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Appraising the Monthly Variation in Physicochemical Characteristics of Effluent Discharge from Abia Shoprite and Its Influence on Environmental Media

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Abstract

Appraising effluent characteristics is crucial to maintaining the integrity of aquatic and terrestrial ecosystems. Representative samples of water, soil, and sediment were abstracted from Abia Shoprite during the wet season (August, September, and October) and dry season (November, December, and January). Effluent water samples, taken from three discharge points during wet and dry seasons, were analyzed for physicochemical parameters while sediment and soil samples were analyzed for chemical properties using standard methods. The highest values obtained in effluent water during the wet and the dry seasons were 8.20±0.10 and 6.70±0.17 for pH, 66.77±2.45 and 38.00±2.19 µS/cm for EC, 1.82±0.01 and 3.03±0.15 mg/L for DO, 193.00±2.00 and 162.67±0.58 mg/L for BOD, 241.67±1.53 and 190.67±1.53 mg/L for COD, 90.87±1.63 and 80.17±0.12 mg/L for TDS, 72.70±2.21 and 51.17±0.45 mg/L for TSS, 18.90±0.36 and 13.17±0.90 mg/L for total alkalinity, 5.10±0.10 and 2.90±0.20 mg/L for total hardness, 4.77±0.15 and 1.77±0.15 NTU for Turbidity, and 29.23±0.15 and 31.60±0.20 °C for Temperature during October. Similarly, maximum pH values (7.13±0.21 and 7.20±0.26), organic carbon (0.10±0.01 and 0.25±0.03 %), organic matter (0.17±0.02 and 0.43±0.04 %), and electrical conductivity (37.67±1.53 and 50.00±1.00 µs/cm) were recorded in October for sediment and soil. A very strong positive relationship exists between physicochemical parameters in the wet and dry seasons. Indeed, the values of Temperature, BOD, and COD in effluent water reached unsuitable quality limits according to FAO/WHO standards. It is recommended that regular assessment of effluent release from Abia Shoprite should be carried out to protect the ecosystems.

Keywords: Effluent water, physicochemical parameters, ShopRite, sediment

Introduction

Large shopping malls are one of the fast-burgeoning firms in Nigeria. For instance, Shoprite Nigeria, with the largest retail chain of grocery stores in Africa. It (i.e., Shoprite) has an enormous purchasing capacity that offers customers a phenomenal buying diversity of grocery butchery, freshly baked breads, domestic items/housewares, and freshest fruit and vegetables at very economical cost all year round. Inside the shopping complex, there are hair and beauty salons, laundries, eateries, photographic studios, and pharmaceutical shops, among others. Since opening her first store in Nigeria, the Organization has over 2,000 employees who are indigenous to Nigeria. Notwithstanding this, most business activities being carried out in the Abia Shoprite culminate in releasing effluent.

The wastewater is discharged into the drainage system and sometimes finds its course into streams and rivers without proper treatment, thus making the stream or river water unfit because of potential contaminants such as organic and inorganic substances in it. Wastewater serves as a medium for transmitting sickness and diseases such as typhoid, cholera, and dysentery, which has resulted in the death of numerous people annually (Sims and Kasprzyk-Hordern, 2020). For this reason, improper discharge of unprocessed wastewater to aquatic bodies has negatively affected man and his habitat (Alwadani and Fatehi, 2018; Obaideen *et al.*, 2022).

In recent times, there has been a legitimate public outcry against offensive odors originating from Abia Shoprite operations from which wastewater is discharged directly into public drains. Additionally, the discharge issue is the complication and diverseness of contaminants, leading to the necessity for specific equipment to maintain acceptable water quality standards (Kakavandi and Ahmadi, 2019). The desirability usability of water is dependent on the amount of organic substance, odor, inorganic substance, color, and taste (Dissmeyer, 2000; Ogbonna *et al*., 2020). Organic contaminants include humic substances, phenolic compounds, petroleum, surfactants, pesticides, hydrocarbons (Wu *et al*., 2003; Barco-Bonilla *et al*., 2013; Birtek *et al*., 2022) while inorganic contaminants include ammonia, hydrogen sulfide, heavy metals, essential elements, sulfate (SO_4^{2-}), chloride (Cl^-), nitrate (NO_3) (Kjeldsen *et al*., 2002; Foli and Nude, 2012).

The human surroundings have undergone rapid transformations over decades due to man's actions that have global impact (Obaideen *et al*., 2022). Urbanization and economic growth have remarkably impacted unfavorable on human habitats (Solarin, 2020; Wilberforce *et al*., 2021; Olabi *et al*., 2022). National and State administrations are perturbed over the challenges and misfortune being perpetuated by large business outfits as well as man to his surroundings. Different regulations set up to safeguard terrestrial and aquatic ecosystems in the country are inefficient to controlling unplanned effluent discharge.

The entire human race is experiencing diverse environmental issues. For instance, water which is a limited asset is in short supply, hence, people should ensure most appropriate utilization of aforesaid assets, and concentration is given to environmental consciousness. It is crucial to ensure a high degree of concentration is designated to eco-friendly, recognizing and making the right endeavors that hamper human development (Obaideen *et al*., 2022). Thus, monitoring the anthropogenic input of inorganic contaminants in the environment is one way of minimizing environmental pollution, *inter alia*, food, water, and human contamination. Determination of water quality variables of concern. Physicochemical properties like total suspended solid (TSS), biochemical oxygen demand (BOD), nitrate (NO3-), total solid (TS), chemical oxygen demand (COD), total dissolved solids (TDS), dissolved oxygen (DO), pH, turbidity, chloride (Cl-) and sulfate ($SO4^{2-}$) in the effluents are of primary importance in assessing the environmental status of the study area. We, therefore, analyzed some physical, chemical and biological parameters in effluent discharged from Abia Shoprite. The findings of the study are expected to aid the Management of Abia Shoprite to adhere to regulations put in place by the Federal Ministry of Environment (FMEnv) for the protection of terrestrial vis-à-vis aquatic ecosystems in Nigeria. It will also enlighten the public on the possible dangers associated with using effluent water for irrigation purposes.

