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ANALYSIS OF THE POSSIBILITIES OF RECOVERY AND DISPOSAL OF SLUDGE FROM WASTEWATER TREATMENT PLANTS

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Abstract

The paper analyses treatment options for sewage sludge generated in wastewater treatment plants and the available options for its recovery and disposal in the country. In parallel, a review of existing legislation concerning the use/utilization of sewage sludge for various purposes is done. Currently, treatment of sludge generated in the Republic of Bulgaria is mainly carried out through landfill or improper disposal and a very small quantity is used in agriculture. The need to seek other approaches to the sustainable management of sewage sludge is defined by two main factors: increasing the amount of sludge from urban wastewater treatment and compliance with requirements of Directive 1999/31/EC on the landfill of waste to reduce the amount of biodegradable waste going to landfills. Given the availability of sufficient quantities of sludge from wastewater treatment plants (stabilised properly) they could be regarded as a valuable energy resource.

Key words: agriculture use, dewatering, drying, incineration, sewage sludge.

Introduction

Nearly all wastewater treatment techniques have one thing in common: the formation of solids or residue from filtration or sedimentation. With that the separation of the pollutant from the aqueous medium is possible, resulting in pollutant-enriched sludge. In as much as this sludge is not returned into the process of direct wastewater treatment, it becomes necessary to have it safely treated on site or forwarded to disposal with different options of secondary use.

The application of appropriate thickening, stabilisation and dewatering processes is crucial in order to get sewage sludge disposed of correctly and efficiently. Thickening and dewatering must be well adapted to the further processes of sewage sludge utilisation. Only input material suiting the subsequent treatment processes will allow the optimum treatment results to be attained. Before a material utilisation, recovery of energy from the organic components or final depositing of the sludge takes place, various stages of pre- and post-treatment must be passed. Within the individual steps and procedures leading to the ultimate use of sludge a variety of process configurations can be applied (GFEA 2013).

An overview and detailed information on the state of the art can meanwhile be obtained from compendia and technical fact sheets, including the Best Available Techniques Reference Documents (BREF).

● Reference Document on Best Available Techniques for the Waste Treatment Industries (BREF WT),

● Reference Document on the Best Available Techniques for Waste Incineration (BREF WI), and

● Reference Document on Best Available Techniques in Common Waste Water and Waste Gas Treatment / Management Systems in the Chemical Sector (BREF TCI).

Many of the wastewater plants in Bulgaria treat domestic and industrial wastewater and therefore the generated sewage sludge is classified as hazardous waste, which also defines the necessity for an adequate solution.

Table 1. Quantity of generated sewage sludge based on tonne of dry matter per year for individual RIEW in the country for 2009 and 2012.

No	Riew	Quantity of sewage sludge, t dry matter per year	
		2009	2012
01	Blagoevgrad	465	882
02	Burgas	2,906	6,541
03	Varna	8,292	5,146
04	Veliko Tarnovo	1,158	1,655
05	Vratsa	109	390
06	Montana	0	364
07	Pazardzhik	0	724
08	Pleven	1,084	1,679
9	Plovdiv	6,150	5,620
10	Ruse	14	2,090
11	Smolyan	131	419
12	Sofia	15,516	29,168
13	Stara Zagora	447	3,173
14	Haskovo	0	400
15	Shumen	429	755
16	Pernik	38	248
	Total	36,639	59,261

According to the definition given in Regulation No 2 on the classification of the waste, sewage sludge from wastewater treatment plants (WWTP) in Dobrich, Razgrad, Pernik and Dupnitsa is hazardous. Regulations do not allow recovery of hazardous sludge in agriculture, which is why its disposal could be done by incineration in appropriate facilities or in extreme cases to be disposed of at landfills for hazardous waste and/or regional landfills, which have a cell for hazardous waste disposal. As shown in Table 1 the total amount of raw sludge in 2009 was 294 322 tons, of which 13 284

Table 2. Chemical characteristics of sewage sludge – average to absolutely dry matter.

