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M.T. Yermekov [1], O.V. Rozhkova [1], Ye.T. Tolysbayev [1], Zh. N. Zhakipbekov[1], S.N.Merkureva [2], V.I. Schefer [2], V.V. Ivanovich[3]

[1] Parasat Scientific and Technological Center JSC, Nur-Sultany, Kazakhstan;
[2] Municipal State Enterprise Astana su Arnasy, Nur-Sultan, Kazakhstan;
[3] Production "Minskochistvod" UE "Minskvodokanal", Minsk, Belarus.
E-mail: yermekov.m@parasat.kz

PROBLEMS AND SOLUTIONS OF THE SILT SLUDGE UTILIZATION ISSUES AT WASTE TREATMENT FACILITIES OF NUR-SULTAN CITY

Abstract. Effective management of wastewater sludge is currently one of the most pressing environmental problems in Nur-Sultan city, which becomes more acute year by year and requires immediate solution. Wastewater sludge is almost completely stored at the treatment facilities, which turns them into a source area of bacteriological and toxicological hazard. For this reason, the most urgent problem now is the development of new sustainable and zero waste technologies that can effectively expedite the reduction of silt sludge and lead to a significant decrease in their final volume. This article analyzes various methods of sludge disposal. It is shown that of all possible technology options with admissible environmental impact and the best economic indicators, the most acceptable is the method of thermo-catalytic oxidation of wastewater sludge in a semi fluidized bed of the catalyst, the use of which can fundamentally change the situation with the sludge disposal. Also, the article studied the composition and carried out measurements of silt sludge contamination with heavy metals and oil products at wastewater treatment plants of Nur-Sultan city. It is pointed out that the LOC for the TPH-in-soil is 1.5 g/kg, from which it can be concluded that there is a significant excess in the wastewater sludge for this indicator, and studies for the heavy metals presence in the wastewater sludge showed that sediments can have a toxic effect and are classified as 4 class of hazard.

Key words: composition, silt sludge, landfill, waste treatment facilities, utilization.

The development of new resource saving and zero waste technologies to efficiently clean human waste with the possibility of their reutilization, is one of the most critical tasks in the field of environmental protection [1].

Self-restoration of natural ecosystems is slow, which is mainly due to the high concentration of xenobiotics, which are not included in the biotic cycle, and their high resistance to decomposition.

As a rule, an increase in the environment of xenobiotics concentration is directly or indirectly associated with human economic activities, which generates industrial and agricultural waste, pollution of water resources, soil, and atmosphere with toxic substances. Therefore, special attention is required to the issues of environmental reclamation, in particular rehabilitation and restoration of land fertility, sustainable processing of municipal waste, aqueous effluents treatment and wastewater sludge utilization of treatment facilities.

As a result of human household and industrial activities, liquid waste is generated in the form of wastewater, which is mainly discharged into the sewage collection system. In the process of wastewater undergoing all stages of treatment at the waste treatment facilities, a silt sludge is generated, which for the most part is resistant to, or difficult to process by any kind of treatment, except for dehydration and storage, which causes the spread of negative air and gas pollution, contamination of soil and underground water with toxic components included in their composition [2]. The composition of silt sediments may

include substances with general toxic, toxicogenetic, embryotoxic, carcinogenic and other negative properties. They may contain heavy metals, pathogens, excess nitrates, toxic substances, pesticides, polychlorinated biphenyls, aliphatic compounds, esters, mono- and polycyclic aromatic substances, phenols, nitrosamines, etc.

