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# Sewage sludge as a source of fertilizer-An over view

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## Abstract
Sewage sludge is a byproduct of municipal wastewater treatment and contains valuable nutrients like nitrogen and phosphorus, which can be beneficial for soil fertility and plant growth. However, concerns over heavy metal buildup in the food chain have led to hesitation in reusing sewage sludge for fertilization. Various methods can extract phosphorus fertilizer from sewage sludge, such as hydrothermal carbonization, pyrolysis, combustion, and composting. One effective approach combines hydrothermal carbonization, acidic leaching, and struvite precipitation, recovering around 80% of total phosphates. The acid catalyst boosts carbonization and increases ammonium availability for struvite formation, thereby enhancing phosphate recovery. Sewage sludge biochar (SSB) is a byproduct of sewage sludge pyrolysis that is rich in carbon and nutrients like phosphorus, nitrogen, calcium, and zinc. Augmenting SSB with mineral potassium sources can address its low potassium content, yielding an organo mineral fertilizer that gradually releases potassium. The potential environmental impact of sewage sludge as a fertilizer includes soil contamination by a range of pollutants, including heavy metals, PAHs, PCBs, microplastics, pharmaceuticals, and pathogens. Without proper management, these contaminants can detrimentally impact soil health, water sources, and ecosystems. On the other hand, reusing sewage sludge as a fertilizer can enhance soil fertility and supply vital nutrients necessary for plant development. Employing sewage sludge as a fertilizer has the potential to enhance crop yields and boost agricultural productivity, thereby fostering economic benefits for farmers.

**Keywords:** *Sewage sludge. Fertilizer, Heavy metal, Pollutants*

## Introduction
Sludge from municipal sewage systems is produced for a purpose; it is a residual product resulting from the processes employed to purify raw sewage before discharging the treated effluent into estuaries, rivers, and seas. Municipal sewage comprises not just human waste from excrement but also products and pollutants from residences, companies, industries, storm water, landfill leachate (in some areas), and pollutants that have leached from pipelines (Harrison *et al.,*

1999). Municipal wastewater treatment facilities produce sludge at various treatment phases, including primary, secondary, and tertiary stages. This sludge harbours concentrated trace metals, heavy metals, less biodegradable organic compounds, and partially harmful microorganisms found in wastewater. Nevertheless, it also contains valuable nutrients like nitrogen (N) and phosphorus (P), along with organic material. These nutrients and organic content render sludge appropriate for land application as a fertilizer or soil enhancer following adequate treatment, including sanitation procedures and composting (Brod *et al.,* 2012). Using sewage sludge as a fertilizer offers a chance to reduce dependence on mineral fertilizers in farming. However, there's been hesitation in reusing municipal sewage sludge for fertilization due to concerns about heavy metal buildup in the food chain (Sogn *et al.,* 2018).

**Transforming sludge to fertilizer**

Various methods can extract phosphorus fertilizer from sewage sludge, such as hydrothermal carbonization, pyrolysis, combustion, and composting. One effective approach combines hydrothermal carbonization, acidic leaching, and struvite precipitation, recovering around 80% of total phosphates. The acid catalyst boosts carbonization and increases ammonium availability for struvite formation, thereby enhancing phosphate recovery (Becker et al., 2019). According to Franz (2008) Phosphorus extracted from sewage sludge ash (SSA) via leaching can be further refined by removing heavy metals using ion exchange or sulphide precipitation. In this process, the strong acid solutions cause heavy metals to form insoluble sulphide compounds, leading to their precipitation as stable phases shown in Fig 1.

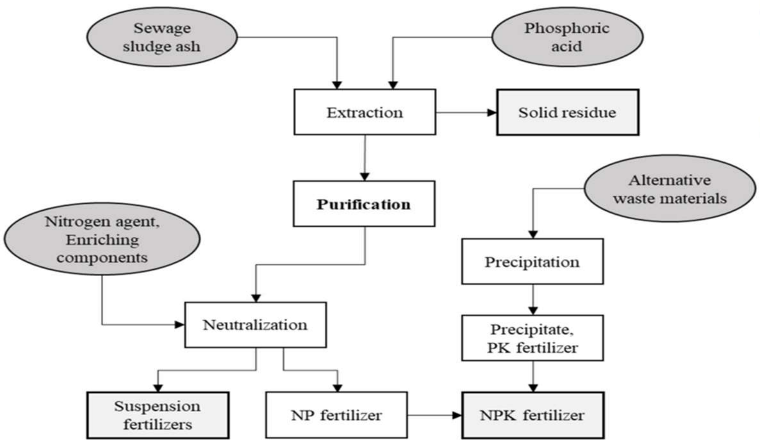


Fig 1. Process scheme of fertilizer production from sewage sludge ash (N: Nitrogen, P: Phosphorus, K: Potassium) (Gorazda et al., 2017).

