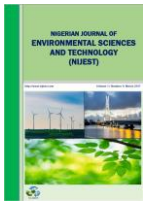
Nigerian Journal of Environmental Sciences and Technology (NIJEST)

www.nijest.com

ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603

Vol 6, No. 2 October 2022, pp 391 - 408



# Spatial Analysis for Surface Water Quality Assessment of the Ikpoba River Using Geographic Information System

Ojeah J. C [1, *] and. Oriakhi O.[2]

[1,2,] Department of Civil Engineering, Faculty of Engineering, University of Benin, Benin City, Edo State, Nigeria

Corresponding Author: *orobosa.oriakhi@uniben.edu

https://doi.org/10.36263/nijest.2022.02.0374

## ABSTRACT

*The aim of this study is to assess the water quality of the surface water body in the study area (Ikpoba River) in Benin City using the Geographic Information System (GIS). The present research involved the spatial analysis of water quality for four stations along the Ikpoba River in Benin City. The four stations were delineated using satellite images of Google Earth. At the same time, water samples were collected at these stations and the parameters such as Temperature, Turbidity, pH, Total Dissolved solids (TDS), Total Suspended Solids (TSS), Dissolved Oxygen (DO), COD, Biochemical BOD, Electrical Conductivity (EC), Zn, Cl, $NH_4N$, Ca, Pb, $SO_4$, Fe, Mg, $NO_3$, $PO_4$, and Total Hardness were analyzed in the laboratory. The analytical result of water samples was compared with WHO (World Health Organization) maximum permissible limits for the parameters tested and it was found that DO, TDS, EC, pH, $NH_4N$, Zn, Ca, Mg, $NO_3$, and Cl all fell below the WHO standard at all four points along the Ikpoba river. Inverse Distance Weighted (IDW) was employed for the spatial analysis using ArcGIS software. The database for all spatial data was created using GIS interpolation according to the IDW method to obtain the spatial distribution of each selected water quality parameter. It was estimated and concluded that the quality of water from the four different stations on the river varies comparatively with the permissible limits given by WHO Standards, with only a few parameters falling below the acceptable limit and the spatial extent of water quality is changing with respect to the parameter and its values.*

**Keywords:** Geographic Information System (GIS), Water Quality Analysis, Surface water quality parameters, Water Quality Index (WQI),

## 1.0. Introduction

Surface water degradation has become a matter of increasing national and global concern as the impact of organic and inorganic contaminants continues to render vital water resources less suitable for their intended uses. With the increase in the exploitation of water as a resource, the rivers, and other water bodies are burdened with external matter (Singh, et al. 2013a; Singh et al., 2013b; Singh, et al. 2013c; Singh, et al. 2015). The protection of the aquatic environment and its associated resources is one of the Programs of Action enlisted in Agenda 21 of the United Nations, geared toward achieving sustainable development (United Nations Agenda 21, 1993). In many African countries, it has been reported that 80% of human illnesses are attributable to contaminated water supplies (Calamari and Naeve 1994). In natural aquatic ecosystems, heavy metals occur in low concentrations; usually at the nanogram to microgram per liter level. In recent times, however, the occurrence of heavy metals also in excess of natural loads has become a problem of increasing concern. This phenomenon is a result of rapid population growth, increased urbanization, expansion of industrial activities, exploration and exploitation of natural resources, an extension of irrigation and other modern agricultural practices as well as poor enforcement of environmental regulations (Calamari and Naeve 1994). On the global level, problems associated with heavy metal contamination were first highlighted in industrially advanced countries because of the larger industrial discharges and such incidents of mercury and cadmium pollution in Japan and Sweden. The consumption of fish and shellfish contaminated with mercury caused an epidemic of paralysis amongst human populations in Minamata, Japan, in 1956 (Ndiokwere 2004). Heavy metals are high-priority pollutants because of their relatively high toxicity and persistent

nature in the environment. Knowledge of the changing concentration and distribution of heavy metals in various compartments of the environment is a priority for good environmental management programs all over the world. (Don-Pedro, Oyewo and Otitoloju 2004)). Heavy metals have been reported in various water bodies in Nigeria. These metals have, in most cases, been traced to effluent discharged to receiving water bodies (Fakayode, 2005; Kanu & Achi, 2011). Heavy metal pollution in natural water bodies may increase due to human activities, which often lead to various negative impacts with consequent disruption of the natural equilibrium and restriction in using natural aquatic resources (Fernandes 1997). Aquatic environments are natural sinks to pollutants, including heavy metals, and such metals reaching aquatic bodies can have grave environmental implications which may manifest through bioaccumulation and biomagnifications up food chains (Wangboje et al., 2001).

Several studies have been conducted on the Ikpoba river to determine its usability and quality. A study carried out showed the capacity of riparian vegetation of the river and the influence of pesticides run-off and sediments on the water using spectral indices determined from remotely sensed data (Chukwuka & Ogbeide, 2021), which has the potential to poison the life force in the river and also deplete the surface water quality. Another study has shown the presence of heavy metals in the river, emphasizing that Iron (Fe) was very high (Jimoh, 2006). At the same time, some other researchers found that the heavy metals now form as sediments at the bottom of the river and are prone to release these metals to the surface of the water at the slightest disturbance (Ogbeibu & Anagboso, 2004), thereby leading to increased concerns about the water quality of the river. The impact of the river content and its influence on the surface quality cannot be overlooked; that is why the Water Quality Index and standard for acceptable water quality standard by the WHO would be used to test for both total dissolved solids (TDS) and total suspended solids (TSS), along with other parameters like dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonia-nitrogen (NH4-N), pH, and turbidity.

GIS has been seen as the key to implementing methods of spatial analysis, making them more accessible to a broader range of users and hopefully more widely used in making effective decisions and in supporting scientific research (Goodchild 1992). The definition of water quality very much depends on the desired use of water. Therefore, different uses require different criteria of water quality as well as standard methods for reporting and comparing results of water analysis (Raj Kumar et al., 2012). Ascertaining the quality is very important before its use for various purposes such as drinking, agricultural, recreational and industrial use. Hence monitoring surface water quality has become indispensable (Sashikkumar, 2013). Geographic Information System (GIS) has emerged as a powerful technology for research (Opensaw 1991). This concept and advancement in space technology have resulted in great efficiency in land and water management (Gogu, et al. 2001). Remote sensing, with its spatial and temporal features and also the availability of data over a large area within a short time, has become a very effective tool to explore, evaluate and manage water resources (Madan, et al. 2007).

Several efforts are being made worldwide to identify, quantify, evaluate, monitor, and control the direct inflow of pollutants into river systems. (Singh, et al. 2017a) (Singh, et al. 2017b) Here, water-quality assessment, planning, and management at different scales play an important role. This leads to assessing the temporal and spatial changes in water quality, identifying contaminated stretches and ascertaining the causes of pollution, and identifying polluters. Traditional methods of water-quality monitoring techniques give accurate measurements, but they are time-consuming and expensive (Christiana and Hadjimitsis, 2013). Furthermore, these methods do not satisfy the regional appraisal and monitoring need (Yao, 2010). It requires excessive traveling, sampling, and expensive laboratory analysis, especially for a large area; thus, it is very difficult to report and predict water-quality situations on time (Stefouli and Charou 2012). Further and most importantly, they do not give the real-time, spatial overview that is needed for the global assessment and monitoring of water quality.

The aim of this study is to assess the water quality of surface water bodies in the Ikpoba River in Benin City using Geographic Information System (GIS).

## 2.0 Methodology

### *2.1. Study Area*

Benin City, the administrative capital of Edo State Nigeria, lies between Longitudes 5°30'and 5°45'E and Latitude 6°30'N. The Ikpoba river is dendrite in the upper reaches and its headwaters originate from the Ishan Plateau, northwest of Benin City. The river receives domestic and agricultural wastes through run-off from the surrounding agricultural lands, including the University of Benin, which is situated close to the bank of the River at Ugbowo. The University of Benin and its Teaching Hospital deposits solid wastes in a forest clearing near the bank of the river. During rainfall, part of the sewage enters the river through run-off and seepage. The Ikpoba weir impounded the river to form the Ikpoba reservoir which separates the downstream from the upstream sections of the river. The climate of the study area is typically tropical with two recognizable annual seasons, the dry and wet seasons. The wet season falls between April and November, while the dry season falls between December and March. The length of the Ikpoba River is flanked by thickets of Indian bamboo (Bambusa sp.), shrubs, and grasses. Human activities include farming, car washing, animal grazing, sand quarrying, and fishing. A drainage channel at the Okhoro end of the reservoir brings in run-off from the city.

