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Evaluation of Wastewater Suitability for Domestic Purposes in Ajegunle Community, Ogun State, Nigeria

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ABSTRACT

The suitability of ten (10) wastewater samples for domestic purposes in Ajegunle community, Yewa South, Ogun State, Nigeria, was assessed. Wastewater samples were collected from one source, abattoirs in the Ajegunle community around the Papalanto environ, Yewa South, Ogun State, Nigeria. These were analyzed for physiochemical property determination. The parameters used for the evaluations include pH, nitrate (NO_3), total dissolved solids (TDS), total solids (TS), and electrical conductivity (EC) using WHO (2004) standard guideline procedures. The wastewater samples (AJ1-AJ10) analyzed contained a reasonable degree of contamination, which showed that the wastewater is polluted for domestic purposes in the study area. The results for the wastewater samples indicated that the pH ranged from 5.38 to 7.68, Electrical Conductivity ranged from 741 to 928µs/cm, Total Dissolved Solid ranged from 1153 to 5143 mg/, Total Solid ranged from 1057 to 1725 mg/L, and Nitrate ranged from 4.32-18.1 mg/L. Most of the physiochemical parameter values were above the maximum permissible levels of WHO standards for domestic purposes. It is therefore recommended that wastewater treatment is required to achieve a minimum acceptable level for domestic reuse; public awareness on the dangers inherent in the possible re-use of the wastewater for domestic purposes needs to be carried out.

Keywords: Wastewater; Wastewater treatment; Abattoir wastewater; Drinking water; Physio-chemical parameters; Domestic reuse; Contamination; Public awareness; WHO standards; Ajegunle community.

1. Introduction

Rapid population growth in Nigeria and other developing countries has led to increased urbanization and a rise in domestic and industrial wastewater generation. This, coupled with existing water scarcity and pollution, is deteriorating the quality of available water sources. Industrial discharges and improper wastewater management are causing irreversible harm to surface water systems, impacting aquatic ecosystems and various sectors like urban development, food production, and industry [1]. Less than 10% of municipalities in developing countries adequately treat sewage before releasing it into natural water bodies, and industrial effluent treatment is often lacking, according to the Pan-American Health Organization. Apart from FCT Abuja and parts of Lagos, most cities in Nigeria lack central sewage systems, leading to decentralized wastewater management by individuals and businesses. Water pollution is a significant issue due to high pollutant concentrations surpassing natural absorption levels. Urgent environmental monitoring and management are necessary to address the high pollutant levels in various water bodies across the country [2,3]. Sewage is water-carried waste, consisting of gray water and black water, originating from domestic or commercial sources. Municipal sewage contains domestic and industrial wastewater, with variations depending on the types of industries present. Each person generates 150 to 200 liters of wastewater daily in a household. Domestic sewage, which includes waste from kitchens, bathrooms, and toilets, is discharged into treatment works. Industrial wastewater may contain toxic elements harmful to plants and animals. Factors influencing the characteristics of sewage include water usage, quality of water supply, sewerage systems, and human habits [4,5]. Untreated sewage discharge into surface waters leads to contamination, affecting human health and agriculture. To mitigate these harmful effects, wastewater can be stored and reused for agricultural and drinking purposes [6]. Agricultural wastewater reuse is categorized as direct or indirect. Direct reuse involves

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supplying irrigation water directly from a wastewater treatment plant, while indirect reuse collects wastewater downstream [7,8]. Direct reuse allows for easy control of irrigation water quality by managing the effluent quality [9]. However, controlling water quality in indirect reuse is challenging due to factors like effluent quality and hydrological conditions. The rise in wastewater treatment plants from urban growth is heightening the impact of indirect reuse on irrigation water quality [10].

The study focuses on wastewater suitability for domestic purposes in Ajegunle, Ogun State, highlighting risks to public health. It offers important data for local communities, governments, and policymakers to propose laws regarding using wastewater for domestic use in both Nigeria and worldwide.