Thus, the silt sludge utilization from wastewater is one of the most major problems of modern cities. Common methods for treating silt sediments in sludge digesters or dumping them on silt landfills are not effective enough and require the alienation of significant land plots near pollution sources [3]. The territories provided for the storage of silt sludge are overflowing quickly and cannot cope with continuous sludge flows. Besides that, silt storage facilities pose a threat to environmental compartments due to the high content of dangerous viruses, bacteria, harmful gases, hazardous chemical compounds. Additionally, in the process of fermentation in vivo offensive odors are produced, which causes great inconvenience to the townspeople. On the flip side, due to the presence of a high concentration of phosphorus and nitrogen, the wastewater sludge can serve as a good fertilizer. Due to this, the main focus in the disposal of silt sludge should have been its use as a local fertilizer. However, the question of the use of silt sludge in agriculture, and especially the matter of the accumulation of toxic substances in soil and plants when applied as fertilizer, is not well understood. As a result, the practical use of silt sludge as a fertilizer can be a source of pollution, since, in addition to various organic substances, it can contain heavy metals, the migration of which in the biosphere have an extremely negative impact on the environment.

This is one of the reasons why methods of sludge incineration have become more widespread in recent years. That process also makes it possible to obtain a positive energy balance and use the calorific value of silt sediment efficiently[4]. The main factor that encourages the use of this method is the fact that the amount of sludge generated at urban wastewater treatment facilities is enormously large compared to the free areas where the sludge can be disposed of or otherwise treated (composting, for instance).

In a number of cities and large settlements of Kazakhstan, dehydrated raw sludge is collected and placed in urban silt landfills, worsening the already tense ecological situation. Thus, the accumulation of a huge amount of off grade sediments - production waste after the biological treatment of wastewater.

Currently, about 89 thousand tons of dehydrated wastewater sludge are taken annually to the landfill of Nur-Sultan city, with a moisture content of 68-73% (initial moisture content of wastewater sludge is 93-97%), for dry solids (estimated value) about 32-33 thousand tons. There is a tendency to its substantial increase with the city's population growth. Sediments of urban wastewater treatment facilities are organic (up to 72%) and mineral (about 28%) impurities isolated from water as a result of mechanical, biological, and physical and chemical treatment. It was determined that silt sediments of Nur-Sultan city contain a significant amount of organic matter, that is, fats, proteins, carbohydrates, etc. Through the analysis it was found that the ash content of the dehydrated sludge from the wastewater treatment facility of MSE Astana Su Arnasy is 27-32%.

In modern conditions, the protection of soil from pollution appears to be important, since any harmful compounds in it sooner or later enter the human body [5,6]. Silt landfills are one of the major and largest in terms of environmental pollutants with harmful and hazardous substances, in particular heavy metals.

Silt landfills operation involves:

1. The washing out of contaminants in open bodies of waters and groundwater;
2. The ingress of contaminants through the food chains into the human body;
3. Many compounds have the ability to accumulate in tissues, and especially in bone tissues.

Heavy metals and their compounds make up a significant group of toxicants [7]. A distinctive feature of heavy metals is their inaptness to break down in the natural environment, instead, they are able to accumulate in ecosystems, causing long-term harm. Following the links of the migration chain (soil - plants - animals - people), heavy metals have toxic and carcinogenic effects on all living organisms. The greatest harm is caused by metals, which are used in significant quantities in human production activities and, as a result of accumulation in the environment, pose a major hazard in terms of their biological activity and toxic properties. These include metals such as lead, mercury, cadmium, zinc, bismuth, cobalt, nickel, copper, tin, antimony, vanadium, manganese, chromium, molybdenum and arsenic. An additional source of heavy metals in wastewater sludge is industrial effluents from electronic, instrument making and other industries. Heavy metals in wastewater are contained in the form of ions and complexes with inorganic and organic substances [8]. They can be in suspended colloidal and dissolved forms in untreated wastewater. Dissolved forms of metal compounds are the most toxic [9].

However, there are no large industrial enterprises in Nur-Sultan city, the activity of which leads to significant pollution of industrial wastewater with heavy metals. Effluents entering the wastewater treatment facilities of Nur-Sultan city are 80% household pollution greywater and the concentration of heavy metals is low in them. Heavy metal ions are contained in coarse dispersed mineral suspended solids and undissolved organic impurities that are trapped in the preliminary settling tanks of treatment facilities and make up wastewater sludge. Metal compounds are almost non-degraded during biological oxidation. Partially, metal compounds are sorbed by active sludge, and then, through a series of biochemical processes, they are converted into an inactive form. The other part of heavy metal ions create complexes with activated sludge protein. The accumulation of metal compounds in activated sludge occurs in both cases [9]. Excess active sludge is a part of a wastewater sediments and is subject to utilization.

