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# ASSESSMENT OF INDUSTRIAL WATER POLLUTION LEVEL IN AWUN RIVER BASIN, NORTH CENTRAL NIGERIA

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## ABSTRACT

Water quality degradation is a major problem in watershed. Physicochemical and bacteriological tests were carried out on water samples within the Awun basin to determine the level of pollution. Three samples were taken from three different locations by random sampling along the river channels and were analysed in the Laboratory. The pH, Turbidity, colour conductance, ionic constituents, heavy metals, bacteriological and other water parameters tests were conducted. Results showed that Lead and Zinc were major parameters higher than the maximum acceptable value of Nigerian FEPA (Federal Environmental Protection Agency) and the WHO (World Health Organization) for effluent discharge into surface water. Statistical analysis showed no significant difference. It was recommended that the river water should be treated before being used for domestic purposes.

## INTRODUCTION

Industrial growth is a major tool for socioeconomic development in Nigeria. Since the industrial revolution Nigeria manufacturing industries have become more efficient and productive. Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater), environmental degradation occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment or remove of harmful compounds (Galadima *et al.,* 2011). It has been suggested that water pollution is the leading worldwide cause of deaths and diseases, and that it accounts for the deaths of more than 14,000 people daily (Aboyeji, 2013; Saidu and Ike 2013). Rapid industrial development and the world global growth have led to the recognition and increasing understanding of interrelationship between pollution, public health, and the environment. The quality of any body of surface or ground water is a function of either or both natural influences and human activities (Stark *et al.*, 2001; Kolawole *et al*., 2008). It is now generally accepted that aquatic environments cannot be perceived simply as holding tanks that supply water for human activities. Rather, these environments are complex matrices that require careful use to ensure sustainable ecosystem functioning well into the future (UNEPGEMS, 2000).

Much of the Ilorin population also depend on River water for various domestic purposes. Salami, (2003) examined the extent of pollution on water quality parameters along Asa river channel, the result shows that the quality of the water deteriorates as the sample point along the river approaches Ilorin; he found out that it was caused by dumping of organic and inorganic refuse to the river. However, Nivruti *et al.*, (2013) in his assessment of the Physicochemical characteristics of some industrial effluents collected from various industries in Vapi Industrial area India, the parameters were found to be high and highly polluted. The high-level pollution of the industrial effluents could cause environmental problems which can affect plant, animal, and human life (Nivruti *et al.,* 2013). In his research, Emeka (2015) found out that colour, odour, turbidity, temperature, PH, total dissolved solid, total suspended solid, total solid, dissolved oxygen, COD, BOD, conductivity, iron, lead, copper, zinc, coliform, *E. coli* and coliform are parameters that determine the pollution of water. He also reported that high rate of suspended solids in surface water can clog fish gills, either killing them or reducing their growth rate. Suspended solids also interfere with effective drinking water treatment. High sediment load interferes with coagulation, filtration, and disinfection of turbid water. Siyanbola *et al.,* (2011) in his study of physico-chemical characteristics of effluents, highlighted the need for treatment of industrial effluent before they are discharged into the environment. He stated that the use of dams polluted by industrial effluents from textiles, shoes, cosmetics, plastics, and other household cum industrial consumables has its negative consequence on the plants through the alteration of the physico-chemical properties of the receiving water body. Agaja *et al.,* (2013) used inferential statistics to analyse the data collected from downstream and upstream in her research of pollution impacts of industries along Eleyele river. She attributed the variation in parameter to land use; she also mentioned that there is a great health risk posed by the concentration of industries along water bodies as disposal of waste by industries into such water bodies can have hazardous implications on man's health and the aquatic ecosystem. This view was also supported by Sirohi *et al.,(*2014). Wastewater effluents have been shown to contain a variety ofanthropogenic compounds, many of which have endocrine-disrupting properties (Okereke *et al.,* 2015).