1.1. Impacts of reuse treated wastewater

- **Heavy metals**

Treated wastewater may contain heavy metals and pollutants, which vary based on the wastewater type and treatment processes utilized. Researchers propose that the use of wastewater for irrigation can lead to the storage of contaminated heavy metals in plants, which may pose health risks as they have the potential to accumulate and contaminate food [11,12]. Factors such as the type of plants, soil properties, temperature, pH, moisture, and organic material content influence the mobility and availability of heavy metals. According to Khan et al. [12], the roots of plants have higher levels of heavy metal accumulation compared to other edible parts or leaves. Excessive metal presence in food can lead to disorders in the nervous, circulatory, enzymatic, and immune systems and potentially result in cancer.

- **Pathogens**

Untreated sewage contains pathogens such as E. coli and Salmonella. Nonetheless, certain organisms may remain in treated wastewater without advanced treatment such as membrane filtration. Schlindwein [11] noted elevated levels of adenoviruses in processed secondary effluent. Standards and laws are in place to protect individuals from dangerous infections when using recycled wastewater for farming purposes. Guidelines and regulations differ depending on the region and country, so the risk of being exposed to pathogens could vary based on the strict criteria that must be adhered to. Scientists have discovered that wastewater surpasses the allowable limit for E. coli and fecal enterococci during recycling. Farmers and farmworkers are at higher risk of contamination than customers, risking human illness. Fecal coliforms indicate the presence of disease-causing microorganisms and can identify bacteria that lead to typhoid, dysentery, and gastroenteritis. Hepatitis, gastroenteritis, pneumonia, and meningitis are among the various human diseases that can be caused by viruses present in wastewater [11]. To avoid irrigation water from directly touching the food, farmers need to understand the types of barriers that can be implemented. During the fruiting season and prior to harvest, it is important to refrain from using furrow and sprinkler irrigation with wastewater due to the high probability of the edible parts being exposed.

1.2. Study Objectives

The objectives of the study include the following: (1) Assess the physio-chemical properties of wastewater from abattoirs in Ajegunle; (2) Determine the pH, EC, TS, TDS, and nitrate level in the wastewater samples; (3) Evaluate the extent of contamination and its deviation from WHO standards; (4) Identify the need for wastewater treatment to meet acceptable levels for domestic reuse; and (5) Promote public awareness regarding the risks of using untreated wastewater for drinking purposes.

2. Materials and Methods

2.1. The Area of study

The Dahomey basin lies between latitudes N06^0 42' and 06^0 47' and longitudes 03^0 58' and 03^0 60' in south-western Nigeria. The study area is Ajegunle Community; it lies between latitude N6^0 53' 16'' and longitude E3^0 7' 50''. The area is about 17.3 km from Ilaro town (Figure 1). The area consists of sandstone and claystone. The area is a road-cut exposure of the Ilaro formation in the Dahomey basin. The area is about 7 km from Papalanto on the Ewekoro-Ifo road in Ogun State. The area is influenced by two seasons, the wet and dry seasons. Rainfall, which characterized the wet season, shows marked seasonal variation, with an average annual precipitation of 1238 mm and an average temperature of 27.10 °C. The climate in this region experiences a wet season from March to October, followed by a dry season. January receives minimal rainfall, while June has the highest average of 197mm, and March has the highest temperatures at 29.10 °C. August is the chilliest month.