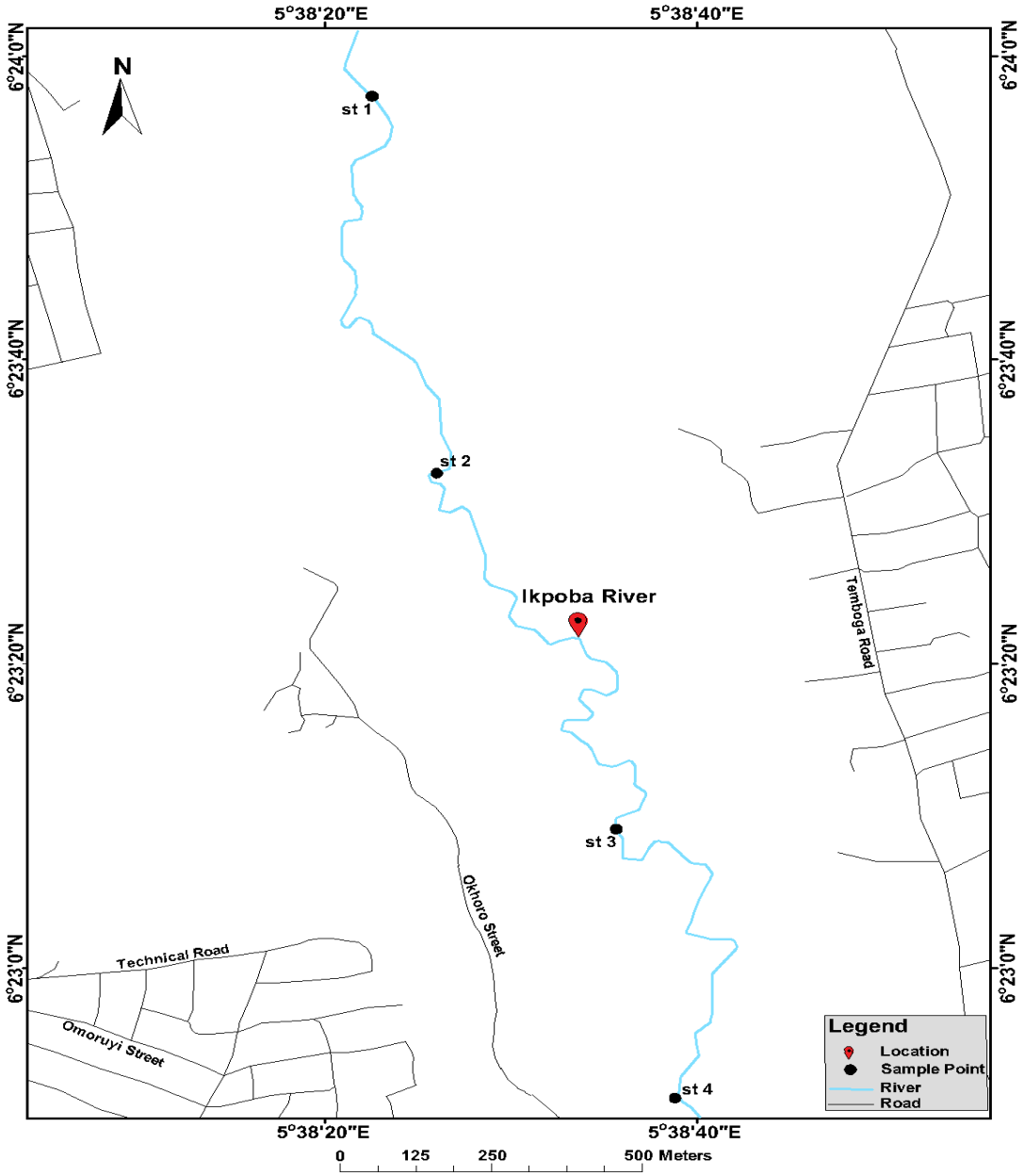



**Figure 1:** Map of the study area

*2.2. Materials and Methods*

Sample collection was done by getting data coordinates of station points where water samples were collected on the Ikpoba river using a handset GPS (GPS Essentials App) and analyzing that data using ArcGIS. Thematic maps were generated using the interpolation technique; Inverse Distance Weighted (IDW) method. This interpolation was done for the four stations, and spatial distribution maps were developed from it.

Water samples were collected from the site using collection bottles and polythene bags to reduce light and other environmental impacts on the sample during transportation to the laboratory. Four points were chosen to collect the water samples in order for us to get a spatial comparison. As shown in the image above, four water samples were collected along the river for about 22km of the Ikpoba River. In the field, coordinates of each sample point were recorded using a handset GPS, GPS Essentials version 4.4.25. Concentrations of twenty optical and non-optical Surface Water Quality Parameters (SWQPs), such as turbidity, total suspended solids (TSS), total dissolved solids (TDS), chemical oxygen demand (COD), biochemical oxygen demand (BOD), dissolved oxygen (DO), power of hydrogen (pH), electrical conductivity (EC), water temperature and some hard metals (Ca, Mg, Cl, Fe, Zn, Pb) were measured according to the World Health Organization (WHO) standards (WHO, 2005).

**Table 1: WHO Standards table (WHO, 2006)**

| S/N | Parameters | Maximum Permissible WHO limits (2006) |
|---|---|---|
| 1 | TDS | 1000mg/l |
| 2 | DO | 5.0mg/l |
| 3 | $NH4^+$ | 1.5mg/l |
| 4 | Fe | 0.3mg/l |
| 5 | Pb | 0.05mg/l |
| 6 | Zn | 5.0mg/l |
| 7 | COD | 10.0mg/l |
| 8 | Mg | 150.0mg/l |
| 9 | pH | 6.5- 8.5mg/l |
| 10 | Ca | 75.0mg/l |
| 11 | EC | 300mg/l |
| 12 | SO4 | 250mg/l |
| 13 | Cl | 250mg/l |
| 14 | NO3 | 50mg/l |
| 15 | Mg | 125mg/l |

The Results of the Water sample analysis was compiled and tabulated as shown in figure 4.7.

Satellite imagery of the Ikpoba River gotten from Google Earth Pro was used for this research, and GPS for data acquisition i.e. the (x,y) coordinates of the Ikpoba River (the study area) was obtained using a handset GPS, GPS Essentials version 4.4.25. The data collection was done taken into consideration the major factors that contribute to the occurrence of surface water quality in the area under consideration. Satellite imagery consists of photographs of earth or other planets made by means of artificial satellites. The imagery used are easily available for download on Google Earth.

**Table 2: Boundary coordinates for study area**

| Sample point | Coordinates |
|---|---|
| Station 1 | 5°38'21.678"E |
| | 6°23'56.876"N |
| Station 2 | 5°38'25.643"E |
| | 6°23'32.392"N |
| Station 3 | 5°38'34.422"E |
| | 6°23'9.033"N |
| Station 4 | 5°38'38.812"E |
| | 6°22'51.443"N |

*Station 1, 2, 3, 4 are points on the Ikpoba river*

*2.3 GIS Analysis.*

Spatial analyses aimed to establish a relationship between water quality parameters by creating a prediction from the sample point values. The laboratory results of samples obtained from the field (non-spatial data) and the spatial data were combined using the ArcGIS software. These spatially referenced data were used to determine the contribution of each water quality parameter across the Ikpoba River through GIS spatial distribution map. These maps for six selected parameters are illustrated in the results in chapter four. The result of the preliminary investigation and spatial analysis shows the variations in these parameters for the Ikpoba River during the study period at different stations along the river. These parameters were later used to determine the quality of these rivers and predict future data for the river. Other Water Quality Standards were also put into consideration. For example, according to the INWQS standards, a high level of BOD concentration in the lake does not support aquatic habitation, and this might suggest why there is a reduction of aquatic population in the study area. A low BOD value indicates good water quality, and a high BOD indicates pollution (Shelton, 1991).
Arc GIS 10.1 was used to interpolate a raster surface for the Ikpoba River from sampling points using the inverse distance weighted (IDW) technique (Lam, 1983).

Inverse distance weighted (IDW) interpolation explicitly makes the assumption that things that are close to one another are more alike than those that are farther apart. To predict a value for any unmeasured location, IDW uses the measured values surrounding the prediction location. The measured values closest to the prediction location have more influence on the predicted value than those farther away. IDW assumes that each measured point has a local influence that diminishes with distance. It gives greater weights to points closest to the prediction location, and the weights diminish as a function of distance, hence the name inverse distance weighted.
The Weights window contains the list of weights assigned to each data point that is used to generate a predicted value at the location marked by the crosshair.

As mentioned above, weights are proportional to the inverse of the distance (between the data point and the prediction location) raised to the power value p. As a result, as the distance increases, the weights decrease rapidly. The rate at which the weights decrease is dependent on the value of p. If $p = 0$, there is no decrease with distance, and because each weight $\lambda i$ is the same, the prediction will be the mean of all the data values in the search neighbourhood. As p increases, the weights for distant points decrease rapidly. If the p-value is very high, only the immediate surrounding points will influence the prediction. Geostatistical Analyst uses power values greater or equal to 1. When $p = 2$, the method is known as the inverse distance squared weighted interpolation. The default value is $p = 2$, although there is no theoretical justification to prefer this value over others, and the effect of changing p should be investigated by previewing the output and examining the cross-validation statistics.

*2.3.1 The Search Neighbourhood*
Because things that are close to one another are more alike than those that are farther away, as the locations get farther away, the measured values will have little relationship to the value of the prediction location. To speed calculations, you can exclude the more distant points that will have little influence on the prediction. As a result, it is common practice to limit the number of measured values by specifying a search neighbourhood. The shape of the neighbourhood restricts how far and where to look for the measured values to be used in the prediction. Other neighbourhood parameters restrict the locations that will be used within that shape.

The shape of the neighbourhood is influenced by the input data and the surface you are trying to create. If there are no directional influences in your data, you'll want to consider points equally in all directions. To do so, you will define the search neighbourhood as a circle. However, if there is a directional influence in your data, such as prevailing wind, you may want to adjust for it by changing the shape of the search neighbourhood to an ellipse with the major axis parallel with the wind. The adjustment for this directional influence is justified because you know that locations upwind from a prediction location are going to be more similar at remote distances than locations that are perpendicular to the wind but located closer to the prediction location.

Once a neighbourhood shape has been specified, you can restrict which data locations within the shape should be used. You can define the maximum and minimum number of locations to use, and you can

divide the neighbourhood into sectors. If you divide the neighbourhood into sectors, the maximum and minimum constraints will be applied to each sector. The points highlighted in the data view show the locations and the weights that will be used for predicting a location at the center of the ellipse (the location of the crosshair). The search neighbourhood is limited to the interior of the ellipse. In the example shown below, the two red points will be given weights of more than 10 percent. In the eastern sector, one point (brown) will be given a weight between 5 percent and 10 percent. The rest of the points in the search neighbourhood will receive lower weights.

The expected result is a discrete assignment of the unknown function *u* in a study region, as shown in equation 1:

$$u\,(x)\colon x \rightarrow \mathrm{R},\ x \in \mathbf{D} \in \mathrm{R}^n \quad (1)$$

Where **D** is the study region
The set of *N's* known data points can be described as a list of tuples, as shown in equation 2:

$$[(x_1, u_1), (x_2, u_2), \ldots, (x_N, u_N)] \quad (2)$$

The function is to be "smooth" (continuous and once differentiable), to be exact ($u(x_i) = u_i$) and to meet the user's intuitive expectations about the phenomenon under investigation. Furthermore, the function should be suitable for a computer application at a reasonable cost (nowadays, a basic implementation will probably make use of parallel resources).