2. Materials and Methods

2.1 Study area

Samples were abstracted at Abia Shoprite situated around Amuzukwu layout Abia State, Nigeria. It lies between latitude 05° 30' to 05° 39' N and longitude 07° 27' to 07° 32' E. Amuzukwu has two times of year, which are the dry season and wet season. The dry period lasts between November and March while the wet period span between April and October. The mean annual temperature of 26.3°C and about 2137 mm of rainfall per year (Maduabuchi and Obikara, 2019). Amuzukwu Community has a stream that runs through Umuoleghe village, and the stream complements the water needs of the people living therein.

2.2 Sample collection

Field trips were done before to identify major activities going on in the Abia Shoprite that result in effluent discharge. These included the most frequent period of effluent discharge, the positions of the underground pipes through which effluents are discharged from Abia Shoprite, and plant species commonly found around the effluent discharged area. Three (3) large pipes of about 45 cm in circumference laid underground from the Abia Shoprite were selected for the collection of water effluent samples.

2.2.1 Collection of effluent samples

Effluent was collected from August to October 2020 for the wet season and November 2020 to January 2021 for the dry season. Six (6) trips comprising three months each for dry and wet seasons for effective comparison were carried out. One (1) liter plastic bottles were thoroughly cleaned with 5% nitric acid, and distilled water, and thoroughly rinsed with deionized water. Samples were collected 9-10 am and 5-6 pm on Wednesday, Friday, and Sunday of the second week of August, September, October, November, December, and January. At each sampling point (e.g., PI), the bottles were rinsed severally with effluent before collection. Bottles were filled to the brim by positioning the polyethylene bottles directly under the pipes for physicochemical parameters. The first composite samples were collected at the point sources PI, PII, and PIII on Wednesday, then at PI, PII, PIII on Friday, and finally, PI, PII, and PIII on Sunday. Since effluent samples from each particular day of sampling (e.g., Wednesday at PI, PII and PIII) were mixed to form composite samples. The Winkler reagent was added immediately to the effluent samples for dissolved oxygen (DO). Samples were covered air-tight, labeled well, packed in ice cubes and taken to the laboratory for analysis (APHA, 1998).

2.2.2 Collection of sediment samples

Sediments were abstracted during August, September, October, November, December and January. Sediment samples were collected from the drainage channels where PI, PII and PIII deposited effluent discharge with fine soil particles from Abia Shoprite. Sediment samples were collected using a sediment collector with an acid-washed plastic scoop and transferred to aluminum foils, well-sealed, carefully labeled and taken to Laboratory for analysis. Sediments abstracted at PI, PII and PIII were bulked together to form composite samples for each month.

2.2.3 Collection of surface soil under scooped sediments

Surface soil not more than sixty centimetres (60 cm) horizontal-wise under sediments deposited by the effluent was collected to determine some parameters from the study site. Soil samples were collected with well-cleaned hand trowels from PI, PII and PIII, bulked together to form a composite sample for each month (e.g., PI, PII and PIII August) placed in polyethylene bags, well-sealed, carefully labeled and taken to Laboratory for analysis.

2.3 Determination of physicochemical parameters in effluent samples

Standard methods were used for the determination of electrical conductivity, temperature, and pH in situ.

2.3.1. Analysis of COD

The COD was determined using the method of APHA (1998).

Calculation:

$$\text{Chemical oxygen demand, COD } \left(\frac{\text{mg}}{\text{L}}\right) = \frac{\text{Blank titre (mL)} - \text{sample titre (mL)}}{\text{Vol of sample titrated (mL)}} \text{ X } 1000$$

2.3.2 Analysis of DO

The content of dissolved oxygen was done according to Winkler's method (APHA, 1998).

$$\text{Dissolved oxygen conc. (mg/L)} = \frac{\text{Volume of 0.0125M thiosulphate (mL)}}{\text{Volume of sample titrated (mL)}} \text{ X } 101.6$$

2.3.3 Analysis of BOD5

The Dilution method of APHA (1998) was used to analyze BOD5.

$$\text{BOD content (mg/L)} = \frac{(x-y-az)\,(a+1)}{(a+1)2}$$

Where:

x = volume of 0.0125 M thiosulphate required for 100 mL of the original dilution (mL)

y= volume of 0.0125 M thiosulphate required for 100 mL of incubated dilution (mL)

a = volume of diluted water to 1 volume of sample (mL)

z = difference between volumes of 0.0125 M thiosulphate requires 100mL of dilution water before and after incubation (mL). (The blank correction).

2.3.4 Turbidity

The values of turbidity were determined using Hanna Instrument, LP 2000 turbid meter. The turbid meter was calibrated with the 1000, 100, 10 and 0.02 NTU standards. The cuvette was rinsed three times with the samples to be tested. The light shield cap was replaced and all outside surfaces were cleaned and made dry. The cuvette was pushed firmly into the optical well and indexed to the lowest reading. The NTU values were measured by pressing and releasing the arrow button and the value was recorded.

2.3.5 Determination of pH

The procedure APHA (1998) was adopted in the determination of pH in effluent samples.

2.3.6 Determination of Total Alkalinity, TA

The alkalinity was determined by a titrimetric method using methyl orange indicator (APHA, 1992). Alkalinity was then calculated using the formula:

$$\text{Total alkalinity (mg/L)} = \frac{\text{Vol of 0.1M H2SO4 x M x 1000}}{\text{Vol of sample used (mL)}}$$

2.3.7 Temperature (^{o}C) and Conductivity

The temperature of effluent water was measured according to the method of APHA (1998) while conductivity was determined by the method of AOAC (1998).

2.3.9 Total Suspended Solids

Total suspended solids in the treated samples were determined gravimetrically by evaporating 20 ml of treated samples in a pre-weighed evaporating dish at 110^o C and expressing it in mg/L.

