Deliverable 3.3. – Agricultural use of sludge

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INTRODUCTION

The middle-sized wastewater treatment plant (WWTP) generates the wastewater sludge in amounts reaching the average of 10 000 -15 000 tons of dewatered sludge every year. In many WWTPs the sewage sludge stockpiles at the sludge storage sites located in proximity of the plants' cities. The steady amounts of the sewage sludge dry mass accumulate at the sludge storage sites since and can reach the growth of the sludge quantities by addition of 2 000 - 5000 tons of dry mass every year.

At some WWTPs during the phase of the sludge processing the produced biogas is used for further conversion to heat power and electricity that is used for own needs in the plant as well, is reused for sludge processing (Klaipeda, Ronne).

In the final phase, the dried sludge is used for an incineration as well as storing at existing local sludge sites. The arrangements of the sludge storage sites required big investments to make the sites suitable for the sewage sludge stockpiling in the ways of covering the sites with the "floating" type of geosynthetic coating and installation of the drainage system. By the date, often the existing storage's sites are almost filled and an additional installation for stockpiling produced sludge is costly and the treatment of produced sludge in the future should be considered.

At the same time, the wastewater sludge is a type of biomass that could be utilized as raw material not only for energy production, but also for agriculture as valuable fertilizer. The sludge contents a significant amount of nitrogen, phosphorus and potassium as well as microelements suitable for plants and food crops vegetation (Horby, Hoor). However, the concentrations of the heavy metals, organic pollutants and microorganism should be under control. Therefore, another sewage sludge utilization methods should be taken into account. One of the well-known and effective ways of the stabilization of the sewage sludge is the composting of the sludge that reduces its quantities and stabilizes its structure (Goleniow)

Growing requirements for the treatment of the sewage sludge produced by the waste water treatment plants leads to quite strict environmental legislation regarding sludge application for agriculture.

However, the different countries are facing different challenges, and this is one of the issues that have been treated in the STEP project in the South Baltic Programme 2014-2020 (see STEP project web site - https://www.step-interreg.eu/).

POLAND

In Poland around 22% of the sewage sludge is reused in the agriculture (data from 2011). Just 6% of the sludge is used for composting using different technologies. Comparing to Denmark, France, Portugal, UK or Spain this percentage is low and requires deeper research and analyses. Landfill sludge disposal is being eliminated and therefore improvements of the existing technologies have been considered. STEP project has the aim to study these technologies in a broader perspective. A major indicators of soil fertility are biogenic elements such as nitrogen, phosphorus and organic carbon. All these elements are found in the municipal sewage sludge however the agricultural use of sludge requires converting it into compost. Composting allows conversion sludge into organic fertilisers or soil improvers and it is in line with circular waste management. Appropriate selection of composting substrate and composting technology enable production of good quality soil amendments. The application of compost produced on base of sludge to soil gives also an opportunity to recover so valuable elements that has already been listed as critical nutrients. Potential barriers to the agricultural use of sewage sludge are heavy metals contained in the sludge, mainly: Cd, Cu, Ni, Pb, Zn, Cr and Hg. In general, the concentration of heavy metals in municipal sewage sludge is below the permissible value for agricultural use. Nevertheless, there is a risk of a temporary increase in the concentration of individual elements as a result of the influence of random factors. Therefore, it is important to determine the share of chemical forms of heavy metals as well as the direction of their transformation during composting. The results of the speciation analysis related to the determination of the concentrations of Zn, Cu and Ni in the sequentially separated chemical forms extracted from compost samples, characterized by different levels of bioavailability, showed that with the composting time favourable changes in the allocation of the determined heavy metals consisting in a systematic increase in their share in non-bioavailable fractions occurred. The research results obtained in the project justify taking steps to change the regulations on the agricultural use of sewage sludge by taking into account the presence of heavy metals in the chemical forms persistent on the influence of reducing factors.

DENMARK

In Denmark the development has been positive for the last decade of years, in the sense that the quality of sludge from wastewater plants has improved, e.g. lower content of heavy metals, as is it presented in the table 1. This development, and more acceptance from the

agriculture, has implicated that the mayor part of the sludge production in Denmark, app. 80%, is now used as fertilizer in agriculture. Even the ecological farmer's organisations are now discussing the possible use of sludge as fertilizer.

