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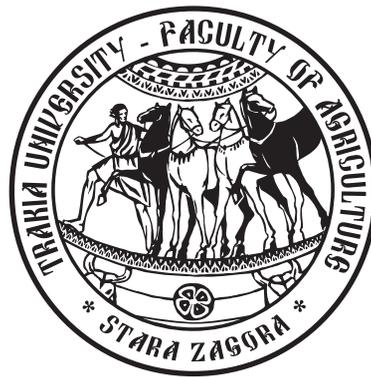
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Student's campus, 6000 Stara Zagora
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Comparative technical and economic analysis of systems for liquid manure management

V. Dimova^{1*}, R. Georgiev¹, Ch. Miteva², N. Nedelcheva³

¹Department of Agricultural Engineering, Faculty of Agriculture, Trakia University, 6000 Stara Zagora, Bulgaria

²Department of Applied Ecology and Zoohygiene, Faculty of Agriculture, Trakia University, 6000 Stara Zagora, Bulgaria

³Student -full-time, Major "Ecology and Environmental Protection", Faculty of Agriculture, Trakia University, 6000 Stara Zagora, Bulgaria

Abstract. *The objective of the study is to make a comparative analysis of the most important technical and economic parameters of technological variants for cleaning, storage and treatment of liquid manure, in order to develop and explain from a theoretical and analytical point of view economical design solution of a system for manure management in a pig farm. To achieve the objective the amount of manure and urine produced in a real farm in Bulgaria with a capacity of 3704 pigs has been determined, a detailed technical and technological project of the facility for storage of liquid manure ("lagoon" type) has been developed and the technological processes for existing farm system for manure separation have been examined and detailed. The total built-up areas and volumes for both variants of the system for managing liquid manure and the initial investment costs for constructing and equipping with equipment have been defined, as on this basis a comparative technical and economic analysis has been made and a preferred variant for the practice has been proposed. It has been found out that the variant with a liquid manure separating system is more economical than the variant with a semi-buried scrape lagoon by the volume and planning parameters: by total built-up area – by 7,4% and by total built-up volume – 2,1 times, which brings less pollution to the environment. The variant with a lagoon is more economical than the one with a liquid manure separating system by the following parameters: by total construction cost for building the manure storage facilities – 2,2 times, by total cost of the manure management equipment – 2,6 times, by total investment costs for constructing and equipping with manure management equipment for the manure storage facilities – 2,4 times.*

Keywords: liquid manure systems, concrete manure storages, technical and economic parameters

Introduction

Each possible management system (cleaning, storage, treatment and utilization) of liquid manure in livestock farming has advantages and disadvantages. When selecting such a system it is necessary to provide a number of important factors such as investment, labor, comfort, aesthetics, regulation, etc. As important are the specific preferences of the farmer. Developing a good manure system for a farm requires also to be provided with adequate own space for its construction, specified sources of manure and wastewater, available farmland for fertilizing and good to know the type and soil properties, the area topography where the farm has been built, the distance to its neighbors and other factors. The system must work flawlessly during change of weather conditions and the state of the farmable land, allowing emptying the heap in the statutory time limits and seasons (Dinev et al., 2009; Fulhage et al., 2001).

When designing a system for cleaning, storage and handling of liquid manure in a pig farm it is needed to be well aware of the regulatory requirements (Directive 96/61/EU, 2012; Directive 91/676/EEC, 1991; Law on Protection of Agricultural Land, 1996; Law on Health and safety at Work, 1997; Law of Environmental Protection, 2002; Regulation No. 44, 2006; Regulation No. 2, 2008; Technological standards, 1982, etc.). In recent years the manure-heaps must not contaminate the soil and groundwater according to the EU requirements, that's why their bottoms and walls must be absolutely hydro insulated (preventing the manure slurry to mix with the soil and preventing the groundwater to mix with the manure). Improper storage of manure can lead to contamination of the area and the air around the buildings and the loss of valuable nutrients in the manure and others. (Dinev and Delchev, 1992; Ivanov, 2009).