The measurements of the heavy metals mass content in raw dehydrated wastewater sludge (gross content) are presented in table 1. The data show that the concentration of heavy metals in dried sludge is higher than in raw sludge.

Table 1 - The content of heavy metals in silt sludge

Sampling Location	S, mg/kg				
	Zn	Pb	Cr	Cd	Ni
raw sludge before dehydration	789	24.4	74.0	1.9	51.3
Dried sludge	1021	23.4	67.8	2.5	59.9
Sediment from deposit sites	618	23.1	63.9	2.4	56.0
Soil APC	220	130	-	2.0	80

The data of Table 1 on heavy metals in wastewater sludge showed that wastewater sludge can have a toxic effect and belong to the 4th class of hazard [10].

Silt sediments were also examined for the content of oil products in them. Given that the MAC for the content of oil products in the soil is 1.5 g/kg, we can conclude that there is an excess for this marker in the wastewater sludge (table 2).

Table 2 - The content of petrochemicals in the sludge

Sample name	Unit	Concentration of petrochemicals
Raw sludge of wastewater dehydration	mg/dm^3	105.4
Dehydrated wastewater sludge	mg/kg	4105
Wastewater sludge from deposit sites	mg/kg	2429

Most sediment is stored at silt sites and landfills, leading to pollution of surface and groundwater, soil and vegetation. When entering subsurface and groundwater, the aqueous extract of wastewater sludge gives them color and flavors, which negatively affects the quality of such waters [10].

Effective management of wastewater sludge is at present one of the severe environmental issues in Nur-Sultan city, which is aggravated every year and requires urgent solutions. Wastewater sludge is almost completely stored in the landfill of treatment facilities, which turns them into a hot spot of bacteriological and toxicological hazard. At the same time, the use of sediment from wastewater sludge will solve the current need to search for alternative energy sources, which wastewater silt sludge may become one.

There are many methods for wastewater sludge utilization. As a rule, the choice of recovery method is determined by the availability of appropriate equipment. The most promising in regards to the processing of sludge are thermal methods.

Due to the high content of volatile solids and colloidal substances generated during fermentation, excess active sludge is hard to treat with mechanical types of dehydration. Wastewater sludge generated at the sewage treatment facility of Nur-Sultan city, is subjected to a dehydration process using flocculants prior to utilization. In turn, the use of flocculants obstructs the processing of the resulting wastewater sludge after dehydration into compost and fertilizer.

The resource of silt sediment deposition on the maps of landfills is significantly limited or exhausted, and recycling methods that radically reduce the initial volumes of silt sediments logically come to the forefront, and, of course, thermal ones are among them; those are divided into two large groups -

incineration and thermal breakdown (drying by the pyrolysis). However, the disadvantage of thermal methods for utilizing sludge is the formation of flue gases, which requires the use of modern and effective methods for their purification and careful monitoring of exhaust gases.

Sludge sediments are traditionally burned in pseudo-boiling-layer furnaces, which, although being an efficient environmental equipment, are quite temperamental to the process conditions, and require capital investments for operation, and input for expensive spare and wear parts. Additionally, due to the high content of heavy metal salts in the sludge, the generation of tar during combustion, and also due to a general lack of technology - the generation of dioxins - sludge incineration cannot be considered as the optimal solution, as it requires a powerful and expensive gas cleaning unit. The search for alternative solutions in the field of thermal technologies leads to thermal breakdown or drying of sediments [11,12].

