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CONTENT

Utilization of the Fermentation Residue From Biogas Plants to Agricultural Lands in Hungary

Attila BARCZI[1,] - Dániel SZALAI[2] - Valeria NAGY[3]*

Abstract: *The wide presence of biogas plants as facilities using organic wastes and by-products to generate energy now seems to warrant attention urgently to the land application of by-products from biogas plants (fermentation residues). The idea of an adaptable and sustainable agriculture based on effects and interactions also requires such attention. This publication analyzes the possibilities and challenges of natural resource management by studying the agricultural use of fermentation residues from biogas plants. In order to be used in agriculture, the nutritional value of fermentation residues should be acknowledged. Land application of fermentation residues therefore requires expert analysis to ensure that ecological functions of soil are not damaged. This, however, requires that the regulations governing the framework for the conditions of such application are carefully studied and interpreted.*

Keywords: ***biogas plant, fermentation residue, arable land***

1 INTRODUCTION

The problem of meeting energy demands in a safe, effective and economical way can currently be solved by combining traditional and renewable energy sources in a harmonized manner. At the dawn of a new era in energy economics, the reason for producing and using renewable energy sources, including biogas, is justified not only by energetical considerations, but also by those of waste management, environmental protection and economy, which is also confirmed by life cycle analyses (EVANGELISTI et al. 2014). Biogas plants are typically established and operated in order to manage various wastes and by-products of vegetable and animal origin. Some of these substances are not directly re-workable into the soil, but they are biodegradable: as a result of the fermentation of various organic materials in the absence of oxygen, biogas is produced with the aid of bacteria. The input of this biogas producing process is biomass and energy, while the output is biogas and fermentation residue (FREEMAN – PYLE 1977; KISSNÉ 1983). Biogas plants established for the management of agricultural and food wastes and by-products are notable inasmuch some of these substances could otherwise easily become harmful to the environment (and to the soil) if not treated properly.

But fermentation residues – under certain conditions and in accordance with relevant requirements – can be reworked into the crop cycle in order to replenish nutrients in the soil. It must be emphasized, however, that the basis for the application of fermentation residues from biogas plants to agricultural lands lies in the making of scientific studies that take the relevant regulatory background into account, as well. The application of fermentation residue to agricultural lands depends on its nutrition qualities. It is precisely the changing nutrition content and the technologies used in the process that necessitate the classification of fermentation residue. Application to agricultural lands in Hungary can occur in a controlled manner, i.e. based on professional principles enshrined in legislation, according to a professional plan, authorized by soil protection authorities.

However, the protection of soils is a priority, so it is necessary to consider first that the erosion of fertile soil has accelerated because of "industrial" farming methods, involving now significant areas (40-50% of Hungary), even though about 25% of the total national wealth of Hungary lies in the market value of arable land (ÁNGYÁN AND MENYHÉRT 2004). Therefore, from the viewpoint of the continuous operation of biogas plants, the careful planning of soil nutrition management and the prevention of the contamination of soil are paramount. The most important problem that rises during planning is the inhomogeneity of fermentation residue. Closely connected to soil, the quality of water is also notable, especially important in case of underground water resources (ÁNGYÁN AND MENYHÉRT 2004).

The protection of soil and the maintenance of its fertility is important not only for the user/farmer of the land, but also for the whole society in the long run, since in many cases it is because of improper land use and an agriculture disregarding soil protection that soil degradation develops, entailing reduced soil fertility and the pollution of waters and drinking water supplies.

2 THE APPLICATION OF FERMENTATION RESIDUES FROM BIOGAS PLANTS TO AGRICULTURAL LANDS

Agricultural activity involves increased use of soil, which must be kept under constant control to ensure the long-term well-being of humanity. In this respect it is important to fix the conditions and circumstances for the applicability of organic matter to arable land or into the soil.

