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Analysis of organic agricultural waste usage for fertilizer production

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Abstract. Waste management, especially biodegradable (organic) waste, is highly relevant in agriculture. Increasing the intensity of agricultural production inevitably increases pollution of soil, water and air due to chemical, biological and other effects because of untidy agricultural waste. Currently there is a search for new and more rational ways to use waste for new forms of energy, making fertilizer, building materials and other products. One of the processes of biodegradable waste management is pelleting; i.e., the processing of recyclable materials into organic ecological products.
The SWOT analysis-expert, literature survey methods were used for the analysis of animal and plant origin organic agricultural waste's suitability for production of fertilizer. The analysis has shown that the granulation of animal waste allows making better use of nutrients, significantly reduces the amount of fertilizer needed to be deposited into the soil and reduces the cost of storing, transportation and spreading into the soil. SWOT analysis motivated the need for further research of manure waste and its pelletizing.

Key words: Composted manure, agricultural plant wastes, pelletizing, SWOT, fertilizer.

INTRODUCTION

Agricultural practices, environment and human health are intrinsically linked. Therefore, environmental quality is crucially important to agricultural production, and management of agricultural waste has potential to harm human health and environment. Accordingly, farmers have a duty to ensure that they do not treat, keep or dispose of agricultural waste in a manner likely to cause pollution of the environment or harm to human health. A non-appropriate treatment or disposal of organic wastes can become risky for environment and humans, for instance it can support the spread of diseases and may pollute soil and groundwater (Roeper et al., 2005).

According to statistics in 2014 Lithuanian agriculture is responsible for about 3.8 million tons of manure and 1.68 million tons of slurry and about 3.7 million tons of straw and other waste (Oficial, 2016). Total amount of organic agriculture wastes is about 4 million tons in Lithuania. Manure compose about 1.5 million tons of waste. Cattle manure forms about 1200 thousand tons dry substance, pig manure about 250 thousand tons dry substance, hen, chicken manure 50–75 thousand tons dry substance, straw about 2 million tons, the different plant origin waste about 500 thousand tons (Brazas et al., 2012). It is composted only a very small part of it. Only a very small proportion (about 3%) of liquid manure (slurry and manure mixture) is currently being treated in anaerobic – producing biogas. Litter per year on average consumed about 1.0 to 1.25 million tons of straw. Currently, most of the resulting manure is liquid or semi-liquid manure – manure, slurry mixture – which is considered manure storage or slurry tanks and almost all, is inserted into the soil or spread out untreated. Crop production farms forms about 5 million tons of wastes in Lithuania. Excess biomass consists of 1.56 million tons while assessing available waste recovery possibilities (Mazeika et al., 2011). Small amounts of crop residues, food processing wastes, municipal bio solids and wastes from some industries are also applied to land.

According to EU requirements manure is considered to be waste by the livestock owner has to account for and eliminate using as crop fertilizer and not polluting the environment. Untreated manure is not humus substances, organic bedding materials are not available for plants condition. Soil spread fresh manure can cause even a short denitrification processes or contaminate soil pathogenic micro flora, weed seeds, and so on (Bleizgys, 2015). Compost made from livestock manure is an effective material for improving the physical and chemical condition of soil (Hara, 2001).

The newest trends in research and production are the recycling of agricultural waste (bio-waste), the search of alternative energy resources as well as the rational use of raw materials (by-products) and waste products. One way of the organic waste management are using these waste as secondary raw material for recycling to organic products by pelleting. Granular manure is a universal complex organic fertilizer containing all the macro and micro elements. Pelleted manure nutrient content for soil micro flora is optimal, it quickly dissolves in water and is easily absorbed by plants. Granular manure can be called concentrated fertilizer, because the recycling process reduces the volume of material more than 10 times, due to water removal (Polovcev & Cherkasov, 1992). It is economically expedient to create and use a granular organic fertilizer (cattle, poultry manure and organic compost) with relevant physical-mechanical properties which influence product warehousing (storage), transport, straggling spreading in the soil and localized insertion. It is really hard to store high amounts of manure, and there is almost no way to spread it over the soil evenly. The process of fertilizing the soil using organic fertilizers is seasonal, while production of manure continues throughout the year. The solution can be recycling of cattle, cow and bird manure compost by pelletizing it. The goal of pelletizing is to produce an easily manageable product for land crop fertilization, that conserves all the properties of the original material (nutrient content), and with better storage and handling properties as compared to a dusty product (compost). In such agricultural waste management the first point is to establish technology for producing high-quality compost. The second is to establish a method of fertilizing crops which takes into account the needs of the environment. Molding composted livestock wastes into pellets can solve both problems, and seems to be a promising technology. The most important task is to reduce the pellets manufacturing cost (Hara, 2001).