## 3.0. Results and Discussion

\
The collected surface water bodies samples were analyzed for 20 different parameters, they include; Temperature, Turbidity, pH, Total Dissolved solids (TDS), Total Suspended Solids (TSS), Dissolved Oxygen (DO), EC, COD, BOD, Zn, CL, $NH_4N$, Ca, Pb, $SO_4$, Fe, Mg, $NO_3$, $PO_4$and Total Hardness. Obtained results are compared with permissible limits given by World Health Organization (WHO) standard. The spatial distribution of six parameters (TDS, DO, Zn, Fe, Pb, and $NH_4N$) is carried out using the spatial analyst tool in ArcMap. These parameters were chosen as a model to study spatial water quality analysis in the river. The water quality values and spatial distribution of water quality are shown in figures 1 to 7.

### *3.1. Detailed Results of Parameters Using a GIS software*

The tabulated results of the surface water quality parameters gotten from the laboratory, which can be found in table 3, was first inputted in the Microsoft Office Excel software, along with the Longitude and Latitude coordinate of the four stations (x and y coordinate/data) and the concentrations of the 20 parameters (z coordinate). Then, these tables were exported into ArcGIS for analysis using the Add XY data command on the ArcMap software
This table was used to create a surface water point layer which could then be exported into a "shapefile" or feature class if need be. This was done simply by right-clicking on the table of contents on the menu bar and then selecting data > Export Data. The exported data was then renamed, saved as a "shapefile," and added to the map as a new layer. To show just the newly created layer, the previous layer on the map was removed by simply clicking on it and selecting "remove"
Next, a polyline dataset, also known as the "boundary," was added. The spatial selection method for the target layer feature was selected to have their centroid in the source layer feature. This exported layer was also saved as a "shapefile", while the previous layer was removed
Thereafter, the Inverse Distance Weighted (IDW) method was then used for interpolation by inputting features and the z-value field, which is the concentration value. Then an output raster was created and then saved as a raster dataset.
In other to better analyze the environment, raster analysis was performed, and this included the selection of cell size. The IDW created a range/variation of colors indicating different pixel values and class values. This color ramp could, however be changed by choice.
In this study, five (5) classes were created and a suitable color ramp ranging from green to red was selected, denoting an increase in values.

All maps generated are shown in Figures 2 – 7.

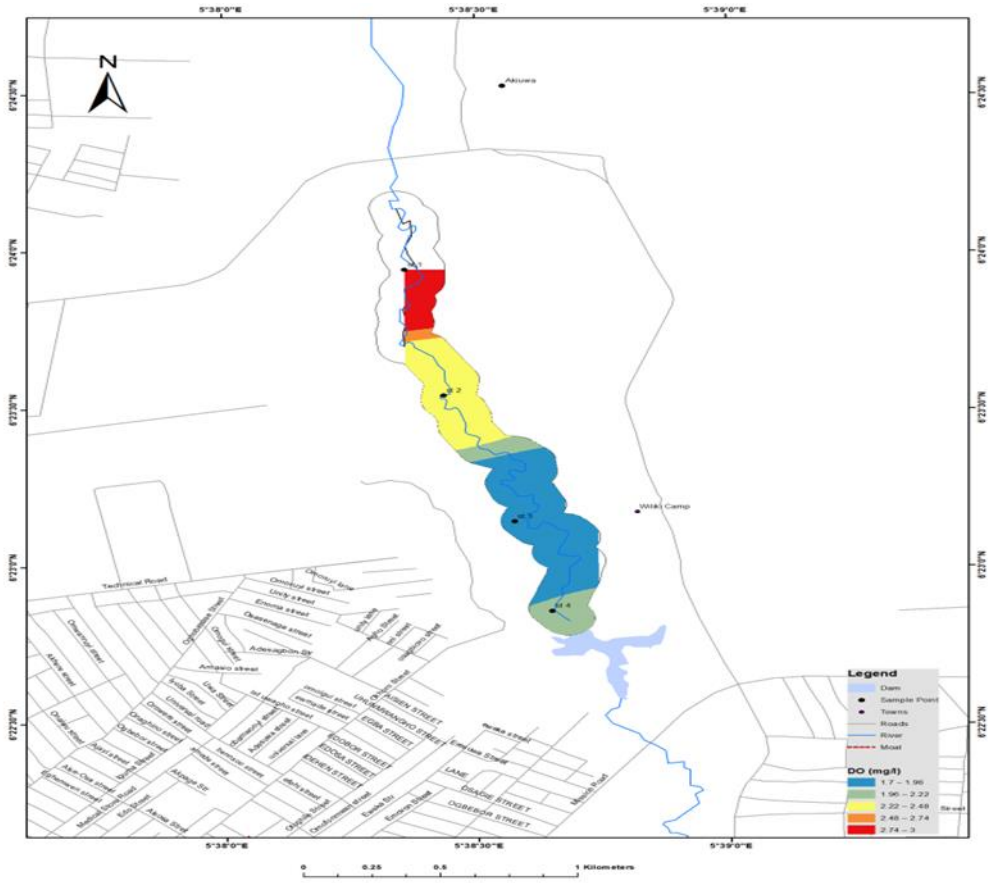



**Figure 2a:** Spatial distribution Map for DO

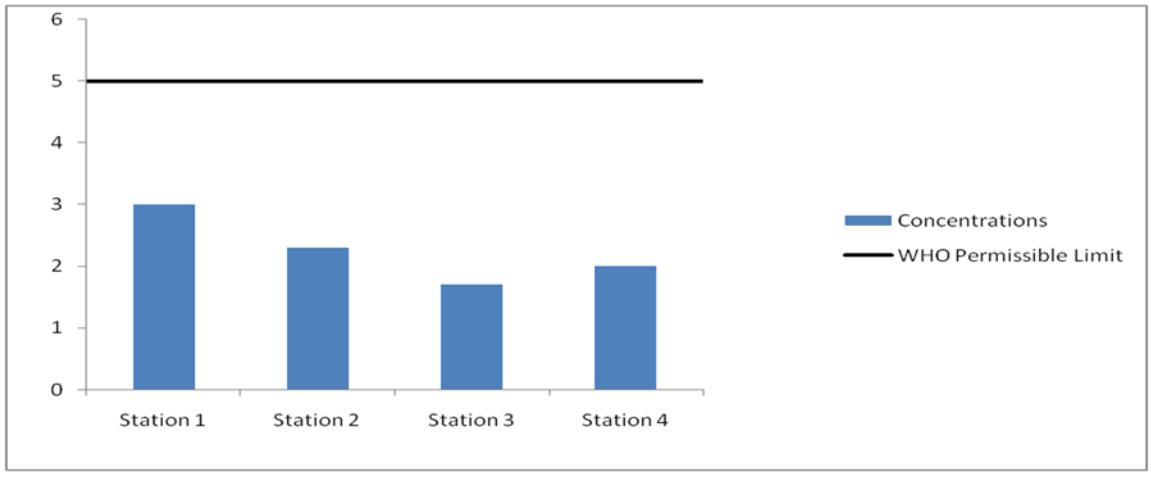



**Figure 2b:** Bar chart showing the DO values for the points and the WHO limit.

**DO:** Dissolved oxygen is by far one of the most important parameters in aquaculture. It can be noted that the amount of dissolved oxygen (DO) in the river increases as temperature reduces and decreases when salinity and altitude increase. The value of DO varied from1.7mg/l to 3.0mg/l along the four stations on the Ikpoba River. The maximum DO of 3.0mg/l was found at the first station; this could be the Mean value of DO was 2.35mg/l of the water bodies along the Ikpoba River. Figure 2a shows the spatial distribution map of DO. The maximum DO was found at the first station, while the minimum value was found at the third station just before the Ikpoba River dam. Variation Map of DO (figure 2a) shows that the concentration of DO mostly range from 2.22 to 2.74mg/l, and the concentration began to reduce along the river as it got to the Dam. It can be inferred that the DO range in the Ikpoba River is within the acceptable WHO limit. This can be seen in figure 2b.

