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RESEARCH ARTICLE

IMPACTS OF HEAVY METALS AND HYDROCARBON CONTAMINANTS ON THE CONDITION FACTOR OF CLARIAS GARIEPINUS (BURCHELL, 1822) FROM QUA IBOE RIVER, SOUTH EASTERN NIGERIA.

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Abstract

The impacts of contaminants on the condition factor of Clarias gariepinus was studied. Fish samples were collected from fishermen and transported to the laboratory for THC and heavy metals analysis. The mean total length, weight and condition factor were 393.72 ± 118.28 cm, 393.72 ± 118.28 g and 0.65 ± 0.15 respectively. The mean heavy metals were 0.78 ± 0.57 mg/kg (Zn), 0.28 ± 0.20 mg/kg (Cd), 0.35 ± 0.21 mg/kg (Cr), 0.04 ± 0.03 mg/kg (Pb), 0.7 ± 0.37 mg/kg (Ni) and 2.82 ± 0.98 mg/kg (THC). The fish muscles had a decreasing heavy metals trend of Zn> Ni> Cr> Cd> Pb. The mean Cr and Ni in the muscles of the fish were above WHO and GESAMP acceptable limits, and were unsafe for consumption. Principal components analysis revealed that Cr, Cd, THC, Ni, Zi and Pb contaminants were introduced from the intense activities within the river, and had negative influence on the condition factor of the fish. In conclusion, Cr, Pb, total length varied significantly ($p<0.05$), while Zn, Cd, Ni, THC, weight and condition factor varied insignificantly ($p>0.05$) between stations. Increased levels of the studied contaminants were also recorded in the highly perturbated stations. Due to the negative influence of the contaminants on the fish condition factor, we recommend that Government enforce against indiscriminate discharge of anthropogenic substances into the river, in order to ensure a healthy condition of our fishery resources, ensure sustainability of these resources.

Introduction:-

Hydrocarbons and heavy metals affect fish growth, damage organs and tissues as well. The lipophilic nature and high chemical stability of the polyaromatic hydrocarbons (Boulloubassi et al., 2001), makes them accumulate in fatty tissues (Van Der Oost et al., 1991), less biodegradable and become more carcinogenic to aquatic organisms like fish and shellfish (Rocher et al., 2004). It can deplete the quality of fish and other marine organisms, affect their marketability and acceptance as food (Doerffer 1992; Dambo, 1992). Hydrocarbons can be introduced into the

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environment during anthropogenic activities such as oil drilling, refining and spillage, fuel combustion (Reeves, 2000). Hydrocarbons are soluble in water, not easily degraded by indigenous micro-organisms, and as such are therefore persistent in water bodies and bio-accumulate in tissues of aquatic organisms (Rocher et al., 2004).

Metal bio-accumulation in fish has been used to detect pollution in different aquatic environment (Karadede-Akin and Unlu, 2007; Tawari-Fufeyin and Ekaye, 2007) and a background to view its biological role in fishes (Anim et al., 2011; Dural et al., 2007). In fish, the accumulation of heavy metals depends greatly on pollution and for different fish species, the accumulation may differ even though they inhabit the same water body (Jezierska and Witeska, 2001).

Clarias gariepinus, a tasty species of commercial value may retain heavy metal residues through different mechanisms. These pollutants may enter their bodies and become accumulated through metabolic activities and physiological conditions that distribute these heavy metals from one tissue to the other (Ibrahim and Omar, 2013). Clarias gariepinus possess unique features like air-breathing organs, long body, prominent barbells and thick skull. They are capable of growing to about 1.7m in length and 60kg in weight. They inhabit the fresh water ecosystems of Africa (Picker and Griffiths, 2011; Anoop et al., 2009) including streams, lakes, rivers, swampy areas, flood plains and pools. They are easily cultured fish of commercial importance, with high reproductive capacity and are harvested all year round, then sold at higher prices than other fish species. They are capable of swallowing large prey with their large mouth (Anoop et al., 2009).