Parameter	Average value
Abs. dry substance, %	100
Ash, %	65.92
N (NH_3-), %	0.10
N (total), %	1.20
P_2O_5 (total), %	0.20
K_2O (total), %	0.50
NaO, %	0.10
MgO, %	0.30
CaO, %	6.80
Zn, mg/kg dry substance	622
Cu, mg/kg dry substance	289
Cd, mg/kg dry substance	5
Pb, mg/kg dry substance	104
Ni, mg/kg dry substance	46
Cr, mg/kg dry substance	80
As, mg/kg dry substance	5
Hg, mg/kg dry substance	2
pH (H_2O)	11.6

tons – hazardous and 281 038 tons – non-hazardous (EEA 2009, 2010, 2011, 2012).

The data shows that the amount of sludge generated is unevenly distributed throughout the country mainly due to the uneven distribution of population. This makes it necessary to find a common decision on national level to that take into account the availability of sludge treatment in other areas (respectively RIEW).

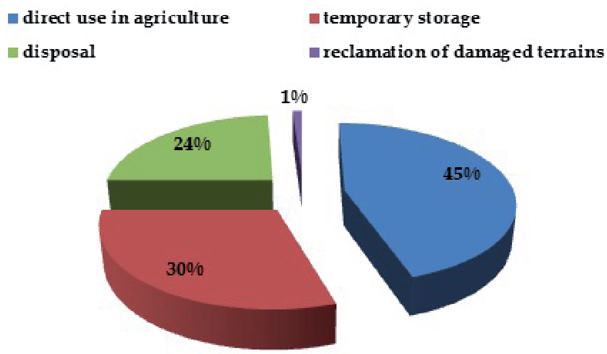

Fig. 1. Methods applied in the country for sewage sludge treatment (EEA 2009, 2010, 2011, 2012).

Average elemental composition of sewage sludge generated in Bulgaria is presented in Table 2.

According to the annual report of the EEA (EEA 2009, 2010, 2011, 2012) of the total amount of sludge generated in Bulgaria in 2009 (Fig. 1) is as follows: 24 % landfilled, 30 % is subjected to temporary storage, 45 % are used directly in agriculture and only 1 % is used for reclamation of damaged terrains.

Given the above, the current situation regarding the management of sewage sludge in Bulgaria can be defined as disturbing. The only normative document is Regulation on the manner of utilisation of sludge from wastewater treatment through its use in agriculture, approved by Decree No 339 of 14.12.2004 (State Gazette No 112/23.12.2004, amended and supplemented No 29/08.04.2011) which examines issues related to requirements to be met in order for the sludge to be utilised in agriculture. Indicated obligations of operators generating WWTP sludge as to achieve sustainable management of waste, sludge must be treated in a way that is environmentally effective, economically accessible and socially acceptable. However, the regulation does not specify methods for sludge treatment (EEA 2009, 2010, 2011, 2012, GFEA 2013).

Materials and Methods

According to Directive 86/278/EEC methods and technologies for the treatment of sewage sludge must meet the requirements for effective and efficient use of natural resources. Choice model for sludge management should lead to minimal negative impact on the environment and human health and to give priority to their use as a resource. The following figure is a block diagram of possible technologies for recovery/disposal of sludge.

EU policy in the field of waste applied five stage hierarchies for waste management. Utilisation of sewage sludge is within the highest priority of the “waste hierarchy” and landfilling – the lowest under the Waste Framework Directive 2008/98/EC and contrary to the fundamental principles of EU waste and sustainable resource management. Management of sludge nationwide is based on the legal framework for waste management. Direct disposal of dewatered sludge in landfills for non-hazardous waste is the most reliable way for recovery in the long term. In subsequent years the landfill will be one of the most expensive and ecologically – as an unacceptable method of sludge treatment.

It should be noted that every application has its advantages and disadvantages, and that therefore not one process technology can claim to provide the “ideal” solution. It is important that local conditions and needs are adequately taken into consideration while selecting the appropriate disposal paths and technologies.

