ASSESSMENT OF THREE PHYSICAL PROPERTIES OF EFFLUENTS FROM SELECTED FOOD PROCESSING CENTRES AND THEIR EFFECT ON RECEIVING WATER BODIES IN ABAKALIKI, EBONYI STATE, NIGERIA

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ABSTRACT

The study assessed three physical properties of effluents from selected food processing centres and their effects on receiving water bodies in Abakaliki, Ebonyi state. Three replicates of both effluent and water samples from effluent-receiving water bodies were collected in 2023 and 2024 from Native Delicacy, Crunches, Chicken Republic and Kilimanjaro. The samples collected were taken to the Soil and Environmental Management Laboratory of Ebonyi State University for analyses of temperature, total dissolved solids (TDS) and total suspended solids (TSS). Data collected were subjected to analysis of variance and mean separated using F-SLD (p<0.05). The results revealed that the effluent temperatures for all the study centres in the dry season ranged from 28.0 – 29.5°C and were higher than that of wet season values. The receiving water bodies' temperatures were lower than the effluent temperatures but higher than WHO standards in all the study centres. The TDS and TSS of effluent studied showed a significant difference in all the food processing centres and were higher in the dry season compared to the wet season in the receiving water bodies. The TDS value ranged from 46.80 – 55.60 mg/L in the dry season and 31.00 – 50.20 mg/L in the wet season though the values were higher than that of control and were within WHO standards. The study showed that the receiving water bodies were poor in quality and there is a need to treat them before use. This research contributes to the growing body of knowledge on industrial pollution in Abakaliki.

Keywords: Urban environment, Food industries, Effluents, Temperature, Total dissolved solids, Total suspended solids

INTRODUCTION

Food processing centres have become an integral part of the urban landscape in many Nigerian cities, including Abakaliki, the capital of Ebonyi State. These establishments cater to the growing demand for quick, convenient and affordable meals, especially among the working population and students. The proliferation of fast-food restaurants in Abakaliki reflects broader economic and social changes, including urbanization, increased disposable income, and changing dietary habits.

The growth of food processing centres in Abakaliki can be attributed to several factors. Firstly, the city has experienced significant urbanization and population growth, which has increased the demand for diverse food options. According to a report by the National Population

Commission of Nigeria, urban areas like Abakaliki are expanding rapidly, leading to changes in consumption patterns and lifestyle choices (Enyim and Nweze, 2013).

Moreover, the rise of a middle class with higher disposable incomes has fuelled the demand for convenience foods. As noted by French *et al.* (2010), the increasing number of dual-income households has led to a higher preference for eating out, particularly in food processing centres. This trend is evident in Abakaliki, where several national and local fast-food chains have established outlets to cater to this growing market.

The operation of food processing centres also raises environmental concerns, particularly regarding waste management and effluent discharge. The production and disposal of packaging materials, as well as the treatment of wastewater from these establishments, pose significant challenges. Improperly treated effluents can contaminate local water bodies, affecting water quality and aquatic life (Singh *et al.*, 2023). The impacts of degradation caused by wastewater effluent from food processing centres may result in physical changes to receiving waters, the release of toxic substances, bioaccumulation or biomagnification in aquatic life, and increased nutrient loads (Ganoulis *et al.*, 2009; Okereke *et al.*, 2016).

The study ascertained the pollution load of food processing centres on receiving water bodies and helped bring to the notice of the companies the effect of their waste on the environment in other to proffer solutions on the best ways of discharging effluent into rivers.

Impurities float and dissolve in water causing it to be muddy and cloudy, which makes the water unfit for usage since it acts as a source of diseases and illnesses (AOS, 2018). The total dissolved solids (TDS) measurement is crucial in water quality analysis for several reasons. Firstly, high TDS levels can cause several health and environmental concerns. High TDS in drinking water can lead to kidney stones, gastrointestinal problems, and mineral imbalances in the body. Secondly, high TDS can also impact the taste, appearance, and odour of the water. Water with elevated TDS levels often has a salty or metallic taste, and it may appear cloudy, yellow, or brown. Thirdly, high TDS levels in water contribute to scaling on pipes and appliances, which shortens their lifespan. On the other hand, low TDS levels can also indicate poor water quality. Water sources with low TDS levels in an area are likely to be more susceptible to contaminants that arise from human activities such as industrial waste, agriculture, and sewage (BOQU, 2007a).

