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Ecological Status of Sludge Drying Beds Almaty, Kazakhstan

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Abstract

In this paper, shows the results of studies of the effect sludge drying beds aeration stations in Almaty, Kazakhstan on the surrounding area. The results showed that the groundwater of surrounding areas sludge drying beds aeration stations Almaty contain elevated concentrations of iron, phosphate, magnesium, zinc. And also, the water of the Big Almaty River after sludge drying beds has some elevated concentrations of heavy metals, such as iron and zinc than the water of the Big Almaty River to sludge drying beds. In general, the sewage sludge that is stored on the sludge beds turns them into a hotbed of bacteriological and toxicological hazard. This article aims to identify environmental problems of handling and disposal of sewage sludge in Almaty.

Keywords

Wastewater Treatment Plant, Sludge, Sludge Drying Beds, Processing, Recycling

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1. Introduction

In the process of mechanical and biological treatment of sewage at wastewater treatment plants are formed of various types' sediments containing organic and mineral components [1].

Displacement produced in the wastewater treatment process of precipitation depending on the concentration of contaminants in the source water is 0,25-12% of the volume of waste water [2].

To date, the sewage treatment facilities in Kazakhstan daily produced several tons of sewage sludge. Sewage treatment facilities in Kazakhstan, which were mainly designed and built in the 60-80-ies of XX century, were not designed for handling and disposal of sewage sludge to the required standards. The bulk of the precipitation is stored in the sludge drying beds, which leads to contamination of surface and ground water, soil and vegetation. At the same time irretrievably are lost useful components containing in the sediments. The level of use of sewage sludge in the national economy in Kazakhstan is still low.

Currently, many economic and technological development of the state refused to use sludge beds that threaten the environment [3, 4] as sludge beds are an environmental issue, both present and in the long term.

Thus dehydration on sludge drying beds and even in a vacuum filter removes only a portion of the free water. Bound water is not removed by these methods. To remove the bound water must be the destruction of the physical and mechanical forms of connection. This requires the creation of mechanisms operating at high pressure or centrifugal force, more capillary and destructive structural links. When vacuum filtration (P value = 0.05-0.06 MPa) theoretically removes moisture of micro capillaries radius of more than 5-10-6 m.

To preserve the proper sanitary-epidemiological and ecological condition of large cities must be immediately

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resolve the question of liquidation of sludge beds. Implementation of engineering measures to return the land taken out of circulation in the city in addition to environmental values has a high economic and social importance: precipitate must be removed, recycled and disposed of safely, and the liberated territory should recultivated for housing or other rational use of[5,6].

Review of modern technologies handling and disposal of sewage sludge, shows that in practice, the following processing methods: sealing, stabilization, dewatering, drying and decontamination, and disposal of used: the use in agriculture as a fertilizer, landfilling, incineration and other methods [7, 8, 9].

In modern treatment plants for dewatering sewage sludge is advisable to apply a mechanical dehydration in vacuum filters, filter presses, centrifuges or other devices [8].

As you know, in the world practice the basic methods of disposing of sewage sludge, except for use in agriculture as fertilizer are costly, in this regard, in the context of Kazakhstan use sludge as organic fertilizer is a promising method [10].

2. Materials and Methods

Actual annual volume of wastewater Almaty entering the aeration station for many years (due to the growth of the city) increased, and reached its maximum in 1990. In 1990, through the treatment plant has been overlooked 212.88 million m^3 of waste (on average 583 thousand m^3 perday).

In subsequent years, the amount of effluent decreased sharply and was in 2010-2014, on average - 390 m^3 per day.

Results of analyzes for 2013 and 2014 coming, clarified and purified water aeration stations Almaty presented in Table (1).

Table 1. Average results of analyzes of wastewater aeration plant of Almaty for 2013 and 2014.