It is thus necessary to assess the level of water pollution within Awun basin to ensure the rivers maintains the required water quality for various uses. There is need to understand the variations of raw water quality as it has a bearing on the risk associated with the final use of the water particularly abstraction for potable water production (WHO, 2006). This study assessed the industrial waste pollution level within Awun River Basin using random sampling method.

## MATERIALS AND METHODS

The study area is situated within Kwara State with coordinate of latitudes $8^0$10'- $8^0$50' and longitude $4^0$10'- $4^0$40'. Awun drainage basin is situated in the north central Nigeria with a catchment area of about 2300km2comprises of Awun sub-basin covering an area 626.66$Km^{2,}$ Asa sub-basin covers 471.94$km^2$, Oyun sub-basin covers 452.80$km^2$ and Moro sub-basin covers 751.56$km^2$. Oyun River flows in a northwest direction at a distance of about 9.6km east of Ilorin, the state capital. The Asa River crosses Ilorin on its north-bound course and the Moro River passes about 11.2km west of Ilorin town on a north-east course. These rivers converge 9.6km north of Ilorin, within Awun drainage basin which in its turn joins the Niger River at Jebba. The climate of Kwara State is characterized by both wet and dry seasons with temperatures ranging from $33^0$ C to $34^0$C from

November to January while from February to April, the values ranges between 34$^0$C to 53$^0$C and mean monthly temperatures of 25$^0$C to 28.9$^0$C (Ajadi, *et al.,* 2011). Kwara state lies within a region described as tropical climate and characterized by double rainfall maxima and has tropical wet and dry climate with both seasons lasting for about six months. The State is a summer rainfall area, with an annual rainfall range of 1000 mm to 1500 mm. The rainy season begins at about the end of March and lasts until early September, while the dry season begins in early October and ends in early March. Temperature is uniformly high and ranges between 25$^o$C and 30$^o$C in the wet season throughout the season while in the dry season it ranges between 33$^o$C to 34$^o$C. Relative humidity in the wet season is between 75 to 80% while in the dry season it is about 65% (Akpenpuun and Busari, 2013). The study area consists mainly of pre-cambrian basement complex rock and elevation of the western side varies from 273-333m while the eastern side varies from 273-364m above sea level (Ajadi and Tunde, 2010).The study area is shown Figure 1 depicts the map of Nigeria showing Kwara State and the study area.

