*Environmental Engineering and Management Journal* March 2021, Vol.20, No. 3, 371-375
http://www.eemj.icpm.tuiasi.ro/; http://www.eemj.eu

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# CONTRIBUTIONS ON THE CENTRALIZED COLLECTION OF MANURE

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**Abstract**

This paper outlines certain contributions on the centralized collection and storage of manure, the building type of storage facility that must be used in order to eliminate the possibilities of spread and infiltration into the soil. Also, the facilities that need to be implemented for the collection of leachates, as well as a method to evaluate the volume of leachate collected from the storage platform, in the case of a rural area locality are addressed. The total built-up area shall be of 1191 $m^2$, while the actual storage area shall be of 825 $m^2$. The entrapped leachate volume was calculated considering the two manure storages pans. The total capacity of the leachate collection tank will be of 145 $m^3$.

*Key words:* collection, chamber, leachate, manure

*Received: June, 2020; Revised final: December, 2020; Accepted: January, 2020; Published in final edited form: March, 2021*

## 1. Introduction

Manure is a natural, complete fertilizer, containing all the substances needed for plant growth and development. It is used on unstructured land, consisting of humus-poor soils, and improves their content in terms of nutrients, structure, aeration, water retention and intensifies the activity of soil organisms (Das et al., 2019; Stătescu et al., 2017). The characteristics of manure are largely related to the animal producing it (i.e. the type, weight, breeding stage, gender, age of such animal), the environment and the living conditions of the animals (Ghirardini et al., 2020; Xiong et al., 2010).

A serious environmental problem occurs from the moment manure is produced: manure can be used as an agricultural fertilizer only after a certain period of time, during which it undergoes a complex process of composting, achieved in two steps: the mechanical treatment (grinding, homogenization and preparation for biological treatment) and the anaerobic digestion process. Manure composting has also been used as a method for the arsenic detoxification by changing its shapes (Wang et al., 2018a), and the addition of carbadox in manure slightly influences the pH variation, as well as the carbon/nitrogen ratio, and improves the decomposition of organic matter (Li et al., 2018; Shi et al., 2016).

It is now considered that using manure for the bioenergy resources conversion processes can be a sustainable development choice, rather than the traditional use as fertilizer (Biali and Schneider, 2018; Fernandez-Lopez et al., 2015; Kumar et al., 2017; Ramos-Suárez et al., 2019). Experimental tests conducted by Zagorskis et al., (2012) have shown that cow manure supplemented by grassy waste, produced a higher amount of biogas and methane concentrations, compared to that produced by simple cow manure. The influence of chlortetracycline (CTC) and copper (Cu) on the anaerobic decomposition was also tracked when pig manure was used as a sublayer in a biogas plant (Mallmann et al., 2012; Wang et al.,

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2018b), as well as the number of bacteria in the manure composted from day 10 to day 60 of composting, by means of the Biolog method (Wang et al., 2018c). In Romania, using manure as fertilizer can be performed only under certain quality conditions imposed by Order No.1270 (2005), in order to avoid increasing the amount of nitrates in the groundwater, as a result of the mismanagement thereof (Simionica Bădilă, 2017; Lin et al., 2018).

In 1991, the European Union introduced Directive 91/676/EEC which aims to protect water quality in Europe, by preventing the pollution of ground and surface water caused by nutrients from agricultural sources and by promoting the use of good agricultural practices (EC Directive, 1991). In accordance with this directive, each Member State had to establish an action plan for areas vulnerable in this respect. In order to comply with the requirements of the EU Directive and to promote a sustainable agriculture, Romania has prepared the "Integrated Nutrient Pollution Control Project for 2017 – 2022", funded by the Romanian Government by means of a repayable loan granted by the International Bank for Reconstruction and Development (World Bank). This project aims to promote investments in local communities, in order to reduce nutrient discharges into (surface and ground) water bodies.

