Analysis of foreign and domestic practice of operating sludge platforms to minimize negative environmental impact

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Abstract. For many European countries, including the United States and Russia, the use of sludge platforms is one of the most appropriate methods for treating sewage sludge. However, a comparative analysis of the operation of sludge platforms showed that the practice of treating sewage sludge on sludge maps in Russia is of little use. Technological methods used to optimize their processing processes require significant revision. Foreign practices are most adapted both to the removal of excess moisture from the sludge and to the neutralization (treatment) of sewage sludge from heavy metals and other soluble forms of pollutants.

1. Introduction
Silt platforms were widely used in the 60–70’s of the last century for the disposal of activated sewage sludge in order to minimize operating costs for their treatment. The main value of sewage sludge is the high content of nutrients (potassium, phosphorus, nitrogen), so sewage sludge is often used in agriculture. The fundamental simplicity of operation of sludge maps and the practice of treating sewage sludge in natural conditions have long established their primacy in the list of economically low-cost technologies.

However, in a number of cases, domestic and foreign practice followed a different path in assessing the technological improvement of design features, both the purpose of silt cards and their environmental protection functions. The latter, in turn, has become one of the dominant factors in the optimization of sludge platforms by combining various methods for treating sewage sludge, which is significantly observed in the foreign practice of modernizing and improving the technological operation of sludge maps.

For the Russian reality, the experience of operating sludge platforms remained at the level of their practical implementation in the 60-70s of the last century. The purpose of the article is a comparative analysis of foreign and domestic practice of operating sludge cards to minimize negative environmental impacts during disposal of sewage sludge.
2. Materials and methods
The main sections of the article relate to the survey part of the study, for which as materials open data of statistical observations of the Federal State Statistics Service of the Russian Federation were used, sources of scientific literature were analyzed.

3. Results and discussion
Unlike Russia, it is recognized in European practice that the disposal of waste water (sewage sludge) is a serious environmental and economic burden due to negative environmental impacts (gas emissions and leachate discharges) and the need to create landfills for these wastes, physically-chemical indicators which do not allow them to be used as a secondary resource [1]. Long-term accumulation of sewage sludge in the body of silt maps and landfills leads to soil degradation [2].

At the same time, it is recognized that national waste management strategies of different countries are very varied (i.e., they have different approaches to rationing and disposal methods), but at the same time they include restrictions on the chemical composition, the excess of which implies high environmental charges.

In 2003, each EU member state had to develop a national strategy for reducing biodegradable waste. The final disposal option provides that the only economically viable method of waste disposal will be heat treatment with subsequent placement of ash in landfills.

Some countries have more stringent waste management policies. In 2005, Sweden passed a new law prohibiting the disposal of sludge. Since then, there are five main areas of application of sludge that are used today: fertilizers, construction soil, coating material, energy production by combustion and biogas production [3].

In the countries of Northern Europe, sludge platforms with reeds using the Limnosolids technology (figure 1) [4] are widely used for dehydration and mineralization of excess sludge.

![Figure 1. Sludge platform processing technology using technology Limnosolids.](image)

During operation, sludge is pumped through the vertical risers (2) and passively distributed over the surface of the sludge platform. Reed plantations (3) carry out the functions of drainage (3) and filtration (4) due to the root system.
The drainage system is usually installed with a rubberized lining in the ground or on concrete structures. The alternation of load and initial sedimentation continues until the layer is filled with sludge, after which the sludge sediment is aged for 8-12 years and disposed of as intended.

The advantages of this technology are low capital costs, the absence of the need to use chemicals due to the use of phytoremediation, which is also noted in studies. It should be noted that the positive experience of introducing and operating civilized wastewater sludge treatment systems on silt platforms is also characteristic of developed countries in the USA and the EU.

The new EPA Process Manual (EPA 625 / 1-87-014), “Urban Wastewater Sludge Dehydration”. states that sludge platforms are still the most commonly used sludge dewatering method in the United States. However, even with the positive practice of using reed sludge dehydrogenation systems on silt platforms, the experience of Denmark has shown that if operation requirements are not met, systems can fail (for example, degradation of the drainage system). One of the most widespread technologies for treating wastewater sludge in greenhouse silt sites (figure 2) is the technology developed by HUBER [5].

