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(RESEARCH ARTICLE)

# Comparative studies of physico-chemical parameters and Total Hydrocarbon Content (THC) of Choba and Iwofe axis of the New Calabar River in the Niger Delta, Nigeria.

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## Abstract

Monitoring physicochemical parameters is important in water quality management. This study examined some physicochemical parameters of the Choba and Iwofe axis of the New Calabar River in the Niger Delta relative to anthropogenic activities in the area. Both in situ and laboratory analysis of the water samples were done. Data analysis was also done using the SPSS version 25 and results compared with regulatory standards. Temperature was highest at Iwofe (stn. 4), 28.24 °C; Choba (stn. 1) was more acidic, pH 5.57; stations at Iwofe had highest electrical conductivity with a value of 613.68 µS/cm; nitrate was above permissible limits across the study area, with an average value of 15.83 mg/l; sulphate was below permissible limits across stations, with an average value of 19.24 mg/l; Iwofe (stn. 3) was the most turbid, with a value of 62.7 NTU; chloride was below permissible limits, with an average value of 47.88 mg/l; phosphate exceeded permissible limits, with an average value of 2.35 mg/l; while THC values at three stations had an average of 0.9 mg/l. The result showed a statistically significant difference in temperature, Conductivity, turbidity, nitrate and sulphate across the study area ($p<0.05$) while values of pH, chloride and phosphate did not differ significantly ($p>0.05$) between the stations examined. The study concluded that there was an imbalance in the levels of physicochemical parameters of the water bodies studied when compared with regulatory limits of WHO. These inconsistences were attributed to the introduction of extraneous materials into the water bodies due to human activities, emphasizing the need for proper waste management practices in these areas.

**Keywords:** Physicochemical parameters; Water quality; Upper Bonny Estuary; Nigeria

## 1. Introduction

Water is an essential component for survival of life on earth, it contains minerals important for humans as well as for plant, animal and aquatic life. Lakes and surface water reservoirs are the most important freshwater resources on the planet, and they provide numerous benefits. They are used for domestic and irrigation purposes, as well as providing ecosystems for aquatic life, particularly fish, and thus serve as a source of essential protein as well as important components of the world's biological diversity. In terms of tourism and recreation, they provide significant social and economic benefits, as well as cultural and aesthetic value to people all over the world [1]. Water is required for the survival and growth of all living organisms on the planet. Only the planet Earth currently has about 70% of its surface covered in water. However, it has become highly polluted with various harmful contaminants as a result of increased human population, industrialization, agricultural fertilizer use, and man-made activity. This necessitates regular checks and monitoring of water quality, because contaminated drinking water causes a slew of problems for humans and other living things [2]. The taste, odour, colour, and concentration of organic and inorganic matter in water determine its quality and suitability for use. Contaminants in water can have an impact on water quality and, as a result, human health. Geological conditions, industrial and agricultural activities, and water treatment plants are all potential sources of water contamination. Microorganisms, inorganics, organics, radionuclides, and disinfectants are all types of contaminants [3].

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The physico-chemical parameters are extremely important to test before using water for drinking, domestic, agricultural, or industrial purposes. Different physico-chemical parameters must be tested on water. The parameters to be tested are solely determined by the intended use of the water and the degree to which its quality and purity are required. It is critical to conduct water quality testing in order to protect the natural ecosystem [4]. This analysis also involves investigating the total hydrocarbon content of water, this according to Victor [5] is environmental contaminants linked to petroleum exploration, transportation, exploitation, offloading, consumption and refining activities. An understanding of this parameters and how they impact on animal and environmental health is a key to environmental protection, preservation and sustainable biodiversity. The aim of the study was to examine some physicochemical parameters of Choba and Iwofe axes of the New Calabar River in the upper Bonny estuary and compare their values with regulatory standards.

## 2. Material and methods

### 2.1. Study site

The sampled point of intersection of the New Calabar River is located around4$^{o}$ 53'18.83N and 6$^{o}$53'53.38E. New Calabar River and its tributaries are located in Rivers state, south-south Nigeria (Fig. 1). It is one of the series of low-lying delta river which empty into coastal lagoons and creeks bordering the Atlantic Ocean [6]. The river is freshwater and acidic at the source, but gradually becomes brackish, tidal and slightly alkaline at the lower reaches, near its mouth.