Therefore, to motivate organic waste recycling strategy was reviewed quantitative and qualitative analysis methods and chosen SWOT method. The SWOT analysis is one of the most popular tools in use for defining a strategic action. The analysis begins with four factors identification list, in order to improve understanding of the typical SWOT analysis structured four-cell table (matrix). Purpose of SWOT analysis is to collect information by analyzing the environment, divide this information to internal and external factors. The entities analyzed with in multi-purpose and multidisciplinary areas are too complicated to be strictly quantitatively described. For the evaluation of system‘s behavior the mechanism of SWOT analysis, which enables to cope with problems static, is frequently employed. In order to fill in SWOT analysis tables, the descriptions of all fuzzy situations should be normalized, which means that characteristics of features should become quantitatively measured and compared (Jasinevicius & Petrauskas, 2008).

Subject of the research – analysis of organic animal and plant origin agricultural wastes suitability for production of fertilizer using SWOT analysis.

MATERIALS AND METHODS

To characterize the organic agricultural waste's suitability for production of fertilizer the SWOT analysis was used. We wanted to find out which agricultural wastes are better to recycle – animal or plant residues origin wastes. There was chosen two waste types. According to Waste Classification (EPA, 2015) those wastes are classified as: 02 01 06 code – animal faeces, urine and manure (including spoiled straw), effluent, collected separately and treated off-site and 02 01 03 code – plant-tissue waste.

Because manure and plant compost is not convenient to spread on the soil, to transport and storage, it was proposed organic waste pelletizing. There was prepared four lists of factors for experts (3 persons) and for analytics (5 persons). The most important factors affecting Lithuanian agricultural organic waste management were identified by using literature research methods. Experts and analytics had task to weight quantitatively each selected factor probability function value μ (till value 1) and impact on influence value c (till value 1) depending on the organic waste pelletizing. Selected experts were competent in agricultural waste management and recycling spheres.

Evaluating the SWOT analysis the each of the four elements is evaluated separately and the detailed analysis of the situation is carried out too. First of all was used simply method to calculate sums of Opportunities, Threats, Strengths and Weaknesses by formulas:

$$OP_{\Sigma} = \sum_{o=1}^{O} \mu_o \cdot c_o \ ; \ TH_{\Sigma} = \sum_{t=1}^{T} \mu_t \cdot c_t \ ; \ ST_{\Sigma} = \sum_{o=1}^{O} \left(\sum_{s=1}^{S} ST_{os} \right) \cdot c_o \ ;$$
$$WK_{\Sigma} = \sum_{t=1}^{T} \left(\sum_{w=1}^{W} WK_{tw} \right) \cdot c_t \qquad (1)$$

where: OP_{Σ} – sum of Opportunities; TH_{Σ} – sum of Threats; ST_{Σ} – sum of Strengths; WK_{Σ} – sum of Weaknesses; μ_o – probability function value of Opportunities, c_o – impact influence value on Opportunities; c_t – probability function value of Threats; μ_t – impact influence value on Threats.

For Opportunities and Threats total amount assessment was used formulas:

$$OP_{\Sigma} = \sum_{o=1}^{O} \left\{ c_o \left(\mu_o + \sum_{s=1}^{S} ST_{os} + \sum_{w=1}^{W} WK_{ow} \right) \right\} \qquad (2)$$

$$TH_{\Sigma} = \sum_{t=1}^{T} \left\{ c_t \left(\mu_t + \sum_{s=1}^{S} ST_{ts} + \sum_{w=1}^{W} WK_{tw} \right) \right\} \tag{3}$$

RESULTS AND DISCUSSION

According to literature survey there was made Opportunities, Strengths, Threats and Weaknesses factors lists for plant and manure wastes, because those two groups are mostly divided. From lists was chosen the most important factors and marked with codes, for example Opportunities – OP1, OP2, OP3, Strengths – ST1, ST2, ST3, Threats – TH1, … , Weaknesses – WK1, … . There was made two SWOT lists, one for plant origin waste, second one for manure wastes (Tables 1, 2).

Table 1. SWOT analysis for plant waste in crop production agricultural raw material granulation

Marking	**Opportunities**	Marking	**Strengths**
OP1	Provision of waste biomass raw materials and rational utilization of plant biomass in order to preserve the fundamental components of ecosystems.	ST1	Purposeful use of waste biomass creates new work places, strengthen energy independence.
OP2	Supply of ecological fertilizers, agricultural waste products and by-products, sustainable use, the EU and other various funds for waste management.	ST2	The growing demand of organic fertilizers and other products.
OP3	High waste biomass processing (crushing, grinding, granulation) equipment acquisition opportunities especially for small and medium-sized farms.	ST3	Balanced accumulation of organic matter in the soil – an important measure to ensure the quality of the soil and a significant opportunity to reduce CO_2 emission.
		ST4	Improvement of environmental conditions.
Marking	**Threats**	Marking	**Weaknesses**
TH1	Processed biomass purchase and sales instabilities, predicted economic change (unstable market).	WK1	In Lithuania there is no biodegradable long-term waste management strategy. Organic farming is less competitive.
TH2	Chemical, biological and physical environment (including work environment) pollution.	WK2	Manure management technological equipment is not produced in Lithuania, and their installation expensive. Lithuanian production of industrial waste processing plant equipment is expensive and difficult to use in, there is need for skilled professionals and high investment.
		WK3	Low farmers education, information and understanding of environmental requirements level.