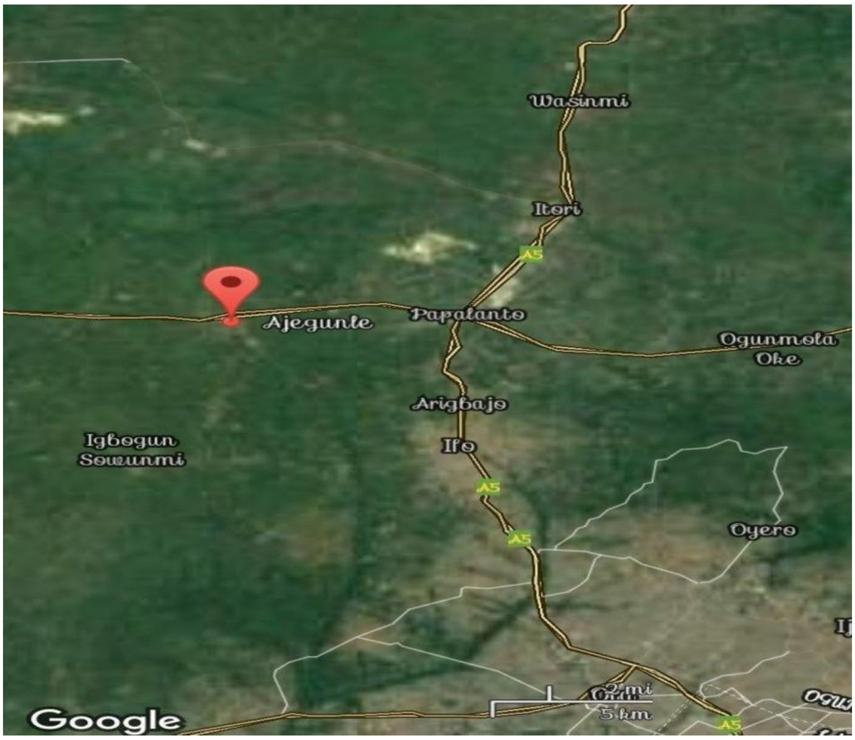

Figure 1. Map of the study area Ajegunle

2.2. The sources of wastewater

This study identified one type of wastewater: domestic wastewater from abattoirs around the Ajegunle community. Abattoirs are sources of sewage water, like urban wastewater. This wastewater may contain hazardous components like microbiological pathogens and chemicals from cleaning and disinfection operations. Activities like washing, disinfecting, and general cleaning use various chemicals. A diagram for direct/indirect wastewater reuse is provided in Figure 2.

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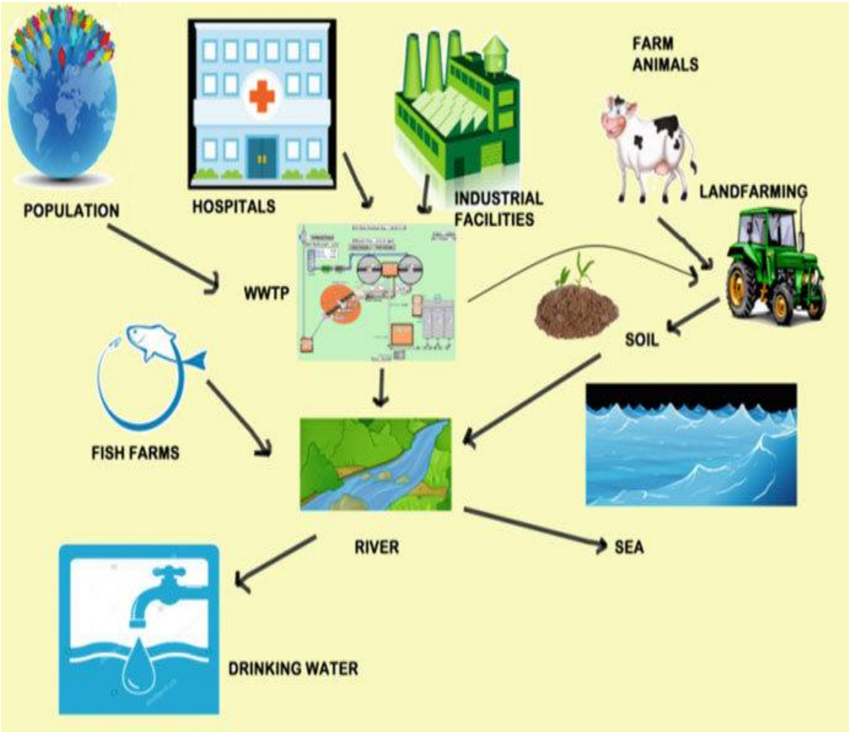