* e-mail: vpdimova@abv.bg

In Bulgaria still lacks research, information and sufficient experience in the reduction of initial investment costs for building liquid manure management systems in pig farms developed by the EU regulatory requirements. The volume and planning parameters and investment costs for building and technic equipment of different design decisions, such as a facility for storage of all liquid manure ("lagoon" type) and the variant for manure separation with separate storage of liquid and solid fractions have not been studied.

The objective of the present study is to make a comparative analysis of the most important technical and economic parameters of technological variants for cleaning, storage and treatment of liquid manure, in order to develop and explain from a theoretical and analytical point of view economical design solution of a system for manure management in a pig farm.

Materials and methods

Subjects of research are two technical and technological variants for system management (cleaning, storage and treatment) of liquid manure:

Variant A (Figure 1) – semi-buried scrape lagoon, developed by the authors of the regulatory requirements of the EU – with hydro insulated concrete walls and bottom and capacity of 1386 m³ for four months of manure storage. The facility's dimensions are: length 30 m, width 12 m, depth 4,35 m (including 0,5 m "dry stock"). The lagoon is pumped out by a liquid manure cistern (single-axis with options), aggregated to a wheel tractor 120 hp – after homogenization;

Variant B (Figure 2) – a manure separation system of solid and liquid fractions, consisting the following facilities: dug collector pit for the incoming farm liquid manure; dug transition pit with sluices for

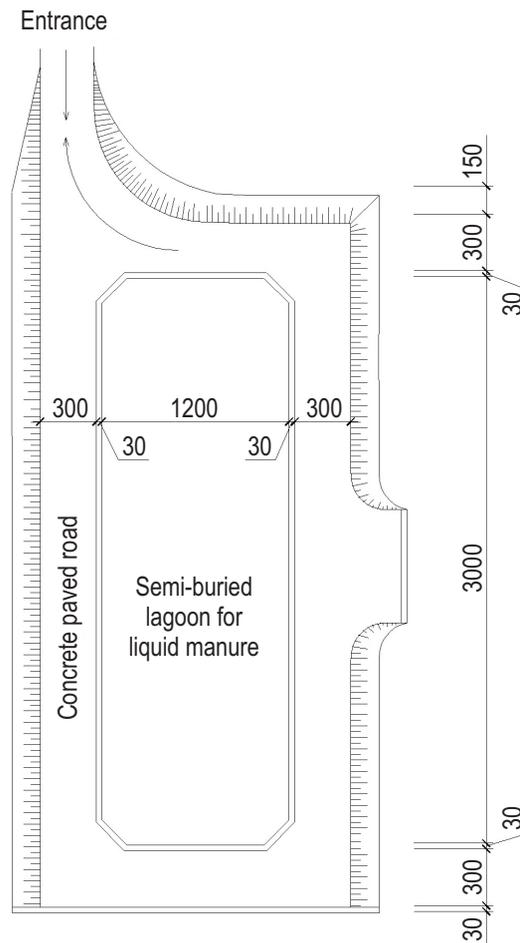


Figure 1. Variant A - semi-buried lagoon with hydro insulated concrete walls and bottom

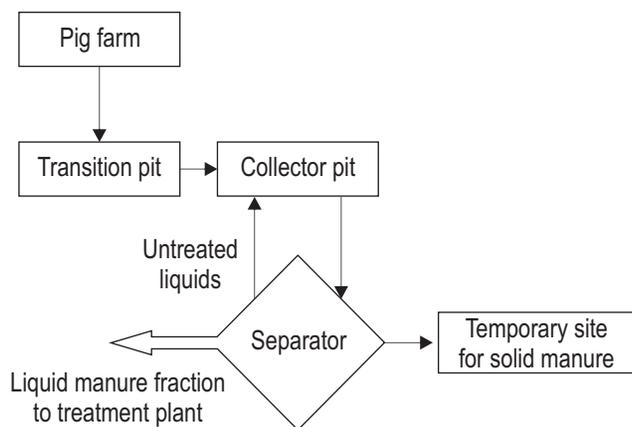


Figure 2. Principle scheme of the technological processes for liquid manure separation system (variant B)

releasing the liquid manure, received from the pig buildings, and directed to the collector pit; construction for the strengthening of the separator; fenced concrete sites and staircases around the separator; four-sided fenced area for six months storage of separated solid manure fraction. The site has hydro insulated concrete walls and floor and has an entrance ramp; pipes for discharge of liquid manure fraction to the treatment plant.

