International Journal of GEOMATE, Nov., 2023 Vol.25, Issue 111, pp.66-73
ISSN: 2186-2982 (P), 2186-2990 (O), Japan, DOI: https://doi.org/10.21660/2023.111.3955
Geotechnique, Construction Materials and Environment

DISPOSAL OF WASTE GENERATED DURING THE OPERATION OF TREATMENT FACILITIES

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ABSTRACT: Biological treatment of domestic wastewater is not limited to wastewater treatment. The main problem in this activity is the processing and disposal of waste generated at treatment facilities, where the main task is to reduce the volume of sludge with its subsequent transformation into a useful product that does not cause environmental pollution. Currently, representatives of landfills refuse to accept this type of waste, arguing that this type of waste does not belong to the category of municipal solid waste. The issue of waste disposal of this production remains open, but, in our opinion, this type of waste can be recycled. The practical value lies in carrying out industrial tests of the converter of municipal solid waste into liquid effluents, including waste generated during the operation of treatment facilities, with subsequent post-treatment of the converted waste at treatment facilities. These tests will reduce the volume of waste by up to 90%, which will minimize the intensive accumulation of waste and sewage sludge and improve the environment.

Keywords: Wastewater, Housing and Communal Service, Waste Recycling, Secondary Resources, Waste Processing Plant

1. INTRODUCTION

Processing and neutralization of sludge from sewage treatment plants is an urgent environmental issue for many countries of the world, including Russia. For a relatively long period, the cleaning of silt sedimentation tanks has not been systematically carried out, a large amount of waste of this type has accumulated in some regions of Russia, and the processing and/or disposal of silt deposits have only become systemic in recent years. At the same time, this and other household waste in the open air causes damage to the environment and human health, sometimes worsening the epidemiological situation in waste disposal sites without proper biological and/or chemical treatment. Therefore, the problem of the use and/or disposal of liquid household waste, including their pre–treatment in sewage treatment plants, is relevant [1].

In the technological chain of wastewater treatment and treatment in sewage treatment plants, various wastes are formed, including sedimentary sludge deposits. In the practice of large and medium–sized cities of Russia, urban wastewater treatment plants often operate using outdated, simplified technologies, due to the need for large financial resources for modern technologies and the expensive equipment necessary for these technologies equipment. By the standard classifying harmful substances, liquid household waste is classified as hazard class IV, and according to its degree — as low-hazard. It is a toxic substance in all respects, subject to regular removal and neutralization. The solution to the problem of processing and/or disposal of silt deposits is necessary through the use of new technologies and methods.

Biological methods of wastewater treatment used recently in Russia are mainly associated with aerobic microorganisms. This means an increase in the resulting sewage sludge, the processing of which is not solved at the proper level. Sewage sludge pollutes the environment and is a serious source of dangerous diseases. The utilization of sewage sludge generated at wastewater treatment plants is an urgent problem related to the prevention of technogenic pollution of the environment [1]. Depending on the technology of treatment facilities, the following types of waste are generated [2]:
(1) Large (garbage), detained by gratings
(2) Heavy (sand), caught by sand traps
(3) Floating (fatty substances) accumulating in sand traps and settling tanks
(4) Suspensions deposited in tanks
(5) Excess sludge
(6) Sludge dewatered on mechanical devices, dried on silt beds, or thermally dried.

The most acute problem is the storage of waste on silty sites, which leads to the spread of an unfavorable gas-air background, and soil and groundwater pollution with toxic components that are part of the sediments [3]. The existing areas of waste disposal are not widely used not only in Russia [4], but also abroad [5, 6], which exacerbates the negative impact of waste on the environment. The proposed methods of disposal of sewage waste require a long time to prepare the sludge to obtain a useful product, for example, pyrolysis requires drying the sludge and obtaining briquettes [7, 8].

Thus, scientists from China have established that sewage sludge is a dangerous by-product of biological wastewater treatment and is the main source of water pollution, causing health problems and even death to people [9]. Historically, more than 80% of sludge has not been effectively and safely treated and disposed of, which poses a serious threat to the environment, especially due to the widespread use of combined urban, industrial, and rainwater treatment systems. Thus, it is necessary to install separate drain-age systems to improve the efficiency and effectiveness of treatment and sludge removal. The purpose of the work is to minimize the amount of precipitation from wastewater treatment plants by converting waste into the water with subsequent biological treatment.