2.3.10 Analysis of Total Dissolved Solids, TDS and Total Hardness

The total dissolved solid was determined by the method of (AOAC, 1998) while total hardness was analyzed using EDTA titrimetric method using eriochrome black T indicator solution. (APHA, 1992).

Total hardness was then calculated using the formula:

$$\text{Total hardness in Mg CaCO3} = \frac{\text{mL of EDTA x M}}{\text{mL of sample}} \text{ X } 1000$$

where M = Molarity of EDTA used.

2.4.1 Determination of chemical content of sediment and soil

2.4.1.1 Organic carbon (OC) content in sediment

The composite sediment and soil samples were separately sieved to remove any stones, and pebbles, then placed in an air-circulating oven to dry at 50 ºC for 5 days. The dried sediment and soil samples were separately crushed to the finest possible fraction using an acid-washed pestle and mortar and sieved with 0.5 mm sieve. The organic carbon (OC) of sediment and soil was analyzed using the procedure of Nelson and Sommers (1996).

$$\text{\% of organic carbon} = \frac{\text{me K2Cr2O7} - \text{me FeSO4 x 0.03 x 100 x (f)}}{\text{Mass (g) of air} - \text{dried sediment}}$$

$$\text{\% of organic carbon} = \frac{\text{me } K_2Cr_2O_7 - \text{me } FeSO_4 \text{ x 0.03 x 100 x (f)}}{\text{Mass (g) of air-dried sediment}}$$

Correction factor, f = 1.33

me = molarity of solution x volume (mL) of solution used

2.4.2 Analysis of organic matter (OM) and pH in sediment and soil

% Organic matter in soil/sediment = % Organic carbon x 1.729, while pH meter (Mettler Toledo, model MP 220) was used via the electrometric method (Page, 1982).

2.5 Experimental design and data analysis

A simple factorial experiment in a randomized complete block design (RCBD) with three replications. The data collected was subjected to one-way analysis of variance

(ANOVA) with statistical package for social science (SPSS) v. 17 and means were separated by Duncan New Multiple Range Test (DNMRT) according to (Steel and Torrie, 1980).

Results and Discussion

Monthly variation in physicochemical properties of effluent

The result of monthly variation in physicochemical properties of effluent discharged from Abia Shoprite Umuahia is presented in Table 1. The result shows that a significant difference was evident among the various physicochemical properties tested within the months of study. The highest and lowest physicochemical properties were observed in effluent discharged at Shoprite and control water, respectively. The highest values of BOD (193.00±2.00 mg/L), COD (241.67±1.53 mg/L), pH (8.20±0.10), EC (66.77±2.45 µS/cm), TDS (90.87±1.63 mg/L), TSS (72.70±2.21 mg/L), Alkalinity (18.90±0.36 mg/L), Total hardness (5.10±0.10 mg/L), and Turbidity (4.77±0.15 NTU) were recorded in effluent water collected in October while DO (3.03±0.15 mg/L) and Temperature (31.60±0.20 °C) were obtained in January. The high value of DO in January may be attributed to the lowest value of BOD (175.33±1.53 mg/L) and COD (212.33±1.53 mg/L) recorded for effluent water in January (Table 1) unlike other months that had high BOD's and COD's in effluent water discharged from Abia Shoprite. The variation in the Temperature of effluent water may be attributed to variability in weather conditions across the months, since the dry season is known for hot weather (especially January) unlike the wet season.

The high values of TDS, TSS, and Turbidity in October may be attributed to decaying food (organic materials from eateries, and bakeries), wastewater discharged from hair salons and photographic shops as well as pharmaceutical shops in Abia Shoprite. Decaying organic material and effluent discharge influences the turbidity, TDS, and TSS of water (Murhekar, 2011). The level of organic material in effluent water discharged from Shoprite in October influenced the pH to peak in October. The decomposition of organic material has a buffering effect in water bodies (Ogbonna *et al*., 2020). Similarly, the high electrical conductivity (EC) recorded in October may be attributed to the high concentration of salts, and organic and inorganic materials in the effluent discharged from Abia Shoprite within October. For instance, the use of sodium chloride (NaCl) to wash meat and fish before cooking and the washing of dishes with sodium-containing soaps and detergents at eateries located in Abia Shoprite release cations contaminated wastewater. The high BOD may be attributed to increasing oxidation of organic matter such as food wastes by aerobic bacteria within October. Effluents from food industries are high in biological oxygen demand and suspended solids (Rao *et al*., 2013). The high content of total hardness in effluent water sampled in October may be associated with wastewater from photo studios and hair and beauty salons, as well as salts and organic particles from eateries at Abia Shoprite.

The values of TDS (63.30±1.84 to 90.87±1.63 mg/L) and TSS (41.37±0.75 to 72.70±2.21 mg/L) which indicate materials carried in suspended form (Amadi *et al*., 2006; Ogbonna *et al*., 2020) falls below the permissible limit of 1,000 mg/L (TDS) and 80 to 150 mg/L (TSS) recommended by World Health Organization (WHO, 2011; 2017, respectively. The values of TDS and TSS in this study were below 230.01±5.77 – 470.03±9.24 mg/L TDS and 68.51±6.63 – 673.03±7.96 mg/L TSS reported in a similar study (Egesi *et al*., 2023). Turbidity is the cloudiness of water caused by a variety of particles that may come from organic material (Ogbonna *et al*., 2018). The value of turbidity ranged from 0.80±0.10 to 4.77±0.15 NTU, which is relatively below the maximum turbidity limit of 5 NTU set by (WHO, 2011). The value of turbidity in this study is well below 52.6 - 338 NTU reported in Ghana's Kete-Krachi District Hospital effluents (Tulashie *et al*., 2018).