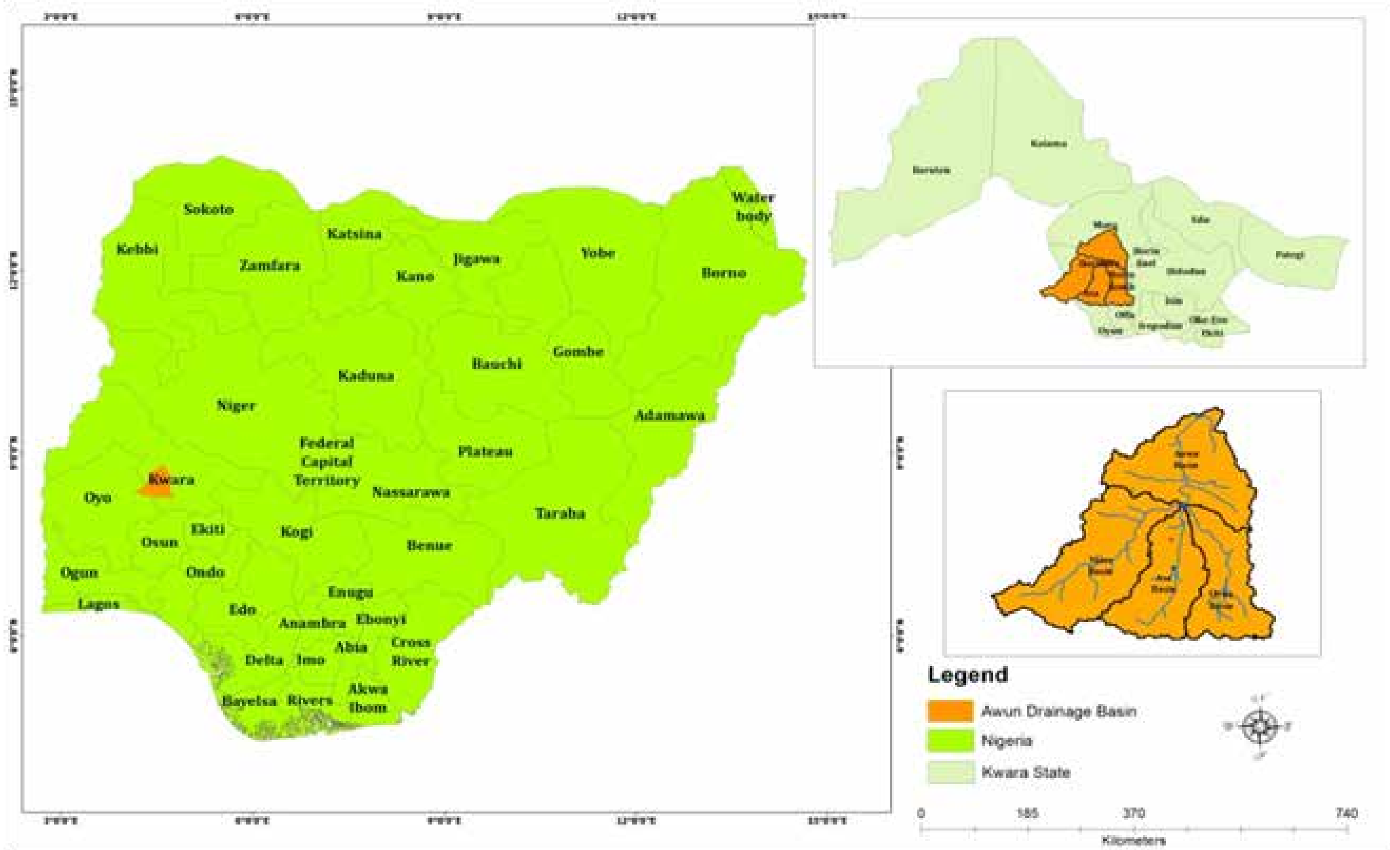



Figure 1: Map of Nigeria showing Kwara State and Awun River Basin

The samples were collected from three points where industrial effluent domestic sewage was available (in flowing condition) using random sampling method. The samples were collected under highway bridges within Awun River Basin. Plastic bottles of 75 ml capacity with stopper were used for collecting samples. Each bottle was washed with 2% Nitric acid and then rinsed three times with distilled water. The bottles were then preserved in a clean place. The bottles were filled leaving no air space, and then the bottles were sealed to prevent any leakage. Each sample was labelled according to the location, preserved at 40C, and transported to the Chemistry Laboratory, University of Ilorin to determine the physical, chemical, and bacteriological parameters in each sample. Collection Point A was at 1.21kilometre to point B, while point B is 2.01 kilometres from Point C. The sampling points were depicted in Fig.2.


Figure 2: Sample locations A, B, and C.

All samples for laboratory analysis, Chlorine(Cl), Calcium($Ca^{2+}$), total hardness, BOD sodium, were determined according to Standard Methods for Examination of Water and Waste water (APHA,1998). Turbidity levels were measured in Nephelometric units (NTUs) using the turbidity meter. Colour, Carbon dioxide, Iron, Copper, Manganese, Lead, Fluorine, Sulphate, Nitrate, potassium, Ammonia, Chromium, Zinc, Arsenic, Aluminum, Cyanide, Nickel,Cadmium and Mercury were determined using Hach DR 6000 Benchtop Spectrophotometer as described by Kodarkar *et al.,* (2008). The results of the evaluations were compared with the maximum values of the Federal Environmental Protection Agency (FEPA, 1991) on Federal water quality standard and effluent limitations, also,by World Health Organization (WHO), 2007 to establish its environmental standard conformity.

