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Environmental and Socio-Economic Impacts of the Sewage Sludge Treatment Plant (SSTP) Activities in Koubia Area of Niamey City, and Related Health Risks

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Abstract

In African cities, waste management poses a major challenge, and the operation of sewage sludge treatment plants (SSTPs) often generates environmental, social, and health nuisances. This study evaluates the potential socioeconomic and environmental impacts of the Koubia SSTP in Niamey, as well as the associated health risks. The methodology is based on field observations and surveys conducted among 75 station users and operators, along with 94 neighboring household heads. The results highlight several major impacts: odor nuisances (20%), road network deterioration caused by vacuum truck traffic (20%), noise pollution (15%), soil pollution from basin overflows (10%), risks of domestic animal contamination due to a lack of site security (15%), groundwater pollution (10%), the proliferation of insect vectors (5%) and respiratory disease (5%). While management optimizations prove vital, 15% of respondents nevertheless emphasize the infrastructure's positive contribution (improving waste collectors' safety, limiting diffuse pollution, agricultural valorization into organic fertilizer, job creation, and municipal revenue).

Keywords

Sewage Sludge, Treatment, Impacts, Health Risks, Niamey

1. Introduction

The continuous growth of the population in African cities generates large amounts of wastewater which poses a real challenge for its management and disposal. Wastewater contains physical, chemical, and/or biological contaminants that become dangerous to the environment when discharged without treatment [1]. Its impact on the environment can be devastating. The various contained pollutants, such as pathogenic bacteria, heavy metals, nutrients, and other toxins, can harm waterways, contaminate soil and groundwater, and endanger wildlife and human health [2]. The presence of these pollutants in surface water can reduce dissolved oxygen (DO) concentrations and hinder solar radiation penetration leading to fish kills and/or algae blooms (eutrophication) [3].

In 2019, approximately 45% of the domestic wastewater generated worldwide was discharged into the environment without any treatment [4]. About 55% of the world's population (4.2 billion people) lack access to properly managed sanitation services [4]. More than 1.7 billion people lack basic sanitation services, such as private toilets or latrines. Of those, 494 million people still defecate in the open area, in gutters, behind bushes, and next to bodies of water. In most African countries, sanitation, particularly wastewater and excreta treatment, remains a major environmental challenge. This situation is certainly one cause of the high rate of waterborne diseases observed in these countries [5] [6].

On-site sanitation systems produce large quantities of sludge [7] that must be managed to minimize pollution. In Niger, approximately 80.6% of the population lacks access to adequate sanitation services [8]. In Niamey city, for example, sewage disposal is carried out mechanically or manually depending on household preferences and financial means. Mechanical emptier dump sludge haphazardly in old quarries or fields on the outskirts of the city, while manual emptying leaves sludge in courtyards, on streets, and in gutters. Direct contact between sewage sludge and the environment poses risks of food contamination through flies and other vectors, as well as groundwater and surface water pollution through infiltration and spillage. This phenomenon has been observed in the Niger River, the city of Niamey's main source of drinking water, as well as in the waters used for market gardening and rice cultivation in gardens and on the riverbanks.

These problems can be significantly reduced through an effective fecal sludge management system that encompasses the entire management chain, from sludge generation to its safe disposal or reuse [9]. In this context, the city of Niamey established a Fecal Sludge Treatment Plant (FSTP) in the Koubia district to improve urban sanitation and mitigate the negative impacts associated with the uncontrolled disposal of fecal sludge. However, while this facility provides important benefits for wastewater and sludge management, its operation may also generate environmental, socio-economic, and health-related effects on nearby communities. Therefore, it is essential to assess these impacts in order to better understand both the benefits and the challenges associated with the treatment plant. The main objective of this study is to evaluate the perceptions of local residents and other

stakeholders regarding the environmental and socio-economic impacts, as well as the associated health risks, of the activities of the Koubia Fecal Sludge Treatment Plant, with a view to supporting more sustainable and socially acceptable management of this facility.

2. Material and Methods

2.1. Study Site

The study was conducted at the SSTP located in the Koubia district of Niamey Commune I (Figure 1). Built in 2018, the SSTP aims to treat wastewater from households in Niamey, primarily from latrines and septic tanks [10]. Financed by the World Bank through the "Urban Water and Sanitation Project" (PEAMU), it remains the only sewage sludge treatment plant in Niamey.