Electrical conductivity (EC) is a measure of the dissolved ionic component in water and hence electrical characteristic (Ogbonna *et al*., 2018) as well as an indication of the amount of total dissolved substitution in water (Yilmaz and Koc, 2014). The values of electrical conductivity in the effluent samples were 26.63±1.55 to 66.77±2.45 µS/cm (Ghalib, 2017) stated that the classification of EC as low saline (EC = 1500 µS/cm), medium saline (EC between 1500 and 3000 µS/cm), and high saline (EC > 3000 µS/cm). Based on this classification, all effluent samples from Abia Shoprite were very low saline (i.e. well below EC = 1500 µS/cm). The EC in this study increased from 26.63±1.55 to 66.77±2.45 µS/cm, which is well below 1,200 µS/cm maximum allowable limit of conductivity set by WHO (2017) and 1,000 µs/cm set by National Drinking Water Quality Standard (NSDW, 2007) as well as 1064 – 1757 µS/cm reported in Ghana's Kete-Krachi District Hospital effluents (Tulashie *et al*., 2018).

The value of total hardness ($CaCO_3$) in effluent water increased from 2.10±0.10 to 5.10±0.10 mg/L, which is well below 500 mg $CaCO_3$/L set by WHO (2017). Meanwhile, Alsuhaimi *et al*. (2019) stated the degree of hardness as soft (0-75 mg $CaCO_3$/L), moderate (75-150 mg $CaCO_3$/L), hard (150-300 mg $CaCO_3$/L), and very hard (> 300 mg $CaCO_3$/L). Based on this classification, the total hardness of effluent water discharged from Abia Shoprite is classified as soft. The values of pH in effluent water ranged from 6.10±0.10 to 8.20±0.10, which is slightly acidic to alkaline. A pH of 7 is considered to be neutral but acidity increases as pH values decrease, and alkalinity increases as pH values increase (Shallcross *et al*., 2002). The value of pH in this study falls slightly below the 6.5 to 8.5 recommended by WHO (2017) but within the 6.0 to 9.0 established by the Federal Ministry of Environment (FMEnv, 2011). The value of pH in effluent water discharged from Abia Shoprite is relatively higher than the pH 6.70 – 8.17 reported in Ghana's Kete-Krachi District hospital effluents (Tulashie *et al*., 2018).

The temperature of effluent water discharged from Shoprite Complex ranged from 28.10±0.30 to 31.60±0.20 °C, which is higher than the 25 to 30 °C recommended by WHO (2003). High-temperature impact negatively water quality by enhancing the growth of microorganisms which may increase odor and color (UNICEF, 2008; Ogbonna *et al*., 2018). Therefore, it is pertinent that the temperature of effluent water released from Abia Shoprite is not so high in order not to boost microbial proliferation and decrease solubility of gases such as oxygen, carbon (iv) oxide (Yilmaz and Koc, 2014; Oyem *et al*., 2014; Ogbonna *et al*., 2018) since the effluent water is carried down to stream at Aba road Umuahia. Total alkalinity (TA) is used to indicate a system's capacity to buffer against acid impacts. The values of alkalinity increased from 7.90±0.46 to 18.90±0.36 mg/L, which is lower than 1.00±0.00 to 25.67±1.53 mg/L (TA) reported by Ovonramwen (2020), 15.03 to 21.14 mg/L (TA) recorded by Ottong and Ekanem (2021), and the maximum permissible limit (MPL) of 200-600 mg/L (TA) set by WHO (2011).

Chemical oxygen demand (COD) is an indicator of organic pollution, which is caused by the inflow of industrial waste that contains high levels of organic pollutants (Garg *et al*., 2010). The values of COD ranged from 174.00±2.00 to 241.67±1.53 mg/L, which is well above the 7.5 mg/L (COD) recommended by WHO (2003) but lower than 602–715 mg/L observed in Ghana's Kete-Krachi District Hospital effluents (Tulashie *et al*., 2018). The high value of COD in effluent water samples is an indication that effluent water discharged from Abia Shoprite is polluted and this may be attributed to high nutrient levels in food wastes (e.g., eateries, bakeries etc.). Biological oxygen demand (BOD) is a measure of the quantity of oxygen used by micro-organisms (e.g., aerobic bacteria) in the oxidation of organic matter (Ogbonna *et al*., 2018; 2020). The values of BOD ranged from 145.00±1.00 to 193.00±2.00 mg/L, which is well above the permissible limit of 3.0 mg/L (BOD) set by WHO (2011) and (FMEnv, 2011) and higher than 60.6 – 75.0 mg/L reported in Ghana's Kete-Krachi District Hospital effluents (Tulashie *et al*., 2018). The high BOD indicates oxygen is less for oxygen-demanding organisms to feed on. The higher content of COD than BOD in this study may be attributed to more organic compounds being chemically oxidized than biologically oxidized in the effluent.

Dissolved oxygen (DO) is the oxygen present in a dissolved form in water. The values of DO increased from 1.52±0.01 to 3.03±0.15 mg/L, which is relatively lower than 1.40 – 3.20 mg/L reported in Ghana's Kete-Krachi District Hospital effluents (Tulashie *et al*., 2018) but below the minimum permissible limit (MPL) of 5.0 mg/L (DO) by WHO (2011) and 7.5 mg/L (DO) by (FMEnv, 2011). The level of DO in effluent water discharged from Abia Shoprite may militate the growth and survival of organisms, since DO is low. Generally, the abundance of the physicochemical parameters tested in this study followed a decreasing order: COD > BOD > TDS > TSS > EC > Temperature > Alkalinity > pH > Total hardness > Turbidity > DO.