Condition factor can be used to explain the general health of a fish and differs according to the prevailing factors in an environment, age of the fish, sex of the fish, and also its reproduction period (Yilmaz et al., 2007). According to Blackwell et al. (2000), the condition factor of fish may vary among species in different locations. Heavy metals are capable of causing a decline in the condition factor of fish due to loss of appetite or excessive use of energy reserves in order to compensate requirements (Sanchez et al., 2008; Alberto et al., 2005).

Mkpanak and Iwuo-Okpom communities of Qua Iboe River are located very close to EXXON Mobil, as a result, discharges of domestic waste from inhabitants and industrial effluents from EXXON Mobil into the river may contain hydrocarbons and heavy metals contaminants. The study was aimed at evaluating the impacts of heavy metals and hydrocarbon contaminants on the condition factor of Clarias gariepinus from Qua Iboe River.

Materials and Methods:-

Study area

Qua Iboe River has its origin from Umuahia, extends through Abia State, flows into Onna and links with Stubb Creek in Eket local government area of Akwa Ibom State. It also flows into Ibeno, surrounding EXXON MOBIL Terminal. Geographically, Qua Iboe River is located between longitude 007^o 48'37.3" and 008^o 15'34.5" East and latitude 04^o 32' 25.0" and 04^o 36' 20.3" North (Figure 1). The River is bounded to the North by Eket and Mbo and to the east by Eket, to the south by Atlantic Ocean and to the West by Eastern Obolo Local Government Area. The length of river system is about 150 to 180km.

The Exxon Mobil Oil Company is located very close to Iwuo-Okpom and Mkpanak Communities which have beach landings close to fish market. The wet season begins from April to October, while dry season follows from November to March (Dan et al., 2014).

Oil exploration and exploitation are the major industrial activities visible at the Qua Iboe Terminal (QIT). Other ways through which contaminants are introduced into the River include forestry and agriculture, open defecation, domestic sewage from coastal dwellers, agricultural runoffs, industrial effluents and oil spillage (Joseph et al., 2017; Antai et al., 2017).