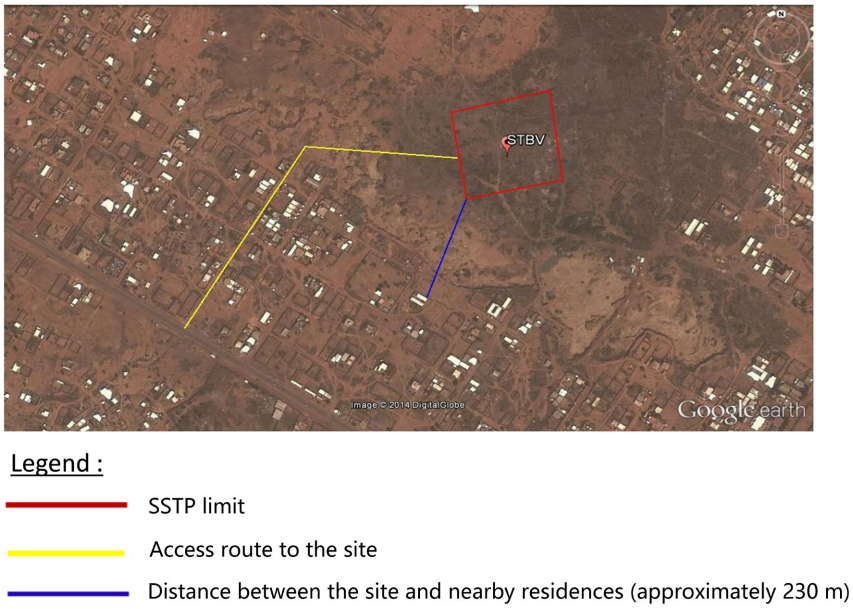

Figure 1. Location of the study area.

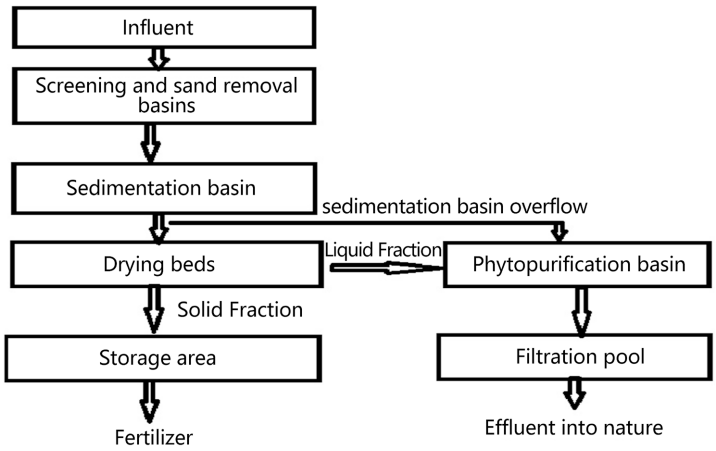

Figure 2. Sewage sludge treatment plant.

The SSTP (Figure 2) consists of following compartments including screening and sand removal basins, sedimentation basin, drying beds, phytopurification basin and filtration basin. The screening and sand removal basins remove large suspended objects.

The Koubia SSTP has a nominal treatment capacity ranging from 300 m^3 of fecal sludge per day [11].

2.2. Method of Disposing of Sewage Sludge

Septic tank emptying can be carried out using two primary methods: manual emptying and mechanical emptying. The latter relies on the use of vacuum trucks equipped with vacuum pumps and storage tanks for the suction, transport, and discharge of fecal sludge and wastewater. The capacity of these vehicles generally ranges from 3000 to 10,000 liters. However, in the course of their operations, mechanical emptying operators face various logistical, technical, and infrastructural constraints that can hinder the efficiency of their interventions.

2.3. Data Collection

- **Data collection**

The survey targeted three stakeholder groups directly concerned by the activities of the Koubia Sewage Sludge Treatment Plant (SSTP): the plant personnel, the mechanical waste collectors responsible for sludge collection and transport, and the local residents likely to be affected by its operation. The selection of these actors was based on their level of involvement in the fecal sludge management chain and their degree of exposure to the potential impacts of the plant. The collected data encompassed the sociodemographic characteristics of the respondents, as well as their perception of environmental impacts (odor nuisances, insect proliferation, and the degradation of soil, water, and access roads). Additionally, it evaluated the socioeconomic effects associated with the plant's activities (job creation, reduction of illegal dumping, and perceived nuisances) alongside perceived or observed health risks (diarrheal diseases, skin conditions, respiratory disorders, and other symptoms linked to sludge exposure). For the SSTP operators and collectors, complementary data were gathered regarding working conditions, the use of personal protective equipment (PPE), and professional occupational exposure to sewage sludge. The study sample comprised 75 plant operators and mechanical waste collectors, along with 94 household heads residing near the station.