Monthly variation in chemical properties of sediment

The result of monthly variation in the chemical composition of sediment collected from the discharge points is summarized in Table 2. The results show that the highest values of pH (7.13±0.21), organic carbon (0.10±0.01 %), organic matter (0.17±0.02 %), and Electrical conductivity (37.67±1.53 µs/cm) in sediment were recorded in October. The high values of pH, organic matter, and organic carbon in sediment during October may be linked to the impact of inundation of effluent water on sediment. Since pH and other physicochemical parameters in effluent water were observed to have peaked in October (Table 1) 1). The high organic matter in sediment may be attributed to the deposition and decomposition of organic materials such as food wastes in effluent discharged from eateries and bakeries located in Abia Shoprite. Wastewater or effluents from firms, companies, or industries is considered a rich source of organic matter (OM) and appreciable amounts of plant nutrients (Haroon *et al*., 2019). The high pH values in sediment are associated with the buffering effect of organic matter against pH change. The high electrical conductivity in sediment may be attributed to the presence of soluble salts in wastewater released from Abia Shoprite. For instance, the release of sodium chloride (NaCl) from the washing of meat, fish, vegetables, and dishes as well as sodium from soaps and detergents in laundries.

The values of pH in sediment ranged from 4.97±0.06 in January to 7.13±0.21 in October, which is relatively higher than 5.20-6.21 reported in sediment in a related study (Islam *et al*., 2021). The value of organic carbon increased from 0.04±0.01 in January to 0.10±0.01 % in October, which is lower than 1.29-3.25g/100g organic carbon in sediment (Islam *et al*., 2021) indicating fewer amounts of plant and animal residues and sediment biota. The values of organic matter in sediment increased from 0.07±0.02 in January to 0.17±0.02 in October, which is lower than the 0.12 to 7.73 % reported by Khan *et al*. (2012). Organic matter in water sediment is controlled by factors such as the productivity and oxygen content of the waters, sedimentation rates, bacterial degradation and sediment mixing (Calvert *et al*., 1995, 1996; Rao and Veerayya, 2000; Khan *et al*., 2012). Organic matter originates from the complex mixture of lipids, carbohydrates, proteins, and other organic matter components produced by organisms such as aerobic bacteria (Meyers, 1997) that have lived in and around the effluent discharge channels. Accumulation of organic matter content of the sediments provides information that is important to interpretations of natural and human-induced changes in the area of study. The value of electrical conductivity in sediment increased from 14.33±1.15 in January to 37.67±1.53 µS/cm in October, which is lower than 24.60-374.00 µS/cm in sediment (Islam *et al*., 2021). Generally, the level or abundance of chemical parameters tested in sediment ranked in the following order: Electrical conductivity > pH > organic matter > organic carbon.

Monthly variation in chemical properties of soil

The result of monthly variation in chemical composition of soil sampled from the discharge points is summarized in Table 3. The result indicated that highest values of pH (7.20±0.26), organic carbon (0.25±0.03 %), organic matter (0.43±0.04 %), and Electrical conductivity (50.00±1.00 µs/cm) in soil were obtained in October and the values were significantly ($p<0.05$) higher than values obtained in August (6.50±0.10, 0.16±0.02 %, 0.28±0.04 %, and 35.33±1.15 µs/cm), September (6.63±0.12, 0.18±0.02 %, 0.31±0.03 %, and 41.00±1.00 µs/cm), November (6.00±0.10, 0.15±0.01 %, 0.26±0.02 %, and 24.33±1.53 µs/cm), December (5.40±0.10, 0.13±0.01 %, 0.22±0.02 %, and 21.33±0.58 µs/cm), and January (5.13±0.06, 0.11±0.01 %, 0.19±0.02 %, and 17.67±1.15 µs/cm). Soil sampled in the month of October exhibited higher values of OM, EC, OC, and pH as compared to other months of the year studied (Table 3). This showed that water effluent from Abia Shoprite profoundly affected the soil chemical composition, since the values of physicochemical characteristics of water effluent were observed to have peaked in the month of October (Table 1). The high value of soil pH (7.20±0.26) in October may be linked to high values of organic matter (0.43±0.04 %) and organic carbon (0.25±0.03 %) recorded in soil within the month of October (Table 2). Some organic materials discharged from Abia Shoprite include sweeteners, sugar, syrup, flavors, and water used in washing meat and vegetables, which has the capacity to rise or buffering effect on pH of the soil. Organic matter is known to have buffering effect on pH (Ogbonna *et al*., 2018). The values of soil pH ranged from 5.13±0.06 in January to 7.20±0.26 in October, which is slightly acidic to slightly alkaline. The values of soil pH (5.13±0.06 to 7.20±0.26) in this study is lower than 7.9–8.1 recorded in soil irrigated with effluent from Hudiara drain at Laloo village, Pakistan (Ogbonna *et al*., 2021). The values of organic matter in soil ranged from 0.19±0.02 in January to 0.43±0.04 % in October, which is lower than 0.65–0.91 % reported in soil irrigated with effluent from Hudiara drain at Laloo village, Pakistan (Ahmad *et al*., 2020). The values of electrical conductivity in soil increased from 17.67±1.15 in January to 50.00±1.00 µs/cm in October, which is higher than 9.79±0.58 to 33.27±0.83 µS/cm (EC) in soil (Ogbonna *et al*., 2021). Generally, the degree of enrichment of chemical parameters in soil is in descending order: Electrical conductivity > pH > organic matter > organic carbon.

Pearson correlation coefficient between physicochemical properties of effluent water in wet and dry season