In connection with the goal, the following tasks were set:
(1) To study the composition of precipitation
(2) Develop a new approach to the waste management system at sewage treatment plants.

The vital activity of a modern person inevitably leads to the formation of a huge amount of waste. Almost every inhabitant produces more than 300 kg of garbage per year, only 15% of which is recycled. All other garbage ends up either at authorized landfills, among which only one has not yet exhausted its resource, and the rest are overflowing, but continue to receive waste bypassing legal procedures, or at one of the many unauthorized landfills, where sorting and processing, of course, are not goes. To date, the problem of waste processing remains an urgent environmental problem. The main areas of research in waste processing consist of finding ways to obtain secondary raw materials, which mainly offer long-term waste processing and require the construction of new plants and factories for the processing of raw materials. A known method of processing sewage sludge with subsequent caking of sediments on sludge maps [10].

The disadvantage of this method is the loading of the sediment on sludge maps. For the subsequent use of the sediment, several years of caking of these wastes are required, and under adverse weather conditions, an unpleasant odor appears, which is unacceptable in settlements. Known for designing year-round dehydration of municipal sewage sludge on sludge sites.

The disadvantage of this method is the loading of sludge on sludge pads, it is already known that the dehydrated sludge with flocculants is not suitable for fertilizing crops, since sludge pads were invented specifically for the subsequent use of fertilizer, after several years of caking these wastes. The invention is known [11] when disposing of activated sludge, chemical treatment is carried out with keeping the reaction from two hours. The disadvantages of this invention are the long-term disposal of activated sludge and the lack of a disinfecting effect.

2. RESEARCH SIGNIFICANCE

The main problem in wastewater treatment is the generation of waste that is sent to landfills [12]. The waste conversation is recognized throughout the world as a serious problem on the way to the implementation of the strategy of sustainable development and "green growth" of the economies of all countries [13]. The United Nations defines "green growth" as a policy that emphasizes environmentally sustainable economic development that reduces carbon emissions. The European Commission's new strategy for sustainable economic growth and job creation "Europe 2020" also includes the concept of green growth and innovation, with a particular focus on the development and enforcement of legislation in the field of waste management. Particular attention is paid to the study of waste as a secondary resource [14, 15].

A serious problem in wastewater treatment at wastewater treatment plants is the presence of sediment accumulation sites that negatively affect the environment. A significant disadvantage of this technology is the use of significant areas. The development of technologies in this area and the study of environmental impact analysis are still urgent tasks [16-18]. Disposal of waste from sewage treatment plants is associated with costs and restrictions due to the stringent requirements of the Russian authorities. Waste recycling provides an opportunity to reduce costs or, in some cases, generate revenue and environmental benefits by reducing waste disposal [12].

3. MATERIALS AND METHODS

In the scientific work, the waste of the treatment facilities "Central" located in the Russian Federation, Vladivostok, Primorsky Territory, after dehydration, was studied. The methodological basis of the study was the applied and fundamental methods of industrial ecology. The research is based on the theory of mass transfer, hydraulics, physical chemistry, and biotechnology. The following precipitation parameters were chosen for scientific research: state of aggregation, mass fraction of moisture, mass fraction of dry matter, mass fraction of ash (mineral substances), organic substances, mass fraction of total nitrogen, mass fraction of total phosphorus, and silicon. in terms of oxide, titanium in terms of oxide, sulfur in terms of sulfate ion, arsenic, the specific activity of technogenic radionuclides, effective specific activity of natural radionuclides, COD and BOD_5 of water extract, study of heavy metals, E. coli bacteria group, pathogenic microorganisms, helminth eggs, and protozoan cysts, the presence of viable larvae and pupae of synanthropic flies.

