situations with nutrient leakage with significant consequences (for instance, odour characteristic to silage effluent, wilted water plants or dead water animals), information shall be reported to the respective state authority.

REFERENCES

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Created in the framework of Interreg Central Baltic project "Sustainable nutrient management in biogas production" NR.CB842