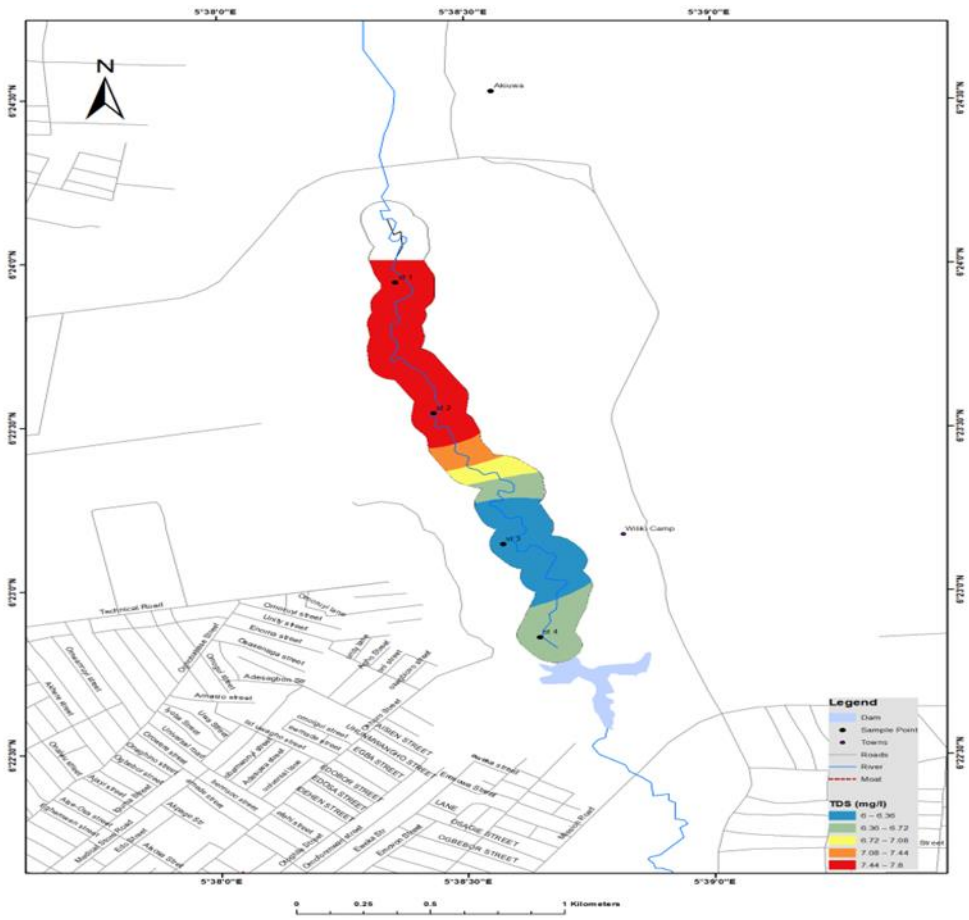



**Figure 3a:** Spatial distribution Map for TDS

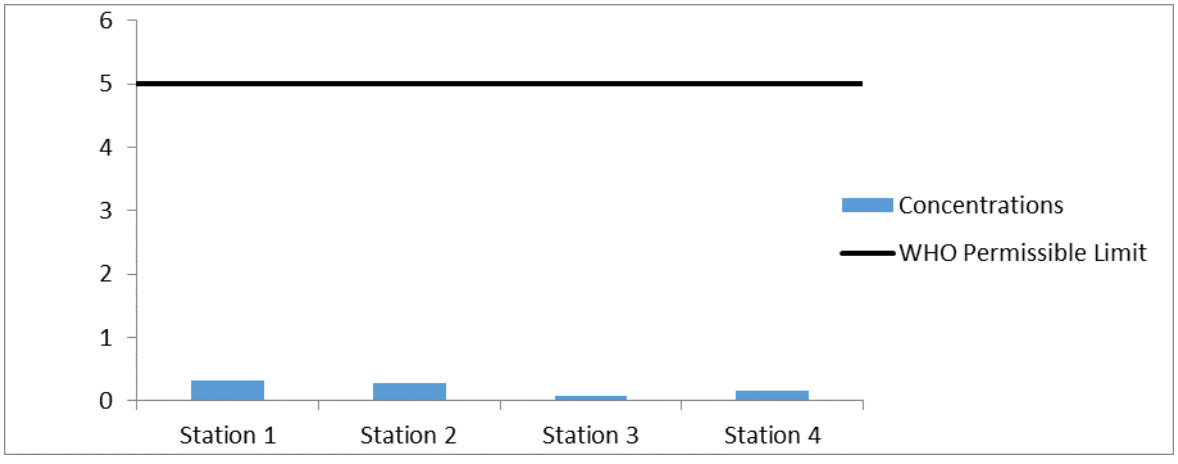



**Figure 3b:** Bar chart showing the TDS values for the points and the WHO limit.

**TDS:** Concentrations of TDS from natural sources have been found to vary from less than 30 mg/liter to as much as 6000 mg/liter (WHO/UNEP and GEMS 1989), depending on the solubilities of minerals in different geological regions. The TDS level fluctuated from 6.0mg/l to 7.8mg/l within the water bodies along the Ikpoba River. The TDS content was well below the WHO permissible limit. The concentration was maximum at the first station along the Ikpoba River, and the minimum was 6.0mg/l just before the Ikpoba dam at Okhoro street (station 3) along the river. The mean value was 6.9mg/l. The Spatial Distribution Map for TDS is shown in figure 3a above. In early studies, inverse relationships were reported between TDS concentrations in drinking water and the incidence of cancer (Burton A.C and Cornhill J.F. 1977) and coronary heart disease (Schroeder H.A. 1960).

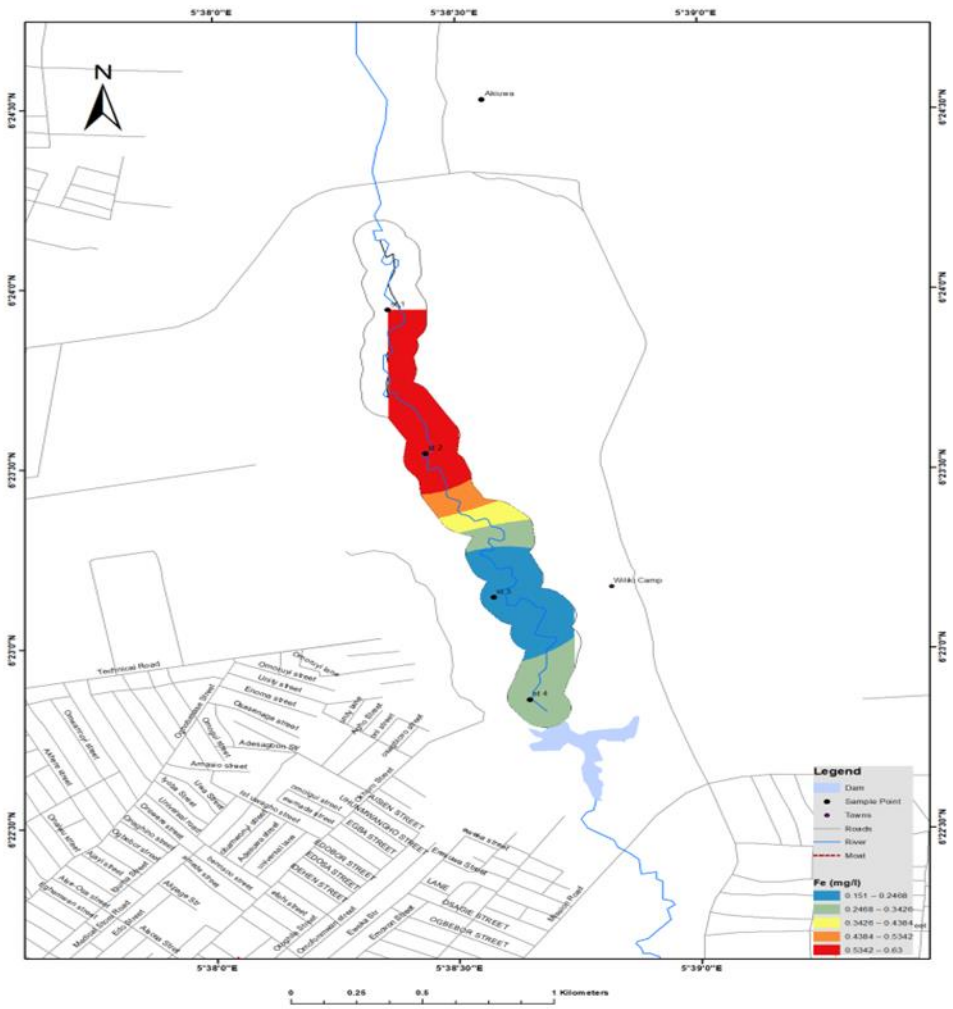



**Figure 4a:** Spatial distribution Map for Fe

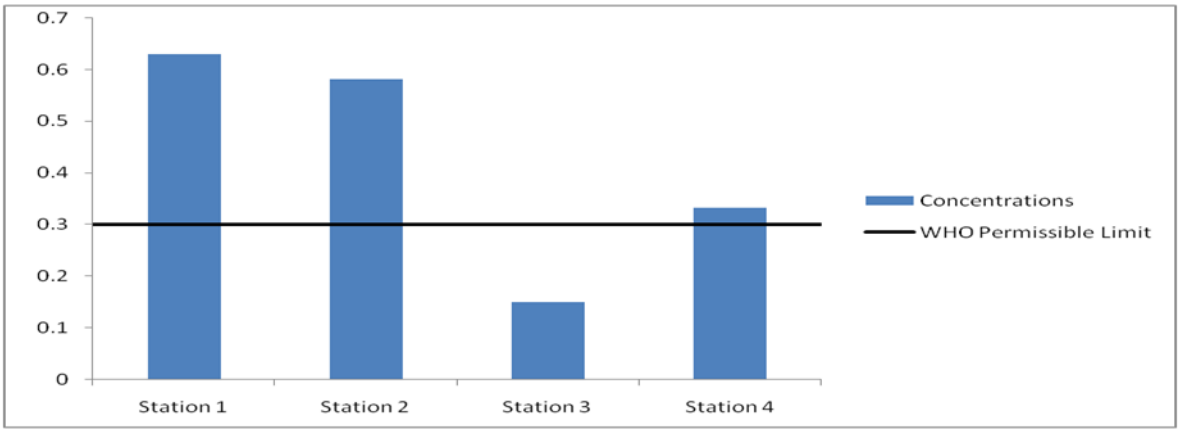



**Figure 4b:** Bar chart showing the Fe values for the points and the WHO limit.

**Fe:** Acidic rainwater releases iron ions into the surface water. Iron-bearing water has an unpleasant taste, which is apparent in drinking and food preparation. In the present study area, the iron ranges from 0.151mg/l to 0.630mg/l. The results show that the total iron value ranges from 0.10 to 0.70. As per the WHO standards, the iron has exceeded the Permissible limits in the areas farther away from the Ikpoba River Dam (i.e., Stations 1, 2, and 4), as shown in figure 4b. This might result from seepage of rainwater run-off, which has dissolved iron into the river. The mean concentration of Fe is 0.3905mg/l, and the Spatial Distribution Map of iron is shown in figure 4a.