Methods of quantitative chemical analysis were selected for the study, these methods are shown in Table 1. Microbiological studies were conducted by the methodological guidelines of MU 2.1.5.3692-21 of 2021. The regulatory requirements for the wastewater indicator were compared by the Order of the Ministry of Agriculture of the Russian Federation No. 552 dated 13.12.2016. The effect of dissolved sewage sludge on activated sludge was studied using a scanning electron binocular microscope MICMED-5 manufactured by LOMO LLC. Stained and unpainted preparations are examined on the MICMED-5 microscope in transmitted light using the light field method in the form of smears, histological sections, and special chambers. To characterize the operation of biological treatment facilities, hydrobiological analysis was used, which is of primary importance, since it characterizes the composition, quantitative distribution, and uniqueness of the organisms of activated sludge - consumers of pollutants coming for cleaning. Characteristic changes in the biocenosis of activated sludge best reflect the ongoing purification processes, allow you to quickly assess their quality level, and draw conclusions about the main adverse factors that worsen the effectiveness of wastewater treatment. The study of activated sludge was carried out by the method of HDPE F SB 14.1.77-96.

The composition of the microscope includes:

(1) Lenses 2x; 2.5x; 20x; 25x; 50x with iris aperture; 60x

(2) Eyepieces: 10x with a scale, 10x with a movable pointer, 15x

(3) Trinocular or monocular nozzle

(4) Light manager

(5) Dark field condenser KOH M5 (numerical aperture A 1.25-1.36 MI)

(6) Digital camera for image output to a computer.

4. RESULTS

The waste converter works as follows. Figure 1 shows the reagent chamber 1, the sludge supply

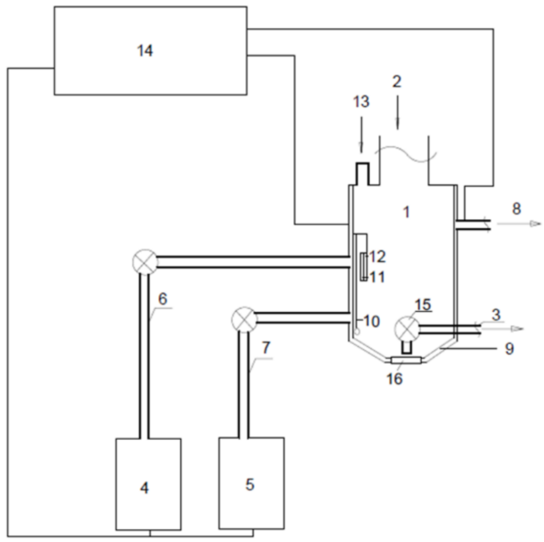

Fig. 1 Waste Converter. 1 – Reagent chamber; 2 – Branch pipe of the Sludge receiver; 3 – Branch pipe for removal of the insoluble fraction of the sediment; 4.5 – Containers with acidic and alkaline reagents; 6,7 – nozzles for removing reagents; 8 – Branch pipe for the removal of the liquid fraction of the sediment; 9 – Reagent chamber body; 10 – Liquid level sensor; 11 – Temperature sensor; 12 – pH sensor; 13 – Gas cleaning device; 14 – Control unit; 15 – Pump unit; 16 – Emergency shutter.

pipe 2, the sludge insoluble fraction outlet pipe 3, the tanks 4 and 5 with acidic and alkaline reagents, respectively, and their inlet pipes 6 and 7, the pipe 8 for the removal of the sediment liquid fraction, the housing 9 of the reagent chamber 1, level sensors 10, temperature 11 and pH 12, respectively, the gas cleaning device 13, the control unit 14, the pump unit 15, shutter 16. Control unit 14 controls the reagent management (determination of concentrations and control of the level of aqueous solutions of reagents in the respective containers 4 and 5, regulation of the supply of these solutions to the reagent chamber 1) and the operation of the reagent chamber 1 (control of the liquid level using a level sensor 10, temperature control using temperature sensor 11, pH using a pH sensor 12, removal of the insoluble sediment fraction, draining the liquid sediment fraction and shutter operation). The installation for the processing of sludge obtained during the operation of treatment facilities contains a vertically oriented reagent chamber 1:

(1) With a cylindrical body 9 with double coaxial walls, in the gap between which the coolant circulates

(2) In which level sensors 10, temperature 11, and pH 12 are located, respectively

(3) In the upper part of which there is a branch

pipe 2 for sludge supply and a gas cleaning device 13

(4) In the lower part of which there is a branch pipe 3 for the removal of the insoluble sediment fraction

(5) Which is equipped with a branch pipe 8 for the removal of the liquid fraction of the sediment

(6) Which is connected with containers with acidic 4 and alkaline 5 reagents through the corresponding inlet pipes 6 and 7.

