Optimization of the environmentally safe technology for the processing of liquid animal breeding

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Abstract. The article discusses the optimization of parameters of environmentally friendly technologies in the processing of liquid waste in order to obtain organic fertilizer and liquid phase for irrigation and increase the fertility of agricultural land. These parameters are established on the basis of studies of the processes of reagent fractionation of highly concentrated biogenic elements of liquid waste from pig farms. The regression equations were used for the experimental data obtained by studying the influence of the doses of ammophos suspension on the process of separation of liquid waste, the settling time in sedimentation tanks, and also the initial temperature of liquid waste. An optimization model of the reagent process has been created, which allows, depending on the volume of treated waste, to determine the ratio of reagent doses and settling time.

Organic and mineral fertilizers have a high value, meanwhile in agriculture is formed tonnage highly concentrated on biogenic elements of wastes, which to relate to liquid waste from meat clusters. Relevance of the use of liquid waste from pig farms is based on their properties and features. Concentrated liquid wastes represent universal organic fertilizer[1-3] as a suspension, which dispersed medium is water solution of mineral salt, organic compounds, and dispersed phase is solid experimental particles, feeds and amount of mineral inclusions. Dry substance in colloidal solution can be isolated just only if use special processing methods [4-6].

Highly concentrated waste from meat clusters, firstly, is liquid waste from pig farms by reagent treatment becomes an exercisable for the irrigation of agricultural lands because it contains valuable compounds as nitrogen, phosphorus and potassium(N,P,K) [7-9].

Liquid fraction of liquid wastes has possessed the high value fertilization and it is satisfied the requirements for health and hygiene standards to ground watering by means of the sprinkling. Formed sediment relates to organic-mineral fertilizer, which use could be the most effective on acidic soil [10]. To among unsolved problems in this field can be attributed to narrow range of reagents for a destabilization of colloid system of concentrated liquid waste from meat clusters. Chemical reagents, which are used by the authors for the treatment of liquid waste, are traditionally used as an ameliorants.

The basic conception of the authors in the treatment of liquid waste from pig farms is the use as a reagent mineral fertilizer which uses in the agricultural production. Mineral fertilizer – ammophos, at first, uses as a reagent for acidification liquid wastes after their treatment of suspension of milk of lime Ca(OH)2 or sludge calcium carbide (CaC2) or suspension of defecation lime of sugar production, and after that brings in agricultural field as organic-mineral fertilizers. Reagent fractionation with the use of
mineral fertilizers is non-destructive method which can save and increase biogenic elements[11,12]. In this way, water is used twice, firstly, for the irrigation of self-alloying manure, and after reagent division for irrigation of agricultural crops.

However, the influence of different factors on process of reagent treatment when using ammophos is studied weakly and in modern science literature imaged few amount of publication. A large number of experimental studies dedicated to the study of the mechanism of separation of liquid waste were studied by native and foreign scientistsBondarenko A.M., Melnik O.A., Surzhko O.A., Shalavina E.V., Afanasyev V.N., Vasiliev E.V., Garzanov A.L., A. Makara, Z. Kowalski, Riano B., Fourne l S. etc. [1,11,13–18].

To continue the work on the use of on biogenic elements of wastes concentrated on biogenic elements of meat clusters, we need studies of changes in the process of destabilization of the colloidal system when using ammophos as an acidifying reagent instead of previously used superphosphate.

Purpose of the study. Purpose of the study is optimization of parameters of environmentally friendly technology for the process of reagent treatment of liquid waste from pig farms with the replacement of a neutralizing superphosphate reagent with a complex mineral reagent not previously studied on this side.

Objects, materials and methods. Described experimental studies, statistical processing with obtaining regression dependencies [19–21], and optimization in Matlab by the method of sequential quadratic programming.

Research was conducted on the basis of M. I. Platov South-Russian State Polytechnic University. The object of the study was the liquid waste of the pig farm of Batayskoye CJSC in the Rostov Region, with a capacity of 30,000 pigs and a liquid waste flow rate of 150 m$^3$/day.

When conducting studies to determine the optimal parameters of the process of separating the liquid waste of pig farms into fractions, standard cylinders with a volume of 1 dm$^3$ were used. Before the test, the liquid waste was settled for 1 hour, then it was filtered through sieves with sizes of holes 3-5 mm. To determine the temperature $t_g$ and pH of liquid wastes an I-160MI ionomer with an ES-10603/7 K80.7 electrode was used. Electrodes for measuring hydrogen ions were prepared according to the instructions of the ionomers. Investigated the liquid waste of the pig farm to determine their dry matter content [21]. Used a drying cabinet with a heating temperature of 105 °C, laboratory balance 4 accuracy classes.

