Wastewater treatment from agricultural enterprises using sprinkler irrigation and utilizing sludge as a fertilizer

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Abstract. The article presents the studies of a sorption-mechanical filter with a combined loading of zeolite and activated charcoal. As a result of the study, the sorption properties of this load in relation to the chemical elements in the wastewater were studied. The experiment showed that the optimal filtration time was 12 hours, and during the chemical analysis, data were obtained on reducing the concentration of impurities to the maximum permissible. Therefore, the use of sewage sludge makes it possible to use it as fertilizer. We propose the introduction of mineral fertilizers (activated sludge) with irrigation water on irrigated crop rotation areas using sprinkler irrigation. The implementation of the above measures will make it possible, with great economic effect, to completely utilize the sludge from the treatment facilities of agricultural enterprises as fertilizer, which indicates great opportunities to use this method of treatment in the national economy.

1. Introduction

Now one of the topical issues is the search for cost-effective, improved methods of wastewater treatment, as well as new technological schemes for the treatment and disposal of sludge. Many agricultural enterprises, such as poultry farms, pig farms, and cattle farms, do not have proper treatment of animal waste. Insufficiently purified or not at all purified wastewater is mainly discharged into storage ponds, where chicken manure is dried on the example of poultry farms, or it is directly discharged into water bodies [1].

At present, sorption-mechanical wastewater treatment with the use of various sorbents is gaining momentum. Cheaper, environmentally friendly, natural origin, and durable sorbents are selected as loading. Now there are a very large number of natural sorbents around the world, and every research scientist finds more and more effective and durable materials for loading sorption filters. In the modern world, the most famous and already proven ones are such natural absorbers as zeolite, vermiculite, activated charcoal, analcime, brucite, and so on [2, 3, 4, 5].

Each of the sorbents has its own chemical structure and performs various actions to remove one or another chemical pollutant in the water under study. So, when considering each sorbent separately, according to its sorption properties to chemical elements, we can say that natural zeolite (clinoptilolite) is more universal and with a wider range of removal of impurities from wastewater.
Table 1. Types of sorbents and their absorption spectrum of chemical elements

| № p/p | Type of natural sorbent | Name of the absorbed chemical element                                      |
|-------|-------------------------|--------------------------------------------------------------------------------|
| 1     | Activated charcoal      | Efficiency in wastewater treatment from oil products                         |
| 2     | Vermiculite             | Cleaning of electroplating drains from nickel and copper-containing compounds |
| 3     | Analcime                | Wastewater treatment from ammonium and phosphorus compounds, little studied in relation to other impurities |
| 4     | Zeolite (clinoptilolite)| Wastewater treatment from ammonium, chromium, phosphorus compounds, as well as non-ferrous and heavy metals |
| 5     | Brucite                 | Cleaning gases from chlorine, as well as removing arsenic impurities from wastewater |
| 6     | Saponites               | Wastewater treatment from copper and cadmium ions                             |

Zeolites and zeolite-containing rocks find an ever-wider range of applications in industrial and agricultural production due to the possibility of their use in various industries. One of the important areas of use is the production of cheap natural sorbents from them for environmental protection, including for wastewater treatment and their subsequent use, for example, for irrigating crops [6, 7].

Environmentally friendly zeolites (clinoptilolite) have many exceptional qualities - high-quality absorption selectivity and the ability to divide ions by size and molecules of different substances, stability to increased temperatures, aggressive alkaline or acidic media and ionizing radiation [8, 9].

2. Materials and methods

When studying various natural sorbents, the choice was made on zeolite. Zeolite possesses ion-exchange properties, good sorption properties, and it is also very durable. Data on the ion-exchange properties of zeolites and zeolite-containing rocks show that they can be used for the concentration and separation of large cations of alkali, alkaline earth, heavy and some non-ferrous metals. After use, the zeolite does not require regeneration, since the service life is about 5 years; this is the maximum service life, since it depends on the concentration of impurities in the studied wastewater. We use activated charcoal as an auxiliary sorbent, since it absorbs oil-containing compounds well.

Figure 1. Scheme of sorption-mechanical wastewater treatment with sludge dewatering:
1 - Sorption-mechanical filter with combined loading, 2, 3 - gate valves; 4 - vertical settling tank, 5 - centrifuge for sludge dewatering, 6 - wash water outlet, 7 - filtrate outlet, 8 - wash water inlet, 9 - drainage pipe for dewatered sludge.

To improve and reduce the load on the ecological state of nature as a whole, it is necessary to minimize the effect on natural resources and the component of the selected sorbent, as well as its physical and chemical components, while its properties can improve for more efficient removal of various impurities.

We propose the use of sorption-mechanical treatment of waste water from agricultural enterprises. The technological scheme is a sorption-mechanical filter with a combined loading of zeolite and activated charcoal, a settler and a centrifuge for sludge dewatering, which will be used as fertilizers (Figure 1).

In recent years and at present, significant work has been carried out to intensify and introduce new technological schemes for wastewater treatment and sludge dewatering for the purpose of its use in agriculture.

3. Results and discussions
The aim of the research is to study the sorption features of the combined loading from natural sorbents for the treatment of waste water from agricultural enterprises. Under laboratory conditions, the installation of a sorption-mechanical filter was designed for experimental studies on the sorption properties of the combined load. The installation is a chemical cylinder with a volume of 1000 milliliters loaded with a combined load of zeolite and activated charcoal, a layer of filter cotton so that the load does not spill and a container for receiving the filtrate in the form of a conical flask. Before filtration, a chemical analysis of the studied wastewater was carried out (Figure 2).