Sediment with moisture content, for example, 98%, is introduced into the reagent chamber 1 through nozzle 2. Further, an acidic reagent, for example, a 25% aqueous solution of sulfuric acid, is supplied from tank 4 through pipe 6 into the reagent chamber 1, at a mass ratio of precipitate: acidic reagent as 1:1, as a result of which the process of dissolving the precipitate and its transformation into liquid and gaseous form, the latter is removed from the reagent chamber 1 through the gas cleaning device 13. Then, an alkaline reagent, for example, a 5% aqueous solution of sodium hydroxide, is supplied from container 5 through pipe 7 to the reagent chamber 1 until the pH of the suspension, measured by the sensor 12, becomes equal to 5.5-6.5 and its temperature measured by sensor 11 will not reach 30 C°.

In the process of acid neutralization with alkali, a large amount of heat is released, As a result, due to the increase in the temperature of the water mixture, reliable disinfection and dissolution of 95% of the sediment occur. The reagent chamber 1 is cooled using a coolant that circulates in the gap between the double coaxial walls of housing 9, and the amount of chemical reagents and dissolved sediment is controlled using a level sensor 10. The liquid and insoluble precipitate fractions are separated. The liquid fraction in the form of clarified water can be redirected to the wastewater treatment plant via pipeline 8 - this reduces the cost of separation and disinfection of water. The insoluble fraction of the sediment after draining the liquid fraction is systematically removed from the reagent chamber 1 by the signal of the level sensor 10 by emptying it using pump unit 15.

In emergencies, the sludge is unloaded and the reagent chamber 1 is emptied through shutter 16 of the bottom of the reagent chamber 1. Installation with a capacity of 10 m^3/h with a diameter of 1 m and a height of 3 m, into which the sludge obtained during the operation of treatment facilities is injected through a pressure pipeline Du 65, and when processing 1 m^3 of sludge, the reagent chamber is emptied by 0.5 m. Conducted a test in the periodic mode for the sediment, the composition of which is shown in Table 1.

100 g of sediment is placed in a 100 ml beaker (Fig. 2). Gradually, 100 g of a 25% solution of sulfuric acid is poured into a beaker, and after stirring, 5 ml of a 5% solution of sodium hydroxide is poured into the resulting suspension, within 1 minute the pH of the suspension becomes equal to 6, and its temperature reaches 30 ° C, then the liquid and insoluble fractions were separated (Fig. 2). Of 100 g of precipitate, 2 g of the insoluble fraction remained (Fig. 3).

Table 1 Waste composition

Waste composition	Value	Method
Aggregate state	Solid	Visual
Moisture contents (W, %)	67	GOST 26713-85
Mass fraction of dry matter (%)	33	Calculation
Ash content (Z, %)	52/17.633	GOST 26714-85
Organic matter	48/15.84	GOST 27980-88
Mass fraction of total nitrogen (N_{total}, %)	3.2/1.06	GOST 26715-85
Mass fraction of total phosphorus (P_2O_5, %)	9.4/3.1	GOST 26717-85
Silicon in terms of oxide (SiO_2, mg/kg)	118336/83600	FR 1.31.2009.06787
Titanium in terms of oxide(TiO_2, mg/kg)	2603/1718	FR 1.34.2010.07097
Sulfur in terms of sulfate ion (SO_4^2, mg/kg)	184/182	FR 1.29.2006.02149

Fig.2 Waste from treatment facilities

Based on the data in Table 2, we can conclude that the inventive installation provides reliable disinfection and a high degree of sediment dissolution. A study was conducted on the effect of dissolved sediment on activated sludge for one month. Can be seen how the precipitate has almost completely dissolved (Fig. 3). Comparative analysis of the sediment composition before and after its processing is given in Table 2.

Table 2 Comparative analysis of sediment composition before and after processing

Waste composition	Before	After
Hydrogen index of salt extract	5.6	5.4
Aluminum in terms of oxide (Al_2O_3, mg/kg)	23559/15317	<0.5
Iron in terms of oxide (Fe_2O_3, mg/kg)	44669/21079	<0.1
Manganese in terms of oxide (MnO, mg/kg)	1849/788	<0.05
Calcium in terms of oxide (CaO, mg/kg)	12977/5991	0.23
Magnesium in terms of oxide (MgO, mg/kg)	2851/1560	0.07
Sodium in terms of oxide (Na_2O, mg/kg)	5387/2396	1.9
Potassium in terms of oxide (K_2O, mg/kg)	12009/4775	0.23
Mercury (Hg, mg/kg)	0.68/0.00002	<0.1
Chromium (Cr, mg/kg)	4.4/0.0001	1.1
Lead (Pb, mg/kg)	14.4/0.0005	<0.1
Cadmium (Cd, mg/kg)	0.98/0.00003	0.015
Nickel (Ni, mg/kg)	6.2/0.0002	<0.1
Zinc (Zn, mg/kg)	217/0.0072	0.194
Coli bacteria, index (cells/g)	<1	<1