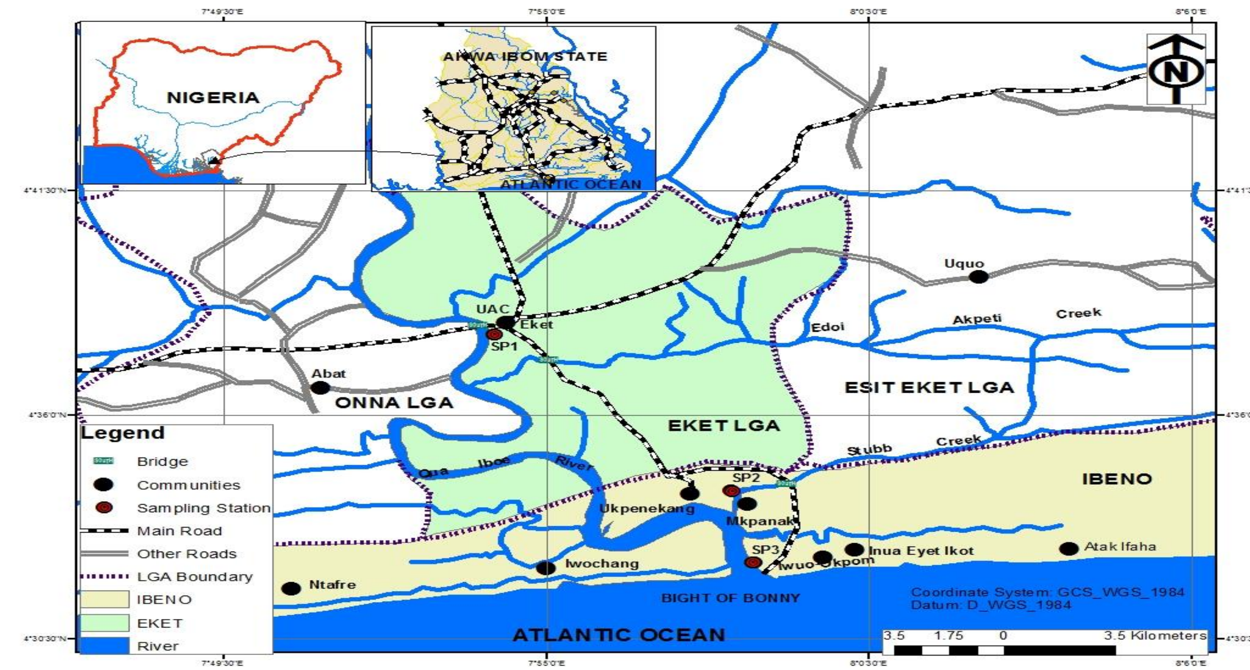

Figure 1: Qua Iboe River showing the 3 Sample Stations

Source: Adapted from Nigeria shapefile, 2006 and google earth pro, 2015.

Fig 1:-Map of Qua Iboe River showing the sampling stations

Sampling stations

Station one

Station one is UAC beach (upstream) and is geographically located between latitude 04^{o} 38' 004" North and longitude 007^{o} 54' 05.7" East. This station is located in Eket Local Government Area of Akwa Ibom State. Some of the human activities that takes place in this station are minimal fishing, trading of petty food stuffs and firewood. Generally, human activities are very minimal in this station and as such taken as the control station.

Station two

Station two is Mkpanak beach and is geographically located between latitude 007^{o} 58' 08.8" North and longitude 04^{o} 34' 08.2" East. This station is located in Ibeno Local Government Area of Akwa Ibom State. This station is within a small commercial environment and has small market for beach landings, firewood trading, fish and crayfish trading, settlements and small shops for petty trading. Severe human activities like local fishing, carpentry, mechanic workshops and engine boat transportation takes place in this station.

Station three

Station three is Iwuo-Okpom beach and is geographically located between latitude 007^{o} 58' 30.5" North and longitude 04^{o} 32' 24.0" East. This station is located in Ibeno Local Government Area of Akwa Ibom State. Some of the activities that take place in this station includes fishing activities, busy fish market, petty trading, cool rooms, shops, mechanic workshops and a large settlement around the community. Other human activities includes welding, use of chemicals in wood work, washing of engine boats, domestic washing, indiscriminate domestic refuse disposal, open defecation, lumbering/firewood activities, fuel and oil discharge from engine boats and industrial discharges.

Collection and preservation of fish samples

Clarias gariepinus samples were obtained from the fishermen on landing in each of the 3 sampling stations of the river over a period of 6 months; from July – December, 2017. Three fish samples were collected from each sampling station and a total of 54 fish samples were collected throughout the period of study. Once the fish samples were collected, they were frozen in the ice chest before transporting to the Ministry of Science and Technology Environmental Laboratory, Uyo, Akwa Ibom State for spectrophotometric analysis of total hydrocarbon (THC) and heavy metals using Atomic absorption spectrophotometer (AAS).

Measurement of morphometric parameters

Morphometric measurements of the lengths and weights of the fish samples from each sampling station were carried-out. The total length of each of the fish sample was measured in the laboratory using a measuring board to the nearest centimetres (cm). The weight of each fish sample was measured in the laboratory using an electronic weighing balance (XP3000) to the nearest grams (g).

Determination of heavy metals concentration in fish samples

In the laboratory, the fish samples were thoroughly washed, then allowed to thaw and assume the room temperature of the laboratory. The fish muscles were then oven dried at about 110 ^{o}C and subsequently ground to powder form. About 0.5g of the ground sample was put in a 125 mL beaker of flask and then digested with 5 mL of hydrochloric acid (HCl). The digest was thoroughly stirred to obtain a proper mix, before allowing to cool. The digest was then analyzed for heavy metals like zinc (Zn), cadmium (Cd), chromium (Cr), lead (Pb) and nickel (Ni) to the nearest milligram per kilogram (mg/kg) using atomic absorption spectrophotometer (APHA, 1998).

