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Research of the oxalic acid effectiveness in the treatment of biodegradable organic waste from livestock complexes

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Abstract
The article presents the results of studies of the process of reagent treatment of biodegradable organic waste of livestock complexes for the purpose of their agricultural use. The basic laws of the process of separation into liquid and solid fractions using oxalic acid are determined and analyzed; optimal doses of reagents; the dependence of changes in the properties of the fraction at various stages of treatment with calcium carbide slurry, comparing them with indicators obtained using lime milk, superphosphate and phosphogypsum.

Keywords: biodegradable organic waste, processing, parameters of the process of fractionation into liquid and solid fractions, oxalic acid

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INTRODUCTION

Nowadays, there is a significant decrease in the introduction of organic-mineral fertilizers into the soil of agricultural lands due to their high cost. A progressive increase in technogenic impact on soils leads to an acceleration of the processes of removal of humus and a decrease in the thickness of the humus horizon. Moreover, biodegradable organic waste is used a little.

The decrease in soil fertility is associated primarily with physical and chemical effects on the land.

The soil in the region of Novocherkassk, Rostov Region, has the following characteristics: density 1.21 g/cm^3; density of a solid phase - 2.46 g/cm^3; total porosity - 52%; humidity - 22%; pH 7.2 - 7.8. The soil belongs to alluvial meadow carbonate low humus and is characterized by the following indicators: physical. clay - 45%; silt - 26.6%; humus - 4.2%; $CaCO_3$ - 0.7%; mobile phosphorus in terms of P_2O_5 - 4 mg/100 g; K_2O - 56 mg/100 g; Ca^{2+}+Mg^{2+} - 32.8 mg/100 g. Chernozem ordinary carbonate medium-power medium-humic: physical. clay - 53.1%; sludge - 32.4%; humus - 3.9%; $CaCO^3$ - 1.1%; mobile phosphorus in terms of P_2O_5 - 3.2 mg/100 g; K_2O - 32.8 mg/100 g; the sum of Ca^{2+}+Mg^{2+} is 33 mg/100 g (Gribut et al. 2012).

The authors formulated the concept of using organic substances as reagents for the treatment of biodegradable organic waste. The resulting product is an organomineral fertilizer and can be used to increase the yield of forage crops.

To implement this idea, a scientific justification for the technology for processing biodegradable organic waste is necessary.

In this regard, it is necessary to develop a non-destructive method that allows you to save valuable nutrients. One of them is fractional separation of biodegradable organic waste by reagent treatment with a suspension of $Ca(OH)_2$ followed by neutralization with oxalic acid solution.(Baba et al 2015)

The aim of the research is to analyze the processing of biodegradable organic waste, using an acidifying reagent - oxalic acid, first used instead of previously used superphosphate and phosphogypsum (Fedorchenko and Surzhko 2003, Fedorchenko 2004).

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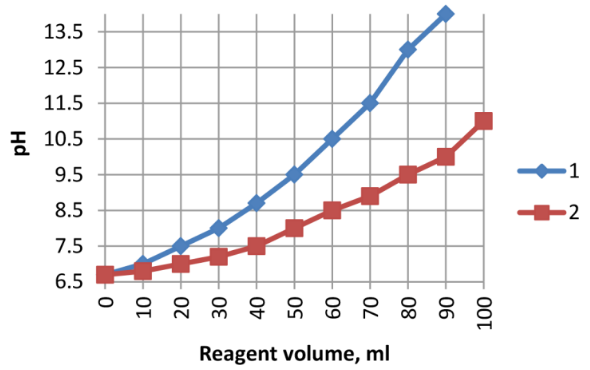

Fig. 1. The pH value of biodegradable organic waste (1dm[3]) after clarification of the volume of the reagent: 1-10% suspension of $Ca(OH)_2$; 2 - 10% slurry suspension CaC_2

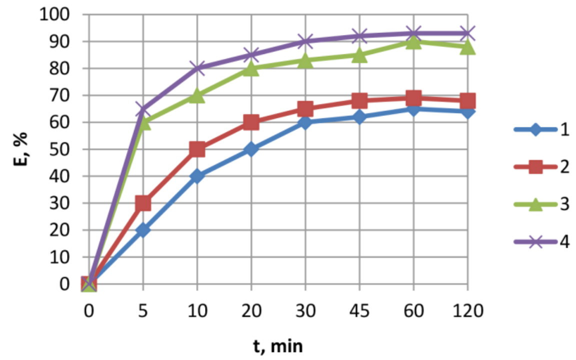

Fig. 2a. The effectiveness of sedimentation of biodegradable organic waste from processing time at doses of slurry suspension CaC_2, g/dm[3]: 1-1, 2-1.5, 3-2.5, 4-3

The objectives of the research were to determine the main criteria for the process of fractionation of biodegradable organic waste into liquid and solid fractions; determination of optimal doses of reagents; revealing the dependences of changes in the properties of the fraction at various stages of the treatment of biodegradable organic waste with a suspension of calcium sludge (CaC_2) (Fedorchenko and Surzhko 2003, Fedorchenko 2004), comparing them with the parameters obtained by processing a suspension of $Ca(OH)_2$.