The implementation of this ambitious program, however, implies to substantiate certain methodologies or techniques for the collection and storage of manure from individual livestock breeders on the one hand, and certain evaluation techniques and measures to avoid the environmental implications induced by such storage process, on the other hand.

The paper presents some contributions regarding the centralized collection and storage of manure involving no environmental impact.

## 2. Material and methods

In the North-Eastern part of Romania, manure from individual households is almost entirely discharged on the most varied sites: mainly on the banks of watercourses, or even directly into surface waters, on abandoned land areas, in natural pits or simply on the roadside at the town entrance or exit. According to the Integrated Nutrient Pollution Control Project (2016), the storage space for manure must be chosen in the outskirts of the village and at least 50 m away from the nearest house. The storage area must be public property. Considering these conditions, a first aspect to be clarified is that of the storage area size. For the calculation of the storage area, it is proposed to use Eq. (1):

$$S = Ts \cdot \sum_{i=1}^{n}(Ni \cdot Ci) \cdot \frac{\sum_{i=1}^{1} Ni}{\sum_{i=1}^{n}(Ni \cdot \rho i)} \cdot \frac{1}{H} \cdot \bar{\mu}\ (m^2) \qquad (1)$$

where: $T_S$ is the time of manure storage in the storage facility up to the agricultural recovery; it is recommend $T_S$ = 3 …6 months; $i$ is the animal species that produces manure in the village; $N_i$ is number of animals of species $i$; $C_i$ is the amount of manure, in tonnes, produced by an animal of species $i$ in one month; these values are found in Annex 7 of the Code of Good Agricultural Practices (2005); $\rho_i$ is the density of fresh manure mixed with urine and bedding materials; according to the Code of Good Agricultural Practices, $\rho_i = 0.5 - 0.75$ t/m$^3$; $H$ is the maximum thickness of the manure layer in the storage facility; according to the Code of Good Agricultural Practices, we recommend H=1.5…2.0 m; $\mu$ is a coefficient of increase of the storage space that takes into account the fact that manure, during storage, must be handled in order to obtain good composting. It is recommended to use $\mu = 1.5 \dots 2.0$.

Another aspect of storage is the evaluation of the annual leachate volume generated by the manure during the storage period ($V_{TS}$). This volume should be evaluated using Eq. (2):

$$V_{TS} = T_{SZ} \cdot a \cdot (\sum_{i=1}^{n} V_u^i + V_b + V_i + V_p\ (1) \qquad (2)$$

where: $T_{SZ}$ is the storage time of manure, expressed in days; α is the percentage of liquid lost from manure through evaporation and fermentation (composting); it is recommended $\alpha = 0.8$; $V_u^i$ is the volume of liquid contained in the urine of species $i$, in L/day; $V_b$ is the volume of water wasted by animals and/or humans during watering, (L/day); $V_i$ is the volume of sanitation water, (L/day); $V_p$ is the volume of water generated by the precipitation dropped on the surface of the storage facility during storage ($L$).

The volume of water generated by precipitation ($Vp$) to be entrapped during the storage period from the surface of the manure platform was calculated using Eq. (3):

$$V_p = 10000 \cdot \sum_{i=1}^{Ts}(P_i - E_i) \cdot (1-\delta) \cdot \sigma \cdot S_p\ (1) \qquad (3)$$

where: $Pi$ is the height of precipitation dropped in month $i$ of the storage period, in an average climatic year, (mm/month $i$); $i$ is the month in the manure storages pan; $E_i$ is the value of evaporation from month $i$ of the storage period, in an average year; $\sigma$ is the coefficient of leachate drainage from the storage facility; we proposed $\sigma = 0.95$; $\delta$ is the coefficient of precipitation retention in manure; we proposed $\delta = 0.2$; $S_p$ is the area of the manure platform(ha).