Management of sludge from WWTPs and barriers to agricultural use

All the sludge produced at the WWTPs on Bornholm is used as fertilizer in agriculture, and it is used without further treatment, which is the most common way in Denmark. Dewatering of sludge is centralized on three largest WWTPs on Bornholm, and a private contractor:

Handle and transport the sludge directly after the dewatering process:

- Stores the sludge until it can be used in agriculture
- Manage the distribution to app. 15 farmers on Bornholm that use the sludge

Despite the strict Danish rules, the sludge from the WWTPs on Bornholm has good enough quality to comply with the national rules, and all sludge is used as fertilizer in agriculture. The main barrier identified is psychological in origin: The so called "Arla directive": The mayor Danish diary-company, Arla, don't allow their milk suppliers to use sludge on fields where their cows feed. This is related to possible reactions from costumers.

LITHUANIA

In Lithuania 83.1% of population used centralized drinking water supply services and 76.5% used centralized wastewater treatment services at the end of 2019. Currently 24% of the total population in Lithuania wastewater treats individually e.g. has their own local small wastewater treatment plant or septic tanks. Wastewater from septic tanks shall be transported to the local wastewater treatment plant for treatment. Lithuanian goal is to make the water supply and wastewater treatment services available to 95% of Lithuanian population till 2023.

According to the European and national regulations (for instance, Lithuanian LAND 20-2005), the wastewater sewage (as well its compost) can be used for fertilization and re-cultivation in agriculture and forestry, when established requirements are met.

Table 1. Requirements for wastewater sludge to be used in agriculture (LAND 20-2005).

REQUEREMENS FOR SLUDGE TO BE USED IN AGRICULTURE

mg/kg	Zn	Cu	Cr	Cd	Pb	Ni
	Hg					
CLASS	I	<300	<75	<140	<1.5	<140
	<50	<1.0				
	II*	300-2500	75-1000	140-400	1.5-20	140-400
	50-300	1.0-8.0				
	III**	>2500	>1000	>400	>20	>400
	>300	>8.0				

*Can be used every 3 years in agriculture except in planting industry of vegetables and fruits

**Forbidden to use

SWEDEN

In Sweden approximately 87% of the population used centralized drinking water supply and wastewater treatment services in 2016 (data given every five years). Approximately 690 000 households in Sweden still had individual wastewater treatment e.g. had their own local small wastewater treatment plant, septic tanks or infiltration installations during the same year. Every year, close to one million tons of sludge is collected from wastewater treatment processes in Sweden. Between 25 to 30 % of this sludge is spread on arable land. The remaining part is used as e.g. soil conditioner or for covering landfills. According to Swedish regulation sludge from e.g. septic tanks is considered waste and is ultimately to be taken care of by the local and regional waste companies however usually the municipal WWTPs take care of this waste fraction. The spread of sludge on arable land is regulated by law, limiting for example heavy metal concentrations allowed in sludge. In addition, WWTPs can become certified in accordance to the national Revaq-certification system which puts even stricter threshold limits for substances in the sludge but also demands the operator of the WWTPs to e.g. actively work with upstream measures to reduce contamination of the sludge. In Sweden, a discussion has been going on regarding the use of sludge as fertilizer for several years. From some sectors there has been a great opposition. Because of this a certification system, called

REVAQ, has been developed in Sweden. REVAQ is a certification system for sustainable recycling of plant‘s nutrition, reduced flow of hazardous substances to wastewater treatment plants and the management of risks on the way there. Certification means that a treatment plant is actively operating upstream, is working on continuous improvements to the sewage treatment plant and is transparent with all information. Behind REVAQ is for example the national organization for water and sewage, Farmers' Association, and the Swedish Environmental Protection Agency. Especially, the cadmium content has fallen sharply in the Swedish sludge. Experiments for more than thirty years in Skene show that the cadmium content is stable in the arable land when spreading normal quantities of sludge. The experiments have shown that the absorption of cadmium in the crops has not increased. Despite the reduction in metal content, the quality of the sludge from Swedish treatment plants needs to improve in order for it to be used as fertilizer in the future.

NATIONAL SLUDGE HANDLING RULES COMPARISON

The wastewater company (Bornholms Wastewater A/S) is responsible for sampling and testing the sludge according to the national rules, which is more strict than the EU-directive in some respects, as described in detail in the STEP delivery 3.2: NATIONAL SLUDGE HANDLING RULES COMPARISON.