METHODOLOGY

In the biodegradable organic waste consisting of organic matter - 5.8%, sand - 0.2%, total nitrogen, phosphorus and potassium - 0.5%, 0.3%, 0.4%, respectively, with a density of 1026 kg/m_3 at a humidity of 90% after gravity settling for 1 hour and subsequent filtration determined the dry matter content (Fedorchenko 2004). All experiments were carried out according to the standard method in triplicate. For research, five samples were taken from different parts of the tank into which biodegradable organic waste was taken. As a result, it was found that in the absence of mixing in different layers of the total volume of organic waste, the dry matter content ranges from 1.5 to 4.5%. The average content is 3% (Fedorchenko 2004, Fedorchenko and Surzhko 2003, Surzhko and Kulikova 2011).

Studies of these products were carried out simultaneously in two directions. In the first direction, the initial biodegradable organic waste was treated with a 10% suspension of milk of lime, (prepared from lime-fluff -97% active calcium oxide) with a concentration of 2.6 g/dm^3 to a pH of 11.0, then the pH level was reduced with a solution of oxalic acid concentration 2.0 g/dm^3 to pH 8.6. In the second direction, a similar treatment was performed with the replacement of a suspension of lime milk with a 10% suspension of CaC_2 sludge. The pH value was measured after continuous mixing of the treated mixture with a dose of reagent for 5 min.

RESULTS

Fig. 1 shows a graph of the change in pH versus the volume of reagents when processing 1 dm^3 of the initial biodegradable organic waste (Fedorchenko 2004, Fedorchenko and Surzhko 2003, Surzhko and Kulikova 2011).

Analyzing the obtained dependences, we see that to bring the pH of the mixture to 10.5-11.5, 10-15% more suspension of calcium carbide sludge is required than suspensions of $Ca(OH)_2$. This is confirmed by a theoretical calculation of the active CaO in the dry sludge up to 80%, it can also be established that 1 dm3 of biodegradable organic waste reached a pH of 10.2 with a volume ratio of reagents 20-1:10, and a suspension of lime milk is required to bring the pH to 11.0 in proportion to the original product 1:17 or CaC_2 sludge in a ratio of 1 to 2 (Fedorchenko 2004, Fedorchenko and Surzhko 2003, Surzhko and Kulikova 2011).

The effect of separation of waste into fractions determined the optimal dose of the reagent necessary for the treatment of concentrated liquid waste. In 4 identical samples with a volume of 1 dm^3 each, various doses of a 10% suspension of CaC_2 sludge were added: 1, 1.5, 2.5, 3 g/dm^3 (based on active CaO). In parallel with the introduction, the pH values of the liquid and solid phases in each sample were determined. Separation into fractions was carried out in a standard cylinder with a height of 500 mm and a base diameter of 65 mm. **Fig. 2a** shows the effectiveness of sedimentation of biodegradable organic waste over time for various amounts of reagent (Fedorchenko 2004, Fedorchenko and Surzhko 2003, Surzhko and Kulikova 2011).

Based on the studies, the optimal volume was determined - 0.1 m^3 of the introduced suspension of CaC_2 sludge, necessary for processing 1 m^3 of product. The corresponding dose of slurry suspension for active calcium oxide is 2.7 g/dm^3. At doses of 1 and 1.5 g/dm^3, a less effective separation of concentrated liquid waste

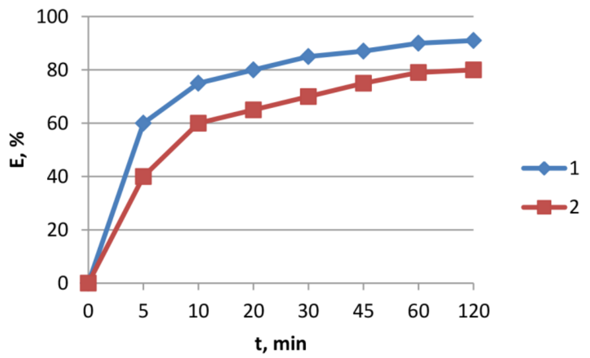

Fig. 2b. Efficiency of sedimentation of biodegradable organic waste from the time of treatment with a CaC_2 suspension during sedimentation in cylinders with a diameter, mm: 1-0.65; 2-0.45