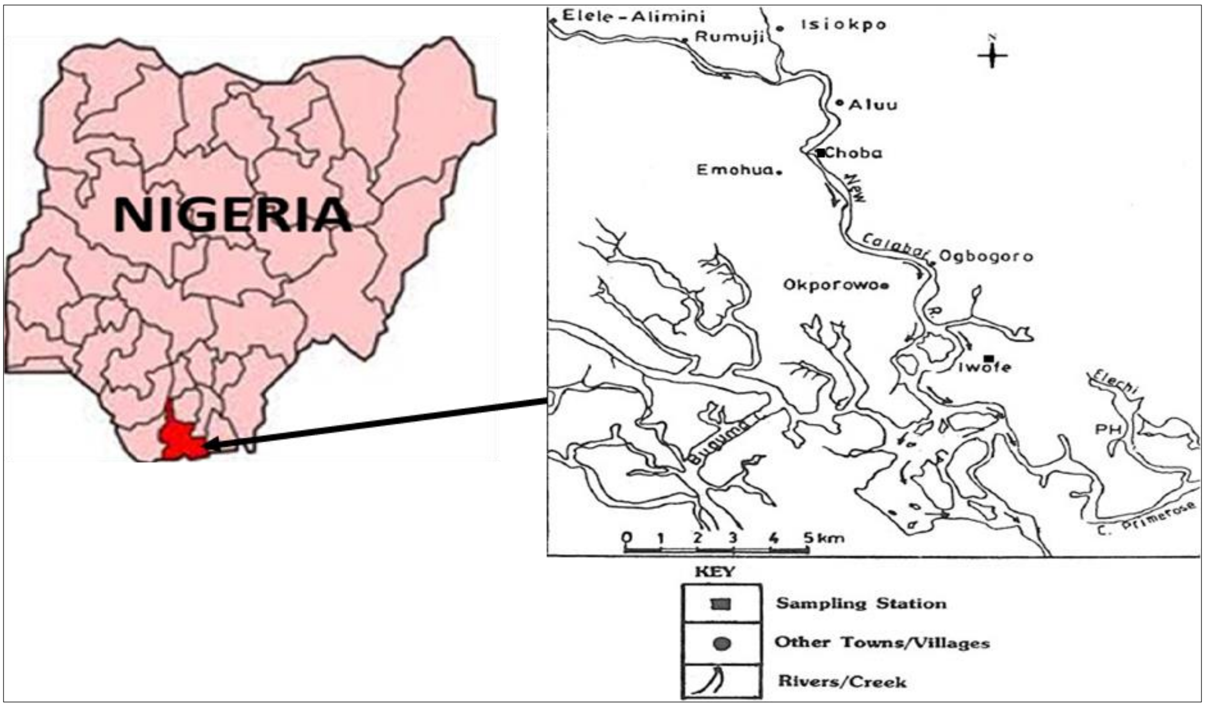


**Figure 1** Map of study area

### 2.2. Sample collection

Water samples were taken from four stations (stations 1and 2 -Choba axis, stations 2 and 3 -Iwofe axis) of the New Calabar river. Samples were collected and analysed monthly for four months. Samples were collected with appropriate containers, properly labeled and prewashed. Before collection sample containers were rinsed thrice with the water from the sampling point for quality control and quality assurance purposes. All samples were preserved in ice-packed containers to ensure sample integrity before laboratory analysis.

### 2.3. Field/in situ analysis

In situ/fast changing parameters like temperature, pH. Conductivity, salinity and turbidity were measured in the field. The instrument used in the *in-situ* reading was the pcsteste35 - a digital instrument designed to read temperature, pH, salinity, and conductivity. After each reading the instrument was calibrated to take the next reading, this was followed by dipping the instrument into the test water. Turbidity values were obtained and recorded using Hanna Instrument, LP 2000 turbidimeter. The turbidimeter 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 cleaned and made dry. The cuvette was pushed firmly into the optical well and index to the lowest reading. The NTU values were measured by pressing and releasing the arrow button and the value recorded.