Figure 2. Schematic structure of wastewater sources

2.3. Sampling and analysis

A study was conducted in the Ajegunle community of Ogun State, identifying wastewater samples AJ1, AJ2, AJ3, AJ4, AJ5, AJ6, AJ7, AJ8, AJ9, and AJ10. The samples were collected in sterilized bottles, cleaned, rinsed, immersed in a 10% HNO_3 solution, and refrigerated. The samples were then analyzed in a lab using physical and chemical tests. Ten samples of wastewater (AJ1-AJ10) were collected from each source for physiochemical tests in a laboratory. The tests included pH, electrical conductivity, total dissolved solid, nitrate, and total solid. Electrical conductivity was determined using a conductivity meter, and pH was determined. The Geoearth Project Limited Laboratory analyzed sewage samples for various parameters such as TDS, TS, and NO_3 using standard water examination methods. The evaluated results of the wastewater samples were compared with WHO [13].

3. Results and Discussion

3.1. Sewage water analysis

Table 1 shows the wastewater results of the analysis of the samples collected that were compared with WHO standards for domestic purposes.

Table 1. Physio-chemical data results for AJI1 - AJ10

Samples	pH	TDS	EC	NO_3	TS
AJ1	7.41	2731	928	6.81	1687
AJ2	5.38	5143	798	18.11	1253
AJ3	6.69	1613	838	13.4	1901

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AJ4	7.35	3958	817	11.17	1131
AJ5	7.68	4153	749	5.08	1057
AJ6	7.61	2817	871	4.32	1725
AJ7	6.95	1153	913	9.02	1401
AJ8	7.21	1241	808	8.11	1032
AJ9	7.34	2017	991	7.18	1581
AJ10	6.88	2116	771	7.83	1505
Min	5.38	1153	741	4.32	1057
Max	7.68	5143	928	18.11	1725
WHO	6-8.5	500	500	50	1000

- **pH:** The pH values of the wastewater samples ranged from 5.38 to 7.68 for samples AJ1, AJ2, AJ3, AJ4, AJ5, AJ6, AJ7, AJ8, AJ9, and AJ10. The lowest values were recorded for sample AJ2, while the highest value was recorded for samples AJ5 and AJ6 (Table 1). These values fall within the permissible safe limit of WHO of 6-8.5 except for sample AJ2, which fell below. However, sample AJ2 has a pH value of 5.38, which is acidic and did not conform to the normal standard of the international limit. Most pH values less than 6.5 are considered too acidic for human consumption and can cause health problems such as acidosis [14]. The pH values obtained in all the sewage sources are suitable for domestic purposes upon thorough treatment of the wastewater.

- **Electrical conductivity:** Significant difference noted among EC of the sewage from the different sources AJ1, AJ2, AJ3, AJ4, AJ5, AJ6, AJ7, AJ8, AJ9, and AJ10, respectively, at 5% level of significance (Table 1). The conductivity of the effluents ranged from 741 to 928 µs/cm. All the sample values fell above the WHO limit of 1000 µs/cm for domestic purposes. With the value observed, all the water samples are not saved for consumption for both human beings and livestock [14].

- **Total dissolved solid:** The TDS levels in the wastewater samples from sources AJ1 to AJ10 varied significantly, ranging from 1153 mg/L to 5143 mg/L. These levels exceed the WHO guideline limit of 500 mg/L, indicating a high concentration of dissolved minerals in the water. This high TDS content can lead to unpleasant color, odor, and taste in the water, as well as a depletion of dissolved oxygen. The values recorded in this study are above the recommended range for drinking water set by WHO.

- **Total solid:** There is a significant difference among the Total Solid (TS) of the wastewater from the different sources AJ1, AJ2, AJ3, AJ4, AJ5, AJ6, AJ7, AJ8, AJ9, and AJ10 (Table 1). The values ranged between 1057 and 1725 mg/L. The total solid values recorded for the wastewater showed that all the samples were higher than the WHO recommended safe limit of 1000.