## RESULTS AND DISCUSSION

Table 1:Water quality parameters within Awun River Basin

| **Physicochemical Parameter** | **Sample A** | **Sample B** | **Sample C** |
|---|---|---|---|
| phenophtalen alkalinity | 0.00 | 0.00 | 0.00 |
| Methyl orange Alkalinity(mg/l) | 200.00 | 140.00 | 160.00 |
| Total Hardness(mg/l) | 52.00 | 48.00 | 60.00 |
| Calcium hardness (mg/l) | 32.00 | 28.00 | 36.00 |
| Magnesium Hardness (mg/l) | 20.00 | 20.00 | 24.00 |
| calcium total (mg/l) | 12.80 | 11.20 | 14.40 |
| magnesium total (mg/l) | 7.60 | 7.60 | 8.40 |
| CO2 (mg/l) | 13.00 | 12.00 | 17.00 |
| Chlorine (mg/l) | 23.00 | 20.50 | 31.50 |
| Iron (mg/l) | 1.40 | 1.10 | 2.30 |
| copper (mg/l) | 0.35 | 0.35 | 0.40 |
| Manganese (mg/l) | 0.20 | 0.20 | 0.10 |
| Lead (mg/l) | 0.35 | 0.30 | 0.15 |
| Fluorine (mg/l) | 0.06 | 0.04 | 0.07 |
| SO42- (mg/l) | 15.50 | 13.50 | 21.00 |
| NO3- (mg/l) | 3.70 | 3.40 | 4.20 |
| PO4 (mg/l) | 0.25 | 0.20 | 0.00 |
| Sodium (mg/l) | 2.50 | 3.10 | 1.90 |
| Potassium(mg/l) | 0.90 | 0.70 | 0.90 |
| TS (mg/l) | 246.00 | 304.00 | 258.00 |
| DS (mg/l) | 212.00 | 252.00 | 228.00 |
| Suspended Solids (mg/l) | 34.00 | 52.00 | 30.00 |
| COD (mg/l) | 6.40 | 6.00 | 7.60 |
| Turbidity (NTU) | 7.50 | 10.00 | 8.50 |
| pH | 8.34 | 8.42 | 7.65 |
| Colour (Hu) | 9.00 | 15.00 | 11.00 |
| DO (mg/l) 1st day | 6.00 | 5.40 | 6.80 |
| DO (mg/l) 5th day | 1.20 | 1.60 | 2.60 |
| BOD (mg/l) | 4.80 | 3.80 | 4.20 |
| Conductance( µS/cm) | 93.67 | 92.84 | 89.67 |
| Silica (mg/l) | 10.00 | 8.00 | 6.00 |
| Ammonia (mg/l) | 0.04 | 0.03 | 0.02 |
| Chromium (mg/l) | 0.04 | 0.03 | 0.03 |
| Zinc (mg/l) | 2.70 | 2.50 | 1.90 |
| Arsenic (mg/l) | 0.00 | 0.00 | 0.00 |
| Aluminium(mg/l) | 2.50 | 2.10 | 3.20 |
| Mercury (mg/l) | 0.00 | 0.00 | 0.00 |
| Cadmium (mg/l) | 0.00 | 0.00 | 0.00 |
| Nickel (mg/l) | 0.05 | 0.03 | 0.03 |
| Cyanide (mg/l) | 0.00 | 0.00 | 0.00 |
| Coliform count | 180+ | 180+ | 10.00 |
| *E.coli* (*Escherichia coli*) | 3.00 | 3.00 | 1.00 |

The values of some of the water quality parameters were plotted against sample locations. The variations were depicted in Figures 3 to 11.