### 2.4. Laboratory Analysis

The HANNA multi parameter logging spectrophotometer (HI83200) was used to digitally determine the nitrate, phosphate and sulphate in the surface water samples. The concentrations of nitrate, sulphate and phosphate were determined using standard procedures [7]. Nitrate as nitrogen was determined by the cadmium reduction metal method 8036. The cadmium metal in the added reagent reduced the entire nitrite in the samples to nitrate; Sulphate was determined using Sulfa Ver methods 8051. Phosphate was determined using direct reading from HI 83200 HANNA multi parameter. Argentometric method [7] was used to determine chloride concentration in the sample. Exactly 50 ml of filtered water sample was pipetted into a 250 ml conical flask. The pH of the diluted water sample was determined. About 1ml of 0.25 M potassium chromate was added to the conical flask. Water sample was titrated against the standard $AgNO_3$ solution slowly while stirring the sample using a magnetic bar and stir plate. The end point was indicated by the persistence of a reddish-brown colour through the yellow solution for about 30 seconds. Blank (distilled water) was titrated using the same procedure. Volume of $AgNO_3$ for the blank was subtracted from the average used for the sample. This volume was used to determine the concentration of chloride ion in the water sample. Total hydrocarbon from the water samples were extracted with 30.0ml toluene for three consecutive times and later made up to 100ml. The absorbance of the filtrates was measured spectrophotometrically at 420 nm with spectrophotometer 4ID. The concentration was calculated from the calibration graph on dry weight basis. Appropriate blanks were run throughout the procedure. Data was analysed by calculating means and frequencies using the statistical package for social sciences (SPSS) version 25. Mean values were computed for all parameters.

## 3. Results and discussion

### 3.1. Physico-chemical Parameters

Graphical expressions of mean values of the physicochemical parameters examined is presented in Fig 2A – J while Table 1 shows the output of statistical analysis (Analysis of Variance - ANOVA). Spatial variations between stations were expressed in comparison with regulatory standards of the world Health organisation.

Differences in mean values of temperature was observed with significant variation ($p<0.05$) between stations (Fig.2A). The lowest value (25.8 $^{o}$C) was recorded at station 2 (Choba) while the highest value (28.2 $^{o}$C) was recorded at station 4 (Iwofe). With the temperature values slightly below regulatory standard, aquatic organisms in these water bodies may not experience thermal stress and there is little risk of biodiversity loss resulting from extreme temperature changes [8] as extreme temperature is linked with high fatality of aquatic life [4]. The mean pH values of the study area ranged from 5.5 – 6.2 across the stations examined (Fig 2 B). There was no significant difference ($p>0.05$) in pH value between the stations assessed. The pH values observed in this study were within the regulatory limits of the world Health organisation and the Federal Ministry of Environment. The pH levels of all stations fell below regulatory standard, with all stations gravitating towards slight acidity, acidity was more at station 1 (Choba) (5.57), followed by station 3 (Iwofe) (5.99), station 2 (Choba) (6.05) and station 4 (Iwofe) (6.28). From these results, station 1 was considered more acidic while station 4 was considered least acidic, this could be due to the continuous introduction acidic wastes into water bodies within this area. The pH range of this study falls within the range (6.5 ± 0.10 – 7.5 ± 0.02) earlier reported by Aigberua and Moslen [9] in the Niger Delta. The pH values of this study also agreed with the reports of Moslen and Daka [10] who reported pH values of 6.39 ± 0.21 – 6.98 ± 0.17 (dry season) and 7.1 ± 0.20 – 7.58 ± 0.46 (wet season). Omer [11] suggested that the acidity of water bodies can be correlated to their temperature as at 25 $^{o}$C (room temperature) water is at normal pH level. In a similar study by Edun and Efiuvwevwere [12] in Choba and Iwofe areas, ecological parameters varied across sites with the highest pH value of 7.87 occurring at Iwofe and lowest of 6.12 at Choba, these results were slightly different from the current study which could be attributed to changes of physical parameters over time. At this pH level across stations, water bodies may have a reduced vitamin and minerals production [13]. The electrical conductivity (EC) values also differed between stations with lowest value (156.33 µS/cm) observed at station 2 (Choba) and the highest value (615.93 µS/cm) observed at station 4 (Iwofe) (Fig 2C). The mean electrical conductivity results indicated high values above permissible limits at stations 3 and 4 (Iwofe) and low EC at stations 1 and 2 (Choba) below permissible limits. Significant difference ($p<0.05$) in EC values between stations were also observed. These results highlight the presence of more positively charged ions [14] in Iwofe water bodies (stations 3 and 4) compared to Choba axis, with implication which may suggest high presence of groundwater seepage, sewage leak and some levels of pollution in waterbodies with high EC as observed in the study area. The Electrical conductivity values observed in this study were far lower than mean values (55266.7 ± 290.9 µS/cm) reported in the upper Bonny estuary by Aigberua and Moslen [9]. Turbidity values showed significant difference ($p<0.05$) between stations with values ranging from 2.93 NTU at station 2 (Choba) to 62.7 NTU at station 3 (Iwofe) (Fig 2D). Except at station 2, turbidity values were above the regulatory standards. High turbidity at stations 3 and 1 could be linked to decay of aquatic plants due to combined effect of high-water temperature and low dissolved oxygen; also, high turbidity has provided favourable conditions for microbes [15].