Pyrolysis technologies are also known and used in various industries [13]. They are about heating the feed materials in an oxygen-free atmosphere that prevents combustion. The manufacture of pyrolysis equipment for the utilization of silt sludge (a crucible updraft furnace) with a couple of operating cycles per day that meets the needs of industrial production will be a rather ergonomic and technologically intensive process. The process product will be carbonized hydrophobic dry residue of hazard class V (not hazardous), which is confirmed by the results of a number of tests [14]. The pyrolysis disadvantage is the increased fire and explosion hazard of the pyrolytic plants. The implementation of sludge utilization by pyrolysis is the most expensive methods. The process of sludge disposal by pyrolysis is less common than utilization by burning, and it is not widespread in the CIS countries.

The most relevant of all the possible technology options with acceptable environmental impact and the best economic factors is the method of thermo-catalytic oxidation of wastewater sludge in a fluidized bed of catalyst. The introduction of sludge incineration technology and the construction of a heating module for thermo-catalytic oxidation of wastewater sludge from sewage treatment facilities are described in the literature [15]. This pilot project allows to solve the problem with large savings of investment costs compared with foreign counterparts and fundamentally turn the situation with the silt sludge utilization, significantly improving the environmental situation in different regions through technological scaling.

There are no technologies used for the thermal utilization of wastewater silt sludge in Kazakhstan. However, such facilities operate in a number of cities of the Russian Federation, such as: St. Petersburg, Novocheboksarsk, and a plant in Omsk was also tested in pilot mode [15].

In summary, there aren't any industrialized options for the use of final products of the silt sludge utilization in Kazakhstan today. All alternative options come down only to theoretical assumptions and experiments, and the implementation of the methods of thermal utilization discussed in this article can quite effectively manage the reduction of silt sludge, and lead to a significant decrease in its final volume.

М.Т. Ермеков[1], О.В. Рожкова[1], Е.Т. Толысбаев[1],
Ж.Н. Жақыпбеков[1], С.Н. Меркурьева[2], В.И. Шефер[2], В.В. Иванович[3]

[1]«Парасат» ғылыми-технологиялық орталық» АҚ, Нұр-Сұлтан, Қазақстан;
[2] «Астана су арнасы» мемлекеттік коммуналдық кәсіпорны, Нұр-Сұлтан, Қазақстан;
[3] «Минскводоканал» БК «Минскочиствод» өндірісі, Минск, Беларусь

НҰР-СҰЛТАН ҚАЛАСЫНДАҒЫ КӘРІЗ ТАЗАРТУ ҚОНДЫРҒЫЛАРЫНДАҒЫ ТҰНБА ШЛАМЫН КӘДЕГЕ ЖАРАТУ МӘСЕЛЕЛЕРІ МЕН ШЕШУ ЖОЛДАРЫ

Аннотация. Ағынды су тұнбасын тиімді басқару қазіргі таңда жыл сайын шиеленісіп келе жатқан және жедел шешуді қажет ететін Нұр-Сұлтан қаласындағы ең маңызды экологиялық мәселелердің бірі болып саналады. Ағынды су тұнбасы толығымен дерлік тазарту қондырғы полигондарының аумағында сақталған, бұл оларды бактериологиялық және токсикологиялық қауіпті ошаққа айналдырады. Тұнба шөгінін сақтауға арналған алаңдар тез толып, тұнба ағынына төтеп бере алмайды. Сонымен қатар, тұнба шөгінінің жиналуы мен сақталуы кезінде ашыту үдерісі табиғи жағдайда жағымсыз иістің пайда болуына орай жүреді (аэрация мәселесіне байланысты мәселе), бұл қала тұрғындарына үлкен қолайсыздық тудырады.

Осылайша қазіргі кездегі ең өзекті мәселенің бірі – тұнба шөгінділерінің азаюына тиімді әсер ете алатын және көлемін азайтатын жаңа инновациялық, тиімді, ресурстарды үнемдейтін және қалдықсыз технологияларды дамыту.