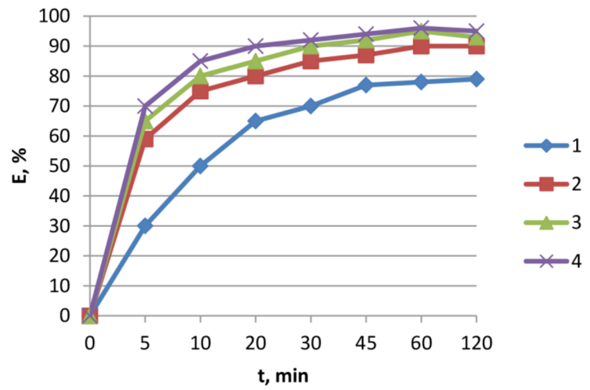

Fig. 3. The efficiency of the separation of biodegradable organic waste into liquid and solid fractions at a dose of oxalic acid 1.0 g/dm^3 of temperature, C°: 1-10, 2-20, 3-30, 4-40

into fractions is observed, and an increase in the dose of the reagent to 3 g/dm^3 is ineffective, because while there is a slight increase in the efficiency of deposition of solid particles (Fedorchenko 2004, Fedorchenko and Surzhko 2003, Surzhko and Kulikova 2011).

The research of the dependence of the effectiveness of sedimentation on time for various diameters of the cylinders is shown in **Fig. 2b**. The separation effect of biodegradable organic waste was 95% in a cylinder with a diameter of 65 mm, with a diameter of 45 mm - 85% (Fedorchenko 2004, Fedorchenko and Surzhko 2003, Surzhko and Kulikova 2011).

The influence of the ambient temperature on the process of separation of biodegradable organic waste into fractions was studied in the range from 10 to 40 C°. The dependence of the separation effect of biodegradable organic waste at various environmental temperatures on time is shown in **Fig. 3**.

We consider that with increasing temperature, the fractionation rate increases. The best separation effect of biodegradable organic waste fractions is observed at 40 C°; however, differences in processing efficiency at 20, 30 and 40 C° are insignificant. It can be concluded

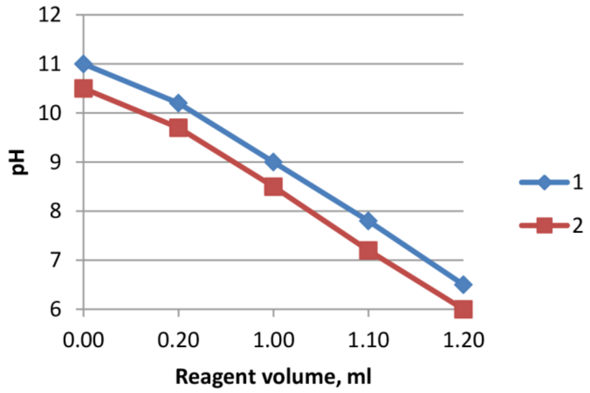

Fig. 4. Changing in pH of the mixture depending on the volume of oxalic acid solution at pH of biodegradable organic waste after treatment with 10% slurry suspension CaC2 (1 dm3) 1-11.0 2-10.0

that the optimum temperature for the treatment of biodegradable organic waste is t=20C° (Fedorchenko 2004, Fedorchenko and Surzhko 2003, Surzhko and Kulikova 2011).

A) Change in pH was achieved by changing the volume of the added solution of oxalic acid. The pH was measured after five minutes of stirring.

Fig. 4 shows the change in pH from a dose of oxalic acid at various initial pH values of biodegradable organic waste. To bring their pH from 11.0 to 8.0, 0.5-1.05 ml of oxalic acid solution is necessary; in this case the ratio of the volumes of the reagent and the mixture will be 1: 33-1: 10.

The amount of suspended solids in the liquid phase obtained as a result of gravitational sedimentation of the mixture is 2.5-10.5 mg/dm^3, it is colorless and transparent. After processing the waste with a 10% suspension of CaC_2 sludge and an oxalic acid solution, a precipitate forms, consisting of large flakes of light gray in color.