Basic stages of the recovery / disposal of sewage sludge are:

- Sewage sludge generated during wastewater treatment is subjected to stabilization, to end the ongoing fermentation processes and decontamination to prevent the spread of pathogens and reduce unpleasant odours.
- For the further utilisation of sludge and in particular to make the necessary transport efficient, it is essential to reduce significantly the water content in the sludge. A first technical step which goes far beyond the simple thickening of the sludge at the WWTP is dewatering.
- Drying – Reduces the amount of precipitate which must be transported and treated, and increases the heating value.
- Conversion – Conversion stands for a wider range of processes in which a material transformation of the sewage sludge is taking place for the purpose of using its ingredients and to substantially neutralize the potentially hazardous components it contains. Conversion processes may require dewatering and/or drying as a pre-treatment stage, under certain

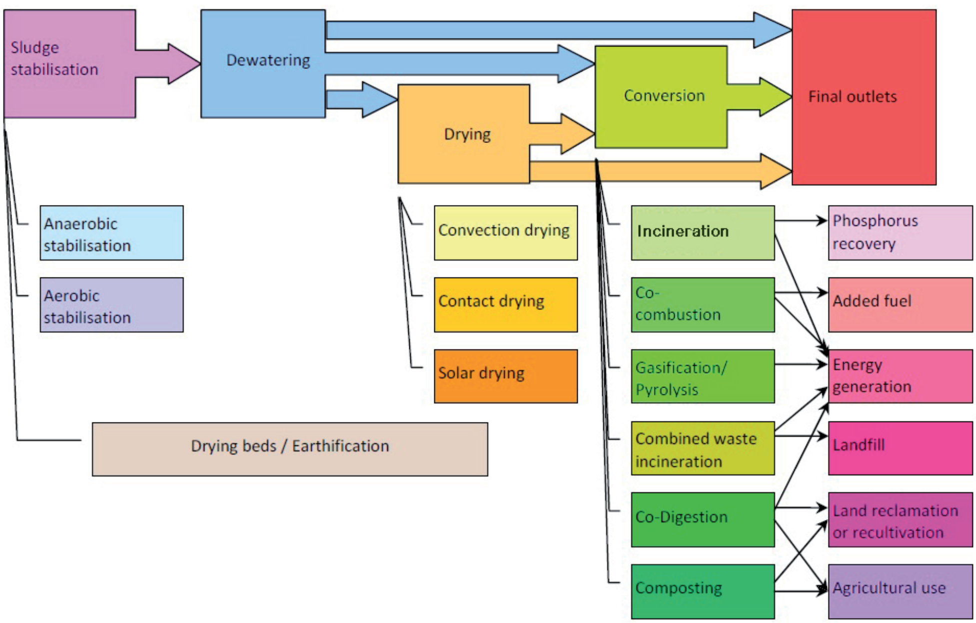

Fig. 2. Overview on possible options for a sludge management process (GFEA 2013).

conditions their application next to stabilisation can also be possible (see Fig. 2).

● Outlets – Pre-processing and conversion of the sludge have one principal purpose; to minimise volume and risks of the sludge to be disposed of and make beneficial use of it whenever possible and economically feasible. Part of the conversion process or ultimate step in the pre-processing chain is the end use of the sludge. Forwarded to thermal processes, sludge can be used as an added fuel for the production of electric energy and heat. It serves the same purpose if used in digesters for biogas production. Principally, the electrical energy can be used to operate the WWTP or it can be fed into the grid. Excess heat contained in the exhaust gases of the turbine or gas engine, from heating the pyrolysis kiln or the support combustion can be used for the thermal drying of sewage sludge. Excess steam or heat from cooling water (from the gas engines) is generally suitable for heating where appropriate users are available in closer distance (e.g. greenhouses) (Amarantos et al. 2007, GFEA 2013, Hall 2000).

From the ash which remains after a monovalent incineration, phosphorous can be directly recovered as a precious resource. Ashes from sludge incineration and the mineral granule respectively vitrified residue left after pyrolysis/gasification may also be used as aggregates or additive in the construction sector.

In the case of compost (or completely stabilised sludge as result of stabilisation and earthening procedures), the final outlets are found in agriculture, wood plantations, landscaping and land reclamation/recultivation activities where it is used as a soil conditioner, fertiliser, or a growth medium. Where landfills come to a close and interim safeguarding and remediation is undertaken, sludge compost can also be a useful substrate for the covering layers (GFEA 2013, Todorova and Yordanova 2012).