- **Nitrate:** There is a significant difference among the nitrate of the wastewater from the different sources AJ1, AJ2, AJ3, AJ4, AJ5, AJ6, AJ7, AJ8, AJ9, and AJ10, respectively, at the 5% level of significance (Table 1). Nitrate concentrations of the analyzed samples varied from 4.32-18.1 mg/L. All values of the wastewater samples fell below the WHO standard, which is 50 mg/L. High concentrations of nitrate in water might contribute to an infant's illness called methemoglobinemia.

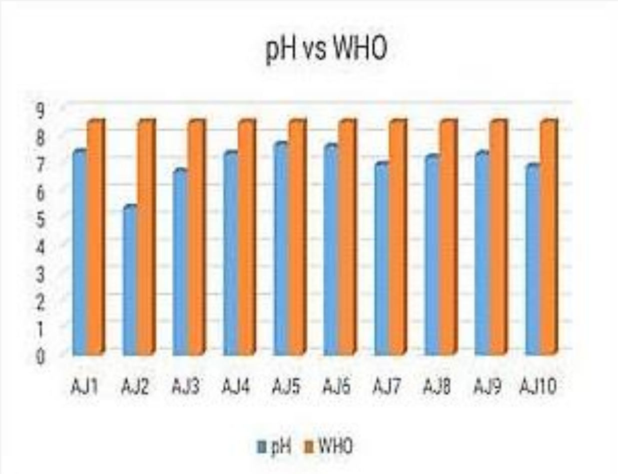

Figure 3. pH vs WHO results of AJ1-AJ10 of the study area

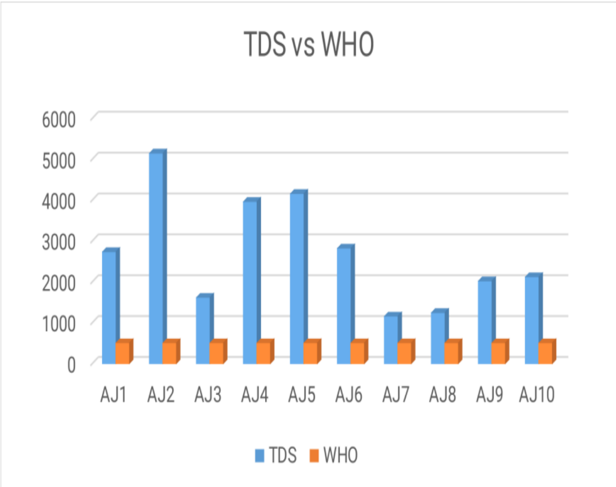

Figure 4. TDS vs WHO results of AJ1-AJ10 of the study area

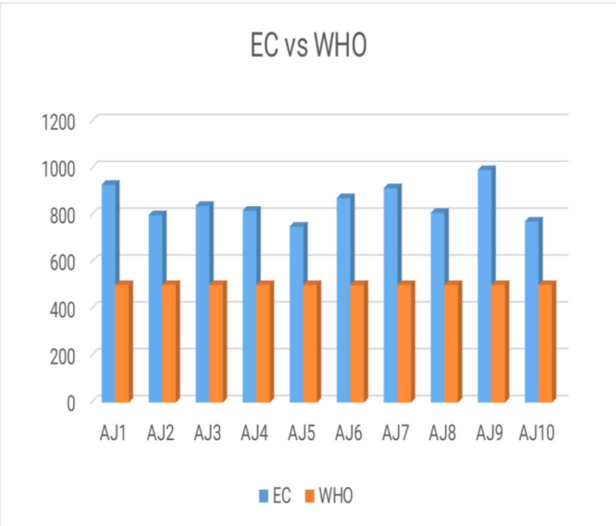

Figure 5. Electrical conductivity vs WHO results of AJ1-AJ10 of the study area

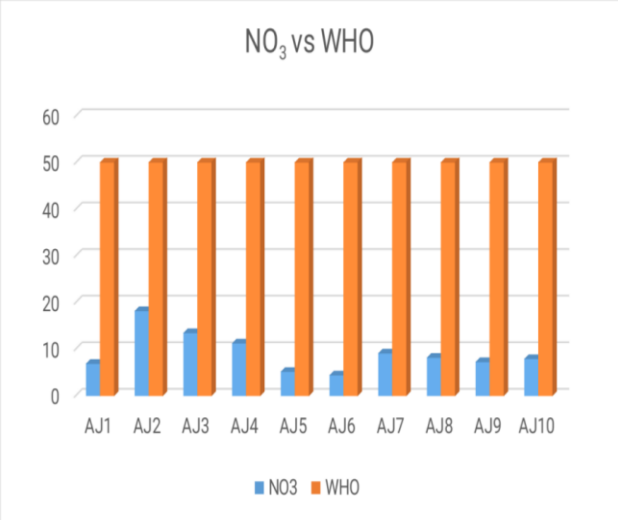

Figure 6. Nitrate vs WHO results of AJ1-AJ10 of the study area

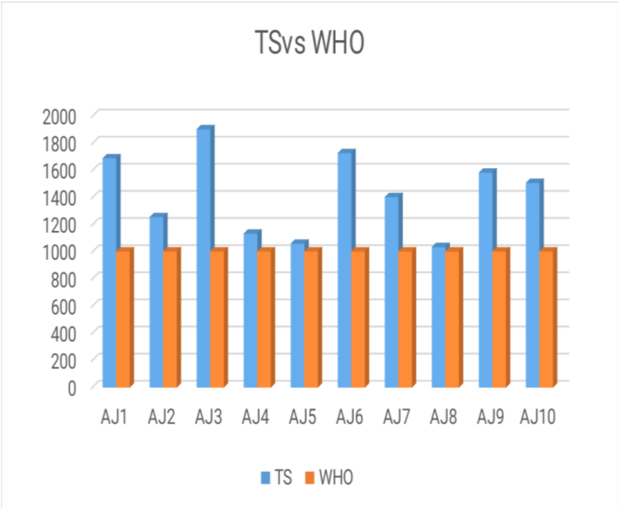

Figure 7. Total Solid vs WHO results of AJ1-AJ10 of the study area

4. Wastewater Treatment

Wastewater treatment typically involves three levels: primary, secondary, and tertiary. While most municipal facilities use primary and secondary treatments, some also incorporate tertiary treatments. The specific types and sequence of treatments can vary between plants.

The primary level of treatment is crucial for removing a significant portion of solids from wastewater. This process involves using screens and settling tanks. Screens, with openings around 10 millimeters, filter out large materials such as sticks and garbage. These materials are then disposed of in a landfill. The water proceeds to settling tanks, or clarifiers, where it remains for several hours. During this time, particles in the form of solids dropped to the bottom as sludge, and a scum layer formed on the surface. Scum and sludge are removed in primary treatment, where about 50% of BOD, 85% of undissolved solids, and up to 50% of fecal coliforms is eliminated. However, harmful pollutants are not completely removed without secondary treatment (Figure 8).

Secondary wastewater treatment involves using bacteria to break down pollutants using the combination of oxygen and bacteria. This enhances the bacteria's ability to digest contaminants. The treated water is then moved to settling

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collection tanks where sludge settles out, leaving water 90–95% free of pollutants [15]. This process reduces BOD and suspended solids by 85–90% and coliform bacteria by 90–99%.