Table 2. SWOT analysis for manure waste in agricultural activities raw material granulation

Marking	**Opportunities**	Marking	**Strengths**
OP1	The economic benefits of a source of raw materials and ecological fertilizers.	ST1	The growing demand of organic fertilizers.
OP2	Manure separation and granulation equipment purchase in world market (especially for small and medium farms).	ST2	Reduced investment in manure storage and transportation systems engineering.
OP3	Smaller environmental risk.	ST3	Significant reduction in manure emissions.
		ST4	Better qualitative indicators of organic fertilizer (NPK ratio).
Marking	**Threats**	Marking	**Weaknesses**
TH1	Not innovative technologies and equipment in Lithuania. Industrial manure managing equipment is expensive.	WK1	In Lithuania there is no biodegradable long-term waste management strategy.
TH2	Chemical, biological, physical (including work environment) pollution.	WK2	Organic farming is less competitive.
		WK3	Low farmers education, information and understanding of environmental requirements level.

According to formulas (1) was calculated Opportunities, Threats, Strengths and Weaknesses sums (Table 3). The difference for manure waste was positive for Strengths (0.67), for plants wastes also positive rate (0.22). Simply Strengths, Weaknesses, Opportunities, Threats assessment results shown that manure wastes are better for agricultural fertilizer production.

Table 3. Simply Strengths, Weaknesses, Opportunities, Threats assessment results

	Plant origin wastes	Manure wastes
OP_{Σ}	0.57	0.96
TH_{Σ}	0.39	0.39
ST_{Σ}	1.38	0.74
WK_{Σ}	1.34	0.64

To obtain more exact and reliable result SWOT analysis summary tables were made. Experts analyze a magnitude of additional factors, and change the weight of influence on strengths and weaknesses on the basis of Opportunities and Threats total results (Tables 4, 5). For total amount calculation was used formulas (1 and 2).

Table 4. SWOT analysis summary for plant origin agricultural wastes

		μ	c	Strengths				Weaknesses			∑
				ST1	ST2	ST3	ST4	WK1	WK2	WK3	
Opportunities	OP1	0.82	0.45	0.68	0.32	0.25	0.4	-0.76	-0.83	-0.48	0.2
	OP2	0.25	0.34	0.15	0.46	0.33	0.24	-0.2	-0.27	-0.15	0.15
	OP3	0.6	0.2	0.28	0.41	0.11	0.14	-0.5	0.28	-0.32	0.078
										Total amount:	0,428
Threats	TH1	0.55	0.46	-0.39	-0.25	-0.19	-0.1	0.3	0.5	0.23	0.188
	TH2	0.35	0.4	-0.2	-0.36	-0.39	-0.2	0.15	0.25	0.36	0.096
										Total amount:	0.284

Table 5. SWOT analysis summary for manure agricultural wastes

		μ	c	Strengths				Weaknesses			∑
				ST1	ST2	ST3	ST4	WK1	WK2	WK3	
Opportunities	OP1	0.55	0.45	0.4	-	-	-	-0.5	-	-	0.2
	OP2	0.65	0.54	-	0.25	0.27	0.37	-	-0.45	-0.5	0.24
	OP3	0.86	0.42	0.57	-	0.65	0.35	-0.5	-0.5	-0.4	0.47
										Total amount:	0.91
Threats	TH1	0.55	0.46	-0.4	-0.25	-0.2	-0.6	0.5	-	0.43	0.184
	TH2	0.35	0.4	-0.3	-	0.65	-0.4	-	0.45	-	0.04
										Total amount:	0.22

SWOT analysis shows that manure wastes suitability for fertilizer production is better (discrepancy of *Strengths* among *Threats* for manure wastes 0.69), compared with plant origin wastes (discrepancy 0.14). SWOT analysis motivated the need for further research of manure waste and its pelletizing. As it mentioned in introduction a granular organic fertilizer with relevant physical-mechanical properties which influence product warehousing (storage), transport, straggling spreading in the soil will be very important for our future research. It is therefore expected to pelletize various mixtures of manure wastes in laboratory conditions and investigate optimal parameters of organic pellets physical-mechanical properties.

CONCLUSIONS

The analysis indicated that organic wastes are utilized in agriculture mainly for improving the soil physical and chemical properties and for nutrient sources for growing crops. The major source of organic waste used in agriculture is animal manure.

Agriculture forms about 4 million tons per year of organic wastes in Lithuania. Excess biomass consists of about 1.5 million tons while assessing available waste recovery possibilities.

To characterize the organic agricultural waste's suitability for production of fertilizer the SWOT analysis was used to determine which agricultural wastes are better to recycle – animal or plant origin. The SWOT analysis shows that manure wastes suitability for fertilizer production is better (discrepancy of Strengths among Threats for manure wastes is 0.69, compared with plant origin wastes discrepancy is 0.14).

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