Results and Discussion

Based on the sludge treatment methods from the world practice reviewed and the amounts of generated sewage sludge the treatment options for sewage sludge for the country could be the following:

● Energy recovery by incineration of sewage sludge – Obtaining energy from biodegradable waste and is encouraged by energy policy. Equipment used must meet higher standards to meet the requirements of Directive 96/61/EC on integrated pollution prevention and control. This approach to treatment of the sludge is acceptable, if the input cost commensurate with the benefits/effects of these. An example is the co-incineration of sludge in cement plants equipped with an integrated permit for this activity. The aim is obtaining/energy recovery and partial replacement of fuel used therein. In this case, except for calorific requirement and requirements placed on the quality of sediments – dry matter content and presence of contaminants in them most often in relation to the content of halogens and heavy metals (Todorova 2004, EC 2006).

● Use in agriculture – Direct use of sludge on agricultural land is possible only when the sludge meets the requirements of the legislation. Use of sewage sludge in agriculture is not a widespread practice in Bulgaria. Direct deposit of sediment in the soil should be made mandatory after appropriate treatment and in compliance with the regulations. The Regulation on the procedure and manner of utilisation of sludge from wastewater treatment through its use in agriculture requires that the sludge to be classified as non-hazardous waste under Regulation No 3/01.04.2008 on waste classification (Todorova 2005, Todorova and Yordanova 2012).

● Used for reclamation of damaged terrains – The use of pre-treated sludge (mainly in the form of compost) for reclamation of disturbed areas is well known option in the world practice. Import of large quantities of organic matter to the sediments is useful for restoring the humus layer of the terrain and soils affected by the extraction of natural resources, mines, abandoned quarries, reclamation of landfill sites and more. Practice in Spain shows that the direct use of sludge for reclamation of degraded forest land is unacceptable, the reason for this being the high risk of contamination of surface and groundwater (GFEA 2013, Amarantos et al. 2007).

● Biogas and electricity generation from sewage sludge – With the implementation of Directive 2001/77/EC on the production of electricity from renewable energy sources (RES) 2020 Bulgaria should produce 16 % of its electricity through renewable energy sources. In this regard, there are technological solutions for co-generation of biogas, electricity and / or heat. Co-generation in this case is the result of a joint anaerobic fermentation of sewage sludge and all kinds of manure derived from pig, poultry and / or cattle farms. This approach has a considerable environmental impact, since it does not depend on the quality of the sludge and in the fermentation process, the generated biogas high in CH_4 – 60–70 % and 30–40 % CO_2. This makes it very suitable for direct use in the production of heat and / or electricity. On the one hand, such technological solutions allow utilization of an extremely problematic waste from livestock, such as manure from pig farms. Currently, it is hard to find an environmentally sound solution for its. On the other hand, the final product after the fermentation process of these technologies is quality compost, which could be used as a fertiliser in agriculture or for reclamation of damaged terrains. All this proves the high ecological relevance of this type of technology. For Bulgaria financing facilities for co-generation for the current programming period was decided on several measures of the Program for Rural Development 2007–2013 (Arlt et al. 2002, Bardarska 2012).

● Use of sewage sludge for other purposes – After suitable stabilisation sludge could be used for incorporation into building materials (cement production/blocks) for the manufacture of an organic substrate used in horticulture, the breeding of worms in fish farming or in appropriate mixing with other edible substances for the production of bio fertiliser.

Conclusion

Based on the data from the analysis of possible treatment methods of this type of waste, the country's ability to manage it and existing legislation, the following conclusions can be made:

● Existing methods for treatment and disposal of sludge in the country do not achieve the expected results and should be improved.

● There are gaps in the legislation regarding the control of direct use of untreated sludge in soil which pose a risk to human health and the state of the environment (soil resources, groundwater and surface water).

● In order to achieve appropriate utilisation of sludge generated in the country the practice to incinerate sludge in power plants or co-incineration plants should be introduced.

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