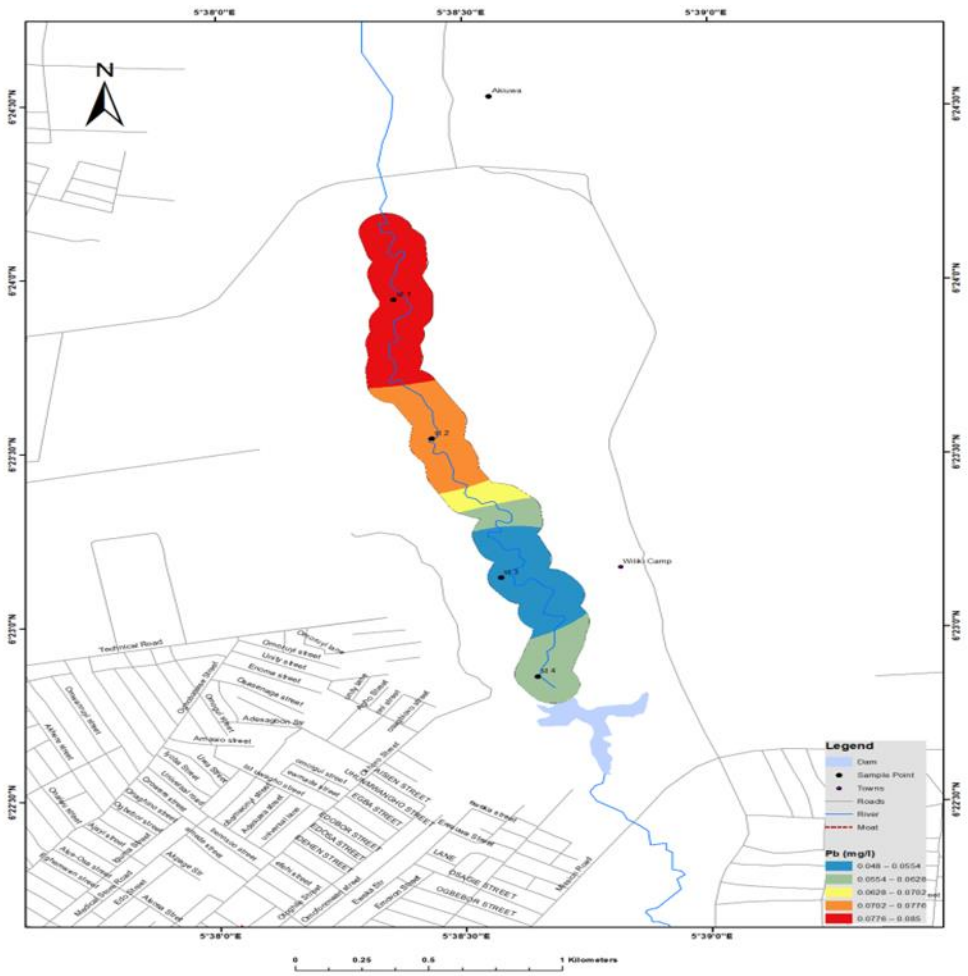



**Figure 5a:** Spatial distribution Map for Pb

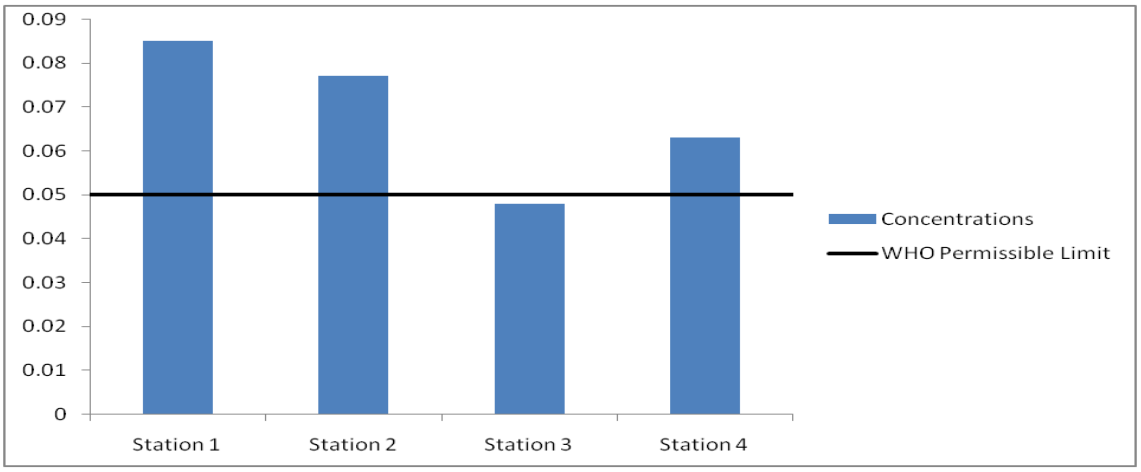



**Figure 5b:** Bar chart showing the Pb values for the points and the WHO limit.

**Pb:** The result of the analysis carried out on the presence of lead in the study area may be explained by data showing lead was mostly present in station 1, with a concentration of 0.085mg/l. The concentration values of Pb ranged from 0.048 to 0.085mg/l, while the mean value was 0.0665mg/l. The spatial distribution map is shown in fig 5a below. Comparing this result with the WHO standard, it can be observed that only one station (station 3) was within the acceptable limit, while the other stations were well above 0.05mg/l, which is the acceptable limit for Pb as shown in fig 5b. This could be a result of the dumping of industrial wastes like metals in the river.

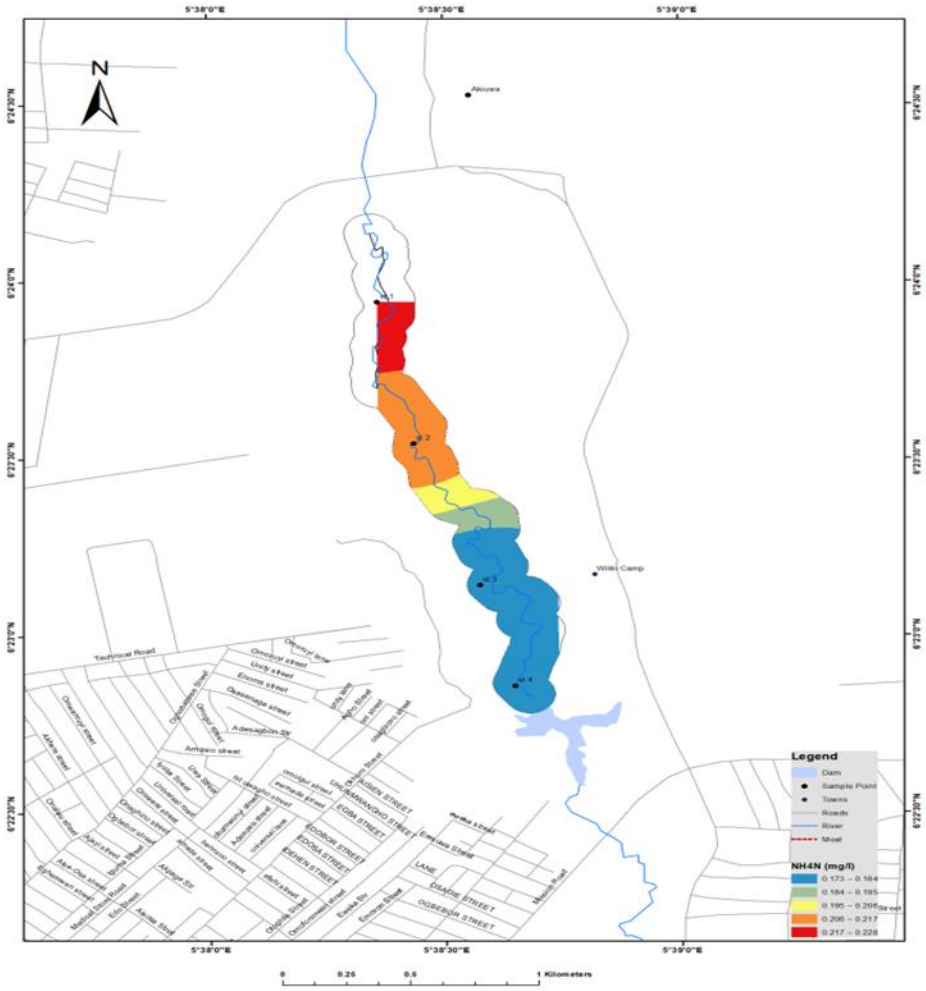



**Figure 6a:** Spatial distribution Map for $NH_4N$

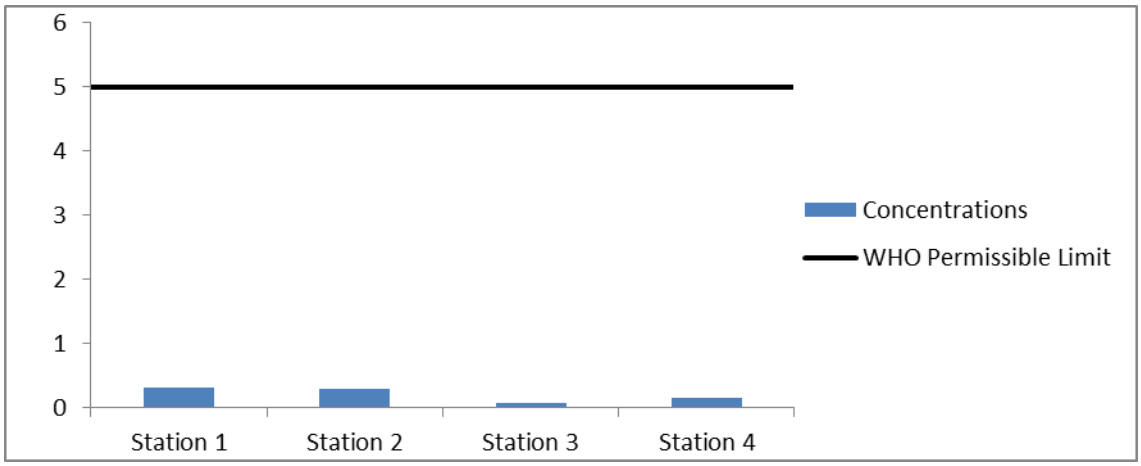



**Figure 6b:** Bar chart showing the $NH_4N$ values for the points and the WHO limit.

**$NH_4N$:** is a physicochemical form of ammonia nitrogen. It is the dissociated form of ammonia (which is a cation). Total Ammonia Nitrogen (TAN) is the sum of these$NH_4N$ and $NH_3N$ molecules in water (Anthonisien A.C., et al. 1976). The value of $NH_4N$ varied from 0.173mg/l to 0.228mg/l along the four stations on the Ikpoba River. The maximum $NH_4N$ of 0.228mg/l was found at station 1. The mean value of $NH_4N$ was calculated to be 0.2005mg/l of the water bodies along the Ikpoba River. Figure 6a shows the spatial distribution map $NH_4N$. The values of $NH_4N$ were well within the permissible limit according to the WHO standards, as shown in figure 6b; this could be due to the low presence of nitrogen.