Over the last decade, the effects of total suspended solids (TSS) on aquatic life have been studied intensively throughout the world. TSS are an extremely important cause of water quality deterioration leading to aesthetic issues, higher costs of water treatment, a decline in fisheries resources and serious ecological degradation of aquatic ecosystems. As such, government-based environmental institutions have set recommended water quality guidelines for concentrations of TSS in freshwater ecosystems (Bilotta and Brazier, 2008).

Temperature measurement is a crucial aspect of water quality analysis because it has a significant impact on the physical, chemical, and biological characteristics of water. The temperature of water affects important processes such as microbial activity, oxygen solubility, and chemical reactions (BOQU, 2007b). Temperature affects the photosynthetic activities of aquatic plants, the metabolic rates of aquatic organisms and the sensitivity of these organisms to pollution, parasites and disease (ARROYO, 2024).

Therefore, when temperature, TSS and TDS are not within the recommended standard, they will make the water unfit for usage. Since these food processing centres are discharging their effluents into nearby water bodies, there is a need to study these parameters. And to proffer solutions on the best ways of discharging effluent into rivers. The objective of the study is to assess three physical properties of effluent from fast food centres and its effects on receiving water bodies in Abakaliki, Ebonyi State, Nigeria.

MATERIALS AND METHODS

Abakaliki is the capital city of Ebonyi State in Southeastern Nigeria. It was the headquarters of the old Ogoja province before the creation of the Southeastern State in 1967.

The geographical coordinate lies within 06°040″ N Latitude and 08°65′0″ E Longitude (Figure 1).

Figure 1: Map of Abakaliki, Ebonyi State where the four fast food centres (Kilimanjaro, Chicken Republic, Native Delicacy and Crunches) (Blue arrows) and the College of Agricultural Sciences are located (Google, 2024)

Abakaliki occupies the eastern axis of Ebonyi State, covering a land area of about 584 km^2. The inhabitants are predominantly agrarians raising livestock and crops at both subsistence and commercial levels (Echiegu and Liberty, 2013). It has an estimated population of 693,000, as updated by Macrotrends (2024). Agro-ecologically, the area is located within the derived savannah zone of Southeast Nigeria, lying within the plains of Ebonyi River, Iyiudele and Iyiokwu Rivers that are tributaries of Cross River (Aja *et al.,* 2020).

Experimental Design: The experiment was conducted using a field survey of four aquatic ecosystems and a control water sample. Four fast food centres were selected namely; (i) Kilimanjaro located at Ogoja Road after Union Bank, (ii) Chicken Republic located at Water Works Road before First Bank of Nigeria, (iii) Native Delicacy located along Ogoja Road and (iv) Crunches located along Afikpo Road.

It was observed that all the selected study sites adopted the practice of discharging their effluents into drainage through an underground pipe from their kitchen down to the nearby water bodies. Three replicate samples of effluent and water were collected in each location in February 2023 and July 2023 to represent dry and wet seasons. The same was repeated in February 2024 and July 2024.

Sample Collection: Samples of effluent were collected at the points of discharge from the drainage and were put in a sterilized 60 cl container packaged in ice cooler vessels and transported to the Soil and Environmental Management Laboratory, Ebonyi State University for analysis. The *in-situ* temperature of the effluents was taken with a digital thermometer. Water samples were collected from water bodies within the discharge areas of the selected fast food centres. The water bodies are the water body behind Kilimanjaro, the water body adjacent to Chicken Republic, Water Works Road, the water body exactly in front of the Native Delicacy kitchen along Ogoja Road, and the Azuinyiokwu water body for Crunches. Also, a water sample was collected from the College of Agricultural Sciences (CAS), Ebonyi State University and used as the control.

Laboratory Analysis: The following parameters were analyzed in the Soil and Environmental Management Laboratory, Ebonyi State University.

Temperature: Temperatures were measured in-situ using a digital thermometer. The thermometric bulb containing the mercury was vertically immersed in the sampled aquatic ecosystem and the control samples and allowed to stand for some minutes. The temperature is read off the digital metre in degrees Celsius (°C) (Anyanwu *et al.,* 2022).