Мақалада авторлар бірқатар қолданбалы мәселелерді шешуге қабілетті, тұнба шламын кәдеге жаратудың түрлі әдісіне талдау жасаған. Барлық мүмкін нұсқалардың ішінен қоршаған ортаға қолайлы әсер

ететін технологиялардың ең тиімді экономикалық көрсеткіштері неғұрлым қолайлы болып саналатын әдісі көрсетілген, ол катализатордың сұйылтылған қабатында ағынды судың термокаталитикалық тотығу әдісі. Мақалада қарастырылған аталған пилоттық жоба шетелдік аналогтармен салыстырғанда күрделі шығынды үнемдеу мәселесін шешуге және тұнба шөгінділерін кәдеге жарату жағдайын түбегейлі өзгертуге мүмкіндік береді, түрлі аймақтардағы экологиялық жағдайды технологиялық масштабтау арқылы едәуір жақсартады.

Сондай-ақ, жұмыста Нұр-Сұлтан қаласының кәрізді тазарту қондырғыларында тұнба шөгінділерінің ауыр металдармен және мұнай өнімдерімен ластану жағдайы өлшенді. Жер қыртысындағы мұнай өнімдерінің шекті рұқсат етілген концентрациясы (ШРК) мөлшері 1,5 г / кг екенін ескерсек, ағынды суда бұл көрсеткіштен асып кету мүмкіндігі бар деп қорытынды жасауға болады, ал зерттеулер ағынды су тұнбасында ауыр металдар болғандықтан, тұнбалар уытты әсер етуі мүмкін және қауіптіліктің 4 тізіліміне енгізілген. Сондықтан, ауыл шаруашылығында тұнба шламын тыңайтқыш ретінде практикалық қолдану мәселесі ластану көзі болып саналады, өйткені оның құрамындағы ауыр металдар қоршаған ортаға теріс әсер етеді.

Осылайша бүгінде Қазақстанда ағынға қойылған тұнба шламын кәдеге жарату кезіндегі дайын өнімдерді пайдалануға арналған нұсқалар жоқ. Барлық балама нұсқалар тек теориялық болжамдар мен эксперименттерге ғана сүйенеді, ал осы мақалада қарастырылған термиялық кәдеге жарату әдісін жүзеге асыру арқылы шөгіндіні азайтумен тиімді күресуге болады.

Түйін сөздер: құрам, тұнба шламы, полигон, кәріз тазарту қондырғылары, кәдеге жарату.

М.Т. Ермеков[1], О.В. Рожкова[1], Е.Т. Толысбаев[1],
Ж.Н.Жакипбеков[1], С.Н. Меркурьева[2], В.И. Шефер[2], В.В.Иванович[3]

[1]АО «Научно-технологический центр «Парасат», Нур-Султан, Казахстан;
[2] Государственное коммунальное предприятие «Астана су арнасы», Нур-Султан, Казахстан;
[3] Производство «Минскочиствод» УП «Минскводоканал», Минск, Беларусь

ПРОБЛЕМЫ И ПУТИ РЕШЕНИЯ УТИЛИЗАЦИИ ИЛОВОГО ШЛАМА НА КАНАЛИЗАЦИОННЫХ ОЧИСТНЫХ СООРУЖЕНИЯХ Г. НУР-СУЛТАН

Аннотация. Эффективное управление иловым осадком сточных вод в настоящее время является одной из наиболее острых экологических проблем г. Нур-Султан, которая с каждым годом обостряется и требует безотлагательного решения. Осадки сточных вод практически полностью хранятся на территории полигонов очистных сооружений, что превращает их в очаг бактериологической и токсикологической опасности. Территории, предусмотренные для хранения иловых осадков, быстро переполняются и не справляются с непрерывными иловыми потоками. Кроме того, при скоплении и хранении иловых осадков происходит процесс брожения в естественных условиях с образованием неприятных запахов (проблема, связанная с вопросом аэрации), что доставляет большие неудобства населению городов.

Таким образом, актуальнейшей проблемой в настоящее время является разработка новых, инновационных, экономичных, ресурсосберегающих и безотходных технологий, позволяющих эффективно справиться с сокращением иловых осадков и привести к существенному уменьшению их конечного объема.