- **Field observations**

The observations focused on monitoring the sewage sludge treatment process and touring the different sections of the SSTP to identify potential impacts and confirm the perceptions of those surveyed.

3. Results and Discussions

3.1. Results

- **Perception of the environmental impacts of SSTP's activities**

Analysis of the perception survey results reveals that SSTP's activities generate various environmental and social impacts on the population living in the surrounding area (Figure 3).

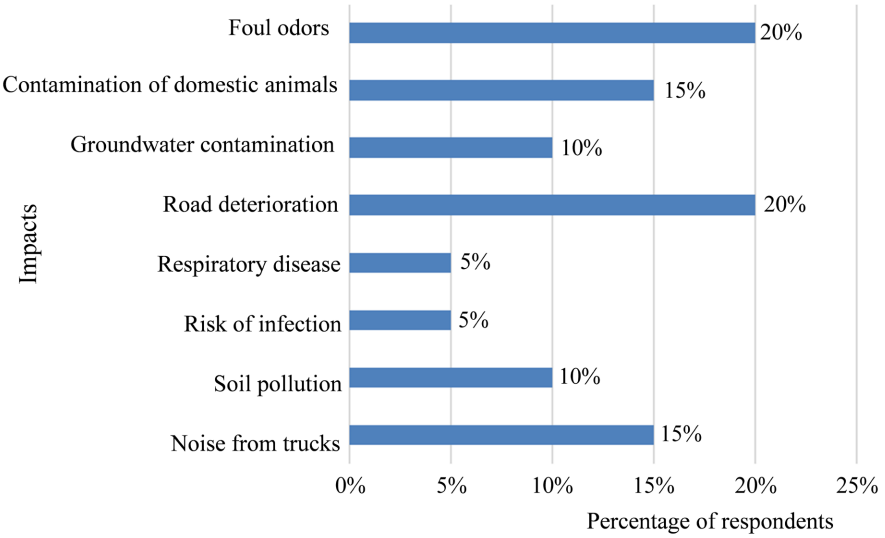

Figure 3. Perception of environmental and social impacts.

In fact, around 20% of respondents report that the most noticeable impact is the unpleasant odors caused by stagnant sewage sludge (Figure 4). Septic tank emptier leave the valves open after emptying to discharge the remaining sludge around the SSTP, which stagnate on the road, spoil the appearance of the street, and affect the quality of the ambient air.

Figure 4. Puddles of mud stagnating in the street.

Additionally, 10% of respondents associate this stagnation with the potential risk of groundwater contamination. Twenty percent of respondents believe that the constant passage of sewage trucks contributes to road deterioration.

Other risks associated with SSTP activities include insect proliferation, domestic animal contamination (Figure 5), respiratory diseases, and noise pollution from truck traffic.

Figure 5. Domestic animals are drinking polluted water from sewage sludge.

➢ **Impacts socio-économiques de l'activité des vidangeurs**

According to septic tank cleaners, manual emptying is more common than mechanical emptying. Eighty-eight percent (88%) of households use manual emptying to empty their septic tanks, compared to twelve percent (12%) who use mechanical emptying. Fourteen percent (14%) of households believe that mechanical emptying operators are better protected because they use personal protective equipment in accordance with SSTP requirements (Figure 6).

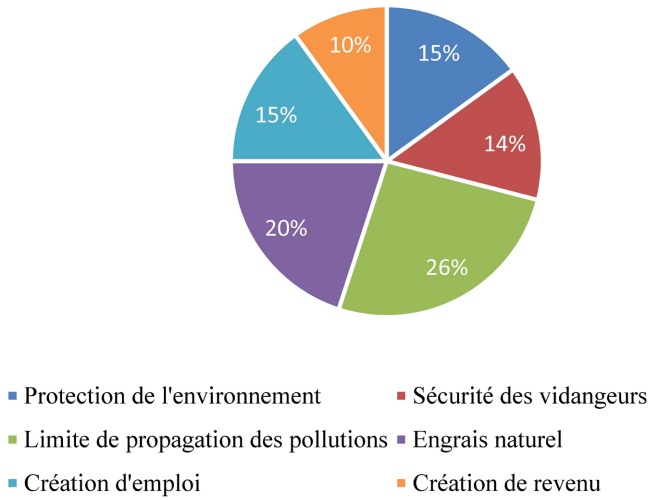

Figure 6. Positive impacts of the creation of the SSTP.