Total suspended solids (TSS): The gravimetric method of analysis was used in TSS determination. A clean 100 mL crucible was dried at 104.0 ± 1.0°C in an oven until a constant weight was obtained. It was subsequently cooled to room temperature in a desiccator and later weighed. A 50 ml sample was measured into the crucible and evaporated to dryness in a steam bath. The outside of the crucible was wiped, and the residue dried in an oven for 1 hour at 104.0 ± 1.0°C. The crucible was quickly transferred to a desiccator, cooled to room temperature, and weighed. The crucible was dried further in an oven for 10 minutes and reweighed after cooling to room temperature. This was repeated until the weight of the dish plus residue was constant to within 0.05 mg (Bhagure and Mirgane, 2011).

Total dissolved solids (TDS): The samples were mixed and filtered. 100 ml of the sample was filtered using 0.45 μm Whatman filter paper, placed in a pre-weighted crucible and evaporated to dryness at a temperature of 104.0 ± 1.0°C, cooled in a desiccator at room temperature, and the remaining residue was weighed (Ministry of Environment, 2020).

Statistical Analysis: Data collected for the three food processing centres and the control were subjected to analysis of variance (ANOVA). Further, mean separation testing was done using Fisher's Least Significant Difference (F-LSD). The significant differences between yearly data (2023 vs. 2024) were separated using the Students' t-test. Significant differences were accepted at a 5% probability level, or 95% confidence interval (Obi, 2002). All recorded water values were compared to the World Health Organization standard (WHO, 2008).

RESULTS

Table 1 shows the result of the three physical properties of effluent in the dry season of the 2023 and 2024 study years. There was a significant ($p<0.05$) difference in the value of temperature, TS and TDS in the locations except in the 2023 study year TDS recorded a non-significant value ($p>0.05$). The order of increase in temperature was Native Delicacy > Crunches = Chicken Republic and Kilimanjaro in the 2023 dry season. While Native Delicacy > Crunches = Chicken Republic and Kilimanjaro in the 2024 dry season.

Kilimanjaro and Chicken Republic recorded the highest value of TDS than Native Delicacy and Crunches in 2023, while Chicken Republic > Crunches > Kilimanjaro > Native Delicacy in the 2024 dry season. The TSS in the effluent ranged from 146.30 ± 0.50 to 151.29 ± 0.50 mg/L with Native Delicacy recording the highest, while Chicken Republic and Kilimanjaro recorded the lowest value. Table 2 presents the result of the three physical properties of effluent from selected food processing centres in Abakaliki during the 2023 and 2024 wet seasons. There was a significant difference ($p<0.05$) in the value of temperature, TSS and the TDS in all the food processing centres in the 2023 and 2024 wet seasons. The observed temperature values of Kilimanjaro effluents (28.0 ± 1.50°C) were similar to the temperature values of Crunches effluents (28.0 ± 1.50°C) and Chicken Republic effluents (28.0 ± 1.05°C). These values were lower than the temperature value of Native Delicacy effluents (29.50 ± 0.5°C) in 2023. In 2024 the temperature values were between 28.0 ± 0.50 – 29.0 ± 0.50°C with Native Delicacy recording the highest value and Chicken Republic and Kilimanjaro recording the lowest respectively in 2024. Native Delicacy recorded the lowest and Kilimanjaro recorded the highest TDS values in 2023. In 2024, TDS value ranged from 80.36 – 101.25 mg/L with Native Delicacy recording the lowest and Chicken Republic recording the highest respectively.

The TSS value was on the increase in Kilimanjaro < Chicken Republic < Crunches < Native Delicacy in 2023, while Native Delicacy > Crunches > Chicken Republic > Kilimanjaro in 2024 wet season respectively.