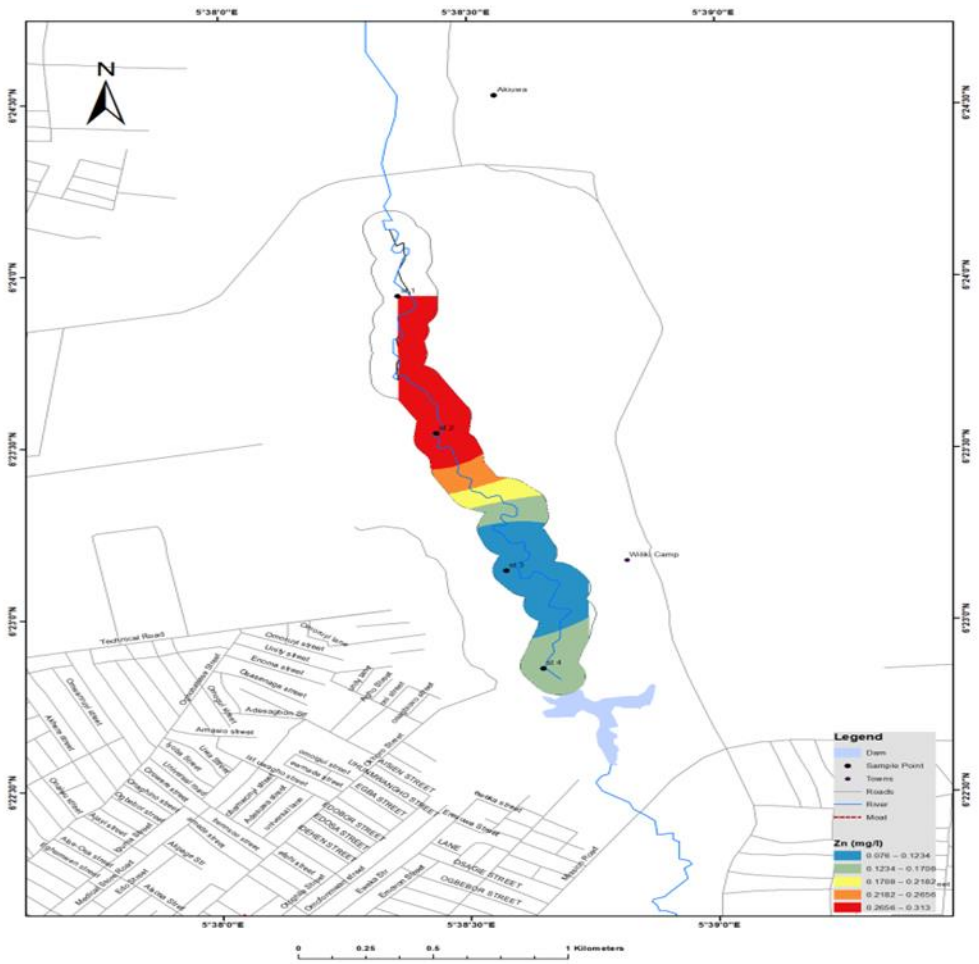



**Figure 7a:** Spatial distribution Map for Zn

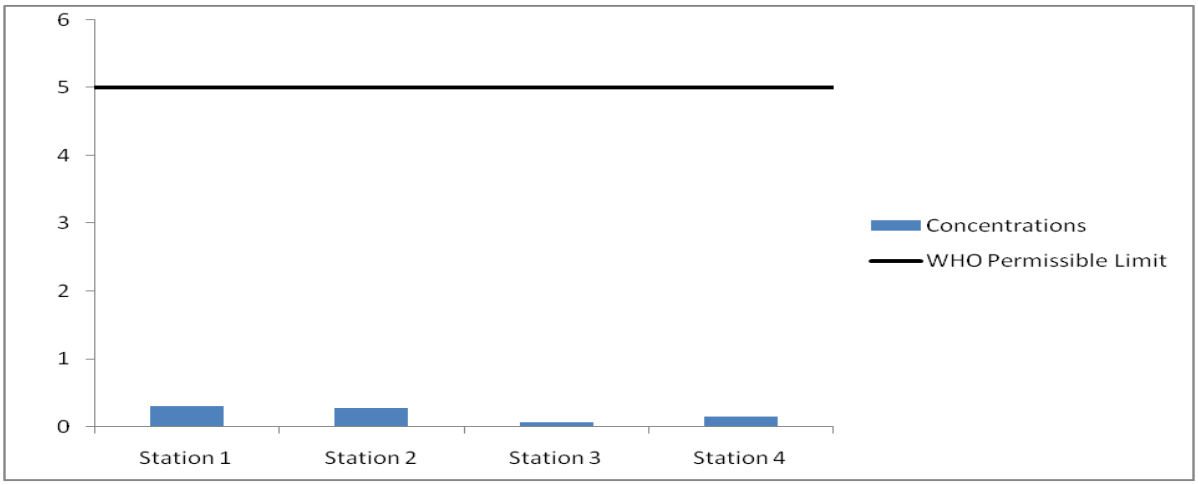



**Figure 7b:** Bar chart showing the Zn values for the points and the WHO limit

**Zinc:** It is an essential nutrient for body growth and development; however, drinking water containing high levels of zinc can lead to stomach cramps, nausea, and vomiting. Water with a zinc concentration of more than 5mg/l may start to become chalky in appearance with a detectable deterioration in taste. The value of Zn varied from 0.076mg/l to 0.313mg/l along the four stations on the Ikpoba River. The maximum Zn 0.076mg/l was found at the first station (station 1). The mean value of Zn was 0.1945mg/l of the water bodies along the Ikpoba River. Figure 7a shows the spatial distribution map Zn. When compared to the WHO standard, all values obtained from the four stations were within WHO acceptable limits, as seen in Figure 7b.

The relationship between all other parameters and the WHO standards can be seen below, alongside the table of values for surface water quality parameters obtained from the lab.

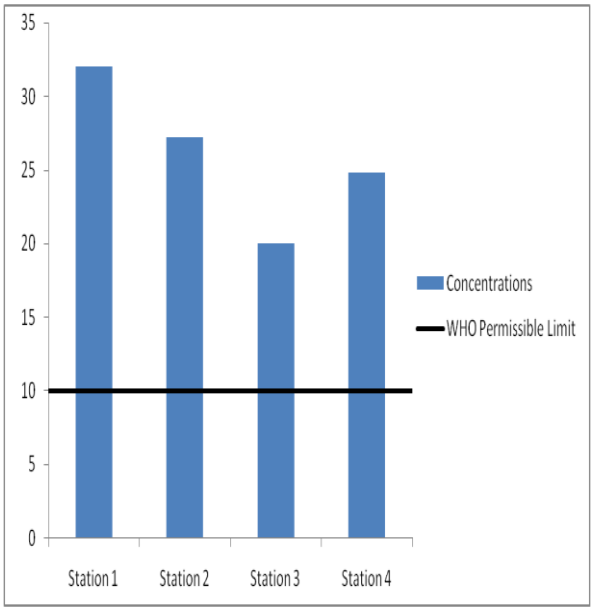



**Figure 8**: Bar chart showing the COD values for the points and the WHO limit.

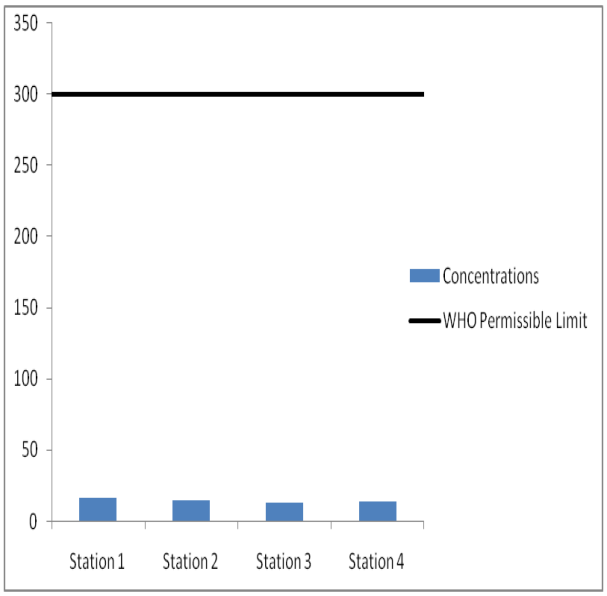



**Figure 9:** Bar chart showing the EC values for the points and the WHO limit.

The results for COD varied between 20-32mg/l, with the mean value being 26mg/l. When compared to the WHO standard (Figure 8), the concentrations at all four stations were above the permissible limit; this could be a result of the discharge of wastewater containing organic matter from industries. While EC varied between 12.315.8mg/l, with the mean value being 14.05mg/l. When compared to the WHO standard (Figure 9), the concentrations at all four stations were below the maximum permissible limit.