The result of the Pearson correlation analysis of physicochemical properties of effluent water in wet and dry season is summarized in Table 4. The result show very strong positive relationship between physicochemical parameters in effluent water in wet and dry season; very strong relationship between physicochemical parameters in wet season, as well as strong positive relationship between physicochemical parameters in dry season. Indeed, very strong positive relationship exist between DO in wet season and BOD in dry season ($r = 0.988$, $p<0.01$), DO in wet season and COD in dry season ($r = 0.977$, $p<0.01$), DO in wet season and pH in dry season ($r = 0.865$, $p<0.01$), DO in wet season and EC in dry season ($r = 0.944$, $p<0.01$), DO in wet season and TDS in dry season ($r = 0.963$, $p<0.01$), DO in wet season and TSS in dry season ($r = 0.960$, $p<0.01$), DO in wet season and TA in dry season ($r = 0.947$, $p<0.01$), as well as DO in wet season and Turbidity in dry season ($r = 0.908$, $p<0.01$). The very strong positive relationship indicates that the parameters originate from the same source (i.e., Abia Shoprite). In addition, very strong positive relationship exist between BOD and COD in wet season (r = 0.987, p0.01), BOD and pH in wet season (r = 0.947, p0.01), BOD and EC in wet season (r = 0.962, p0.01). Also, BOD and TDS in wet season (r = 0.860, p0.01), BOD and TSS in wet season (r = 0.951, p0.01), BOD and TA in wet season<0.01). In furtherance of this, very strong positive relationship exist between COD and pH in wet season (r = 0.963, p0.01). COD and EC in wet season (r = 0.961, p0.01), COD and TDS in wet season (r = 0.881, p0.01), COD and TSS in wet season (r = 0.939, p0.01), COD and TA in wet season (r = 0.954, p0.01). In addition, COD and TH in wet season (r = 0.976, p0.01), COD and Turbidity in wet season (r = 0.958, p0.01)01)<0.01). In addition, very strong positive relationship exist between pH and EC in wet season (r = 0.954, p0.01). pH and TDS in wet season (r = 0.870, p0.01), pH and TSS in wet season (r = 0.954, p0.01), pH and TA in wet season (r = 0.979, p0.01), pH and TH in wet season (r = 0.988, p0.01), pH and Turbidity in wet season (r = 0.957, p0.01). As well as pH and in wet season and DO in dry season (r = 0.930, p0)01)<0.01). However, very strong negative relationship exist between DO and BOD in wet season ($r = - 0.973$, $p<0.01$), DO and COD in wet season ($r = - 0.993$, $p<0.01$), DO and pH in wet season ($r = - 0.977$, $p<0.01$), DO and EC in wet season ($r = - 0.961$, $p<0.01$), DO and TDS in wet season ($r = - 0.888$, $p<0.01$), DO and TSS in wet season ($r = - 0.937$, $p<0.01$), DO and TA in wet season ($r = - 0.963$, $p<0.01$), DO and TH in wet season ($r = - 0.983$, $p<0.01$), DO and Turbidity in wet season ($r = - 0.979$, $p<0.01$), DO in wet season and DO in dry season ($r = - 0.911$, $p<0.01$) as well as DO in wet season and Temperature in dry season ($r = - 0.940$, $p<0.01$).

Pearson correlation coefficient between chemical properties of sediment in wet and dry season

The result of the Pearson correlation analysis of chemical properties of sediment in wet and dry season is summarized in Table 5. The result show very strong positive relationship between chemical parameters in sediment in wet and dry season; very strong relationship between chemical parameters in sediment in wet season, as well as strong negative relationship between chemical parameters in sediment in dry season. Indeed, very strong positive relationship exist between pH and organic carbon in sediment in wet season ($r = 0.848$, $p<0.01$), pH and organic matter in sediment in wet season ($r = 0.849$, $p<0.01$), and pH and EC in sediment in wet season ($r = 0.869$, $p<0.01$). Similarly, very strong positive relationship exist between organic carbon and organic matter in sediment in wet season ($r = 1.000$, $p<0.01$), organic carbon and EC in sediment in wet season ($r = 0.855$, $p<0.01$), as well as organic matter and EC in sediment in wet season ($r = 0.858$, $p<0.01$). However, very strong negative relationship exist between pH in sediment in wet season and pH in sediment in dry season ($r = - 0.891$, $p<0.01$) while strong negative relationship exist between pH in sediment in wet season and organic carbon in sediment in dry season ($r = - 0.711$, $p<0.01$), pH in sediment in wet season and organic matter in sediment in dry season ($r = - 0.714$, $p<0.01$), and pH in sediment in wet season and EC in sediment in dry season ($r = - 0.7.85$, $p<0.01$).

Pearson correlation coefficient between chemical properties of soil in wet and dry season

The result of the Pearson correlation analysis of chemical properties of soil in wet and dry season is summarized in Table 6. The result show very strong negative relationship between chemical parameters in soil in wet and dry season; very strong relationship between chemical parameters in soil in wet season, as well as strong negative relationship between chemical parameters in soil in dry season. Indeed, very strong negative relationship exist between soil pH in wet season and soil organic carbon in dry season ($r = - 0.906$, p0.01), soil pH in wet season and soil organic matter in dry season ($r = - 0.906$, p0.01). And soil pH in wet season and EC in soil in dry season ($r = - 0.846$, p0.01)<0.01). Very strong negative relationship exist between soil organic carbon in wet season and soil pH in dry season ($r = - 0.808$, p0.01). Soil organic carbon in wet season and dry season ($r = - 0.909$, p0.01), soil organic carbon in wet season and organic matter in soil ($r = - 0.910$, p0.01), as well as soil organic carbon in wet season and EC in soil in dry season ($r = - 0.801$, p0.01)<0.01). Similarly, very strong negative relationship exist between soil organic matter in wet season and soil pH in dry season ($r = - 0.808$, p0.01). Soil organic matter in wet season and organic carbon in soil in dry season ($r = - 0.909$, p0.01), soil organic matter in wet and dry season ($r = - 0.910$, p0.01), and soil organic matter in wet and dry season ($r = - 0.910$, p0.01). And soil in wet and dry season ($r = 0.910$, p0.01), and soil in dry season ($r = 0.910$, p0.01), and soil in wet season ($r = 0.910$, p01)<0.01). Notwithstanding this, very strong positive relationship exist between soil pH in wet season and soil organic carbon in wet season ($r = 0.934$, p0.01). Soil pH in wet season and EC in soil in wet season ($r = 0.847$, p0.01), soil pH in wet season and EC in soil in wet season ($r = 0.847$, p0.01)<0.01). In addition, very strong positive relationship exist between soil organic matter and EC in soil in wet season ($r = 0.874$, $p<0.01$), soil organic carbon and organic matter in soil in wet season ($r = 1.000$, $p<0.01$), and soil organic carbon and EC in soil in wet season ($r = 0.874$, $p<0.01$).