Indicators, mg/l	For 2013			For 2014		
	Incoming water	Clarified water	Purified water	Incoming water	Clarified water	Purified water
1	2	3	4	5	6	7
Temperature, ºC	18,3	18,7	19,4	18,6	19,0	19,6
pH	7,6	7,7	7,8	7,6	7,7	7,8
Suspendedsubstances	477,1	99,6	8,5	484,3	115,3	8,2
The dry residue	540,2	486,7	456,2	549,6	488,7	449,5
Ammonium nitrogen	31,7	24,7	5,7	26,18	25,98	10,08
Nitrites	0,04	0,05	0,27	0,04	0,03	0,23
Nitrates	0,1	0,15	1,85	0,16	0,1	1,33
BOD_5	340,0	84,4	4,6	380,4	102,2	4,4
COD	691,8	174,4	11,1	790,38	119,0	19,6
Detergents	1,51	0,81	0,03	1,75	0,77	0,03
Phosphates	8,4	6,1	3,2	8,7	8,6	5,4
Petroleum products	2,94	0,55	0,013	3,2	0,52	0,012
Chlorides	87,0	75,7	60,2	85,0	71,2	60,0
Sulfates	84,0	73,5	64,6	83,4	72,6	58,6
Iron	3,01	1,48	0,25	1,4	0,7	0,3
Hydrogen sulfide	2,42	1,23	0,25	2,4	1,36	0,22

The obtained test results in Table 1 show that:

-There treatment facilities provide full performance of biological purification, wherein the concentration of organic contaminants on the COD of the treated water was on average 15.35 mg/L., BOD_5 purified water averaged 4.5 mg/L., the content of suspended solids in purified water averaged 8.35 mg/L;

- concentration of ammonium at the initial average - 28.94 mg/L reduced to an average of 7.89 mg/l and the concentration of nitrate in the outlet of the secondary sedimentation tank is increased to 1.59 mg/l and higher, it means that the biological treatment process is carried out only nitrification;

- Average phosphate concentration of the incoming water is 8.55 mg/l in purified water and 4.3 mg/l. High concentrations of phosphorus after treatment, probably due to the presence in wastewater organ phosphorus compounds.

According to the research work we examined the effect of sludge lagoons WWTP Almaty on adjacent territories [11].

According to the research currently aeration station in Almaty for the treatment of sewage sludge used only sludge beds. Aeration station sludge beds are designed for natural drainage, storage, disposal of sediments, as well as receiving small amounts of waste water.

The bulk of the pumped through two channels on the sludge beds of sediment is surplus activated sludge from the biological treatment plant and raw sludge from the primary clarifiers. On sludge beds aeration station also neutralized the dregs with gratings mechanical cleaning and sand from sand traps.

Crude precipitated by a settler, scrapers, scrapers mounted on a farm, moved to the pit from which is pumped to the sludge

beds. Raw sludge is pumped from the primary circular tanks, differs a great heterogeneity and a gelatinous suspension grey or light brown in colour with a sour smell. Due to the large amounts of organic matter, it rots quickly, gaining a dark grey or black and uttering unpleasant sour smell. Average moisture content of sludge from the primary clarifiers, is 97%.

In the secondary settling tanks activated sludge settles and silt through the camera and then airlift, is pumped into the sludge aeration channel from which part is returned to the aeration tanks. Surplus sludge pumps main pumping station is pumped to the sludge beds. Activated sludge is a suspension comprising amorphous flakes of aerobic bacteria and protozoa, and adsorbed to fine contaminants from wastewater. During storage and seal it quickly rots. Moisture activated sludge from the secondary settling tanks after aeration is 99.7%.

Sludge beds, including sections for sludge and sand, created through the construction of dams enclosing and separating. The maximum height of the dam is from 3 to 4.4 meters, width of levees along the crest of 6 meters, dividing dams - 4.5 meters.

The distance from the card to the nearest water body of the Big Almaty River is 250-500 meters. Area sludge beds is 120 ha., Area acting sludge beds - about 80 ha., And the volume of the mixture of precipitation - 3500 m^3/day.

Figure (1) shows photographs of sludge beds.

Figure (1). Photos of sludge beds.

Table 2. The summarized results of analyzes of water of the Big Almaty River and groundwater sludge beds.