Table 3 shows the three physical properties (Temperature, TSS and TDS) of receiving water bodies in Abakaliki in the 2023 and 2024 dry seasons. There was a significant difference ($p<0.05$) in all food processing centres and seasons, but the temperature values showed a non-significant difference ($p>0.05$) in 2023. The temperature of the receiving water bodies in 2023 ranged from 25.0 to 26.0°C, and in 2024, it was consistently 25.0°C in all the receiving water bodies studied. All temperature values were within the WHO guideline value of ≤ 25°C. The TDS levels increased in the order Kilimanjaro receiving stream < Native Delicacy receiving stream < Crunches receiving stream < Chicken Republic receiving stream in the 2023 dry season. In 2024, the TDS value ranged from 41.70 – 50.10 mg/L with the Chicken Republic receiving stream recording the lowest while the Kilimanjaro receiving stream had the highest TDS value. The control level was lower in all the food processing centres and seasons. All TDS values were within the WHO guideline value of ≤ 1000 mg/L, indicating that the levels of dissolved solid concentrations were within safe limits for the receiving streams.

Table 1: Physical properties of effluent from different food processing centres in Abakaliki 2023 and 2024 dry season

Food Processing Centres	Temp °C		TDS mg/L		TSS mg/L	
	2023	2024	2023	2024	2023	2024
Native Delicacy	29.50 ± 0.50[c]	29.00 ± 0.50[c]	122.46 ± 1.50[b*]	120.13 ± 1.00[b]	151.29 ± 0.50[c]	146.99 ± 1.50[c]
Crunches	28.00 ± 1.50[b]	28.50 ± 1.50[b]	122.35 ± 0.50[b]	123.46 ± 1.50[c*]	146.35 ± 1.00[b]	145.90 ± 0.50[b]
Chicken Republic	28.00 ± 1.05[b]	28.00 ± 0.50[b]	123.48 ± 1.50[c]	123.48 ± 1.05[c]	146.30 ± 0.50[b]	145.85 ± 1.50[b]
Kilimanjaro	28.00 ± 1.50[b]	28.00 ± 1.00[b]	122.48 ±1.05[b]	123.35 ± 1.50[c*]	146.30 ± 1.50[b]	145.86 ± 1.05[b]
Control	26.00 ± 0.50[a*]	25.00 ± 1.00[a]	16.10 ± 1.05[a*]	14.95 ± 1.05[a]	24.70 ± 0.50[a*]	21.40 ± 1.00[a]
WHO Standard	≤ 25.00	≤ 25.00	1000.00	1000.00	-	-

*Temp = Temperature, TDS = Total dissolved solids, TSS = Total suspended solids, * = values with an asterisk are significantly different ($p<0.05$) using student t-test pairwise comparison, [a, b, c, d] = means in the same column bearing different letter superscripts are significantly different ($p<0.05$)*

Table 2: Physical properties of effluent from different food processing centres in Abakaliki 2023 and 2024 wet season

Food Processing Centres	Temp °C		TDS mg/L		TSS mg/L	
	2023	2024	2023	2024	2023	2024
Native Delicacy	26.50 ± 1.50[b]	27.00 ± 0.50[c*]	82.61 ± 1.05[b*]	80.36 ± 0.50[b]	69.60 ± 1.50[e]	90.96 ± 1.00[e*]
Crunches	26.00 ± 0.50[b]	26.50 ± 1.00[b]	89.81 ± 1.50[c]	96.10 ± 1.05[c*]	60.39 ± 0.50[d*]	52.91 ± 0.50[d]
Chicken Republic	26.00 ± 1.00[b]	26.00 ± 1.50[b]	98.20 ± 1.05[d]	101.25 ± 0.50[d*]	54.78 ± 1.05[c*]	50.25 ± 0.50[c]
Kilimanjaro	25.90 ± 0.50[a]	26.00 ± 0.50[b*]	98.51 ± 0.50[d]	100.13 ± 1.50[d*]	51.29 ± 0.50[b*]	46.22 ± 1.50[b]
Control	26.00 ± 0.50[b*]	25.00 ± 1.00[a]	16.10 ± 1.05[a*]	14.95 ± 1.05[a]	24.70 ± 0.50[a*]	21.40 ± 1.00[a]
WHO Standard	≤ 25.00	≤ 25.00	1000.00	1000.00	-	-

*Temp = Temperature, TDS = Total dissolved solids, TSS = Total suspended solids, * = values with an asterisk are significantly different ($p<0.05$) using student t-test pairwise comparison, [a, b, c, d] = means in the same column bearing different letter superscripts are significantly different ($p<0.05$)*