In the tests conducted for heavy metals, Comparison of Zinc level is depicted in figure 3, Lead and Iron variations are presented in figures 4 and 5 respectively. The variation in Manganese, Chromium, Aluminium and Copper in the sample locations were depicted in figures 6 to 9 while the variations in Silica and Nickel are shown in figures 10 and 11 respectively.

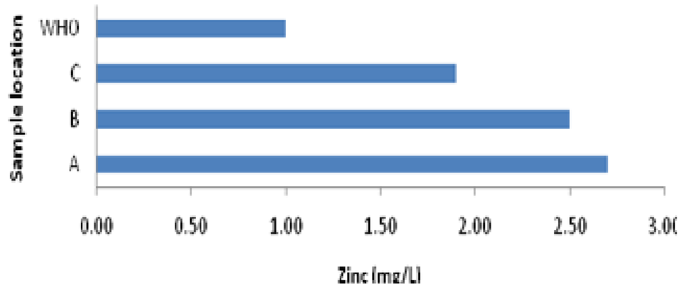



Figure 3: Comparative analysis of Zinc in sample points

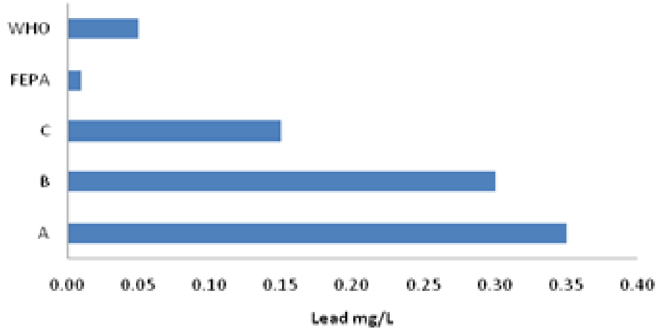



Figure 4: comparative analysis of lead in samples

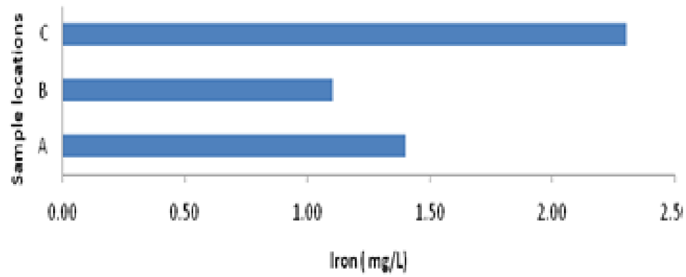



Figure 5: comparative analysis of Iron in samples

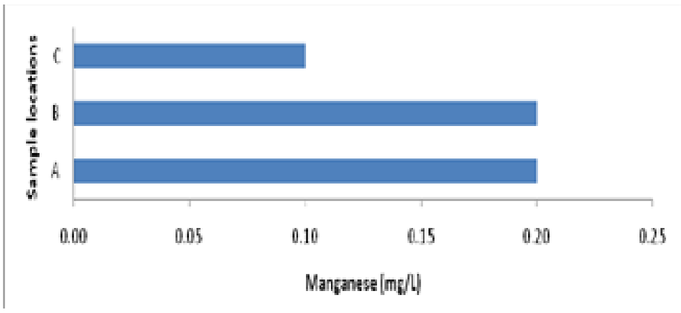



Figure 6: comparative analysis of Manganese in the sample location

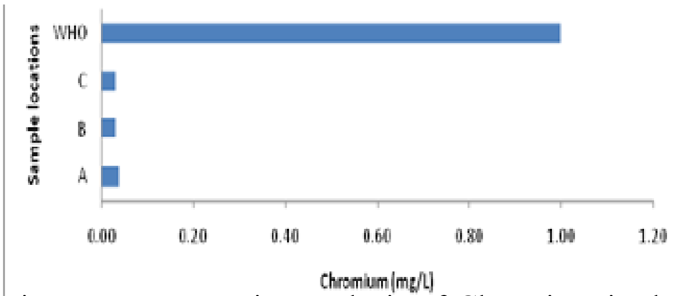



Figure 7: comparative analysis of Chromium in the sample with WHO standard

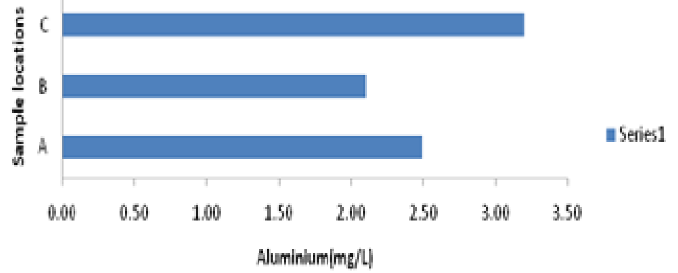