![Figure 1. Dependence of separation efficiency on mixing time, temperature of liquid waste, dose of applied ammophos: 1 - 0.5 g / dm$^3$; 2-1.0 g / dm$^3$; 3-1.5 g / dm$^3$.](image-url)
As a result of mathematical processing of experimental data was obtained a regression dependence:

\[ \Theta = 45,148 + 75,483 \cdot C_a - 3,058 \cdot t_p - 0,049 \cdot t_g - 22,138 \cdot C_a^2 + 0,417 \cdot t_g^2 - 2,39 \cdot 10^3 \cdot t_g^2 - 1,907 \cdot C_a \cdot t_p - 0,229 \cdot C_a \cdot t_g + 0,163 \cdot t_p \cdot t_g \]

The results of the studies made it possible to establish that the optimal dose of the introduced ammophos was 0.5-1.5 g / dm\(^3\).

**Figure 2.** Dependence of separation efficiency on mixing time, temperature of liquid waste, dose of applied ammophos: 1 - 0.5 g / dm\(^3\); 2 - 1.0 g / dm\(^3\); 3 - 1.5 g / dm\(^3\).

Obtained regression dependence:

\[ t_{ot} = 56,154 - 105,281 \cdot C_a - 6,713 \cdot t_p + 8,044 \cdot t_g - 66,566 \cdot C_a^2 + 0,761 \cdot t_p^2 - 0,175 \cdot 10^3 \cdot t_g^2 - 2,873 \cdot C_a \cdot t_p - 1,133 \cdot C_a \cdot t_g - 0,012 \cdot t \cdot t_g \]

Since the initial temperature of the liquid waste has the least effect on the settling process in the selected temperature range and cannot be regulated under the technological regime, we believe that it can be ignored in the analysis.

In this regard, we consider the following two-factor regression dependencies:

\[ \Theta = 40,656 + 74,945 \cdot C_a - 0,52 \cdot t_p - 23,364 \cdot C_a^2 + 0,563 \cdot t_p^2 - 2,754 \cdot C_a \cdot t_p \]

\[ t_{ot} = 169,032 - 197,315 \cdot C_a - 0,564 \cdot t_p + 74,364 \cdot C_a^2 - 1,75 \cdot t_p^2 + 9,989 \cdot C_a \cdot t_p \]

Based on two-factor dependencies, we will optimize the parameters of the process of reagent processing of liquid waste from the pig complex using the conjugate gradient method by finding a local extreme of the function based on information about its values and its gradient.

As weighting coefficients during optimization, we select the minimum doses of the reagent and the settling time. The results are shown in table 1.
Table 1. Optimization results of the studied reagent method.

| №  | Weight coefficient | Optimized parameters |
|----|--------------------|----------------------|
|    | $\alpha_1$ | $\alpha_2$ | $E$, % | $t_{\text{sat}}$, min |
| 0.1| 0.9 | 94.992 | 49.446 |
| 0.2| 0.8 | 95.149 | 49.455 |
| 1  | 0.7 | 95.521 | 49.552 |
| 2  | 0.6 | 95.741 | 49.672 |
| 3  | 0.5 | 95.989 | 49.877 |
| 4  | 0.4 | 96.266 | 50.219 |
| 5  | 0.3 | 93.571 | 50.794 |
| 6  | 0.2 | 96.894 | 51.782 |
| 7  | 0.1 | 97.197 | 53.557 |
| 8  | 0.0 | 97.359 | 56.979 |

By technical -economic basis revealed that when processing liquid waste from a pig complex with volumes from 50 to 100 m$^3$/ day the priority for the efficiency of separation into fractions is the mixing time, which leads to small volumes of structures and a lower dose of reagents. With an increase in the volume of processed liquid waste from 100 to 500 m$^3$/ day, the dose of reagents has the greatest influence, and the mixing time is of secondary importance.

When the volume of liquid waste of pig farms from 50 to 100 m$^3$/ day, the most optimal is a mixing time of 5 minutes, providing separation efficiency of up to 97% when standing for 50 minutes, and with a productivity of liquid waste of pig farms from 100 to 500 m$^3$/ day, fractionation efficiency is determined mainly by the dose of ammophos; the highest separation efficiency, equal to 98%, is achieved with a dose of ammophos-1.0 g / dm$^3$.

The temperature of the liquid waste of pig farms varies depending on climatic conditions and operational characteristics in the range from 10-30 ° C and in the indicated range of values does not significantly affect the separation process.

The obtained regression equations allow us to optimize the parameters of environmentally friendly technology for processing liquid waste of meat clusters, allowing us to significantly reduce the processing time while increasing the efficiency of separation into a liquid fraction suitable for irrigation and sediment organic-mineral fertilizer.

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