Table 3: Effects of effluent on physical properties of receiving water bodies in the 2023 and 2024 dry seasons

Receiving Water Bodies	Temp °C		TDS mg/L		TSS mg/L	
	2023	2024	2023	2024	2023	2024
Native Delicacy	25.00 ± 0.50[a]	25.00 ± 1.05	50.81 ± 0.50[b*]	46.80 ± 1.00[c]	31.10 ± 1.05[b]	35.90 ± 0.50[c*]
Crunches	26.00 ± 1.00[b*]	25.00 ± 1.05	50.63 ± 1.05[b*]	49.20[b] ± 1.05[d]	33.50 ± 1.00[c*]	31.00 ± 1.00[b]
Chicken	26.00 ± 0.50[b*]	25.00 ± 1.05	55.60 ± 1.00[d*]	41.70[c] ± 1.00[b]	34.03 ± 0.50[c]	43.20 ± 0.50[d*]
Kilimanjaro	26.00 ± 0.50[b*]	25.0 ± 0.50	52.90 ± 0.50[c*]	50.10 ± 1.00[e]	27.80 ± 1.00[a]	30.60 ± 1.05[b*]
Control	26.00 ± 0.50[b*]	25.00 ± 1.00	16.10 ± 1.05[a*]	14.95 ± 1.05[a]	24.70 ± 0.50[a*]	21.40 ± 1.00[a]
WHO Standard	≤ 25.00	≤ 25.00	1000.00	1000.00	-	-

*Temp = Temperature, TDS = Total dissolved solids, TSS = Total suspended solids, * = values with an asterisk are significantly different ($p<0.05$) using student t-test pairwise comparison, [a, b, c, d] = means in the same column bearing different letter superscripts are significantly different ($p<0.05$)*

The TSS levels ranged from 46.10 – 55.57 mg/L with the control recording the lowest and the Chicken Republic receiving stream recording the highest in 2023 and 2024 respectively. There are no specific WHO guidelines for TSS, but lower TSS levels generally indicate better water quality.

Table 4 shows the three physical properties of receiving water bodies in Abakaliki for the years 2023 and 2024 wet seasons. There was a significant difference ($p<0.05$) in the value of temperature, TDS and TSS for all the effluent-receiving water bodies studied

The temperature value ranged from 25.0 – 26.0^{O}C in the 2023 and 2024 wet seasons. All temperature values were within the WHO guideline value of ≤ 25°C, indicating no significant thermal pollution. The control temperature values were consistent at 26.0°C.

The TDS values were higher than the control value in all the effluent-receiving water bodies. The TDS value observed the order of increase from the Chicken Republic receiving stream< Crunches < Kilimajaro < Native Delicacy receiving stream in 2023. In 2024, the TDS value ranged from 40.90 – 50.20 mg/L with the Native Delicacy receiving stream recording the lowest, while the Kilimanjaro receiving stream recorded the highest. All the TDS values were within the WHO guideline value of ≤ 1000 mg/L, indicating that the dissolved solid concentrations were within safe limits for the effluent receiving streams. The TSS value ranges from 66.40 – 70.32 mg/L, with Kilimanjaro receiving streams recording the highest and lowest values in the 2023 and 2024 wet seasons. There is no WHO guideline for TSS.

Table 4: Effects of effluent on physical properties of receiving water bodies in the 2023 and 2024 wet season

