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COMPARISON OF SEWAGE SLUDGE CONDITIONING METHODS

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Abstract. *The article discusses the advantages and disadvantages of various methods of sewage sludge conditioning. It was found that the addition of mechanical additives to sewage sludge (fly ash, vermiculite) makes it possible to reduce the costs of sludge dewatering and use the resulting dewatered sludge in soil restoration or as a fertilizer. Choosing a rational method of sewage sludge conditioning ensures further effective sludge dewatering and the possibility of its environmentally safe disposal.*

Key words: *sewage sludge, conditioning, dewatering, fly ash, vermiculite, Advanced Oxidation Process (AOP)*

Introduction

The problem of the formation and accumulation of huge volumes of sewage sludge has reached a huge scale. In the world in 2017, 45 million tons of sewage sludge were formed and accumulated [1]. The lack of a systematic approach to the treatment and further disposal of sewage sludge leads to pollution of the environment, soils, surface and groundwater. The accumulation and storage of sewage sludge in open areas leads to atmospheric pollution and negatively affects the ecological state of territories [2, 3].

The traditional approach to the treatment and disposal of sewage sludge includes several stages: thickening, conditioning and dewatering. After the effective course of the dewatering process, the issue of further disposal of sewage sludge can be addressed.

The first stage of sludge thickening is usually characteristic of excess activated sludge, because its humidity after secondary settling reaches 98-99%. The next stage of sludge conditioning is necessary to increase the efficiency of removing excess moisture from the sludge. The variety of methods for conditioning sewage sludge requires a rational approach to choosing a specific method, taking into account possible further ways of disposing of the dewatered sludge [4-6].

Therefore, the issue of choosing a method for conditioning sewage sludge is important, requiring scientific justification in order to ensure the efficiency of the subsequent dewatering process and the possible ecological use of the resulting product.

Main text

Sludge conditioning is essential for improving the dewaterability of sludge before it undergoes final treatment. Conditioning enhances the separation of water from solids, making subsequent processes more efficient. The primary goal of sludge conditioning is to alter the physical and chemical properties of the sludge to facilitate easier and more effective dewatering [7, 8].

Common Conditioning Methods:

Chemical Conditioning:

Process: Involves the addition of coagulants and flocculants (such as ferric chloride, lime, or polymers) to bind the sludge particles together, forming larger aggregates that can be more easily separated from water.

Pros: Highly effective in improving dewaterability and can is adjusted based on sludge composition.

Cons: Chemical costs and potential environmental issues from residuals.

Thermal Conditioning:

Process: Heat is applied to break down the sludge structure and release bound water. This can be done through processes such as hydrothermal treatment or thermal hydrolysis.

Pros: Increases dewaterability and reduces sludge volume.

Cons: High energy consumption and costly equipment.

Mechanical Conditioning:

Process: Mechanical methods, such as shearing or grinding, are used to alter the sludge structure, making it easier to dewater.

Pros: Suitable for large-scale operations and avoids chemical additives.

Cons: Limited efficiency compared to chemical methods.

Mechanical Conditioning:

- Fly Ash Application: Fly ash can be added to sludge to improve its mechanical

structure, reducing water content and enhancing dewaterability [9].

- Natural Minerals: Minerals like vermiculite can be used to improve dewaterability while remaining cost-effective [10].

Advanced Conditioning Methods:

Advanced Oxidation Processes (AOPs): These involve using chemical oxidants, such as ozone, to break down organic materials, improving the overall efficiency of dewatering [11, 12].

Each methods of sludge conditioning in Table 1 have unique pros and cons, with effectiveness depending on sludge type, organic content, and facility needs. Selecting the right method ensures optimal dewatering and cost-efficiency.

Table 1 – Overview of Sludge Conditioning Methods

Conditioning Method	Process	Common Chemicals/Additives
Chemical Conditioning	Coagulants and flocculants bind particles into flocs.	Ferric chloride, lime, polymers
Thermal Conditioning	Heat treatment to break down structure, release water	None (heat application)
Mechanical Conditioning	Adds structural agents to improve dewaterability.	Fly ash, vermiculite
Advanced Oxidation	Strong oxidants break down organics, improve separation	Ozone, hydrogen peroxide

Examples of Conditioning in Practice:

Municipal WWTPs: Often use chemical conditioning with polymers to enhance sludge dewaterability before mechanical dewatering processes like centrifugation or belt filter pressing.

Industrial Facilities: May use a combination of chemical and mechanical conditioning to handle complex sludge compositions, such as those containing high levels of fats, oils, and greases.

Benefits of Effective Sludge Conditioning:

- Improved Dewaterability: Enhanced separation of water from solids, leading to more efficient dewatering processes.

- Reduced Volume: Lower sludge volumes reduce transportation and disposal costs.
- Enhanced Resource Recovery: Improved conditioning can enhance the recovery of valuable by-products, such as biogas from anaerobic digestion.
- Environmental Protection: Proper conditioning reduces the risk of environmental contamination from untreated sludge.

Effective sludge conditioning is a critical step in the overall sludge management process, ensuring that subsequent treatment stages are more efficient and cost-effective. By selecting the appropriate conditioning methods based on the specific characteristics of the sludge, WWTPs and industrial facilities can optimize their sludge management practices.

Summary and conclusions

Sludge dewatering has been shown to be important in reducing the volume of sludge, making its transportation and disposal easier and more economical. It plays a crucial role in the overall wastewater treatment process, helping to minimize waste and recover valuable by-products such as water and biological solids. The main goal is to remove as much water as possible, reducing the weight and volume of the sludge.

The authors found that the sewage sludge conditioning stage directly affects the efficiency of the sludge dewatering process. A well-founded choice of an effective method of sludge conditioning leads to a reduction in sludge volume. Smaller sludge volumes reduce transportation and disposal costs.

We found that the use of natural materials (vermiculite) or production waste (fly ash) leads to the possibility of using the dewatered sludge as a fertilizer for agriculture.

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