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COMBINED USE OF A MIXTURE OF LIQUID MANURE AND PLANT WASTE TO PRODUCE BIOFERTILIZERS

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Intensive livestock farming often leads to undesirable environmental consequences due to air, soil and water pollution by animal waste products. A special place in this process is occupied by manure management, which now mostly acts both as a pollutant and as a source of organic fertilizers for agricultural plants (Shablia & Tkachova, 2020).

Despite the availability of modern, sufficiently environmentally friendly manure processing technologies, they are still little used due to their significant cost. Instead, most livestock farms continue to use traditional, outdated, but cheap methods of manure processing. The latter are characterized by additional concomitant negative environmental impacts, including emissions of ammonia, methane, nitrous oxide, carbon dioxide, as well as leaching of nitrates and nitrites into air, soil and water resources.

At the same time, technologies for processing plant organic waste and peat into humates and humic acids are emerging. These technologies have significant environmental and agronomic value in several aspects (Xiao-xia & Hongtao, 2019).

First, plant organic waste (straw, sawdust, leaves, etc.) and peat are available, but often underutilized resources. Therefore, processing these materials can significantly reduce the amount of waste going to landfills, and also prevent soil, water and air pollution.

Second, humic acids are key components of humus, which improves soil structure, its water-holding capacity, and aeration. The introduction of humates into the soil also promotes the development of microorganisms, which improves their biological activity. In addition, humic acids are able to bind heavy metals and other pollutants, preventing them from entering plants.

Humates also stimulate the growth and development of plants, improve their resistance to stress conditions (drought, diseases). They contribute to the assimilation of nutrients from the soil by plants, which increases the yield of crops. Besides, the use of humates reduces the need for mineral fertilizers, which reduces the environmental load on the soil and water resources.

Thus, there are two parallel directions of processing organic waste from crop production and animal husbandry, which have both common features and differences.

Therefore, we consider it advisable to combine manure processing with the production of humates and humic acids from peat and plant organic waste as a promising direction that allows us to simultaneously solve two important problems: waste disposal and the production of valuable organic fertilizers. In this case, manure and plant waste are mixed in optimal proportions and in this form are subjected to further processing.

The combination of these processes can give the proposed technology option a number of advantages. In particular, in the case of composting, plant organic waste or peat can serve as sorbents, absorbing moisture and ammonia from manure, as well as enriching the compost with humic substances. The resulting compost will be a valuable organic fertilizer rich in humates and humic acids.

The option of using joint biofermentation of manure, plant organic waste and (or) peat in bioreactors is capable of providing both biogas and biofertilizer enriched with humic substances. At the same time, peat and plant organic waste improve the structure of biofertilizer and increase its holding capacity.

The most promising, from our point of view, technological direction is the extraction of humic acids from plant organic waste and (or) peat using the liquid fraction of manure. In this case, the liquid fraction of manure is used as a solvent for the extraction of humic acids from peat. The obtained extract of humic acids together with mineral components of nitrogen, phosphorus and potassium can be used as a liquid organic fertilizer for plants. The solid fraction of manure can be subjected to further composting or biofermentation.

We tested one of the options for combining manure processing and obtaining humates from peat using the AVS-100 vortex layer apparatus and microbial consortia.

The AVS-100 apparatus can be effectively used at different stages of the joint processing of manure with peat due to several of its positive qualities. Firstly, it provides intensive dispersion of peat to the required fraction, which increases the surface area and improves the availability of humic substance precursors for further processing (Malyushevskaya et al., 2023).

Secondly, peat processing in AVS-100 can activate humic substances, making them more reactive. AVS-100 can be used for effective mixing of crushed peat with liquid manure fraction, creating a homogeneous suspension.

At the same time, the device provides high-quality homogenization of the peat and manure mixture, which contributes to uniform distribution of components, improves the efficiency of biochemical processes, and also intensifies the extraction process of humic acids, increasing their yield. In addition, processing in the device can modify the structure of humic substances, giving them the necessary properties.

According to our laboratory studies, the use of manure as a liquid component in peat processing with the AVS-100 apparatus resulted in a more concentrated extract with a higher percentage of dry matter compared to the use of water as a liquid component. Thus, the dry matter content in the extract with the washing out by liquid pig manure was 2.66% versus 0.66% in the extract prepared when processing peat with water. As a result of such use of the method of washout humates with liquid pig manure in the same containers and for the same time, it was possible to obtain in the extract: humic acids - 3.4 times more, fulvic acids - 2.6 times more, total nitrogen (N) - 2.7 times more, total potassium (K) - 6.4 times more and organic matter - 3.3 times more. In addition, this extract contained 0.007% total phosphorus (P), while this plant nutrient was not detected in the extract obtained from the water-peat mixture.

Thus, our studies have established that the efficiency of technologies for processing plant organic waste and peat into humates, humic acids and fertilizers can be significantly improved when they are mixed with the liquid fraction formed during pig manure hydro-washing, as well as when microbial consortia are added. Such a solution can provide the process with additional environmental, agronomic and economic advantages.

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OVERVIEW OF CLUSTERING OF BIOLOGICAL SAMPLES USING PRINCIPAL COMPONENT ANALYSIS

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Clustering [1] of biological samples using Principal Component Analysis (PCA) [2] is important for simplifying complex data, revealing hidden structures, and enhancing the interpretation of biological patterns. This approach supports more informed research and decision-making in biology and medicine.

In K-means clustering [3], each data point xi is assigned to the nearest centroid ci based on the Euclidean distance [4] which is demonstrated within formula 1. Formula 2 shows how the centroids [5] are recalculated as the mean of all points assigned to each cluster.

$$d(x_i, c_j) = \sqrt{\sum_{p=1}^{n} \left(x_{i,p} - c_{j,p}\right)^2} \quad (1)$$

$$cj' = \frac{1}{|C_j|} \sum_{x_i \in C_j} x_i \quad (2)$$

Figure 1 shows an example output for K-means clustering, illustrating how data points [6] are grouped into clusters with distinct centroids.