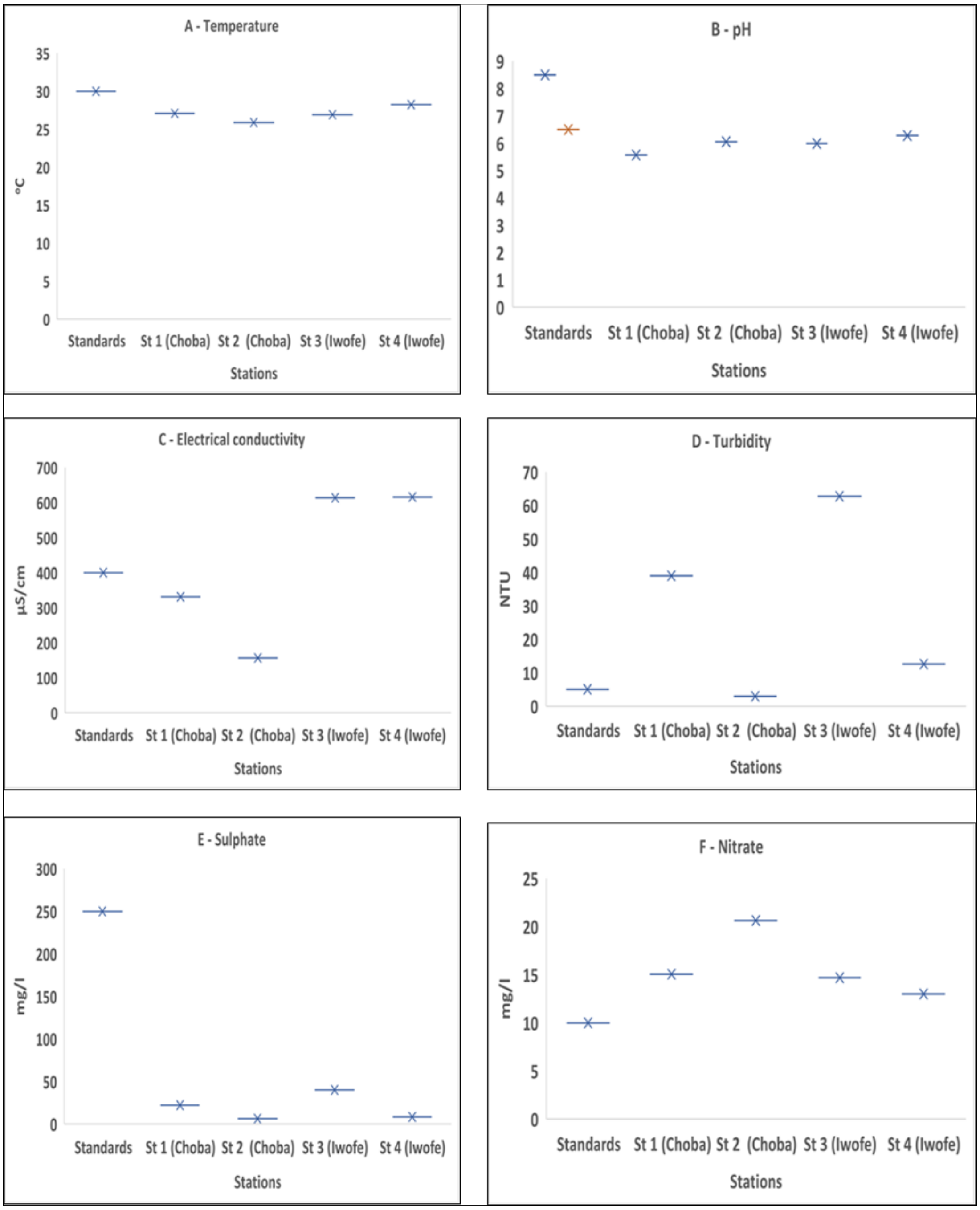


**Figure 2A-F** Variations in physicochemical parameters examined in the study area

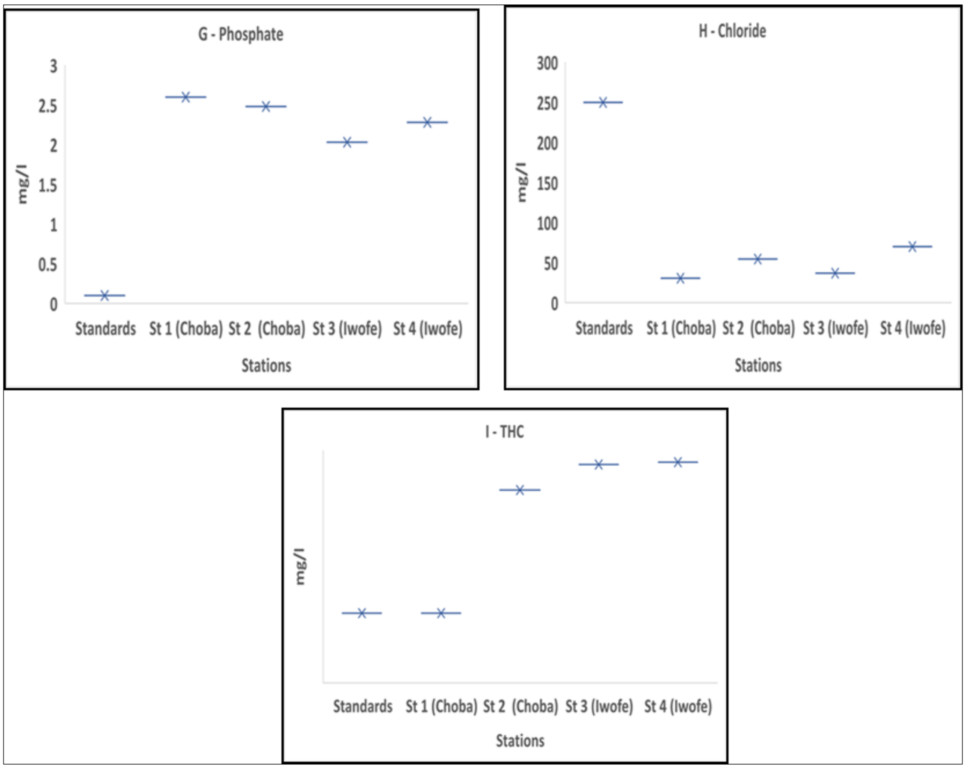


**Figure 2G-**I Variations in physicochemical parameters examined in the study area

**Table 1** Summary of ANOVA Tables for Parameters examined

| Parameter | F | DF (Numerator) | DF (Denominator) | *p*-value |
|---|---|---|---|---|
| Temperature | 25.6469 | 3 | 6.4941 | 0.0005 |
| pH | 2.4251 | 3 | 5.9267 | 0.165 |
| Turbidity | 46.2256 | 3 | 6.0234 | 0.0001 |
| Electrical conductivity | 69.5145 | 3 | 6.22 | 0.001 |
| Nitrate | 18.577 | 3 | 6.5298 | 0.0014 |
| Sulphate | 45.1118 | 3 | 6.2316 | 0.0001 |
| Chloride | 13.1259 | 3 | 6.0531 | 0.0047 |
| Phosphate | 8.6346 | 3 | 5.4286 | 0.0169 |
| THC | 1.3395 | 3 | 5.308 | 0.356 |