The principle of operation of the system is as follows: manure from pig buildings enters a pipeline in the dug transition pit, equipped with two sluice – one serves to interrupt the flow coming from the

farm and the other – to direct the gathered liquid manure to the collector pit. From there to the separator the manure is transported by pipe. Separated solid fraction falls to four-way fenced platform with hydro insulated concrete walls and floor and with an entrance ramp, and the separated liquid fraction is discharged to the treatment plant. A little amount of not separated liquid manure remains during the process, which returns to the collector pit through a pipe, and becomes a subject for reprocessing.

The data for liquid manure separation system, built in a real object in Bulgaria – farm for 3704 pigs are used in variant B. The system is equipped with a screw-press separator for separating solid from liquid fractions and a pump for viscous liquids BAUER, tractor DEUTZ FAHR (Germany), a front tractor loader TRIMA (Sweden) and a trailer for spreading manure BERGMAN (Germany).

For the studied two variants (variants A and B) were taken same starting conditions corresponding to those in a real pig farm. Only the installations for storage of farm produced manure and their equipping with manure cleaning technic were examined. Production processes in the pig buildings and removal of manure from them and transporting it to the manure facilities are not subject of study or consideration.

To achieve the objective of the study in the Bulgarian standards (Regulation No. 44 2006; Technological standards, 1982) the quantities of manure and urine released for a day by various categories of pigs and the quantities of manure in options A and B, which are stored in the manure facilities and are used in the farm are defined.

The variants are compared by the following parameters: total built-up area and volume; total construction cost for building the manure storage facilities; total value of manure management equipment (including purchase and installation); total investment costs (capital investment) for construction and technic equipment for the cleaning system, storage and treatment of liquid manure in the farm, environmental pollution. The comparative analytical method is used in the study.

Results and discussion

In Table 1 are presented the different categories with corresponding number of animals in the issued real pig farm, the emitted quantities of manure and slurry for a day, and the manure quantities, stored temporarily (according with EU requirements) in the farm and subsequently used for fertilization of agricultural areas. Essential difference is seen between the amount of manure in the lagoon (variant A) and the separating system for solid and liquid manure fractions (variant B). While in variant A for four-months the amount of manure would be about 1 586 820 kg, in variant B for six months it is generally 978 588 kg, ie with 62,2% less. The reason for this is that the lagoon stores all the manure and urine produced by the farm animals, while in variant B the liquid manure fraction leads to the treatment plant and only solid manure remains in the farm.

In Table 2 investigated several options for liquid manure management system is compared by their volume and planning

indicators: total built-up area and volume. The data show that while the difference between the total built-up areas (respectively 680,8 m² for Variant A and 633,7 m² for Variant B) is 7,4%, that between the total built-up volumes (respectively 2291,9 m³ for Variant A and 1102,9 m³ for Variant B) is 2,1 times. The big difference is due to the significantly greater depth of the lagoon (4,35 m) compared to the platform for solid manure (1,6 m), whose share is greatest in Variant B.

Volume and planning parameters of the different facilities to the liquid manure separation system are shown in Table 3 (Variant B). It is seen that each of them affects differently the total area and volume. For example, the temporary storage sites share for separated solid manure is with an area of 519,8 m², which represents 82% of the total value for this parameter (633,7 m²); the collector pit share (area 19,4 m²) is 3,5% etc. These facilities occupy a share of the total volume of variant B (1102,9 m³) – respectively 77,1% and 7,9% (850,6 m³ and 86,9 m³).