Determination of total hydrocarbons

The ultra-violet spectrophotometer was switched on and allowed to warm for 20 minutes. The muscles was first washed, then oven-dried at about 110 ^{o}C and then ground in the laboratory mortar. After grinding, it was sieved with 600 mL aperture sieve and about 25 mL of xylene was added to 10g of the ground sample. The mixture was shaken for 5 minutes and poured through a filter paper placed in a funnel. Another 25 mL of xylene was added to the sample, then shaken for 5 minutes and allowed to settle. The xylene layer was drained off into the filter paper and funnel. The extracted oil in the xylene was collected close together. The extract was centrifuged to eliminate water. A sample cuvette was filled with xylene (the black) and placed in the holder of the spectrophotometer. The atomic spectrophotometer was set to a wavelength of 425nm and adjusted (zero absorbance) and the oil concentration of sample extract was determined from the calibration curve.

The total hydrocarbon (THC) content was estimated according to the formular:

$$\text{THC} = \frac{\text{Abs X Volume of xylene X MF (mg/kg)}}{\text{Weight of sample}}$$

Where;
Abs = absorbance from the UV spectrophotometer.
Vol of xylene = volume used for the extraction.
MF = multiplying factor which is a constant (2024)
Weight of sample = weight of the sample used for the oil extraction.

Determination of condition factor

Condition factor was used to describe the health status of C. gariepinus as described by Fulton (1902) using the formula:

$$K = \frac{W}{L^3} \times 100 \qquad - \quad - \quad - \quad - \quad - \quad - \quad - \quad - \qquad 1$$

Where;
K = condition factor or coefficient of condition or “K factor”
W = weight of the fish in grams (g)
L = length cube of the fish in centimetres (cm)

Statistical analysis

Data obtained were subjected to descriptive statistics (mean, standard deviation and ranges). Analysis of variance (ANOVA) was used to assess the significant difference in condition factor, heavy metals and total hydrocarbon content (THC) between the 3 sampling stations at 0.05 level of significance and at their relevant degree of freedom. Principal component analysis (PCA) was also used to evaluate the relationship between heavy metals, THC and condition factor of the fish. All statistical analysis were carried-out using predictive analytical software (PASW) version 20.

Results:-

Morphometric parameters and condition factor of fish

The summary of the morphometric parameters and condition factor of C. gariepinus from the study area is shown in Table 1. At UAC beach, the total length of the fish ranged from 37.00 - 50.01 cm, with a mean and standard deviation of 44.17 ± 5.56 cm, while the weight ranged from 365.00 - 605.00 g, having a mean and standard deviation of 467.67 ± 97.86 g. The condition factor ranged from 0.41 – 0.83, with a mean and standard deviation of 0.56 ± 0.16 (Table 1).

At mkpanak beach, the total length of the fish ranged from 19.00 - 42.88 cm, with a mean and standard deviation of 34.33 ± 8.14 cm, while the weight ranged from 54.87 - 485.00 g, having a mean and standard deviation of 314.98 ± 143.40 g. The condition factor ranged from 0.59 – 0.82, with a mean and standard deviation of 0.71 ± 0.09 (Table 1).

Table 1:-Mean and Ranges of Morphometric Parameters and condition factor of Clarias gariepinus from Qua Iboe River during the study.