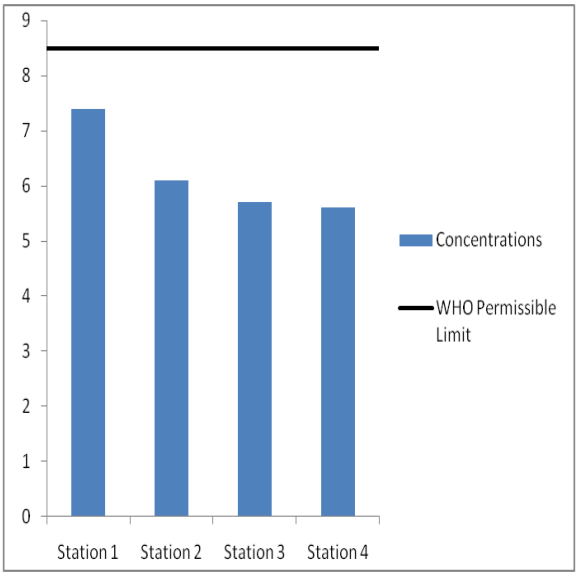



**Figure 10:** Bar chart showing the pH values for the points and the WHO limit

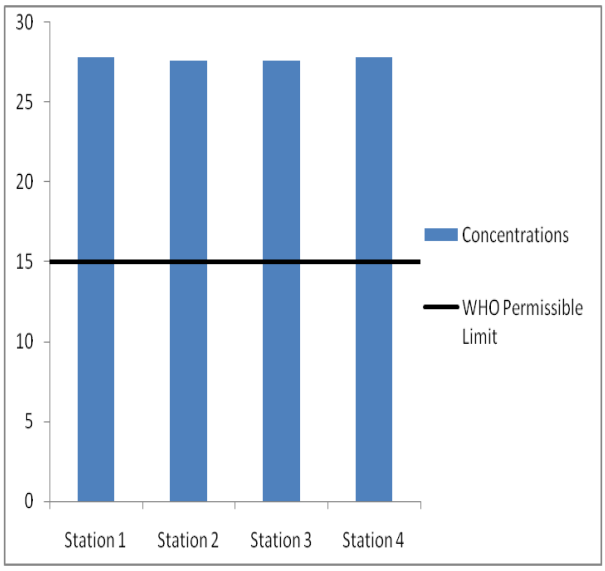



**Figure 11:** Bar chart showing the Temperature values for the points and the WHO limit

The results for pH varied between 5.6-7.4mg/l, with the mean value being 6.5mg/l, and that of temperature varied between 27.6–27.8mg/l. When compared to the WHO standard (Figure 10), pH concentrations at all four stations were above the permissible limit while that of temperature at all four stations was above the maximum permissible limit; this could be due to unstable climatic conditions.

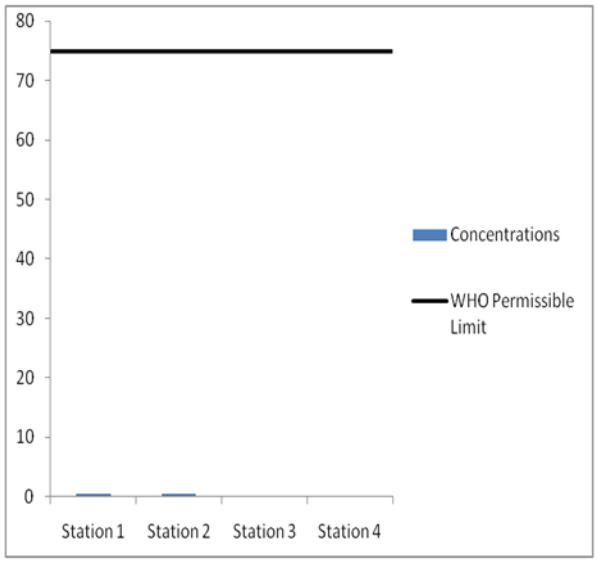



**Figure 12:** Bar chart showing the Ca values for the points and the WHO limit

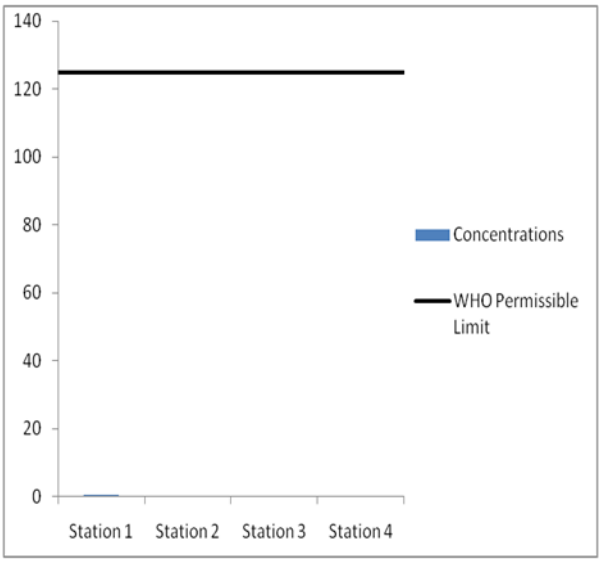



**Figure 13:** Bar chart showing the Mg values for the points and the WHO limit

The results for Ca varied between 0.2-0.51mg/l, with the mean value being 0.355mg/l. When compared to the WHO standard (Figure 12), the concentrations at all four stations were below the permissible limit. That of Mg varied between 0.11-0.28mg/l, with the mean value being 0.195mg/l. when compared to the WHO standard (Figure 13), the concentrations at all four stations were below the permissible limit.

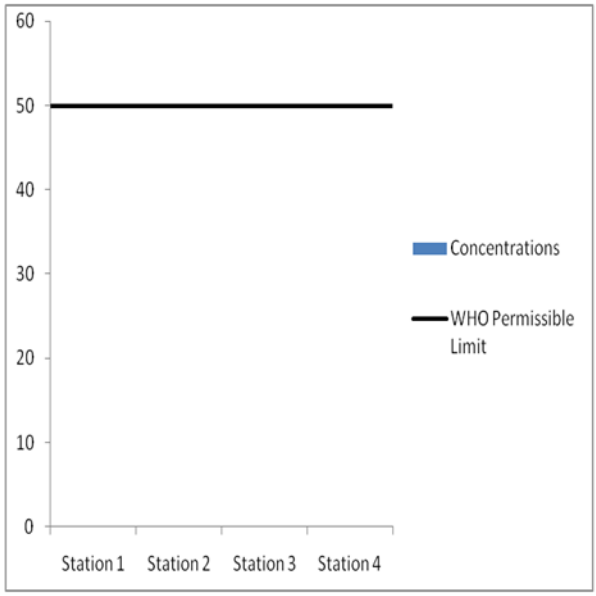



**Figure 14:** Bar chart showing the $NO_3$ values for the points and the WHO limit

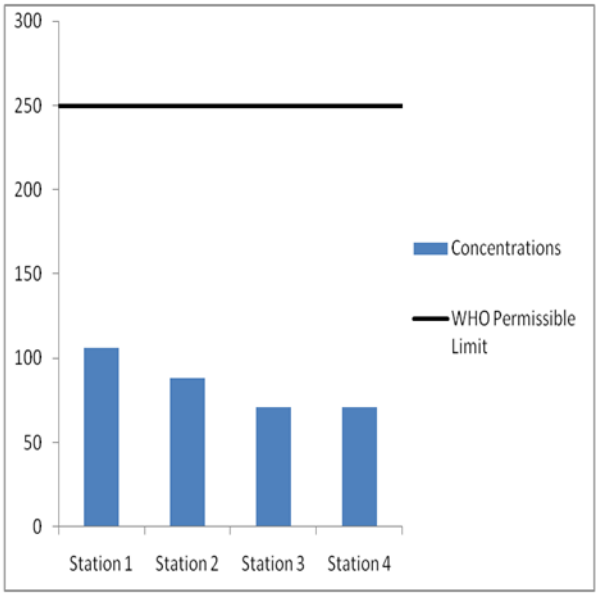



Figure **15:** Bar chart showing the Cl values for the points and the WHO limit

The results for $NO_3$ varied between 0.084-0.122mg/l, with the mean value being 0.103mg/l. When compared to the WHO standard (Figure 14), the concentrations at all four stations were below the maximum permissible limit. At the same time, the results for Cl varied between 70.9-106.4mg/l, with the mean value being 88.65mg/l, and when compared to the WHO standard (Figure 15), the concentrations at all four stations were below the maximum permissible limit

*3.2 Results of laboratory Analysis*

**Table 3: Surface water quality parameter**

| Code | pH | EC | Temp | Turb. | TSS | TDS | DO | $BOD_5$ | COD | Ca | Mg | Hardness | Cl | NH4N | $PO_4$ | $NO_3$ | $SO_4$ | Fe | Zn | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (µS/cm) | (ºC) | (NTU) | | (mg/l) | | | | | | | | | | | | | | |
| St. 1 | 7.4 | 15.8 | 27.8 | 0.45 | 1.21 | 7.8 | 3.0 | 1.2 | 32.0 | 0.51 | 0.28 | 2.43 | 106.4 | 0.228 | 0.031 | 0.122 | 0.780 | 0.630 | 0.313 | 0.085 |
| St. 2 | 6.1 | 14.8 | 27.6 | 0.43 | 1.11 | 7.6 | 2.3 | 0.3 | 27.2 | 0.48 | 0.20 | 2.02 | 88.6 | 0.211 | 0.030 | 0.107 | 0.653 | 0.582 | 0.285 | 0.077 |
| St. 3 | 5.7 | 12.3 | 27.6 | 0.38 | 0.50 | 6.0 | 1.7 | 0.3 | 20.0 | 0.24 | 0.11 | 1.05 | 70.9 | 0.173 | 0.021 | 0.084 | 0.506 | 0.151 | 0.076 | 0.048 |
| St. 4 | 5.6 | 13.3 | 27.8 | 0.41 | 0.91 | 6.6 | 2.0 | 0.5 | 24.8 | 0.20 | 0.15 | 1.12 | 70.9 | 0.184 | 0.028 | 0.101 | 0.581 | 0.333 | 0.152 | 0.063 |

## 4.0. Conclusions

There are several factors that can affect the quality of water; these range from industrialization to domestic factors. The Ikpoba rivers span across the city of Benin, and most of the activities carried out at the upper end of the river are agricultural and fishing (Odigie, 2014). The Nigerian Brewery and the University of Benin Teaching Hospital also discharge effluent into the Ikpoba River. Wastes from these activities and organizations, along with untreated wastewater being run off into the river, contribute grossly to the increased level of pollution and impurities like heavy metals, which result in low water quality which is harmful to locals who depend on the water for survival. The study area of four station points along the Ikpoba River reveals that some values of parameters such as Zn, Pb, and COD are more than the permissible limits of the WHO standard. Out of the four (4) station points analyzed, three stations were below the permissible range for pH, three (3) station points had more Iron (Fe) values, three (3) station points had more lead (Pb) values, while all four stations exceeded the COD values. The values of other parameters are well within the limits. The spatial distribution maps of surface water quality parameters are prepared, and the maps are well integrated. The surface water variation maps show a broad idea of the stress zones in the study area. The obtained results on water quality can be used in making the public, local administrators, and government to be aware of the poor quality of surface water bodies, and it helps in taking necessary actions in protecting the water bodies and ecosystem. Government should provide necessary regulations to develop suitable management practices to protect surface water bodies. Using IDW in GIS, one can predict a value for any unmeasured location using the measured values surrounding the prediction location.