All investment costs results for construction and technique equipment of the researched liquid manure management system variants in the pig farm are presented in Table 4. The data in the table shows that all indicators of the investment costs for manure separation system (Variant B) are much more expensive solution than the semi-buried lagoon for liquid manure (Variant A). Thus the construction cost for building the facilities for the storage of manure for variant B (155 636,92 EUR) is 2,2 times greater than that in Variant A (72 300,60 EUR) the value of the manure management technology is 2,6 times greater (154 300,00 EUR for Variant B, and 59 400,90 EUR for Variant A), and total investment costs – 2,4 times

Table 1. Manure utilization in pig farm, obtained from variants of slurry management systems, kg

Pigs category	Number of pigs	Quantities of the separated manure and slurry for a day:						Manure utilization in the farm, obtained from:	
		of 1 animal*			of all animals from the different categories			Semi buried lagoon (variant A)	Manure separation system (variant B)
		kg/head/day			kg/day			kg/4 months	kg/6 months
		Manure	Slurry	Total	Manure	Slurry	Total	Total	Total
Sows	351	3.0	5.0	8.0	1053.0	1755.0	2808.0	336960	189540
Growing pigs	1557	0.8	1.5	2.3	1245.6	2335.5	3581.1	429732	224208
Fattened pigs	1056	2.5	2.5	5.0	2640.0	2640.0	5280.0	633600	475200
Boars	8	3.0	5.0	8.0	24.0	40.0	64.0	7680	4320
Gilts	54	2.5	2.5	5.0	135.0	135.0	270.0	32400	24300
Piglets	678	0.5	1.3	1.8	339.0	881.4	1220.4	146448	61020
Total	3704				5436.6	7786.9	13223.5	1586820	978588

* The quantities of the separated manure and slurry for 1 day from 1 animal are adopted under the regulations in Bulgaria (Technological regulations, 1982)

Table 2. Volume and planning parameters of variants of systems for liquid manure management in pig farm

Variant	Manure management system	Total built-up area, m ²	Total built-up volume, m ³
A	Storage in semi-buried manure reservoir ("lagoon" type)	680.8	2291.9
B	Separation of different fractions: - storage of solid fraction on the four-sided enclosed concrete reservoir; - discharge of liquid manure fraction to the treatment plant	633.7	1102.9

Table 3. Volume and planning parameters of facilities for a liquid manure separation system in the pig farm (Variant B)

№ in order	Type of facility	Total built-up area, m ²	Total built-up volume, m ³
1.	Dug collector pit for the incoming liquid manure from the farm.	19.4	86.9
2.	Dug transition pit with sluices for releasing the liquid manure, received from the pig buildings, and directed to the collector pit.	3.8	5.8
3.	Construction for the strengthening of the separator.	47.3	147.6
4.	Fenced concrete sites and staircases around the separator, including discharge of liquid manure fraction to the treatment plant.	43.4	12.0
5.	Four-sided fenced area for six months storage of separated solid manure fraction.	519.8	850.6
Total		633.7 m ²	1102.9 m ³

Table 4. Investment costs for constructing and equipping with technic of variants of systems for liquid manure management in pig farm

Variant	Manure management system	Investment costs, EUR		
		Construction costs for constructing of manure storage facilities	Cost of the manure management equipment (including installation)	Total investment costs*
A	Storage in semi-buried manure reservoir ("lagoon" type)	72 300.60	59 400.90	131 701.50
	Separation of different fractions:			
B	- storage of solid fraction on the four-sided enclosed concrete reservoir; - discharge of liquid manure fraction to the treatment plant	155 636.92	154 300.00	309 936.92

higher (309 936,92 EUR for Variant B and 131 701,50 EUR for Variant A). Variant B is additionally expensive, because the farm owner pays the water treatment plant to discharge the separated liquid fraction.

Conclusion

The variant with liquid manure separating system of solid and liquid fractions is more economical than the semi-buried scrape lagoon by the volume and planning parameters: by total built-up area – by 7,4%, by total built-up volume – 2,1 times, which brings less pollution to the environment.

The variant of semi-buried scrape lagoon is more economical than the manure separation system by the parameters: by total construction cost for building the manure storage facilities – 2,2 times, by the total value of manure management equipment – 2,6 times, in total investment costs for construction and technical equipment of manure storage facilities – 2,4 times.

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