![Figure 2. Sludge treatment technology on industrial silt platforms of the greenhouse type.](image)

The sludge is dehydrated by two centrifuges (2) and is automatically transported to drying platforms (greenhouses) using screw conveyors. In the greenhouse (3) it is evenly distributed on five separate lines. In the event of failure of one or more lines, the electrical control system automatically changes the supply to the unit so that the remaining lines process the formed sludge. Above the sediment layer,
several heaters are installed that introduce heat from the exhaust gases of the biogas plant. The greenhouse is equipped with a special condensate drainage system that minimizes re-wetting of sludge. Heaters are made of galvanized steel to prevent corrosion and are sized to supply the required amount of heat even in the event of contamination. In addition, fans that are installed above the sludge bed move dry and hot air over the drying surface through the greenhouse. Fans are adjustable in speed. The advantages of this method are the combinatorial system of drying sediments, energy savings through the use of biogas.

France has a special position in Europe. Despite the fact that a significant part of the population lives in urban areas, 25% of the population lives in 31.900 administrative districts with a population of less than 2.000 people. This situation explains the large number of treatment facilities of low power.

In France, about 80% of the 15.000 treatment plants have a load capacity below 2.000. Here, for the disposal of sludge, simple sludge treatment technologies are used: ponds to stabilize sludge, silt platforms with a reed layer.

In countries with underdeveloped or developing economies, the problem of sludge utilization causes serious environmental problems, associated primarily with the risk of population disease and land degradation.

Thus, studies emphasize that in urban and suburban areas of Africa, Asia and Latin America, where more than a billion people live, sanitary systems for treating sewage sludge were absent or degraded.

In the Russian Federation, about 100 million m$^3$ of sewage sludge is formed annually [4]. It is expected that the dynamics of sedimentation will increase every year. The fact that almost 90% of all sludge produced in the country is processed on silt platforms in Russia indicates the scale of distribution of these facilities and their contribution to the environmental management system.

In most EU and US countries, sludge platforms are used for the treatment of wastewater with relatively low concentrations of pollutants for the subsequent use of waste in agriculture. However, a high percentage of the total volume of waste is disposed of in landfills (due to their high toxicity), up to 1/5 of the total volume is burnt, and dumped into the sea (table 1).

| Country    | Use in agriculture | Landfill | Burning | Discharge into the sea |
|------------|--------------------|----------|---------|------------------------|
| England    | 53                 | 16       | 7       | 24                     |
| Austria    | 20                 | 49       | 31      | –                      |
| Germany    | 25                 | 55       | 15      | 5                      |
| Denmark    | 45                 | 28       | 18      | 9                      |
| USA        | 25                 | 25       | 35      | 15                     |
| Italy      | 20                 | 60       | –       | 20                     |
| Finland    | 40                 | 41       | –       | 19                     |
| Switzerland| 50                 | 30       | 20      | –                      |
| Sweden     | 60                 | 30       | –       | 10                     |
| France     | 23                 | 46       | 31      | –                      |

The lack in Russian practice of unified approaches to the normative assessment and rules for the operation of sludge platforms and the disposal of sewage sludge is due to the specific physicochemical composition of the sludge components that cannot be subjected to destruction (as well as heavy metals) during biological wastewater treatment (most economically acceptable) [6–8]. A significant contribution to this problem is made by the lack of high-quality local treatment at many industrial enterprises, and in some cases, the lack of treatment facilities.

The problem is aggravated by the fact that in Russian reality the disposal of sewage sludge on silt platforms has stopped at technological methods of the 50–m70s of the last century. Typical silt platforms are primitive natural-technical structures (figure 3). A distinctive feature of which is a direct dependence
on the climatic features of the area of their location. In a changing climatic background, open sludge platforms exposed to atmospheric influences lose both operational and environmental protection functions.

Figure 3. Sewage sludge disposal on sludge maps.

Excessive humidity of wastewater disposal due to increased precipitation (slit and sewage sludge) [9] does not allow to dispose of them in landfills, due to the instability of the slopes of landfills, which in the case of overhaul leads to the destruction of the frame. Loading and unloading and construction of the landfill in this case can be difficult, because even dehydrated sludge after wetting (atmospheric moisture) doubles the volume.

It is also important that these objects are often located within the boundaries of protected areas of various levels and the problems that arise when assessing and ranking territories are closely related to the life cycle of the anthropogenic impact of NEC objects, which affect the subjective attractiveness of territories and pollution of surface water bodies [10].

4. Conclusion

The lack of proper attention in Russia to the problem of wastewater sludge treatment on silt platforms contributes to the inadequate quality of wastewater sludge treatment. The latter often provokes illegal sludge removal, which may be due, among other things, to the degradation of sludge platforms that do not provide the necessary conditions for sludge dewatering and its further disposal with corresponding financial losses.

The main reasons for the negative impact of the operation of sludge platforms (compared with foreign practice) is the lack of local pre-treatment of effluents (and, as a result, the accumulation of toxic pollutants by sewage sludge entering the city sewage treatment plants and adaptation technologies for optimizing the dewatering and bioremediation of sewage sludge water

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