Heavy metals

For all the heavy metals the Danish limit values is stricter than the general EU limit values, and regarding the sludge from WWTPs on Bornholm, Cadmium is usually the only metal in sludge that might come closest to, or surpass, the limit value in DK. This is not surprising because Denmark has one of the lowest limits for Cadmium in EU: 0,8 mg/kg DM (or 100 mg/kg P), where the EU directive operates with 20-40 mg/kg DM. The low Danish Limit value for Cadmium is generally not a barrier to agricultural use of sludge in Denmark or Bornholm, and it gives us a natural focus on industrial wastewater permissions, where the allowed concentration of Cadmium in wastewater is usually quite low.

Organic pollutants

Denmark (and Sweden) are some of the few countries in EU where the national legislation has Limit Values for groups of organic compounds:

LAS: Linear Alkylbenzene Sulphonates are the most extensive used anionic detergents in cleansing agents, and on the Danish Environmental Protection Agency's list of undesirable substances, in the group of non-anaerobic-degradable substances

PAH: Polycyclic aromatic hydrocarbons are of interest because of their potential toxic and carcinogenic properties

NPE: NPE are a group of nonionic detergents which are present in many laundry and cleaning agents.

DEHP (diethylhexylphthalat) belongs to a group of phthalate esters which is used in large amounts as softener or plasticizer in Polyvinyl chloride (PVC). Much more information on the fate of phthalates in wastewater and sludge is gathers in the STEP Deliverable 3.1.: "Study on distribution of phthalate acid esters (PAEs) in water and sludge in Lithuania, Poland and Denmark." In general, the above mentioned groups of organic pollutants are well reduced in the WWTPs on Bornholm, and are generally not a barrier to the use of sludge in agriculture.

The last EU requirements

New research also implies, that risks of transfer of metals, organic substances and medicine residues, from sludge used in agriculture, is insignificant, when the use complies with EU/national regulations (Using sewage sludge in farming: Directive 86/278/EEC, Decision (EU) 2018/853, Regulation (EU) 2019/1010).

Processing of the sewage sludge, using the composting process, fundamentally changes the properties of the final product. However, the compost products if not enriched with the mineral additives containing nutrients cannot be equalled directly to fertilizers although, it can be used to enrich the substrate purposed for planting as well, can be used to increase the quality of the soils. The minerals contained in compost enrich physical and chemical properties of the soils as well, its biological activity. Therefore, everyone partner of the STEP project has been presented the main measures how to increase the quality of the sewage sludge. For these purposes, each partner has described the handling of the septic tanks or excess sewage in order to reduce heavy metals and pathogenic flora concentrations.

CONCLUSIONS (AS POINTED OUT IN DELIVERABLE 3.2):

Our common understanding among the STEP project partners based on an ecological approach is that sludge from WWTPs:

- **is a valuable biomass** and as much as possible of the nutrients in the treated wastewater should be collected in the sludge/as little as possible of nutrients, organic matter and chemicals in the treated waste water should pass onto the recipients.
- **Should, if possible, be used as fertilizer in agriculture**, so the valuable nutrients are recycled, and the carbon in the sludge is built into the soil, instead of quickly released as CO_2.
- Should, if possible, be digested to produce biogas /energy, thus replacing fossil fuels.

The EU framework legislation and the national legislations, is generally ensuring a safe and sustainable use of sludge as fertilizer, and based on our work in the STEP – project we want to point out that:

- **Accumulated scientific evidence in general points to, that there are no adverse effects of using sludge from WWTP's in agriculture**. The fate of certain persistent substances needs to be further clarified, both regarding the amounts in sludge and the fate in the ecosystem, e.g. FAS.
- Barriers to the use of sludge from WWTP's as fertilizer in agriculture is sometimes psychological.
- Extremely strict National Limit Values can also be a barrier (e.g. copper in Sweden), and could be reviewed.
- Use of heavy metals and persistent chemicals in different products should be further restricted (e.g. cadmium in artists paints).
- The research results obtained in the project justify taking steps to change the regulations on the agricultural use of sewage sludge by taking into account the presence of heavy metals in the chemical forms persistent on the influence of reducing factors.