B) The result of the analysis established the feasibility of effectively replacing the suspension of lime milk with a suspension of sludge CaC2 (Surzhko and Kulikova 2011, Surzhko et al. 2009). Next, the optimal doses of the CaC2 slurry and oxalic acid slurry were revealed by separation of the different dry matter content of organic wastes. It was determined that the amount of reagents is directly dependent on the dry matter content of the organic waste. When increasing the dry matter content from 2.5 to 8.5%, to achieve a settling effect of 95%, it is necessary to increase the doses of calcium carbide sludge suspension from 0.8 to 2 g / dm3, and when the dry matter content is 8.5-10, The 5% coagulant dose increased to 4 g / dm3 (**Fig. 5a**). To achieve a pH of 10.5, 2-2.5 g / dm3 of sludge suspension was required in biodegradable organic waste samples, and with increasing solids content of 4.5 to 6.5%, the reagent dose increased from 2.5 to 3.5 g / dm3 (**Fig. 5b**) (Surzhko and Kolesnikova 2011).

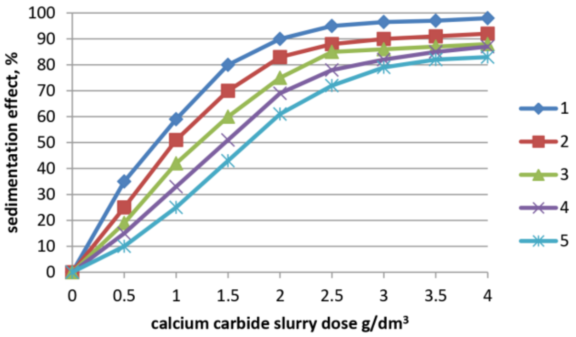

Fig. 5a. Efficiency of separation of biodegradable organic waste from dose with a slurry suspension of CaC_2 and the percentage of dry matter: 1-2.5%, 2-4.5%, 3-6.5%, 4-8.5%, 5-10.5%

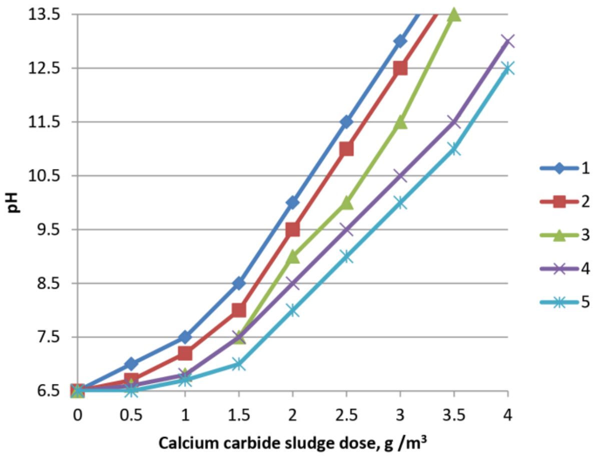

Fig. 5b. Change in pH of a dose of a suspension of CaC_2 sludge and the percentage of dry matter in organic waste: 1-2.5%, 2-4.5%, 3-6.5%, 4-8.5%, 5-10.5%

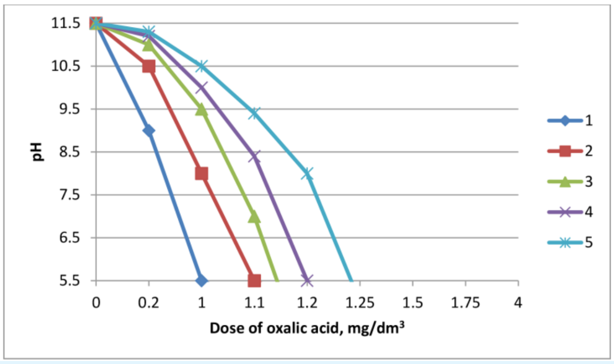

Fig. 6. The dependence of pH on the dose of oxalic acid with different dry matter content in biodegradable organic waste 1-2%, 2-4%, 3-6%, 4-8%, 5-10%

The analysis established the feasibility of effectively replacing a suspension of milk of lime with a suspension of CaC_2 sludge (Surzhko and Kulikova 2011, Surzhko et al. 2009). Further, the optimal doses of a suspension of CaC_2 sludge and oxalic acid were detected in the separation of organic waste with different dry matter contents. It was determined that the amount of reagents

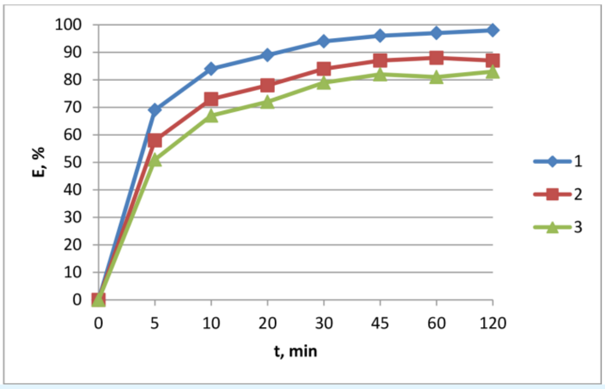

Fig. 7. Efficiency of sedimentation from the time of treatment of biodegradable organic waste with various reagents: 1-oxalic acid, 2-phosphogypsum, 3 - superphosphate.

