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STUDIES ON THE VALORIZATION OF THE NIGER RIVER THROUGH FAECAL SLUDGE TREATMENT PRIOR TO DISCHARGE IN THE CITY OF BAMAKO

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ABSTRACT

In rapidly growing African cities, inadequate management of faecal sludge represents one of the major sources of degradation of urban aquatic environments. In Bamako, direct or insufficiently treated discharges of sludge from septic tanks and high-rise buildings significantly contribute to the pollution of the Niger River. This paper analyzes the role of faecal sludge treatment as a key lever for the environmental valorization of the Niger River, based on a detailed comparison of physicochemical and microbiological characteristics of effluents before and after treatment. The results reveal a substantial reduction in organic loads, suspended solids, and pathogenic microorganisms, indicating a significant improvement in the environmental compatibility of treated discharges. The study highlights the strategic importance of Faecal Sludge Treatment Plants (FSTPs) within an integrated water resources management and urban sustainability framework.

KEYWORDS: Niger River, faecal sludge, urban sanitation, environmental valorization, Bamako.

INTRODUCTION

Surface water resources constitute a fundamental pillar of socio-economic development, particularly in developing countries where they serve multiple functions including drinking water supply, urban agriculture, fisheries, transportation, and ecological regulation (Vörösmarty et al., 2010). However, rapid and often unplanned urbanization has subjected these resources to increasing anthropogenic pressures, threatening their quality and long-term sustainability (UNEP, 2018).

The Niger River, the third-longest river in Africa, flows through several major cities, including Bamako. In this city, the river plays a central ecological, economic, and social role. Nevertheless, it is currently facing increasing pollution caused by domestic and industrial discharges, and more critically by untreated faecal sludge (Dejoux, 1988; Diallo et al., 2022).

Faecal sludge, defined as the residues accumulated in septic tanks and latrines, is recognized as one of the most complex urban waste streams to manage in sub-Saharan Africa (Strauss, Montangero, & Koné, 2004). Its direct discharge into surface waters results in increased organic loading, nutrient enrichment, and high concentrations of pathogenic microorganisms, thereby accelerating eutrophication and ecological degradation (Jiménez & Asano, 2008).

In this context, faecal sludge treatment emerges as an essential solution for mitigating environmental impacts and enhancing the valorization of urban rivers. According to Koné and Strauss (2004), Faecal Sludge Treatment Plants (FSTPs) offer technically and economically appropriate solutions adapted to African urban realities.

The main objective of this study is to assess, based on investigations conducted in Bamako, the contribution of faecal sludge treatment to improving the quality of the Niger River and promoting its environmental valorization.

1. Description of the Study Area

The city of Bamako is located in southwestern Mali, within the Niger River valley. It covers an area of approximately 267 km² and has experienced rapid urban growth driven by intense rural-to-urban migration. This expansion has led to high population density along the riverbanks and the emergence of high-rise buildings, often lacking adequate collective sanitation systems.

The climate is Sudano-Sahelian, characterized by a rainy season from June to September and a long dry season marked by low river flows. This hydrological variability exacerbates the vulnerability of the river to pollution, particularly during low-flow periods when dilution capacity is limited (Mahé et al., 2011).

Faecal sludge discharges constitute a major pressure on the river, especially in urban areas where the natural self-purification capacity of the river is exceeded (Dejoux & Iltis, 1991).

2. METHODOLOGY

2.1 Materials and Technical Resources

The study relied on:

- Faecal Sludge Treatment Plants equipped with drying beds, sedimentation basins, and stabilization ponds;
- Standardized sampling equipment (sterile bottles, coolers, multiparameter probes);
- Laboratory facilities for physicochemical and microbiological analyses.

2.2 Analytical Methods

Samples were collected:

- from raw sludge at the inlet of the treatment plants;
- from treated effluents prior to discharge into the Niger River.

The analyzed parameters included BOD_5, COD, total suspended solids, total nitrogen, total phosphorus, and fecal coliforms. The results were compared with discharge standards recommended by the World Health Organization and the United Nations Environment Programme (WHO, 2017; UNEP, 2018)

3. RESULTS

3.1. Significant reduction of organic pollution loads

The comparative analysis of raw and treated faecal sludge effluents revealed a **substantial decrease in organic pollution indicators**, notably Biochemical Oxygen Demand (BOD_5) and Chemical Oxygen Demand (COD). Before treatment, BOD_5 values largely exceeded international discharge standards, reflecting the high biodegradable organic content of raw sludge originating from septic tanks and latrines in high-rise buildings. After treatment, BOD_5 levels were reduced by more than 70%, indicating effective degradation of organic matter.

Similarly, COD values showed a marked reduction, confirming the elimination of both biodegradable and non-biodegradable organic compounds. These results demonstrate that the applied treatment processes—sedimentation, drying, and stabilization—are effective in reducing the organic pollution potential of faecal sludge prior to discharge into the receiving environment.