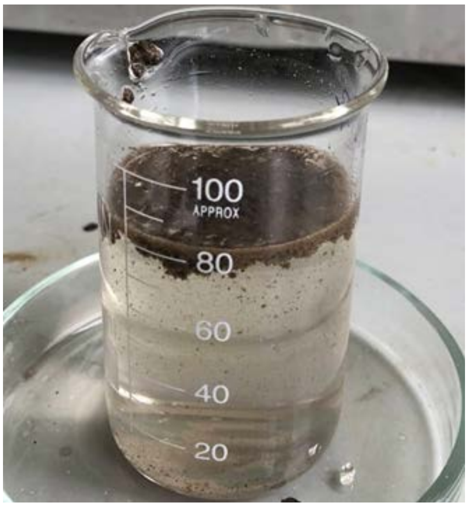

Fig.3 Turning waste into an aqueous solution

The essence of this dissolution process is explained using the phase equilibrium constant - the product of solubility. When acid is added, the equilibrium is disturbed by shifting towards the dissolution of the precipitate until it completely dissolves. It was found that at higher concentrations of acid, the precipitate will completely dissolve, but higher concentrations of acids are very dangerous and costly in production.

To characterize the operation of biological treatment facilities, hydrobiological analysis is of primary importance since it characterizes the composition, quantitative distribution, and uniqueness of the organisms of activated sludge consumers of pollutants coming for cleaning. Characteristic changes in the biocenosis of activated sludge best reflect the ongoing purification processes, allow you to quickly assess their quality level, and draw conclusions about the main adverse factors that worsen the effectiveness of wastewater treatment. According to the results of the research, it was revealed that during the month the quantitative composition of aquatic organisms did not change, In the composition of activated sludge there were Rotifers – nitrifiers oxidize ammonia to nitrites and nitrates. They provide reduction of turbidity of drains, loosening of silt; increase in the efficiency of water treatment; regulate the species and age composition of microorganisms, maintaining it at an optimal level (Fig. 4), Gastro ciliary ciliates and colonial ciliates (Fig. 5), Aspidisca are very

Fig.4 Investigation of activated sludge by scanning electron microscopy (rotifers)

Fig.5 Investigation of activated sludge by scanning electron microscopy (gastro ciliary ciliates and colonial ciliates)

common species living in active sludge (Fig. 6), Vorticella – it is resistant to low oxygen concentrations, increased loads on organic substances (Fig. 7). The maximum amount of Amoebae – contributes to the weighting of activated sludge and better sedimentation (Fig. 8). These figures confirm the low impact of processed waste on the activated sludge biocenosis.

The biocenoses of activated sludge contain representatives of six departments of microflora (bacteria, fungi, diatoms, green, blue-green, euglena microalgae) and nine taxonomic groups of microfauna (flagellates, sarcodes, infusoria, primary and secondary cavities, gastropod worms, rotifers, slow walkers, arachnids). To correctly characterize the biocenosis of activated sludge as a whole, it is necessary to characterize both the state of bacterial populations, the main destructors of pollutants, and protozoa, which makeup approximately 5-10% of the total biomass and actively eat dispersed bacteria.

Constant monitoring of the development of the hydration community makes it possible to identify deviations in the number and ratio of organisms of the main indicator groups from those typical for the examined stations. In the presence of such deviations, especially in cases of a return of the biocenosis to earlier stages of development, prompt identification and elimination of the causes that caused these changes are required. When the dissolved sediment entered the aeration tank, the number and ratio of organisms of the main indicator groups remained the same.