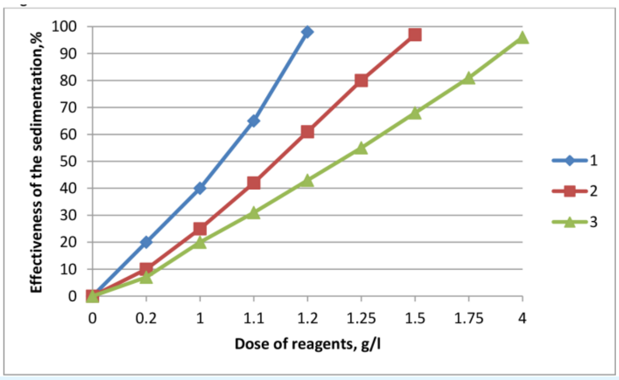

Fig. 8. Dependence of the effect of sedimentation on the dose of acidifying reagents 1 - oxalic acid, 2 - phosphogypsum, 3 - superphosphate

is directly dependent on the dry matter content of organic waste. With an increase in the dry matter content from 2.5 to 8.5%, in order to achieve a settling effect of 95%, it is necessary to increase the dose of the suspension of calcium carbide sludge from 0.8 to 2 g/dm^3, and with a dry matter content of 8.5-10,5% of the coagulant dose increased to 4 g/dm^3 (**Fig. 5a**). To achieve a pH of 10.5 in samples of biodegradable organic waste, a slurry suspension of CaC_2 was required 2-2.5 g/dm^3, and with an increase in the dry matter content from 4.5 to 6.5%, the dose of the reagent increased from 2.5 to 3.5 g/dm^3 (**Fig. 5b**).

For the test sample of liquid waste with a dry matter content of 6%, the optimal dose of oxalic acid is 1.0-1.2 g/dm^3, at which a pH value of 6.5 is reached (**Fig. 6**).

Analyzing the results, we consider that with the same settling time, the best effect of the separation of biodegradable waste - 98% has a solution of oxalic acid.

According to the obtained dependences of comparing the efficiency of fractionation of biodegradable waste with the addition of various acidifying reagents, it was found that the lowest dose with the greatest effect is required for oxalic acid (Surzhko et al. 2009).

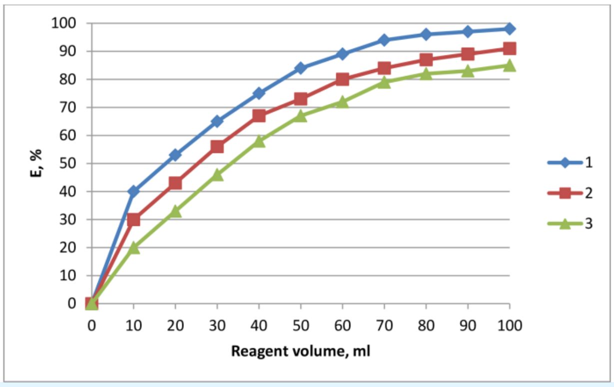

Fig. 9. Dependence of the effect of sedimentation on the volume of the reagent 1 - oxalic acid, 2 - phosphogypsum, 3 - superphosphate

According to the given dependences, it can be established that with the same volumes of acidifying reagents required to neutralize the pH, the fractionation efficiency of biodegradable waste is significantly higher in the case of oxalic acid (Surzhko et al. 2009).

CONCLUSION

As a result of studying changes in pH, the content of organic substances, C, all forms of N (total, ammonium, nitrite, nitrate), total P, total K, nutrients, it was found that the use of oxalic acid as a reagent for alkalization after treatment compared to the waste material reduced the content of N (total and ammonium), total P, total K, and the ratio N:P:K has changed from 1:1: 1.18 to 4:1:1 (Fedorchenko 2004, Fedorchenko and Surzhko 2003, Surzhko and Kulikova 2011).

Analyzing the research results, it was found that the products obtained after processing and separation into liquid and solid phases can be characterized as highly concentrated in terms of the main biogenic elements, this is the basis for their use in agriculture.

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