## 3. Results and discussion

### 3.1. Storage area and building solution

The method of evaluating the storage area presented above has been applied, for example, to a manure platform for a village in the county of Iași, where there is no centralized water supply system. The storage area will be located in the outskirts of the village, on public property, and the distance from the last village house to the manure platform are shown in Fig. 1. Given the functionality of the construction, it is therefore aimed for the assembly to serve both small-sized farmers and the entire population from the township area. In this way, the quality of life will be improved, the risk of affecting the health of the citizens will be reduced and the air hygiene will be maintained to an appropriate level of comfort within the village.

The design data were:

- total number of cattle = 45; with $C_1$= 0.870 t/month; $\rho_1$ = 0.725 t/m$^3$; $V_u$=12 litres;
- total number of swine = 89; with $C_2$= 0.135 t/month; $\rho_2$ = 0.225 t/m$^3$; $V_u$= 3.5 litres;
- total number of sheep = 278; with $C_3$= 0.040 t/month; $\rho_3$ = 0.435 t/m$^3$;
- thickness of the manure layer in the storage facility = 1.5 m;
- coefficient of increase of the storage space = $\mu$=1.5.

An actual manure storage area of: $S$ = 825 m$^2$ resulted following the replacing of values in Eq. (1). Within this demand area, the manure platform shall have the following features: rectangular shape, built of concrete, walled on 3 sides (except the front side), with the following top view sizes:

$L \times B \times h$ = 33 x 25 x 2 m.

The total built-up area is of 1191 m$^2$. The characteristics and main building elements of the manure platform are shown in Fig. 2.

*3.2. Collection of the leachate*

The following design data is known for the calculation of the leachate volume:

- the volume of urine from a bovine, $Vu_1$=13 L/day;
- the volume of urine from a pig, $Vu_2$=3.5 L/day;
- the volume of urine from a sheep, $Vu_3$=0.6 L/day;
- the precipitation and evaporation regime for an average year in the climatic area of the village site is shown in Table 1;
- the manure storage spans are September 1$^{st}$– February 28$^{th}$andMarch 1$^{st}$ –August 31$^{st}$.

The following results were obtained by applying Eq. 2-3:

- the total volume of leachate for the September 1$^{st}$ – February 28$^{th}$ span resulted in: $V_T^1 = 145\ m^3$;
- the total volume of leachate for the March 1$^{st}$ – August 31$^{st}$span resulted in: $V_T^2 = 19\ m^3$.

As shown, it is necessary that the leachate collection tank be sized to the values calculated for the September 1$^{st}$ – February 28$^{th}$ storage span. In terms of building design, the fact that there should not be pollution on the soil will have to be considered when collecting the leachate.

Thus, the possible infiltration of leachate into the soil will be avoided by waterproofing measures, both by placing a waterproofing membrane on the layer of earth on which the platform is built and by applying a waterproofing substance, by means of brushing to the outside, on the inner surfaces of the platform walls and floor.

The collector ditch will also be waterproofed. For the storage of leachate and rainwater, the building of a semi-buried reinforced concrete tank was provided, which was placed in the immediate vicinity of the storage platform.