Figure 8: comparative analysis of Aluminum in the sample

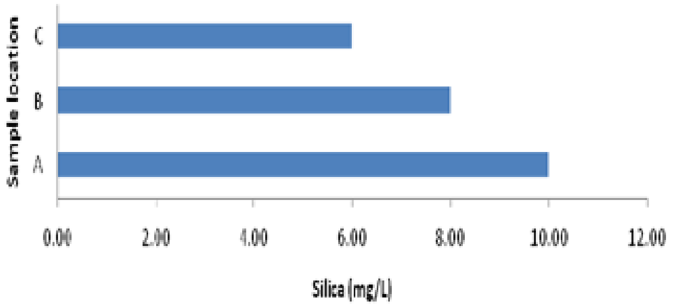



Figure 9: Comparative analysis of copper

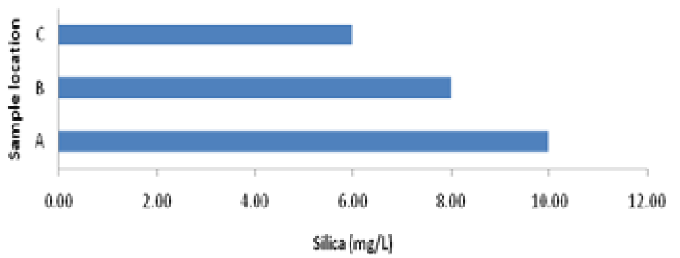



Figure 10: comparative analysis of silicon in samples

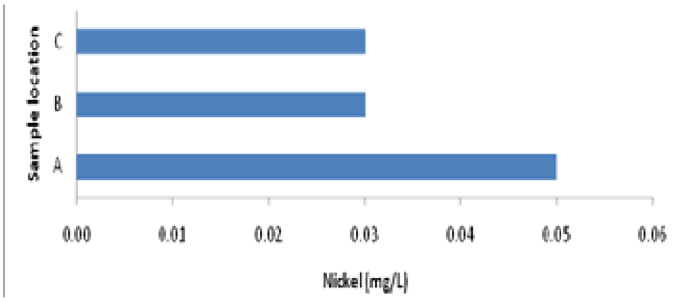



Figure 11: comparative analysis of Nickel in samples

**A. Bacteriological test**

The variation is depicted in figure 3.36 for the three locations

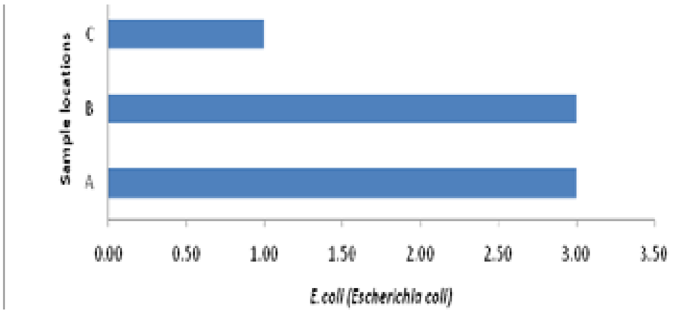



Figure 12: Comparative analysis of *E.coli*

The pH of effluents from point A and B (8.34mg/l and 8.42mg/l respectively) were slightly alkaline with a slight increase in sample B, this may be due to domestic and laundry discharge at point A and the high level of sawdust leakage to Point B might be the cause of the alkalinity in Sample B, the pH of effluents from point C was neutral and all in the range of FEPA and WHO upper limit requirements.