Significance level = $p<0.05$

Mean sulphate values in the study area were significantly difference ($p<0.05$) between stations with values ranging from 6.34 mg/l at station 2 (Choba) to 40.07 mg/l at station 3 (Iwofe). Observed sulphate values were all below the regulatory standard of 250 mg/l, these findings agree with the comments by Meride and Ayenew [16] who observed that sulphate concentration in natural water ranges from a few to some 100 mg/l. The sulphate concentrations of the current study were generally less than mean values (12.3 ± 1.5 – 2021.7 ± 23.2 mg/l) reported in a tidal creek of the Niger Delta [9]. Nitrate levels were higher at Choba (stations 1 & 2), with 20.63 mg/l and 15.05 mg/l at stations 2 and 1 respectively, and lower across Iwofe stations (stations 3 & 4), with 14.63 mg/l & 13.0 mg/l at stations 3 and 4 respectively. Interestingly, these values were above the regulatory standard for nitrate in water (10 mg/l) but showed significant difference ($p<0.05$) between stations. While higher nitrogen concentration may be best for agricultural and plant production activities [17], they pose great problem for aquatic life, as an increase in nitrate could encourage the growth of blue green algae in water bodies [18]. It is also interesting to note that the high presence of nitrogen across these water bodies is indicative of pollution by organic matters [18]. Phosphate levels across the water bodies exceeded the regulatory standards for phosphate in water (0.1 mg/l). Stations 1 and 2 (Choba) had a mean phosphate level of 2.6 mg/l and 2.48 mg/l respectively, while stations 3 and 4 had mean phosphate levels of 2.03 mg/l and 2.28 mg/l respectively (Fig. 2G). Variation in phosphate values across stations was significantly different ($p<0.05$). Phosphate values of this study were generally lower those (5.83 $\pm$ 1.02 - 26.64 $\pm$ 6.87, wet season: 7.26 $\pm$ 1.02 – 19.71 $\pm$ 3.23, dry season) reported by Moslen and Daka [10]. According to Nyamangara [19], high phosphate levels in water bodies may be indicative of the presence of some industrial and sewage pollutants and increase in phosphate levels could lead to eutrophication. Chloride levels across the stations were low and below regulatory standard, with station 1 (Choba) having 30.43 mg/l, station 2 (Choba) having 54.38 mg/l, station 3 (Iwofe) having 36.8 mg/l and station 4 (Iwofe) having 69.9 mg/l (Fig.2H). The mean values of chloride recorded indicated statistically significant difference ($p<0.05$) between the stations sampled. The low level of chloride in these water bodies indicates that the sampled areas were fresh water habitats and not saline, this also may indicate minimal introduction of Cl ions from industrial and agricultural activities into these water bodies [20]. THC at Iwofe stations exceeded the regulatory standard of 0.3 mg/l with values of 0.94 mg/l and 0.95 mg/l at stations 3 and 4 respectively, indicating some form of petroleum-related activities in these areas [21]. Choba stations (1 and 2) showed lower THC with station 2 having 0.83 mg/l and station 1 with 0.3 mg/l (Fig. 2I) just on par with the regulatory standards [22]. THC values obtained in this study were less than 0.18 $\pm$ 0.01 mg/l and less than mean concentrations reported by Moslen and Ekweozor [23] within the Bonny estuary of the Niger Delta. According to Moslen and Ekweozor [23], THC level observed in the study areas could be attributed to contaminations with regards to industrial effluent discharges in the study area as well as illegal bunkering activities.

## 4. Conclusion

Findings from this study highlights an imbalance in the physico-chemical parameters of water bodies studied with respect to regulatory standards as some areas were within regulatory standard while others were found to be above or below regulatory standard of WHO. Temperature levels across study area was below regulatory standards, but pH of the water bodies indicated slight acidity. Electrical conductivity was high above regulatory standards at Iwofe stations and low below regulatory standards at Choba stations. With respect to chemical properties, nitrate level was generally high above regulatory standards across study areas while sulphate level was below regulatory standards across study areas. Two out of the four stations, one in each study area, showed high turbidity levels above regulatory standards while chloride levels were generally low across study areas. Findings shows that phosphate levels across study area were generally high above regulatory standards and total hydrocarbon content was high across 3/4 of the stations sampled. Most alterations in physico-chemical properties of water are attributable to the introduction of pollutants into the water bodies hence, effective waste management and treatment at source is recommended to reduce aquatic contamination. Continuous monitoring of physico-chemical parameters of water bodies should be encouraged to detect changes. Also, adequate and proper enforcement activities should be carried out to ensure that businesses and industrial activities around Iwofe and Choba waterfronts observe proper waste management and treatment measures before discharging to the water body.

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

The authors (Beauty Happiness WOSU, Miebaka MOSLEN and Calista Adamma MIEBAKA) declare that that there is no conflicts of interest/ Competing Interests regarding this publication.

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