№	Indicators	The content in the samples, mg/l				
		№ 1	№ 2	№ 3	№ 4	№ 5
1	2	3	4	5	6	7
1.	Suspended solids	5,0	7,0	50,0	80,0	40,0
2.	BOD_5	3,0	5,0	2,7	2,4	2,7
3.	COD	4,0	26,0	30,0	30,0	14,5
4.	Nitrite	0,11	0,36	0,04	0,112	0,168
5.	Nitrates	24,5	43,6	8,5	20,0	10,0
6.	Calcium	24,0	34,0	96,0	56,0	56,1
7.	Magnesium	1,2	7,3	77,0	81,5	81,5
8.	Phosphates	0,8	1,7	8,5	8,2	6,8
9.	Petroleum products	0,06	0,08	0,6	0,8	0,6
10.	Chlorides	10,6	11,5	24,0	28,0	18,0
12.	Sulfates	28,8	37,0	120,0	427,0	103,0
13.	Hydrocarbonate	109,8	134,2	274,5	750,0	463,6
14.	Copper	0,06	0,06	0,46	0,39	0,09
15.	Iron	0,3	0,42	0,31	4,2	0,5
16.	Zinc	0,06	0,09	0,46	0,39	0,9
17.	Bromine	0,08	0,12	0,21	0,29	0,07
18.	Strontium	0,44	0,54	5,85	6,95	1,02

Sludge beds with backup emergency sites are located on the right bank of the Big Almaty River in Ili district of Almaty region. They are located 12 km north of the aeration station and the eastern side bordering the fields filtration. Sludge beds are stretched in terms of a narrow strip from south to north and executed on a natural basis without drainage. The site is located on the loess various capacities from 5 to 20 meters. In some areas loams have sagging properties of the 1st and 2nd type.

In order to study the geological structure of the sludge drying

beds of treatment facilities in Almaty were conducted geophysical surveys sludge drying beds. They included electromagnetics vertical electrical sounding (VES) and seismic correlation refraction (refraction). Geophysical surveys were carried out in the VES - 6 physical points with a step on the profile from 250 m to 100 m and refraction - 4 sensing increments from 520 meters to 140 meters and covered a distance 1070 meters.

Next, we define indicators of sewage sludge drying beds. Chemical analysis of the research was conducted by the following methods: atomic absorption spectrometry, photometry, gravimetry and cultivation on selective media.

In accordance with the general rules of sampling was carried out manually. All samples were numbered and allocated in the laboratory. All analyses were carried out in the laboratories of the Kazakh National Technical University and the aeration stations in Almaty.

3. Results and Discussion

3.1. Results of Geophysical Research Sludge Beds

According to geophysical research conducted in Figure (2) shows the wave field and built on it the first waves travel time curves, typical for the investigated area.

Directly from the point of excitation at a distance of 10-30 m, spread a wave with a speed of 0.35 km/s, which characterizes the elastic properties of the upper, dry part of the section, in this case, to a depth of 4-6 m. Further, this wave is replaced by another wave, formed as a result of abrupt changes of speed (from 0.34 to 1.8 km/s) due to complete water saturation layer.

Register wave field in increments of 2 m (Figure 2) provide certain velocity in the overlying medium and unequivocal diagnosis of the bow wave of the groundwater level. To increase the interval follow this wave were observed with the removal of the excitation point (EP) at 40 m. If you change the underlying conditions (immersion study abroad) removal of EP value was increased.

The results of geophysical work, reflected in Figure (2). Profile, which performed works by refraction and VES crosses the area sludge beds in the central portion thereof, from west to east. The total length of the profile is 1160 meters. Start the profile is located in the valley of the Big Almaty River (PC-110) on the end of the 100 meters east of the sludge beds. The profile has six observation points VES (PC 0, 160, 500, 600, 800, 1050m) and four point's seismic sounding (PC0,160.500,1030m).