The turbidity values are 7.50mg/l, 10.00mg/l and 8.50mg/l respectively. They are all higher than WHO requirements for water bodies.

Colour has a value of 9Ntu, 15Ntu and 11Ntu which are well above FEPA standard for effluent discharge and in the three samples and also varies from sample A to C. High level of colour in Sample B may be due to the effluent discharge from sawmill and other industrial discharge.

The conductivity of the sample varies due to different degrees of the discharge entering it. The conductivity at point A was 93.67 µS /cm and the value decreases to 92.84 µS /cm at point B and then 89.67 µS /cm in sample C. The variation in conductivity may be due to the difference in concentration of the effluent at each location.

Magnesium hardness (20mg/l. 20mg/l, 24mg/l) and calcium hardness (32mg/l, 28mg/l and 36mg/l)) varies in the samples locations, the total hardness in location C is the highest, followed by location A and smallest in location B. Also. the highest magnesium hardness is noticed in location C, and same in location A and B. In the case of calcium hardness, the value in location C is the highest followed A and smallest in location B.

The Biological oxygen demand and Chemical oxygen demand contents of the samples are low. The BOD was in the range of 3.8-4.7mg/l while the COD is in the range of 6.0 - 7.8 mg/l. The BOD and COD result shows the water is moderately polluted, however, the variation in the BOD and COD might be due to difference in temperature of various sample points and the variation in organic pollutants in the sample locations.

The dissolved oxygen (DO 1st day and DO 5th day) was highest at point C and lowest at point A (6.4mg/l and1.2 mg/l respectively). The low level of dissolved oxygen in sample B might be due to high content of dissolved and suspended solids. It could also be due to increase in growth rate of bacteria in location B.

In the test conducted for heavy metals, Arsenic, Mercury, Cadmium and Cyanide were not detected. Tests conducted indicate that the level of copper is highest at Sample C at 0.40mg/l, manganese result for sample A and B at 0.20mg/l are the same and low in sample C. Chromium and Aluminium were moderate and within the FEPA requirements. Comparison of Zinc level of the samples withFEPA, revealed slightly higher value than the FEPA requirement. Lead and iron variations also revealedthe value of Lead wasabove the FEPA and WHO standard for effluent. It was observed that the level of Iron was high in sample C which might be caused by the effluent from Pharmaceutical Company around the zone. Silicon and Nickel variations showed Nickel was within the FEPA requirement, it ranges between 0.03mg/l and 0.05mg/l.

The Ionic constituents of water can be divided into two; anions and cations. The anions in the samples include Chloride, Fluoride Sulphate and Nitrate. The dominant anion in the sample locations was chloride, followed by Sulphate, Nitrate and fluoride in that order. The slightly high level of Sulphate, chloride and Nitrate in sample C may be due to pharmaceutical industry effluent discharge. The cations are Phosphate, Sodium ion, Magnesium ion, Calcium ion, and potassium ion. Sulphate was the dominant cation, it has a value of 21mg/l in sample C. Phosphate was absent in sample C.

The level of DS, TS and suspended solids are high in sample B. This might be because of sawmills effluent discharge on the river channel.