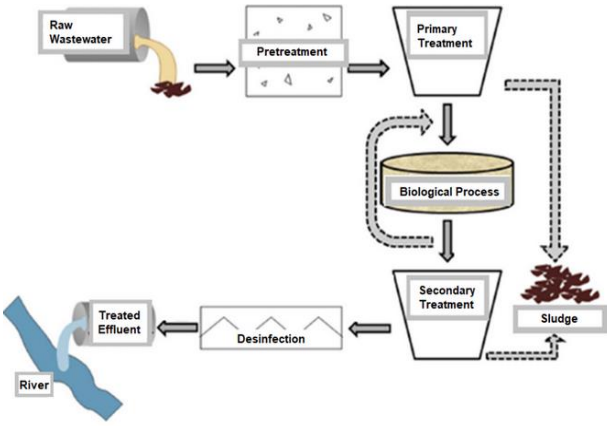

Figure 8. Typical Urban Wastewater Treatment Plant

Treatment from the tertiary method aims to remove dissolved substances such as color, metals, organic chemicals, and nutrients like phosphorus and nitrogen. This stage employs a range of physical, chemical, and biological methods, including biological nutrient removal (BNR). The diagram below shows the treatment process used for wastewater in Saskatoon [15]. In this treatment plant, wastewater undergoes treatments in both primary and secondary methods before entering the tertiary stage. During tertiary treatment, the Biological Nutrient Removal (BNR) process takes place in specialized bioreactors. This process utilizes bacteria under varying conditions across several tanks to break down contaminants. Each of the three tanks provides distinct environments with different oxygen levels (Figure 9). As the water moves through these tanks, phosphorus is effectively removed, and ammonia is converted into nitrate and nitrogen gas—transformations that other bacterial processes cannot achieve. The BNR process can eliminate over 90 percent of phosphates, significantly outperforming traditional methods. After spending approximately nine hours in the bioreactors, the water flows into the secondary clarifier, a settling tank where sludge containing bacteria settles at the bottom.

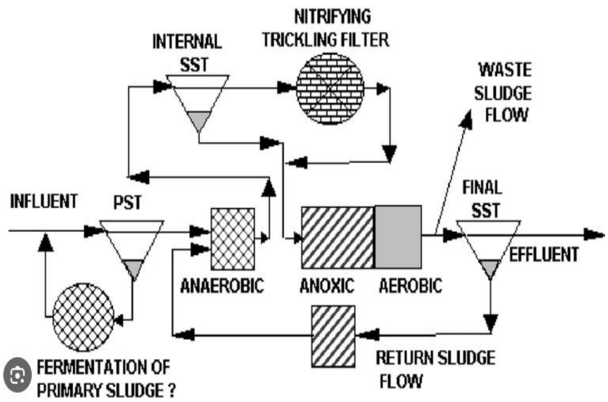

Figure 9. Biological Nutrient Removal Process

5. Conclusion

Reusing treated wastewater for domestic and agricultural purposes has benefits and drawbacks. A study in Nigeria evaluated the suitability of wastewater from abattoirs in Ajegunle for domestic reuse, finding it polluted and unsuitable. The water quality from the sources was significantly different, indicating the need for treatment options. Preventative measures are crucial for trouble-free operation and the long-term viability of wastewater for domestic use. With proper management, treated wastewater can be a safe and effective alternative to freshwater, helping address water scarcity. However, the study highlights the importance of assessing the quality of wastewater to ensure it is suitable for reuse in domestic settings.

The following recommendations need to be taken into consideration for future purposes of reusing of wastewater for domestic use: (i) Continued research on treatment technology may improve using treated wastewater for domestic purposes; (ii) Using treated wastewater at home can protect the environment and health, with improved monitoring and management; (iii) By piping treated wastewater directly to communities for household use, wastewater treatment facilities could become more connected to community water systems; (iv) Areas with limited water resources could experience a rise in the consumption of purified wastewater for household purposes due to the ongoing effects of global change on water supply; (v) Considering factors like infrastructure expenses, water conservation, and possible impacts on health and the environment can help determine if utilizing treated wastewater for household activities is financially feasible; and (vi) Promoting collaboration between the public and private sectors to facilitate investments in wastewater treatment infrastructure and encourage the use of treated wastewater for household needs.

Further research is needed to improve sustainable development strategies regarding the use of treated wastewater for domestic purposes. Insufficient studies on the long-term effects and economic viability for small community populations highlight significant research gaps. Enhanced treatment methods and monitoring techniques are necessary to ensure the safety and quality of treated wastewater. Filling these gaps can inform policy decisions and promote more equitable and sustainable water resource management practices.

Declarations

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This study did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interest and Ethics

The author declares no competing financial, professional, or personal interests.

Consent for Publication

The author declares that he consented to the publication of this study.

Authors' Contributions

Author's independent contribution.

Availability of data and material

Supplementary information is available from the author upon reasonable request.

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