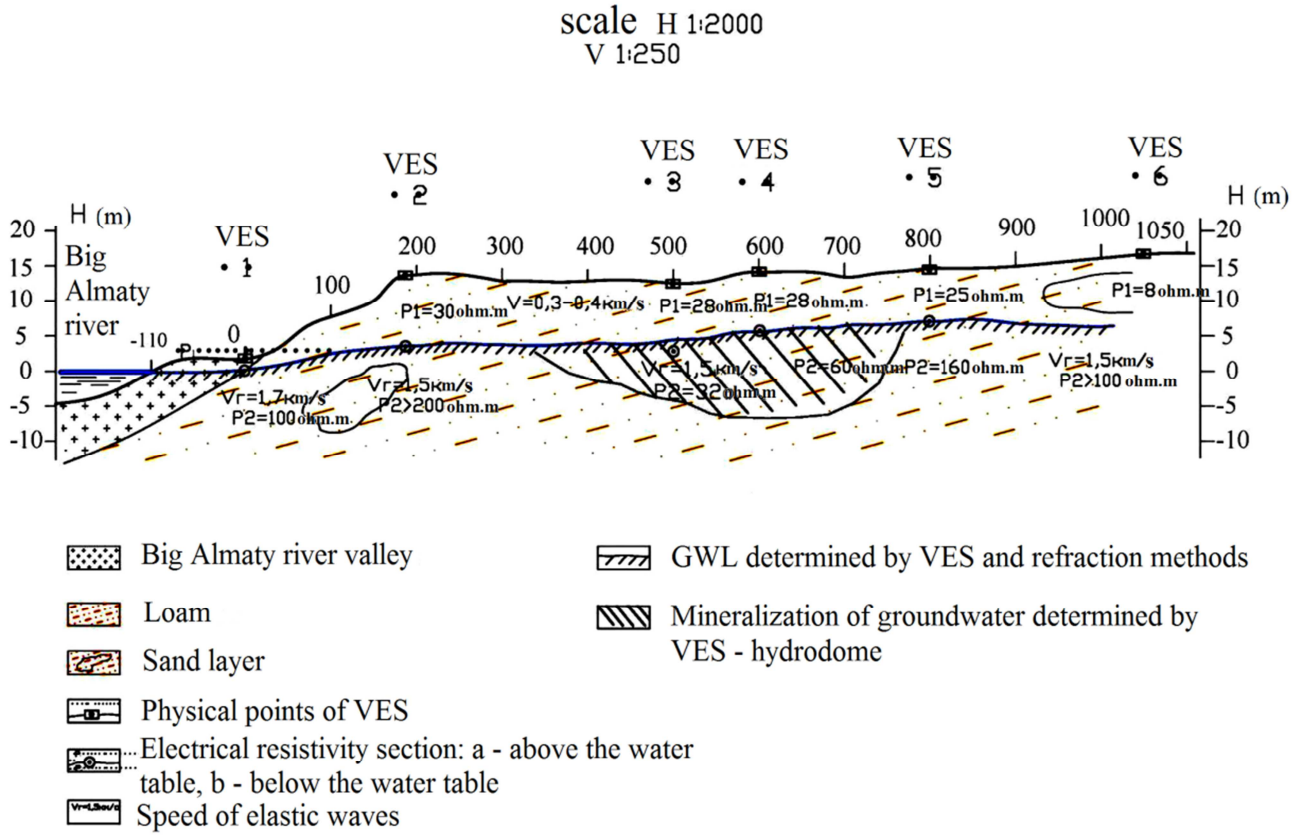

Figure (2). Geological and geophysical profile of sludge beds.