**Summary statistics:**

| Variable | **Observations** | **Obs. with missing data** | **Obs. without missing data** | **Minimum** | **Maximum** | **Mean** | **Std. deviation** |
|---|---|---|---|---|---|---|---|
| Sample A | 42 | 0 | 42 | 0.000 | 246.000 | 28.877 | 62.178 |
| Sample B | 42 | 0 | 42 | 0.000 | 304.000 | 29.927 | 67.468 |
| Sample C | 42 | 0 | 42 | 0.000 | 258.000 | 25.203 | 57.263 |

| Kruskal-Wallis test / Two-tailed test: | |
|---|---|
| K (Observed value) | 0.032 |
| K (Critical value) | 5.991 |
| DF | 2 |
| p-value (one-tailed) | 0.984 |
| alpha | 0.05 |

An approximation has been used to compute the p-value.

Test interpretation:

H0: The samples come from the same population.

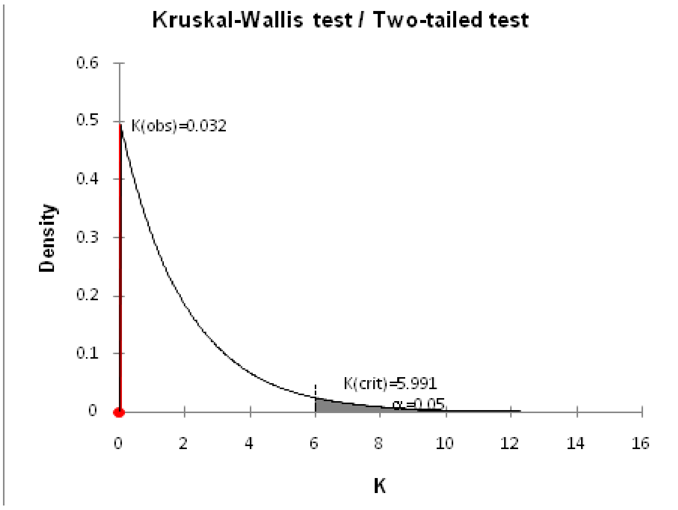
Ha: The samples do not come from the same population.

As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.

The risk to reject the null hypothesis H0 while it is true is 98.39%.

Hence, Sample A, B and C are similar in characteristics

Ties have been detected in the data and the appropriate corrections have been applied.




Multiple pairwise comparisons using Dunn's procedure / Two-tailed test:

| Sample | Frequency | Sum of ranks | Mean of ranks | Groups |
|---|---|---|---|---|
| Sample A | 42 | 2694.000 | 64.143 | A |
| Sample B | 42 | 2672.500 | 63.631 | A |
| Sample C | 42 | 2634.500 | 62.726 | A |

**Pairwise comparisons:**

Differences:

| | Sample A | Sample B | Sample C |
|---|---|---|---|
| Sample A | 0 | 0.512 | 1.417 |
| Sample B | -0.512 | 0 | 0.905 |
| Sample C | -1.417 | -0.905 | 0 |

p-values:

| | Sample A | Sample B | Sample C |
|---|---|---|---|
| Sample A | 1 | 0.949 | 0.859 |
| Sample B | 0.949 | 1 | 0.910 |
| Sample C | 0.859 | 0.910 | 1 |

***Bonferroni corrected significance level: 0.0167***

Significant differences:

| | Sample A | Sample B | Sample C |
|---|---|---|---|
| Sample A | No | No | No |
| Sample B | No | No | No |
| Sample C | No | No | No |

Among the three Sample A, B, and C there are no significance statistical difference.

Ties have been detected in the data and the appropriate corrections have been applied.

The samples are similar in characteristics and comparing with one another shows no difference.

## CONCLUSION

The assessment of water pollution within Awun river basin, revealed that some water quality parameters were higher in value than WHO and Nigerian acceptable standard. The study also showed the impact of industrialization and domestic effluent discharge caused water pollution ascertained by the variations in the FEPA and WHO standard for effluent discharge into surface water. This will have great impact on water quality, affect the aquatic life and cause health hazard especially among the downstream users that uses the untreated water for domestic purposes. Interventions of effluents/ pollutants into the AwunRiver Basin and also, water sample analysis along the river channel should be carried out periodically to ascertain the level of pollution.

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