Twenty-six percent (26%) of septic tank cleaners report that they remove sludge from two (2) to six (6) tanks daily, at rates ranging from 20,000 to 30,000 XOF (F CFA) per tank.

The creation of the SSTP has benefited the environment and the population's living conditions. Fifteen percent of households report that septic tank cleaners no longer dump sludge directly into fields or streets because the SSTP site is developed, fenced, monitored, and under the responsibility of the central town hall.

This has limited the spread of pollution, according to 26% of those surveyed. Other positive impacts include producing natural fertilizer, creating jobs for young people, and generating funds for the city hall. However, it was noted in the field that sewage collectors lack safety equipment, such as gloves, boots, coveralls, and protective masks. This exposes them to the risk of disease when in contact with fecal matter. Overuse of the station was also observed, which could damage its infrastructure.

3.2. Discussions

Households in the city use two methods of sewage disposal: manual and mechanical emptying. According to the emptier, mechanical emptying is the more common method. This can be explained by the fact that the surveyed households belong to the middle class. Defo *et al.* (2015) [12] reported that, in Bafoussam, high-income individuals rarely use manual emptying services. According to Gning *et al.* (2017) [13], most poor households in developing countries cannot afford mechanical emptying services due to their high cost.

The SSTP receives mechanical sludge from 66 removal companies in the city of Niamey [14]. The choice of technique depends on the characteristics and volume of the sludge to be treated as well as a number of criteria that the designer must take into account. These include simplicity, effectiveness, social acceptance, implementation and operating costs, technology used, space occupied, and associated contamination risks. However, the technique adopted by the SSTP has health impacts and risks. According to Goumar *et al.* (2022) [15], this plant's purification efficiency reveals the beds' inefficiency in treating sludge. They report that the elimination of elements such as MS, MES, BOD_5, COD, and NTK never exceeds 50%, and the average COD/BOD_5 ratio of this biodegradable sludge is 1.9. Residents living near the SSTP experience the consequences of this situation in various ways, including foul odors, insect proliferation, and the risk of disease, contamination, and poisoning of animals grazing near the site. The population has identified several other impacts associated with SSTP activities, including noise pollution from the constant movement of trucks, road damage caused by truck drivers, and flooding during the rainy season. For instance, this site has received several complaints from local residents due to the nuisance it causes. Defo *et al.* (2015) [12] reported similar perceptions of impacts in Bafoussam, Cameroon, where complaints have also been filed. Thus, the leachate and sludge from the SSTP were not suitable for other uses and posed environmental and health risks. Magoumbala (2007) [16] reported that wastewater byproducts can carry certain diseases, including waterborne diseases. He also stated that sewage sludge management is generally problematic in less developed countries due to poor-quality leachate and dry sludge. According to Goumar *et al.* (2022) [15], co-composting is necessary prior to any use to prevent environmental and human health contamination. Additionally, there is a potential risk of soil and groundwater contamination from recalcitrant organic and inorganic pollutants in these effluents.

Nevertheless, the SSTP's activities have had a positive impact. It has significantly reduced the illegal dumping of untreated sewage sludge in fields and streets, limiting the spread of environmental impacts and health risks reported by local residents. There are also opportunities to produce natural fertilizer for farmers, provided they comply with pollution standards. According to Yahaya (2014) [14], dried sludge should be properly treated before being sold to farmers and market gardeners as fertilizer and to livestock farmers as fodder, which would add value to the treatment byproducts. Indeed, when valorized, the by-products provide substantial income [16].

However, public perception surveys undermine the income generation impact through job creation for young people and the town hall, which generates an average daily revenue of 109,000 XOF (FCFA). Tagba (2019) [17] reported similar results. Yahaya (2014) [14] stated that this activity reduces unemployment in peri-urban areas.

4. Conclusion and Recommendations

The study demonstrates that the Koubia SSTP serves as an essential infrastructure for sewage sludge management in Niamey. Although it contributes to reducing illegal dumping and diffuse pollution while generating positive socioeconomic spillover effects, its operation also induces environmental nuisances and health risks—most notably foul odors, road deterioration, soil and groundwater pollution, and insect proliferation.

These findings highlight the critical need to reinforce environmental management and monitoring protocols at the plant, while simultaneously improving site security and the valorization of its treatment byproducts. Furthermore, given the continuous increase in sewage sludge volumes generated within the city of Niamey, the establishment of additional treatment facilities appears indispensable to guarantee sustainable sanitation and preserve the local population's living environment.

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Conflicts of Interest

The authors declare that there are no conflicts of interest relevant to this article.

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