**Fig. 1.** The manure platform site

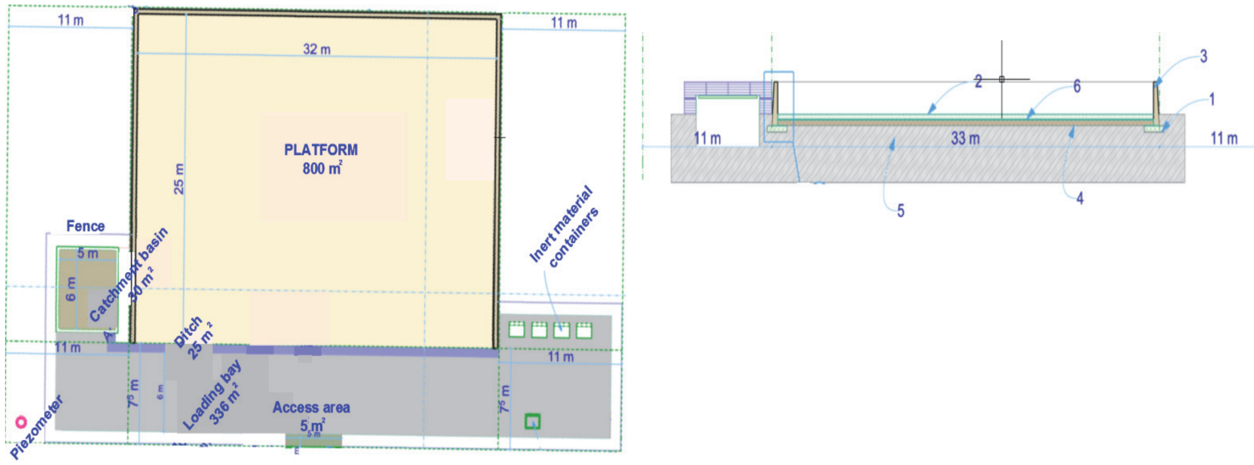


**Fig. 2.** Components of the manure platform:1 - reinforced concrete foundation, 2 - manure platform, 3 - reinforced concrete wall, 4 - ballast layer, 5 - natural land, 6 - membrane for waterproofing.

**Table 1.** Monthly amounts of precipitation and evaporation in an average year

| ***Elements*** | ***Month*** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***I*** | ***II*** | ***III*** | ***IV*** | ***V*** | ***VI*** | ***VII*** | ***VIII*** | ***IX*** | ***X*** | ***XI*** | ***XII*** |
| P (mm) | 32 | 31 | 31 | 53 | 63 | 101 | 83 | 56 | 48 | 25 | 35 | 31 |
| E (mm) | 0 | 0 | 13.66 | 57.44 | 90.09 | 96.81 | 95.5 | 79.61 | 58.94 | 35.55 | 13.50 | 0 |
| $\sigma$ | 0.95 | 0.95 | 0.95 | 0 | 0 | 0.95 | 0 | 0 | 0 | 0 | 0.95 | 0.95 |
| $\delta$ | 0.2 | 0.2 | 0.2 | 0 | 0 | 0.2 | 0 | 0 | 0 | 0 | 0.2 | 0.2 |
| $S_p$ | 0.119 | 0.119 | 0.119 | 0.119 | 0.119 | 0.119 | 0.119 | 0.119 | 0.119 | 0.119 | 0.119 | 0.119 |

A single slope of 2% was provided towards the collector ditch for the disposal of rainwater from the road surface inside the composting platform. In order to observe if any infiltration of effluents come from the manure into the groundwater occurs, the placing of two piezometers was provided, both downstream and upstream, which will periodically monitor the quality of the groundwater.

The paper also presents an example of calculation for a village in the county of Iași. For this specific case, a storage area of 825 $m^2$ resulted, as well as a leachate collection tank of 145$m^3$ to a filling degree of 90%. The building details used in the execution of the two actual constructions are also presented for the storage facility and the collection tank for which the quantitative sizes were determined.

## 4. Conclusions

Lately, in Romania, great focus is placed on the controlled storage of manure and the collection of the leachate therefrom. However, the planning of these storage facilities, at present, is performed chaotically, unprofessionally, differing from one area to the other and from one planner to the other. Therefore, there was a critical need to develop the most precise calculation technique, adapted as much as possible to the actual requirements imposed by the amounts of manure resulting from the breeding of animals and by the need to compost them before their use.

The paper is based on hard data, both quantitative and qualitative, established by the "good agricultural practices for the protection of water bodies against pollution with nitrates come from agricultural sources", and proposes a technique of precise calculation of the storage areas and of the amount of leachate collectable therefrom. The proposed method also has the merit of taking into account the climate of the area as long as the storage is most often made outdoors in Romania, under no roof (currently, planners totally neglect this aspect).

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