Fig.6 Investigation of activated sludge by scanning electron microscopy (aspidistra)

The method of feeding the organisms of activated sludge determines their structural position in the biocenosis and the nature of relationships. The predominance of one or another group of organisms with a certain type of nutrition indicates the ongoing processes of structural changes in the biocenosis and suggests possible changes in the environmental conditions of the habitat of activated sludge. The studied samples are characterized by a large variety of protozoa, especially ciliated infusoria, but with a small quantitative predominance of any of the species. Representatives of the fourth trophic level were present, which positively affects the degree of water purification from organic pollutants by increasing the intensity of metabolism. We believe that the revealed structure of the complex of unicellular and multicellular organisms of the activated sludge of the aeration tanks of these treatment facilities may indicate their effective reactivity, which allows for a fairly good cleaning.

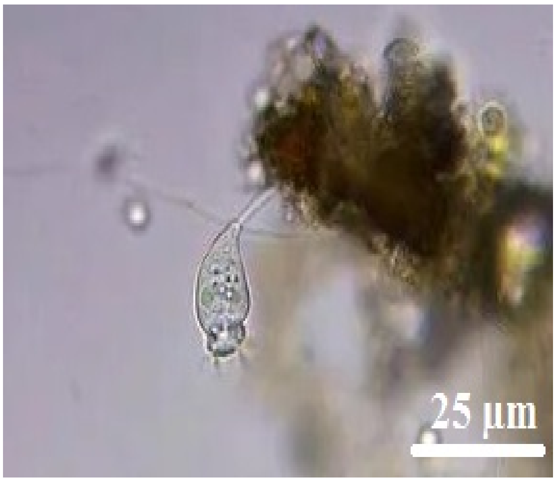

Fig.7 Investigation of activated sludge by scanning electron microscopy (vorticella)

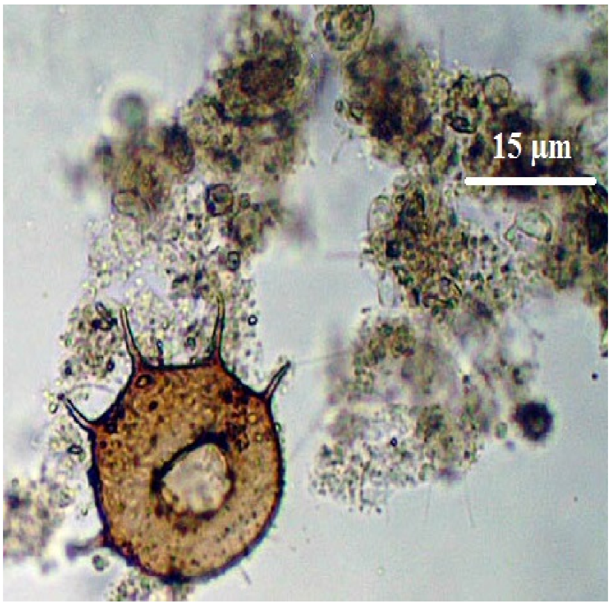

Fig.8 Investigation of activated sludge by scanning electron microscopy (amoebae)

5. DISCUSSION

In conclusion, it should be noted that, according to the results of the analysis, it was found that the situation with sewage sludge will begin to change in the first months of operation of such installations. In further work on the study of dissolved sew-age sludge after the developed installation, it is necessary to conduct a complete chemical composition of the resulting sludge and study its impact on the environment.

6. CONCLUSION

It is revealed that when sulfuric acid is added, the phase equilibrium is disturbed due to the displacement towards the dissolution of the precipitate until it completely dissolves, due to which the waste is converted into an aqueous solution. In the technology of sewage treatment plants with biological treatment, it is advisable to include waste converters that reduce the amount of waste from treatment plants to a technologically possible minimum.

Theoretically and experimentally confirmed the high efficiency of the technology for converting waste into a liquid medium when using a waste converter, the advantages of which lie in the technical solution, which consists in developing an effective and simple technology for processing sludge obtained during the operation of treatment facilities, which makes it possible to recommend a waste converter for a wide range of applications. applications both in the development and construction of new treatment facilities and in the reconstruction of existing ones.

The results of the study confirmed the low impact of processed waste on activated sludge biocenosis. It has been experimentally determined that the converted waste into an aqueous solution, when entering the treatment plant, does not create a load on the activated sludge, thereby guaranteeing the continuous operation of the treatment plant. The identified research factors confirm the safe introduction of a waste converter into the technological scheme of biological treatment facilities.

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