В данной статье были проанализированы различные способы утилизации илового шлама, которые способны решить ряд прикладных задач. Показано, что из всех возможных вариантов технологий с допустимым воздействием на окружающую среду с наилучшими экономическими показателями, наиболее приемлемым является способ термокаталитического окисления осадков сточных вод в псевдожиженном слое катализатора. Данный пилотный проект, рассмотренный в статье позволяет решить проблему с большой экономией капитальных затрат по сравнению с зарубежными аналогами и принципиальным образом изменить ситуацию с утилизацией иловых осадков, улучшив существенным образом экологическую ситуацию в различных регионах путем технологического масштабирования.

Также в настоящей работе изучен состав и проведены измерения загрязненности иловых осадков тяжелыми металлами и нефтепродуктами на канализационных очистных сооружениях г.Нур-Султан. Учитывая то, что ПДК по содержанию нефтепродуктов в почве составляет 1,5 г/кг, можно сделать вывод о том, что в осадках сточных вод наблюдается значительное превышение по данному показателю, а исследования на наличие тяжелых металлов в осадках сточных вод показали, что осадки могут оказывать токсическое действие и относятся к 4 кассу опасности. Поэтому вопрос о практическом использовании илового шлама в сельском хозяйстве в качестве удобрений может представлять собой источник загрязнения, так как содержащиеся в нем тяжелые металлы оказывает крайне отрицательное воздействие на окружающую среду.

Таким образом, на сегодняшний день в Казахстане отсутствуют какие –либо поставленные на поток варианты использования конечных продуктов утилизации иловых осадков. Все альтернативные варианты

сводятся лишь к теоретическим предположениям и экспериментам, а реализация рассмотренных в данной статье методов термической утилизации может довольно эффективно справиться с сокращением иловых осадков.

Ключевые слова: состав, иловый шлам, полигон, канализационные очистные сооружения, утилизация.

Information about authors:

Yermekov M.T., Director of the Department of Strategic Planning and Analysis of the Parasat Scientific and Technological Center JSC, Nur-Sultan, Kazakhstan, mob.: +7 702 100 22 63, yermekov.m@parasat.kz, https://orcid.org/0000-0002-5226-2710;

Rozhkova O.V., Dr. of chemical sciences, Professor of the Kazakh Agrotechnical University, General manager of the Parasat Scientific and Technological Center JSC, Nur-Sultan, Kazakhstan, rozhkova.o@parasat.kz, https://orcid.org/0000-0001-8163-7035;

Tolysbayev Ye.T., PhD student, Satbayev University, Almaty, Kazakhstan, Chairman of the Board of the Parasat Scientific and Technological Center JSC, Nur-Sultan, Kazakhstan, 1115263@mail.ru, https://orcid.org/0000-0003-3122-9425;

Zhakipbekov Zh.N., PhD student, Satbayev University, Almaty, Kazakhstan, Asset Management Director of the Parasat Scientific and Technological Center JSC, Nur-Sultan, Kazakhstan, zhandos-zh@mail.ru, https://orcid.org/0000-0001-9750-7542.

Merkureva S.N., Candidate of Chemical Sciences, Head of the Laboratory of Sewage treatment facility of the Municipal State Enterprise Astana su Arnasy, Nur-Sultan, Kazakhstan, snezhok_msn@mail.ru, https://orcid.org/0000-0003-1886-3640.

Schefer V.I., Head of Production Department Sewage treatment facility of the Municipal State Enterprise Astana su Arnasy, Nur-Sultan, Kazakhstan, e-mail: schefer1960@mail.ru, https://orcid.org/0000-0002-1175-6319.

Ivanovich V.V., Master of Engineering, Process engineer of the Production «Minskochistvod» UE «Minskvodokanal», Minsk, Belarus, mrrichards91@gmail.com, https://orcid.org/0000-0003-0545-9016.

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