Conclusion

The analyses of physicochemical properties of effluent water discharged from Shoprite and its impact on soil and sediment have shown that the effluent contain the selected physicochemical parameters tested, which also influenced the chemical content of soil and sediment. Although the concentration of some physicochemical parameters of effluent samples was in the allowable range of Codex Alimentarius Commission except for temperature, BOD and COD. This might result to water pollution when the effluent run into aquatic bodies such as stream and rivers vis-à-vis cause serious health issues in people that are drinking water from such contaminated aquatic bodies. A comparison of the results with those of similar areas in Nigeria showed that soil and sediment in nearby areas of effluent discharge contain lower values of physicochemical parameters. Consequently, it is recommended that regular monitoring and control procedures must be implemented by the Management of Abia Shoprite in order to minimize or prevent disease outbreak.

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Competing Interests

The authors declare no conflicting interest.

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Table 1: Monthly variation in physico-chemical properties of effluent water

Month	DO	BOD	COD	pH	EC	TDS	TSS	Alkalinity	Total hardness	Turbidity	Temp
August	$1.82^{c} \pm 0.01$	$175.33^{c} \pm 1.53$	$212.33^{c} \pm 1.53$	$7.20^{c} \pm 0.10$	$45.33^{c} \pm 2.96$	$82.30^{c} \pm 3.10$	$55.73^{c} \pm 1.20$	$12.80^{c} \pm 0.62$	$2.43^{de} \pm 0.15$	$2.67^{c} \pm 0.23$	$29.23^{d} \pm 0.15$
September	$1.72^{cd} \pm 0.01$	$182.67^{b} \pm 1.53$	$223.00^{b} \pm 1.00$	$7.67^{b} \pm 0.12$	$55.37^{b} \pm 2.21$	$86.03^{b} \pm 1.21$	$65.77^{b} \pm 1.15$	$15.93^{b} \pm 0.76$	$3.73^{b} \pm 0.15$	$3.30^{b} \pm 0.26$	$28.10^{f} \pm 0.30$
October	$1.52^{d} \pm 0.01$	$193.00^{a} \pm 2.00$	$241.67^{a} \pm 1.53$	$8.20^{a} \pm 0.10$	$66.77^{a} \pm 2.45$	$90.87^{a} \pm 1.63$	$72.70^{a} \pm 2.21$	$18.90^{a} \pm 0.36$	$5.10^{a} \pm 0.10$	$4.77^{a} \pm 0.15$	$28.80^{e} \pm 0.20$
November	$1.90^{c} \pm 0.10$	$162.67^{d} \pm 0.58$	$190.67^{d} \pm 1.53$	$6.70^{d} \pm 0.17$	$38.00^{d} \pm 2.19$	$80.17^{c} \pm 0.12$	$51.17^{d} \pm 0.45$	$13.17^{c} \pm 0.90$	$2.80^{cd} \pm 0.44$	$1.77^{d} \pm 0.15$	$29.63^{c} \pm 0.21$
December	$2.60^{b} \pm 0.20$	$158.00^{e} \pm 1.00$	$184.33^{e} \pm 1.53$	$6.40^{e} \pm 0.20$	$32.93^{e} \pm 1.42$	$71.63^{d} \pm 1.45$	$46.13^{e} \pm 1.12$	$10.83^{d} \pm 0.75$	$2.90^{c} \pm 0.20$	$1.17^{e} \pm 0.21$	$30.77^{b} \pm 0.15$
January	$3.03^{a} \pm 0.15$	$145.00^{f} \pm 1.00$	$174.00^{f} \pm 2.00$	$6.10^{f} \pm 0.10$	$26.63^{f} \pm 1.55$	$63.30^{e} \pm 1.84$	$41.37^{f} \pm 0.75$	$7.90^{e} \pm 0.46$	$2.10^{e} \pm 0.10$	$0.80^{f} \pm 0.10$	$31.60^{a} \pm 0.20$

Values are mean ± standard deviation of 3 replications

^{a,b,c} Means in the same column with different superscripts are significantly different ($P<0.05$)

Table 2: Monthly variation in chemical properties of sediment samples

Month	pH	Organic carbon	Organic matter	EC
August	$6.30^{c} \pm 0.10$	$0.07^{b} \pm 0.01$	$0.12^{b} \pm 0.02$	$25.33^{c} \pm 1.53$
September	$6.63^{b} \pm 0.12$	$0.08^{b} \pm 0.01$	$0.14^{b} \pm 0.02$	$32.00^{b} \pm 2.00$
October	$7.13^{a} \pm 0.21$	$0.10^{a} \pm 0.01$	$0.17^{a} \pm 0.02$	$37.67^{a} \pm 1.53$
November	$5.80^{d} \pm 0.10$	$0.07^{b} \pm 0.01$	$0.12^{b} \pm 0.02$	$16.67^{d} \pm 1.53$
December	$5.23^{e} \pm 0.15$	$0.05^{c} \pm 0.01$	$0.09^{c} \pm 0.02$	$15.33^{d} \pm 1.15$
January	$4.97^{f} \pm 0.06$	$0.04^{c} \pm 0.01$	$0.07^{c} \pm 0.02$	$14.33^{d} \pm 1.15$

Values are mean ± standard deviation of 3 replications

^{a,b,c} Means in the same column with different superscripts are significantly different ($P<0.05$)

Table 3: Monthly variation in chemical properties of soil samples

Month	pH	Organic carbon	Organic matter	EC
August	$6.50^{b} \pm 0.10$	$0.16^{b} \pm 0.02$	$0.28^{b} \pm 0.04$	$35.33^{c} \pm 1.15$
September	$6.63^{b} \pm 0.12$	$0.18^{b} \pm 0.02$	$0.31^{b} \pm 0.03$	$41.00^{b} \pm 1.00$
October	$7.20^{a} \pm 0.26$	$0.25^{a} \pm 0.03$	$0.43^{a} \pm 0.04$	$50.00^{a} \pm 1.00$
November	$6.00^{c} \pm 0.10$	$0.15^{bc} \pm 0.01$	$0.26^{bc} \pm 0.02$	$24.33^{d} \pm 1.53$
December	$5.40^{d} \pm 0.10$	$0.13^{cd} \pm 0.01$	$0.22^{cd} \pm 0.02$	$21.33^{e} \pm 0.58$
January	$5.13^{e} \pm 0.06$	$0.11^{d} \pm 0.01$	$0.19^{d} \pm 0.02$	$17.67^{f} \pm 1.15$