![Figure 2](image)

**Figure 2.** The content of chemicals in the original wastewater.

According to the results of the study, it can be seen that all substances that have been identified in wastewater exceed the maximum permissible concentration. After chemical analysis, filtration of the studied wastewater was carried out at different time intervals to identify the optimal one, at which the best sorption properties of the combined loading of the sorption-mechanical filter will be revealed.

In the course of the experiments, the ability of the combined load to absorb ions of chemical elements at various intervals was studied. The results of the experiments on sorption properties showed that in the experiment the sorbents absorb, to one degree or another, the ions of chemical elements. Percentage data in effluents are shown in Table 2.
Table 2. Determination of the absorption of the combined load in percentage

| Name of the adsorbed ion | Absorption of chemical impurities from wastewater, % | Filtration time |
|--------------------------|--------------------------------------------------|----------------|
|                          | 20 min   | 1 hour | 12 hours | 24 hours | 48 hours |
| Iron total               | 28.1     | 56.3   | 94.7     | 59.7     | 54.6     |
| Zinc                     | 32       | 66.3   | 89.2     | 67.3     | 64.1     |
| Copper                   | 35.5     | 67     | 96       | 72.7     | 70.3     |
| Ammonium                 | 50       | 68.2   | 97.2     | 84.5     | 79.1     |
| Total nitrogen           | 51.5     | 80     | 97.6     | 86       | 77.6     |
| Phosphorus oxide         | 53.7     | 68.5   | 81.4     | 62       | 57.1     |
| Magnesium                | 18.75    | 50     | 76.25    | 53.1     | 46.8     |
| Petroleum products       | 55.6     | 71.2   | 95.6     | 78.3     | 54.3     |

The result of the experiment showed that a greater percentage of absorption of chemical elements after 48 hours of completed experiments is observed. After 12 hours of contact of the combined load with the investigated effluents, it can be seen that ions of total iron are absorbed by 94.7%, copper by 96% and magnesium by 76.25%. And the rest of the impurities were best absorbed by filtration during 12 hours of wastewater.

There is a domestic and foreign experience in the use of activated sludge as fertilizer for crops. A significant obstacle is the presence of toxic ions of non-ferrous and heavy metals. According to the tests of the sorption-mechanical filter with a combined loading, the removal of toxic impurities of metals is almost one hundred percent; therefore, the use of sewage sludge makes it possible to use it as a fertilizer.

Studies by Russian and foreign scientists have shown the value of sludge from wastewater treatment plants of agricultural enterprises.

![The composition of the treated sludge for the content of nutrients, %](image)

Figure 3. Diagram of the percentage of nutrients in the dewatered sewage sludge

Dehydrated sewage sludge is significantly superior in value to cow sawdust and is recommended by researchers as fertilizer for vegetable crops, as well as means to improve the structure of the soil. The recommended rate of sludge application is 8-12 t/ha.
Treatment of sludge at treatment facilities is carried out according to the same type of technological scheme, which assumes the stabilization of excess sludge, which is obliged as a result of wastewater treatment and dehydration in a centrifuge.

It is known that fertilizers are one of the leading factors in increasing the productivity of agricultural products, reducing its cost. The use of wastewater during sprinkling as a fertilizer will provide the plants' need for nutrients, activate the course of biochemical and physiological processes, as a result, will lead to an increase in yield.

With irrigation, the lack of soil moisture is reduced, but there is a risk of nutrient leaching, the introduction of diluted wastewater enriched with minerals will solve this problem. The new sprinkler technology being created today makes it possible to use stationary installations for applying mineral fertilizers (activated sludge) with irrigation water. When using the dry residue of wastewater, the technological process consists of:

1. preparation of saturated fertilizer solutions;
2. controlled supply of solution with irrigation water to a field or a group of fields in a crop rotation area.

In this regard, we propose the following scheme for the application of mineral fertilizers (activated sludge) with irrigated water on irrigated crop rotation areas using sprinkling. At the mechanized storage of sewage sludge (fertilizer) equipped with scales, fertilizer plumb, loading into a car, and delivery to a sprinkler equipped with special tanks - hydraulic feeders are made. From the main water pipe, water is supplied to the fertilizer dissolution tank. With this method, the introduction of mineral fertilizers occurs with the continuity of the technological process with minimal labor costs. The solution should be fed at the end of the area irrigation. Covered with rain from one position. In this case, the duration of the application will depend on the set rate, but the process should last no more than 25 minutes, on average, the application time can be determined at an interval of 10-15 minutes [10, 11].

During the growing season, it is necessary to alternate a combination between sprinkling with liquid water and water with a fertilizer solution, where the nutrients are in an easily assimilated form [12].

Fertilization is carried out according to a given program based on the combined irrigation and fertilization schedule. This method provides complete mechanization of high-quality fertilization on irrigated lands with sprinkler irrigation.

4. Conclusions
On the basis of the studies carried out, in order to simplify and reduce the cost of the technological scheme of wastewater treatment, it is proposed to use a sorption-mechanical filter with a combined loading of natural zeolite and activated charcoal. Filtration time is 12 hours; the absorption percentage of all chemical impurities is over 90%. The supply of fertilizers at the end of irrigation will allow them to be relatively evenly distributed in the soil layer up to 0.5 m, that is, in the zone of the main placement of the root system of cultivated plants. The alternation of sprinkling of fields with clean water and water with dissolved fertilizer will allow the most complete use of nutrients contained in the sewage sludge, as well as meet hygienic requirements.

The implementation of the above measures will make it possible, with great economic effect, to completely utilize the sludge from the treatment facilities of agricultural enterprises as fertilizer, which indicates great opportunities to use this method of treatment in the national economy. The joint use of sprinkler machines for irrigation with clean water and the introduction of sewage sludge as a mineral fertilizer will allow denser loading of sprinkler installations, will reduce the cost of mineral fertilizers, which will lead to a decrease in the cost of agricultural products.

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