The application of fermentation residues from biogas plants is one of the most common problems for both the farmer and the expert. As described above, fermentation residue is formed by the anaerobic degradation of starting materials of various character and during the fermentation it comes into contact with other materials used in the technology. Therefore, application to arable land may largely depend on the properties of the fermentation residue. It is normally classified as harmless waste from sources other than agriculture.

Application to arable land is an activity which requires authorization, therefore the expert interpretation of the relevant provisions of Regulation 90/2008. (VII. 18.) FVM (FVM stands for Ministry for Agriculture and Rural Development of Hungary) is necessary. The permit is issued by the soil protection authority, in the possession of a plan designed by a pedology expert. Based on a review of several recent soil protection plans, the problems that may arise during the licensing process can be summarized as follows.

- The client who wishes to dispense the fermentation residue is unaware of the requirements for the land application and the classification of the substance.
- The pedology expert and the accredited laboratory do not perform the tests (or have them performed) as prescribed by the Hungarian Standard, or the measurement is not based on the standard assigned to that parameter.
- In most biogas plant fermenters, there are substances (e.g. heavy metals) that justify the compulsory test for sewage / sewage sludge. So it is not enough just to check nutrient content.

Eliminating all of this requires accuracy, discipline and strict compliance with the statutory regulations by the client, the expert and the laboratory alike. The following flow diagram (Figure 1) shows the steps required for successful authorization procedures.

The detailed rules of land application in accordance with the concerns of soil protection in Hungary are contained in the legislation referred to in the flowchart. An important tool for the practical implementation of soil protection is the soil protection plan, which is a kind of link between the farmer and the authority.