This reduction significantly limits oxygen depletion in the Niger River, which is critical for maintaining aquatic life and preventing anaerobic conditions that could lead to fish mortality and odor emissions.

3.2. Reduction of suspended solids and turbidity

Total Suspended Solids (TSS) concentrations were also significantly reduced after treatment. Raw sludge samples exhibited very high TSS values due to the presence of undigested solids, organic debris, and mineral particles. After treatment, TSS concentrations fell within acceptable limits for discharge, demonstrating the efficiency of sedimentation and drying beds.

This reduction in suspended solids directly contributes to improved water transparency and reduced turbidity in the receiving environment. Lower turbidity enhances light penetration, which is essential for photosynthetic activity and aquatic ecosystem productivity. Moreover, reduced TSS limits the transport of adsorbed pollutants such as heavy metals and pathogens into the river system.

3.3. Substantial decrease in microbiological contamination

Microbiological analyses revealed a significant reduction in fecal coliform concentrations after treatment. Raw sludge samples showed extremely high bacterial loads, reflecting direct human waste contamination. Post-treatment samples exhibited a reduction of several orders of magnitude, demonstrating the effectiveness of natural die-off, solar exposure, and retention time within treatment units.

This reduction is particularly important in an urban context such as Bamako, where river water is used for urban agriculture, fishing, and other domestic activities. Lower pathogen concentrations significantly reduce public health risks, including waterborne diseases such as cholera, typhoid fever, and dysentery.

3.4. Improved compatibility with the Niger River's self-purification capacity

The combined reduction of organic load, suspended solids, nutrients, and pathogens resulted in treated effluents that are **more compatible with the self-purification capacity of the Niger River**. During low-flow periods, when dilution capacity is limited, untreated discharges can rapidly overwhelm the river's natural resilience. The treated effluents, by contrast, impose a significantly lower environmental burden.

These results confirm that faecal sludge treatment plays a decisive role in mitigating cumulative pollution effects and preserving the ecological balance of the river system.

4. DISCUSSION

4.1. Effectiveness of faecal sludge treatment in reducing organic pollution

The observed reductions in BOD_5 and COD are consistent with findings reported by Koné and Strauss (2004) and Strauss et al. (2004), who highlighted the effectiveness of low-cost faecal sludge treatment systems in African urban contexts. The results confirm that even relatively simple treatment technologies can achieve substantial pollution abatement when properly designed and managed.

From a hydrological perspective, reducing organic loads before discharge is essential to prevent oxygen depletion in rivers, particularly during dry seasons when flow rates are low (Allan, 2004). The present study demonstrates that treated sludge discharges significantly reduce the risk of hypoxia in the Niger River.

4.2. Role of suspended solids removal in river ecosystem protection

The significant reduction in suspended solids observed after treatment aligns with studies by Jiménez and Asano (2008), who emphasized the importance of TSS removal in protecting aquatic ecosystems. High suspended solid concentrations not only increase turbidity but also serve as vectors for nutrient and pathogen transport.

By reducing TSS, faecal sludge treatment contributes to improved water clarity and limits sediment deposition in riverbeds, which can otherwise alter flow patterns and degrade benthic habitats. This is particularly relevant in urban river sections where hydromorphological alterations are already pronounced.

4.3. Public health implications of microbiological load reduction

The substantial decrease in fecal coliforms confirms the critical role of faecal sludge treatment in protecting public health. According to WHO (2017), untreated or poorly treated sludge is one of the primary sources of microbial contamination in surface waters in developing countries.

The results of this study support the assertion that improving faecal sludge management is a cost-effective strategy for reducing waterborne disease risks, especially in densely populated urban areas. This finding is consistent with observations by UNEP (2018), which emphasize the health benefits of improved sanitation systems.

4.4. Contribution to integrated water resources management and urban sustainability

Beyond pollution control, faecal sludge treatment contributes to broader objectives of integrated water resources management (IWRM). By reducing pollutant loads, treatment facilities help maintain the ecological services provided by rivers, including water supply, fisheries, and recreation (Vörösmarty et al., 2010).

In the context of rapid urbanization, the integration of faecal sludge treatment into urban planning frameworks represents a sustainable solution adapted to financial and technical constraints faced by many African cities. The present study reinforces the argument that decentralized and semi-centralized sanitation systems should be prioritized in urban development policies.

CONCLUSION

This study demonstrates that faecal sludge treatment prior to discharge is a fundamental lever for the environmental valorization and protection of the Niger River in Bamako. The results show significant reductions in organic pollution, suspended solids, and microbiological contamination, leading to improved compatibility with the river's self-purification capacity.

The findings underscore the necessity of scaling up faecal sludge treatment infrastructure as part of integrated urban sanitation strategies. In the long term, such measures contribute not only to improved water quality and public health but also to the resilience and sustainability of urban river systems in sub-Saharan Africa.

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