Sewage Sludge biochar (SSB), the byproduct of sewage sludge (SS) pyrolysis, is rich in carbon and nutrients like phosphorus (P), nitrogen (N), calcium (Ca), and zinc (Zn). Augmenting SSB with mineral potassium sources can address its low potassium content, yielding an organo mineral fertilizer that gradually releases potassium (Ndoung et al., 2023). Though sewage sludge is commonly used as fertilizer, it often contains heavy metals above the permitted limits. There are several methods available to assess this. A widely used method for evaluating the metal-binding properties of heavy metals in waste materials involves the three-step extraction process outlined by the Standards, Measuring, and Testing Programme of the Commission of the European Communities. This method, which evolved from the Community Bureau of Reference (BCR) programme of the European Union, entails sequential extraction steps (Santoro et al., 2017). Firstly, acetic acid extraction targets the exchangeable and acid-soluble fraction. Secondly, hydroxylamine hydrochloride extraction focuses on the reducible fraction. Finally, hydrogen peroxide digestion following ammonium acetate extraction addresses the oxidizable fraction. This extraction technique is commonly referred to in the literature as the BCR sequential extraction (Kazi et al., 2005).

**Environmental impact**

Sewage sludge serves as a repository of both organic material and nutrients, rendering it suitable for diverse reuse applications. Its potential extends to serving as a renewable energy source and aiding material reclamation, thereby supporting the principles of a circular economy (Rorat et al.,2019). Utilizing sewage sludge as a fertilizer has the potential to enhance soil fertility and supply vital nutrients necessary for plant development. On other hand Reutilizing sewage sludge as a fertilizer carries the risk of soil contamination by a range of pollutants including zinc, copper, cadmium, lead, polycyclic aromatic hydrocarbons (PAH), polychlorobiphenyls (PCB), microplastics, pharmaceuticals, as well as pathogens like Escherichia coli and Salmonella. Without proper management, these contaminants can detrimentally impact soil health, water sources, and ecosystems. (Styszkoet al.,2022).

**Economic Benefits**

Employing sewage sludge as a fertilizer has the potential to enhance crop yields and boost agricultural productivity, thereby fostering economic benefits for farmers (Lagae et al.,2009). Moreover, integrating sewage sludge into agriculture can aid in revitalizing the economy by offering supplementary value to agricultural output and endorsing sustainable farming methodologies (Sarov, 2021). According to Bagheri, (2022) the economic advantages of sewage sludge also encompass resource recuperation, particularly regarding phosphorus. Sewage sludge harbors phosphorus, a pivotal raw material, and reclaiming phosphorus from sewage sludge via combustion not only aids in waste management but also fosters resource sustainability and cost efficiencies in phosphorus acquisition.

**Conclusion**

In conclusion, sewage sludge, a byproduct of municipal wastewater treatment, presents both opportunities and challenges for transformation into fertilizer. While it contains valuable nutrients and organic matter beneficial for soil fertility and plant growth, there are concerns regarding the presence of pollutants that could harm the environment if not managed properly. Various methods such as hydrothermal carbonization, pyrolysis, and combustion offer avenues for extracting phosphorus fertilizer from sewage sludge, contributing to resource recovery and sustainability. However, careful assessment and management of heavy metal content and other contaminants are essential to ensure the safety and effectiveness of sewage sludge as a fertilizer. Despite these challenges, the economic benefits of utilizing sewage sludge in agriculture, including enhanced crop yields and resource recuperation, underscore its potential contribution to a circular economy and sustainable farming practices. Therefore, integrating sewage sludge into agricultural systems requires a balanced approach that maximizes its benefits while mitigating environmental risks.

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