Receiving Water Bodies	2023	2024
	Temp °C	
Native Delicacy	25.00 ± 1.00^{a}	25.00 ± 1.05^{a}
Crunches	25.00 ± 0.50^{a}	26.00 ± 1.00^{b*}
Chicken Republic	25.00 ± 1.05^{a}	26.00 ± 0.50^{b*}
Kilimanjaro	26.00 ± 1.00^{b}	26.00 ± 0.50^{b}
Control	26.00 ± 0.50^{b}	26.00 ± 1.00^{b}
WHO Standard	≤ 25	≤ 25
	TDS mg/L	
Native Delicacy	39.70 ± 1.05^{e}	40.90 ± 0.50^{b*}
Crunches	34.80 ± 0.50^{c}	41.70 ± 1.05^{b*}
Chicken Republic	31.00 ± 1.05^{b}	46.80 ± 1.00^{c*}
Kilimanjaro	36.80 ± 1.05^{d}	50.20 ± 1.05^{d*}
Control	24.10 ± 1.00^{a*}	21.10 ± 0.50^{a}
WHO Standard	1000	1000
	TSS mg/L	
Native Delicacy	70.10 ± 1.00^{c}	69.80 ± 1.00^{b}
Crunches	66.70 ± 1.05^{b}	69.70 ± 1.05^{b*}
Chicken Republic	66.60 ± 1.05^{b}	70.10 ± 1.00^{c*}
Kilimanjaro	66.40 ± 0.50^{b}	70.32 ± 1.00^{c*}
Control	31.60 ± 1.00^{a*}	30.50 ± 0.50^{a}
WHO Standard	-	-

*Temp = Temperature, TDS = Total dissolved solids, TSS = Total suspended solids, * = values with an asterisk are significantly different ($p<0.05$) using student t-test pairwise comparison, $^{a, b, c, d}$ = means in the same column bearing different letter superscripts are significantly different ($p<0.05$)*

DISCUSSION

The result of this study showed a significant difference in the temperature value of the effluent in all the food processing centres and seasons. This was in line with the study by Kanu and Achi (2011) who in their study on the environmental assessment of industrial effluents in Nigeria, noted that the differences in effluent temperatures were influenced by the specific processing activities, technology employed and seasons in the different food processing centres.

However, the temperature of the effluent receiving water bodies in all the food processing centres was consistently higher than the control which justifies the report of Akan *et al.* (2008) who stated that temperatures of effluents from food processing plants significantly impact the thermal regime of receiving water bodies. The temperature values were within the WHO guideline value of ≤ 25°C, indicating no significant ($p<0.05$) thermal pollution (WHO, 2008). In this study, TSS and TDS levels were significantly different in all the food processing centres and seasons. The TDS and TSS levels in the effluent were higher in the dry season compared to the wet seasons in all the food processing centres. This was in agreement with the study of Ojo *et al.* (2022) who in their study on the seasonal variation of physicochemical properties of effluent discharge from food processing industries in Akure South-west Nigeria, observed that significant differences in low TDS and TSS levels in the wet season were attributed to rainfall patterns and changes in water quality with increase dilution in the rainy seasons. Also, there was a notable difference in TDS and TSS levels across the centres in both seasons. The observation is still in line with the report of Ojo *et al.* (2022) who reported significant differences in TDS and TSS levels among different centres, attributing these differences to the scale of operations and the type of food processing activities conducted.

On the receiving water bodies, TDS and TSS in the control were much lower than those in the receiving streams, highlighting the impact of effluent on increasing suspended solids in water. It collaborated with the report of Simate *et al.* (2011) who highlighted those effluents from food processing industries are typically rich in organic and inorganic suspended solids. They noted that TDS and TSS levels in the effluents could range from 50 - 300 mg/L and affect the receiving water bodies depending on the type of processing and the efficiency of wastewater treatment systems. There are no WHO guidelines for TSS, but lower TSS levels generally indicate better water quality. TDS values were all within the WHO guideline value of ≤ 1000 mg/L, indicating that the dissolved solid concentrations are safe for water quality standards.

Conclusion: This study on the assessment of three physical properties of effluent from food processing centres in Abakaliki and their effects on receiving water bodies reveals that the physical properties of effluents from food processing centres in Abakaliki were significantly different in all food processing centres and seasons, and it has a negative effect on the receiving water bodies. Temperature values remained within safe limits, while TSS and TDS levels indicated some degree of pollution, though still within acceptable ranges according to WHO standards. The control values generally showed better water quality, indicating the impact of effluent discharge. Based on the findings, the following recommendations are made to mitigate the effects of the physical properties of effluents on receiving water bodies: Enhanced effluent treatment, regular monitoring and compliance, public awareness and training, and policy. Further research to better understand the long-term effects of the physical properties of effluent on the ecosystem and public health is needed. This research should also explore more effective and sustainable treatment methods. By adopting these recommendations, it is possible to significantly reduce effluents' environmental and health impacts.

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