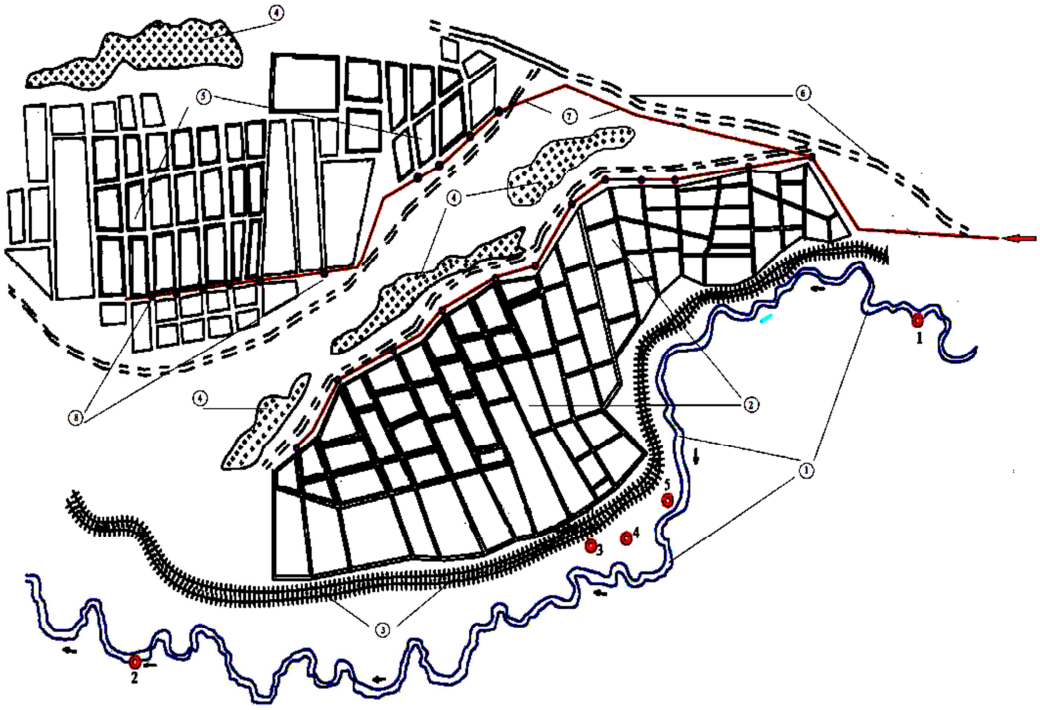

Figure (3). Sampling points adjacent to the territory of the sludge beds aeration stations Almaty.

1 - Big Almaty River; 2 - sludge beds; 3 - dams; 4 - polygon of dried sediments; 5 - field filtering and spare sludge beds; 6 - roads; 7 - a conduit for feeding sewage sludge; 8 - wells for the production of precipitation

Compiled geological and geophysical section (Figure 2) shows that the total excess of daily marks on the profile of the water level in the Big Almaty River to PC-1050 is ≈18 meters. The position of the groundwater level on the water level in the river ranges from zero (the river level) to +8.5 m (PC 800).

Maximum excess groundwater level corresponding to the PC-800 is located within the area of sludge beds, closer to their eastern side. The central dividing line sludge beds on the western and eastern parts of the PC correspond to 600 m.). This arrangement exceeding the groundwater level on the profile says that on the background of reducing the groundwater level in the river from +5.5 m. (PC-1050) to 0, there is a dome, which was formed in the region of 500-1050 m PC. Epicenter dome located in the picket 800 m., where it exceeds the edge portions of +3.5 meters. The nature of this hydro dome can be explained only by groundwater recharge silt waters flowing from the sludge beds of treatment facilities in Almaty.

Given the above, on the nature of changes in groundwater level, you can make some observations about the dynamics of groundwater in the area of sludge beds. The overall slope of ground water level in the Big Almaty River indicates that the latter is a system of groundwater discharge sludge beds. The presence of hydro dome activates the existing natural hydrodynamics, because the creation of additional exceedances of groundwater level.

On geological and geophysical sections besides the data about the behavior of the groundwater level there are information reflecting the speed and electrical properties of rocks cut. So loams occurring traced above the groundwater level, characterized by electrical resistivity in the range of 25 Ohm*m to 30 Ohm*m. The same loam below the groundwater level, characterized by high values of electrical resistivity ranging between 32 Ohm*m to 160ohm*m and more. The lowest values ρ_2=32-60 ohm*m are typical for the central part of the profile and, therefore, the central square location sludge beds.

The nature of these fairly sharp fluctuations in resistance of the medium is due to heterogeneity on groundwater salinity. This is typical for the profile in the region of 500-600 pc, where the sludge beds. Saturation of groundwater organic impurities, apparently, and the effect on the resistivity of the medium under study.Higher values of resistivity in the region of 160 picket explained by the presence in the context of irrigated sand. In the area of picket 1050 section above the water table greeted lens clays, for which the resistivity is 8 Ohm*m.

Of the speed parameters for each of the four sites studied refractive related to the groundwater level, the values of the

critical velocity of elastic waves, which are characterized by values of 1.5-1.7 km/s. Consistency of the critical velocity of groundwater level indicates speed identity among all segments of the studied profile.

3.2. Results of the Analysis of Water Quality of the Big Almaty River and Groundwater

To determine the effect of sludge beds on the water quality of the Big Almaty River and groundwater analyzes were made of river water before and after sludge beds and groundwater at some distance from the sludge beds. Water samples were selected and analysis of pollutants has been made on the appropriate procedure.

Water samples were taken for analysis at five locations adjacent to the territory of the sludge beds aeration stations in Almaty. Sampling points adjacent to the territory of sludge beds, are shown in Figure (3): 1 point - the Big Almaty River to sludge beds; 2 point - the Big Almaty River after sludge beds; 3 point - ground water from a depth of 7 m at a distance of 180 m from the sludge beds and 130 m from the Big Almaty River; 4 point - ground water from a depth of 9 m at a distance of 200 m from the sludge beds and 125 m from the Big Almaty River; 5 point - ground water from a depth of 6 m at a distance of 245 m from the sludge beds and 20 m from the Big Almaty River.