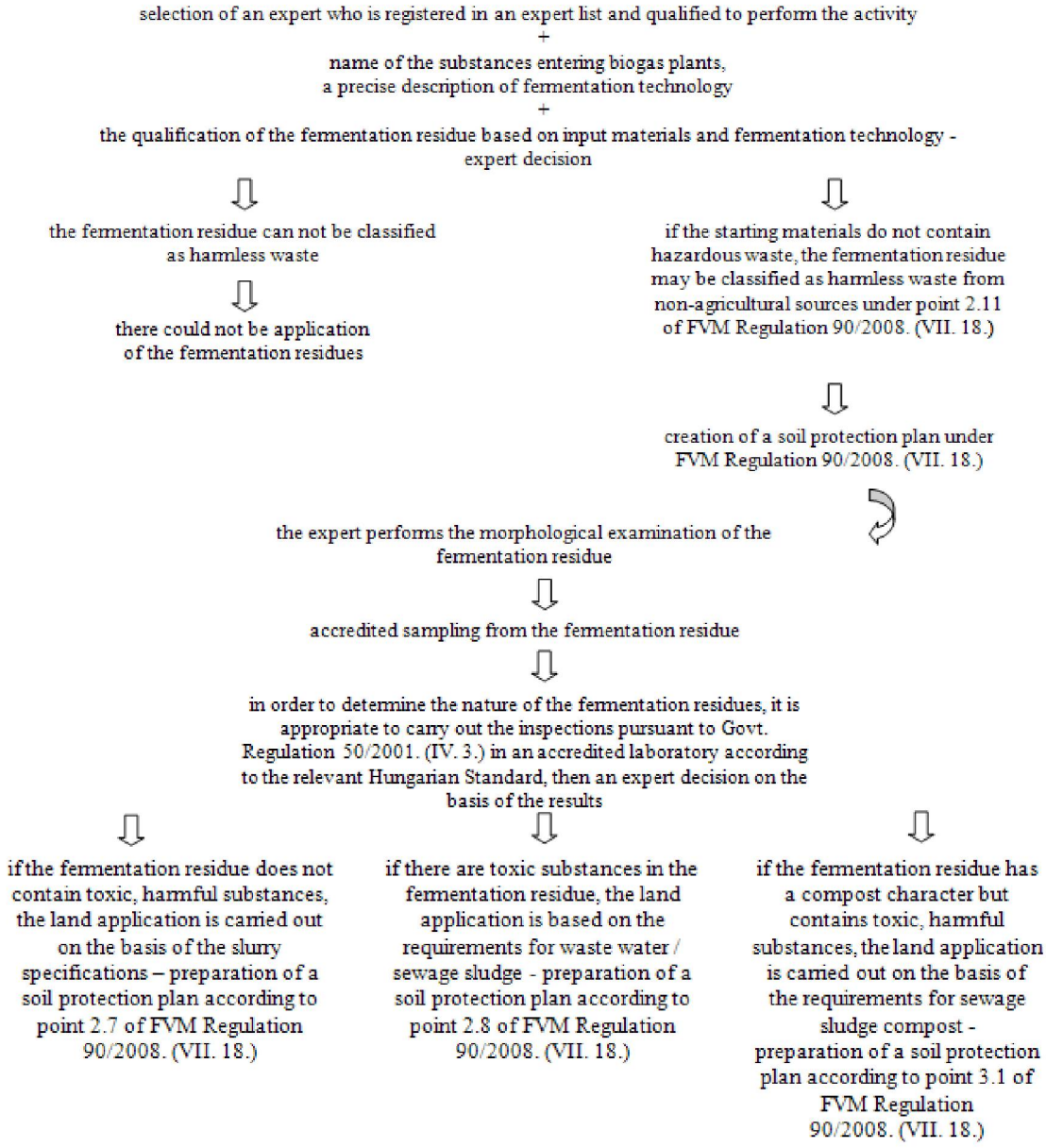

Fig. 1. Activities to be performed before the land application of by-products from biogas plants

Detailed rules for the preparation of the soil protection plan are set out in FVM Regulation 90/2008. (VII. 18.). The design types associated with the application of fermentation residues from biogas plant to agricultural land as prepared by the soil protection expert can fall into any of the following:

- soil protection plan for the use of slurry in agricultural areas
- soil protection plan for the use of waste water and sludge slurry in agricultural areas
- soil protection plan for the use of harmless wastes from non-agricultural sources in arable land

Pedological investigations that are grounded in the soil protection plan and the examination of the substances to be applied shall be carried out using the standards set out in this regulation or according to an equivalent accredited method. Examinations may only be carried out by accredited laboratories on the basis of the relevant Hungarian Standard. For the soil sampling, the regulation itself and the manuals of the farmers provide guidance with illustrations. It should be noted here that the soil data contained in the soil protection plan is recorded by the soil protection authority in a soil database.

The application dose is usually determined on the basis of the nutrient content, but it is exactly the character of the substance to be delivered and its potential pollutant content that may affect it. Therefore, even when all the input materials and the full technology are well know, a comprehensive examination of the fermentation residue may be recommended to enable the expert to decide whether the substance is classified in accordance with points of this regulation, since for further examinations this classification will be the norm.

Waste water, sewage sludge and sewage sludge composts are invariably subject to the provisions of Government Regulation No 50/2001. (IV. 3.). The testing and qualification of the fermentation residue determines the method of soil and water testing methods and the parameters to be tested, which are contained in the concise tables (Table 1, Table 2) based on the annexes of the Regulation.

Table 1. Annex 1 to Government Regulation No 50/2001. (IV. 3.)
Pedological and hydrological tests required for the agricultural use of waste water, sewage sludge and sewage sludge compost

Parameter to be tested	Waste water, liquid sewage sludge	Sewage sludge	Sewage sludge compost
From the soil:			
pH (H_2O)	+	+	X
Humus content H%	+	+	X
Total carbonate content	+	+	X
Total water-soluble salt content	+	+	X
Plasticity index according to Arany (PI_A)	-	-	X
Mechanical composition	o	o	-
Bulk density	o	-	-
pF-row*	o	-	-
Exchangeable cations	o	o	-
Toxic elements (As, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, Se, Zn)	X	X	X
Soil toxicity test (*Azotobacter agile* test)	X^I	X^I	-
Available nutrient content P_2O_5, K_2O, Mg, NO_3-NO_2	X	X	X
Determination of current groundwater level down to 5 m	required	required	-
From groundwater:			
pH, EC, KOI, Ca^{2+}, Mg^{2+}, Na^+, K^+, NH_4^+, CO_3^{--}, HCO_3^-, Cl^-, SO_4^{--}, NO_3^-, NO_2^-, toxic elements, ΣPAH**, ΣPCB**,TPH**	X^{II}	X^{II}	–