Furthermore, the application of GIS has shown to be very effective in water quality management since if the level of pollution is known for each water quality parameter across the river, planning effort through processing observed data, analyzing and interpreting the levels of pollution will be made easier. The use of spatial analysis on ArcGIS using the IDW technique has proven to be cost-effective in water quality assessment because it reduces the amount of field data collection, provides information on areas not measured, and identifies the stressed zones in the study area. GIS does not eliminate the effort of data collection since it will help in the verification of spatial data and their interpretations.

It is recommended that the enforcement agencies and water and sanitation agencies, responsible for ensuring proper disposal of human waste and treatment of sewage, endeavor to do their jobs and prevent improper disposal of both domestic and industrial waste in surface waters. Mandating that wastewater from industries must be treated before it is discharged into the Ikpoba River. Although this study did not include a periodic monitoring strategy that could be used to tell the temporal variations of pollution parameters, the data collected were analyzed using the Interpolation technique, Inverse Distance Weighted (IDW) method to predict unmeasured areas using the measured area data analyzed in the laboratory. Also, surface water quality analysis can be extended to an artificial intelligence framework, and the present study can be kept as basic data for future investigation for analyzing various parameters of surface water studies.

**References**

Anthonisien A.C., Loehr R.C., Prakasam T.B.S., and Srinath E.G. "The Importance of Nitrification." *Water Pollution Federation Vol. 48,* 1976: 835-852.

Burton A.C, and Cornhill J.F. " Correlation of cancer death rates with altitude and with the quality of water supply of the 100 largest cities in the United States." Journal of toxicology and environmental health, 1977: 3(3):465-478.

Calamari, D., and Naeve H. (1994) "Review of pollution in the African Aquatic Environment." *CIFA Technical Paper No.25 Rome, FAO*: 118.

Christiana P., and Hadjimitsis D.G. (2013) "Remote sensing for water quality surveillance in inland waters: the case study of Asprokremmos Dam in Cyprus. In: Hadjimitsis DG (ed) Remote sensing of environment—integrated approaches. ." *InTech Publisher, London,*, 2013: 224.

Chukwuka, A. V. & Ozekeke Silver Ogbeide (2021). Riparian-Buffer Loss and Pesticide Incidence in Freshwater Matrices of Ikpoba River (Nigeria): Policy Recommendations for the Protection of Tropical River Basins. *River Basin Management - Sustainability Issues and Planning Strategies.* DOI:10.5772/intechopen.95521

Don-Pedro, K.N., Oyewo E.O., and Otitoloju A.A.(2004) " Trend of heavy metal concentration in Lagos Lagoon ecosystem, Nigeria. ." *West African Journal of Applied Ecology, Volume 5*: 103-114.

Earth. *Google Earth.* March 1, 2012. www.google.com (accessed November 19, 2012).

Fakayode S.O. (2005)" Impact assessment of industrial effluent on water quality of the receiving Aloro River in Ibadan, Nigeria." *African Journal of Environmental Assessment and Management, Volume 10*: 1-13.

Fernandes, H.M., (1997) "Heavy metal distribution in sediment and ecological risk assessment. The role of dys- genic processes in reducing metal toxicity in botton sediments." *Journal of Environmental Pollution, Vol. 97, No. 3,* 317-325.

Gogu, R.C.,, Carabin G, Hallet V, Peters V, and Dassargues A. (2001) "GIS-based hydrological databases and ." *proceedings of the 8th Stockholm Water Symposium,10-13 August.* Sweden, pp: 79-90.

Goodchild M. F. (1987). "A spatial analytical perspective on Geographical Information Systems". *International Journal of Geographical Information Systems, 1*(4), 327 – 334.

Goodchild M. F and Longley P. A. (1992). The future of Geographical Information Science and Spatial Analysis.

Jimoh, H.E. (2006). Surface water physico-chemical and bottom sediment quality of the Ikpoba River, Benin City and stated Recovery after five (5) years of Dredging. B.Sc. Thesis, University of Benin, Benin City. 82pp.

Kanu I., and Achi O.K. (2011)"Industrial effluents and their impact on water quality of receiving Rivers in Nigeria." *Journal of Applied Technology in Environmental Sanitation, Vol. 1, No.* : 75-86.

Lam NS-N. (1983) Spatial Interpolation methods: a review. *Am Cartogr 10*(2): 129-149

Sashikkumar M.C., (2013) "Good book." *Real Journal*, 3.

Madan K., A., Chowdhury, V. M., Chowdary, and Peiffer S. (2007) " Groundwater management and development by integrated remote sensing and geographic information systems: prospects and constraints. ." *Water Resources Management, 21* (2), 427–467.

Ndiokwere C.L. (2004) "Chemistry and Environment." *73rd Inaugural lecture series, University of Benin.* Benin city, Nigeria, 2004. 71.

Odigie J. O. (2014) Harmful Effects of Wastewater Disposal into Water Bodies: A Case Review of The Ikpoba River, Benin City, Nigeria. *Tropical Freshwater Biology, 23*(2014) 87 – 101. DOI: http://dx.doi.org/10.4314/tfb.v23i1.5

Ogbeibu, A.E. and Anagboso, M.U. (2004). Baseline limnological investigation of the Utor river in Esan Southeast, Edo State, Southern Nigeria. 1: Physical and chemical hydrology. Tropical Freshwater Biology. 12/13:45-62.
Opensaw, S., (1991) "Spatial Analysis: Modelling in a GIS Environment." Chapter 4: p-56.

Oronsaye J. A. O., Wangboje O.M., and Oguzie F. A. (2001) "The Potential Ecological Risk Assessment of Heavy Metals in Ogba River, Benin City, Nigeria." *Bioscience Research Journal 23* (3*)* 175 – 183.

Raj Kumar V., Raikar, Sneha M. K. (2012) "Water Quality Analysis of Bhadravathi Taluk, using GIS – A Case Study" *International Journal of Environmental Sciences, 2*(4) 2443 – 2453.

Schroeder H.A. "Relation between mortality from cardiovascular disease and treated water supplies. Variation in states and 163 largest municipalities." Journal of the American Medical Association, 1960: 172:1902.

Singh S. K., Srivastava P.K, Pandey A.C, and Gautam S.K. (2013c) "Integrated assessment of groundwater influenced by a confluence river system: concurrence with Remote Sensing and Geochemical Modelling." *Water Resour Manag*, 2013c: 27:4291–4313.

Singh D, Gautam P.K, Gautam I.K, and Singh S.K. (2013a) "Assessment of Ganga River water quality using multivariate statistical techniques. ." *In: Dwivedi PK, Singh SN (eds) Technol Innovation through Mod Eng Sci. Savera Publishing House, New Delhi, India,* 2013a: 36–38.

Singh H, Singh D, Singh S.K, and Shukla D.N.(2017b) "Assessment of river water quality and ecological diversity through multivariate statistical techniques, and earth observation dataset of rivers Ghaghara and Gandak, India." *Int J River Basin Manag 15(3)*: 347–360.

Singh H., Pandey R, Singh S.K, and Shukla D.N. (2017a) "Assessment of heavy metal contamination in the sediment of the River Ghaghara, a major tributary of the River Ganga in Northern Ind." *Appl Water Sci 7(7):* 2013a: 4133–4149.

Singh S.K, Srivastava P.K, Singh D, Han D, Gautam S.K, and Pandey A.C. (2015) "Modeling groundwater quality over a humid subtropical region using numerical indices, earth observation datasets, and X-ray diffraction technique: a case study of Allahabad district, India." *Environ Geochem Health* , 2015: 37(1):157–180.

Singh S.K., Srivastava, and Pandey. (2013b) "Fluoride contamination mapping of groundwater in Northern India integrated with geo- chemical indicators and GIS." *Water Sci Technol Water Supply*, 2013b: 13:1513–1523.

Shelton R. M. (1991) Aloe-Vera: its chemical and therapeautic properties. *International Journal Dermatol 30*(10): 679-683

Stefouli M, and Charou E. (2012) "Ohrid Lake monitoring using MERIS and Landsat images." *a BALWOIS 2012-Ohrid, Republic of Macedoni*, 2012.

United Nations Agenda 21(1993): "United Nations." *Programmes of Action for Sustainable Development. Rio Declaration on Envi- ronment and Development*: 294.

World Health Organization (2005). Combating Water Borne Diseases at the Household Level;. World Health Organization.

Yao Y., (2010)"Water quality remote sensing monitoring research in China based on the HJ-1 satellite data." *Satellite Environ. Center, Minist. of Environ. Protection, geoscience and remote sensing symposium (IGARSS), 2010 IEEE International, pp*: 620–623.

**Cite this article as:**
Ojeah J. C and. Oriakhi O., 2022. Spatial Analysis for Surface Water Quality Assessment of the Ikpoba River Using Geographic Information System *Nigerian Journal of Environmental Sciences and Technology*, 6(2), pp. 391-408. https://doi.org/10.36263/nijest.2022.02.0374