Values are mean ± standard deviation of 3 replications

^{a,b,c} Means in the same column with different superscripts are significantly different ($P<0.05$)

Table 4: Pearson correlation coefficient showing the relationship between physico-chemical properties of effluent wate in wet and dry seaso

		Wet											Dry										
		DO	BOD	COD	pH	EC	TDS	TSS	Alkalinity	T/Hard	Turbidity	Temp	DO	BOD	COD	pH	EC	TDS	TSS	Alk	T/Hard	Turbidity	Temp
Wet	DO	1																					
	BOD	-.973**	1																				
	COD	-.993**	.987**	1																			
	pH	-.977**	.947**	.963**	1																		
	EC	-.961**	.962**	.961**	.954**	1																	
	TDS	-.888**	.860**	.881**	.870**	.777*	1																
	TSS	-.937**	.951**	.939**	.954**	.966**	.821**	1															
	Alkalinity	-.963**	.954**	.954**	.979**	.929**	.925**	.965**	1														
	T/Hard	-.983**	.961**	.976**	.988**	.976**	.872**	.975**	.978**	1													
	Turbidity	-.979**	.925**	.958**	.957**	.926**	.882**	.925**	.952**	.966**	1												
	Temp	0.174	-0.308	-0.216	-0.286	-0.327	-0.237	-0.464	-0.356	-0.315	-0.120	1											
Dry	DO	-.911**	.931**	.921**	.930**	.961**	.770*	.971**	.915**	.949**	.875**	-0.508	1										
	BOD	.988**	-.981**	-.991**	-.942**	-.950**	-.858**	-.917**	-.933**	-.953**	-.960**	0.138	-.893**	1									
	COD	.977**	-.988**	-.981**	-.961**	-.977**	-.825**	-.952**	-.945**	-.965**	-.936**	0.278	-.947**	.982**	1								
	pH	.865**	-.896**	-.893**	-.840**	-.868**	-.785*	-.800**	-.816**	-.852**	-.754*	0.333	-.856**	.859**	.881**	1							
	EC	.944**	-.928**	-.926**	-.939**	-.913**	-.906**	-.951**	-.977**	-.953**	-.962**	0.297	-.878**	.924**	.922**	.735*	1						
	TDS	.963**	-.981**	-.976**	-.954**	-.955**	-.868**	-.978**	-.970**	-.976**	-.936**	0.370	-.942**	.956**	.962**	.845**	.944**	1					
	TSS	.960**	-.975**	-.969**	-.943**	-.983**	-.844**	-.970**	-.949**	-.977**	-.923**	0.375	-.951**	.949**	.964**	.890**	.935**	.976**	1				
	Alkalinity	.947**	-.943**	-.945**	-.914**	-.971**	-.821**	-.956**	-.921**	-.957**	-.938**	0.320	-.940**	.941**	.949**	.827**	.941**	.943**	.979**	1			
	T/Hard	.774*	-.724*	-.759*	-.753*	-0.626	-.705*	-0.570	-.701*	-.680*	-.729*	-0.214	-0.557	.781*	.744*	.667*	0.633	0.656	0.596	0.550	1		
	Turbidity	.908**	-.864**	-.885**	-.943**	-.932**	-.810**	-.941**	-.933**	-.962**	-.912**	0.372	-.900**	.847**	.874**	.760*	.922**	.904**	.933**	.920**	0.518	1	
	Temp	-.940**	.971**	.952**	.946**	.930**	.894**	.975**	.981**	.961**	.910**	-0.455	.935**	-.927**	-.947**	-.840**	-.952**	-.988**	-.962**	-.923**	-0.638	-.897**	1

**. Correlation is significant at the 0.01 level ($P<0.01$). *. Correlation is significant at the 0.05 level ($P<0.05$)

Table 5: Pearson correlation coefficient showing the relationship between chemical properties of sediment samples in wet and dry season

		Wet				Dry			
		pH	Organic carbon	Organic matter	EC	pH	Organic carbon	Organic matter	EC
Wet	pH	1							
	Organic carbon	.848**	1						
	Organic matter	.849**	1.000**	1					
	EC	.869**	.855**	.858**	1				
Dry	pH	-.891**	-.851**	-.852**	-.935**	1			
	Organic carbon	-.711*	-0.550	-0.553	-.770*	.789*	1		
	Organic matter	-.714*	-0.555	-0.558	-.772*	.790*	1.000**	1	
	EC	-.785*	-0.489	-0.493	-0.622	0.645	0.402	0.400	1

**. Correlation is significant at the 0.01 level (P<0.01). *. Correlation is significant at the 0.05 level (P<0.05)).

Table 6: Pearson correlation coefficient showing the relationship between chemical properties of soil samples in wet and dry season

		Wet				Dry			
		pH	Organic carbon	Organic matter	EC	pH	Organic carbon	Organic matter	EC
Wet	pH	1							
	Organic carbon	.934**	1						
	Organic matter	.934**	1.000**	1					
	EC	.847**	.874**	.874**	1				
Dry	pH	-.750*	-.808**	-.808**	-.917**	1			
	Organic carbon	-.906**	-.909**	-.909**	-.850**	.896**	1		
	Organic matter	-.906**	-.910**	-.910**	-.850**	.896**	1.000**	1	
	EC	-.846**	-.801**	-.800**	-.923**	.895**	.857**	.856**	1

**. Correlation is significant at the 0.01 level (P<0.01).m*. Correlation is significant at the 0.05 level (P<0.05).