+	It shall be determined from samples taken from the genetic layer of a soil segment explored in up to every 10 hectares, in a depth of 150 cm.
o	It should be determined from soil samples taken from genetic soil layers explored in soil patches with representative physical, chemical and water management properties, collected from a maximum of every 50 hectares.
X	A composite sample should be made from 25 probes in sampling areas from a maximum of every 5 hectares, collected from a soil layer of a depth of 0-25 cm, which should serve as the basis for testing the indicated parameters. In case of injection, an average sample should be collected from soil layers between 25-60 cm from every 5 hectares.
X^I	It should be determined from composite samples taken according to „X”, collected from soil samples from a depth of 0-25 cm.
X^{II}	If groundwater is available within 5 m, 1 water sample per 50 hectares, if it is available within 3-1.5 m, two

	water samples per 50 hectares should be taken.
*	A series of measurements characterizing the soil's water management properties.
**	Their definitions can be ignored by prior consultation with the authorities.

Table 2: Annex II to Government Regulation No 50/2001. (IV. 3.)
The components and other characteristics of waste water, sewage sludge and sewage sludge compost to be examined prior to use in agriculture

Parameter to be tested	Waste water	Sewage sludge	Sewage sludge compost
pH	+	+	+
Electrical conductivity (salinity)	+	-	+
Total solids	+	+	+
Total organic matter	+	+	+
All solutes / dissolved minerals	+	-	-
Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}	+	-	-
CO_3^{--}, HCO_3^{-}, Cl^{-}, SO_4^{--}, NO_3^{-}, NO_2^{-}	+	-	-
KOI	+	-	-
Total N	+	+	+
NH_4-N	+	-	-
Total phosphorus (P_2O_5)	+	+	+
Total Potassium (K_2O)	+	+	+
Pb, Cd, Co, Cr, Cu, Mo, Ni, Hg, Se, Zn, As	+	+	+
Fe, Al, Mn, B, Ba	+	-	
Anionic surfactants	+	-	-
Animal-vegetable fats (organic solvents extract)*	+	+	+
Total aliphatic hydrocarbon (TPH)*	+	+	+
Polycyclic aromatic hydrocarbons (ΣPAH)*	+	+	+
Polychlorinated biphenyls (ΣPCB) *	+	+	+
Fecal coli and fecal streptococcus	-	+	+
Salmonella sp.			+
Human parasite nematode egg			+
* Their definitions can be ignored by prior consultation with the authorities.			

3 CONTROLLING AND MONITORING

The official revision and supervision of soil protection plans created for land applications are regulated according to the law. The control plans shall be created according to the provisions of points 2.7., 2.8., 3.1. of FVM Regulation 90/2008. (VII. 18.), and as prescribed by the licensing authority. The tests should cover all the previously investigated or prescribed parameters. Comparison with the previous data series has a monitoring purpose (among others).

The monitoring of the pedological research of biogas production projects primarily involves the continuous examination of the fermentation residue and the soils affected by its land application.

Adaptability, constructive co-operation and responsible thinking are needed to maintain such environment that ensures a good quality of life. On the one hand, this is the real foundation for a farm that is adapted to local conditions, circumstances and needs (NAGY 2015).

If we take these principles into account, the fermentation residue from the biogas plants can be taken on the arable land (on the soil). However, the varied character of this material requires that the main emphasis is placed on the protection of the land, in addition to the nutrition management.

All these require responsible and compliant behavior and effective cooperation between the biogas plant that wishes to use biogas fermentation residue, soil protection expert who prepares soil protection plan, accredited laboratories that do the soil tests, and the licensing authority, too.

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