Table 3. Summary measures of aeration station sludge Almaty.

Indicators	Fats mg/kg	Protein mg/kg	Total nitrogen mg/kg	Total phosphorus mg/kg	Heavy metals, mg/kg						
					Cd	Cu	Mn	Ni	Pb	Cr	Zn
The precipitate was aged 1 year	12,1	5316,0	1220,0	617,0	5,01	19,01	202,0	45,57	57,63	214,0	916,0
The precipitate was aged 3 years	26,75	6013,0	1380,0	529,1	4,56	17,72	256,0	37,7	57,00	887,0	876,0

Results of analyzes of studies of basic water quality parameters are shown in Table (2).

From the results of analysis shows that groundwater from the field adjacent to the territory of the sludge beds has high levels of contaminants.

3.3. Results of the Analysis of Sewage Sludge from Sludge Beds

Next, we identified the following indicators of sewage sludge from sludge beds: proteins, fats, total nitrogen, total phosphorus content of bacteria, heavy metals.

Samples were taken from the sediment sludge beds at the age of 1 year and sediment sludge beds at the age of 3 years.

Summary measures of aeration station sludge Almaty are shown in Table (3).

Relatively high levels of organic matter in dry matter can be used to further precipitate the physical properties of the soil [12]. The nutrients present in the precipitate, such as nitrogen (N), phosphorus (P) and potassium (K), required for the growth of plants and are feeding. The nutrient content is a key factor for future use of sewage sludge [13].

Analyzes of the physic-chemical characteristics and chemical composition of sewage sludge beds showed that the main indicators, sewage sludge meets the requirements for organic fertilizer.

The main factor limiting the use of sludge as organic fertilizer or technical grounds, is the content of heavy metals and pathogenic microorganisms [14].

As the results of studies have found that in sewage sludge from sludge beds there are many different pathogens, i.e. if index - over 2,380, if titre - less than 0.4.

4. Conclusions

The analysis shows that currently aeration station Almaty, Kazakhstan for treatment and disposal of sewage sludge used only sludge beds that lead to contamination of surface and ground water, soil, vegetation.

We carried out engineering-geological surveys have shown that between the bottom sludge beds and groundwater is soil, which prevents the penetration of weak drainage sludge water into the groundwater. And also according to the nature of changes in groundwater level on the dynamics of groundwater in the area of sludge beds celebrated general slope of ground water level in the Big Almaty River and the availability of hydro dome activates the existing natural hydrodynamics, due to the creation of additional exceedances of groundwater level.

In general, at the present time between the river and the sludge beds formed artificial swamp water which contains elevated concentrations of metals, sulfates, nitrites, nitrates, phosphates and other elements that occurs due to an imbalance of filtration.

Our studies on the influence of sludge beds surrounding area showed that the groundwater near the territory of sludge beds have high levels of metal ions, phosphates and other contaminants.

And the water of the Big Almaty River after sludge beds has increased concentrations of virtually all indicators than the water of the Big Almaty River to sludge beds. This suggests that the drainage water from the sludge beds contaminate the water of the Big Almaty River various chemical elements.

Found that sewage sludge has a lot of different pathogens that pose a threat to public health. Possible complications associated with the presence of organic matter in the sediment, is a direct hit them with food to animals grazing on areas (fields) that host sediment. Most of the organic matter is concentrated in the tissues (fat) and liquids (milk) animals. It is therefore necessary to establish in such areas restricted zones around sludge beds, which only address the relevant authorities of the Republic of Kazakhstan can be used as pasture for livestock farms.

In general, the sewage sludge that is stored on the sludge beds and turn them into a hotbed of bacteriological and toxicological hazard. At the same time are lost containing useful components in the sediments. This problem becomes aggravated with each passing year and requires an immediate solution.

Out of the current environmental situation is related to ecologization of economic activity, the introduction of low-waste and non-waste technology.

Sewage sludge is rich in macro- and trace elements useful and advisable to use it in an appropriate treatment for a variety of purposes, including as a fertilizer for the production of biogas and electricity. This requires the development of appropriate and effective technologies for treatment and disposal of sewage sludge, taking into account the climatic conditions of the Republic of Kazakhstan.

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