Morphometric parameters	UAC	Mkpanak	Iwuokpom	Mean
Length (cm)	44.17 ± 5.56[a] (37.00 - 50.01)	34.33 ± 8.14[b] (19.00 - 42.88)	39.00 ± 1.41[c] (37.00 - 40.48)	39.17 ± 6.80 (19.00 - 42.55)
Weight (g)	467.67 ± 97.86[a] (365.00-605.00)	314.98 ± 143.40[a] (54.87 - 485.00)	398.50 ± 58.30[a] (356.00 - 515.00)	393.72 ± 118.28 (54.87 - 605.00)
Condition factor (CF)	0.56 ± 0.16[a] (0.41 – 0.83)	0.71 ± 0.09[a] (0.59 – 0.82)	0.68 ± 0.16[a] (0.56 – 1.02)	0.65 ± 0.15 (0.41 – 1.02)

*Values are in mean ± standard deviation
*Ranges are in parenthesis ( )
* Values with different superscript across sampling stations are significantly different (p<0.05)

At iwuokpom beach, the mean total length of the fish ranged from 37.00 - 40.48 cm, with a mean and standard deviation of 39.00 ± 1.41 cm, while the weight ranged from 356.00 - 515.00 g, having a mean and standard deviation of 398.50 ± 58.30 g. The condition factor ranged from 0.56 – 1.02, with a mean and standard deviation of 0.68 ± 0.16 (Table 1).

The distribution of the total length and weight of C. gariapinus across the 3 sampling station of the study area is shown in Table 1. Through-out the study, the total length of the fish ranged from 19.00 - 42.55 cm, with a mean and standard deviation of 393.72 ± 118.28 cm, while the weight ranged from 54.87 - 605.00 g, having a mean and standard deviation of 393.72 ± 118.28 g. The condition factor ranged from 0.41 – 1.02, with a mean and standard deviation of 0.65 ± 0.15 (Table 1). Statistically, the total length of fish varied significantly (p<0.05), while the weight and condition factor of the fish varied insignificantly (p>0.05) between sampling stations.

Heavy metals and total hydrocarbon content

The summary of the mean concentrations of heavy metals (Zn, Cd, Cr, Pb, and Ni) and total hydrocarbons contents (THC) in the muscles of Clarias gariepinus from Qua Iboe River is shown in Table 2. At UAC beach, the concentration of zinc in C. gariepinus muscles ranged from 0.13 to 1.18 mg/kg, with a mean and standard deviation of 0.63 ± 0.54mg/kg. Cadmium concentrations had 0.03 to 0.29 mg/kg, with a mean and standard deviation of 0.15 ± 0.13mg/kg. Chromium concentrations ranged from 0.05 to 0.33 mg/kg, with a mean and standard deviation of 0.16 ± 0.11 mg/kg. Lead concentrations ranged between 0.03 to 0.03 mg/kg, with a mean and standard deviation of 0.01 ± 0.01 mg/kg. Nickel concentrations ranged from 0.12 to 0.75 mg/kg, with a mean and standard deviation of 0.44 ± 0.27 mg/kg. Total hydrocarbons contents ranged from 1.95 to 2.62 mg/kg, having a mean and standard deviation of 2.31 ± 0.26 mg/kg (Table 2).

At Mkpanak, zinc concentrations in C. gariepinus ranged from 0.24 to 1.35 mg/kg, with a mean and standard deviation of 0.74 ± 0.54 mg/kg. Cadmium ranged from 0.27 ± 0.43 mg/kg, with a mean and standard deviation of 0.37 ± 0.06 mg/kg. Chromium concentrations ranged from 0.21 to 0.62 mg/kg, with a mean and standard deviation of 0.43 ± 0.17 mg/kg. Lead ranged from 0.00 to 0.06 mg/kg, with a mean and standard deviation of 0.03 ± 0.23 mg/kg. Nickel concentration ranged from 0.35 to 1.33 mg/kg, with a mean and standard deviation of 0.79 ± 0.43

mg/kg. The total hydrocarbons content ranged from 2.01 to 3.81 mg/kg, with a mean and standard deviation of 3.14 ± 0.75 mg/kg (Table 2).

At Iwuokpom, zinc concentration ranged from 0.33 to 1.82 mg/kg, with a mean standard deviation of 0.97 ± 0.68 mg/kg. Cadmium ranged from 0.06 to 0.63 mg/kg, with a mean and standard deviation of 0.33 ± 0.30 mg/kg. The concentrations of chromium ranged between 0.21 to 0.71 mg/kg, with a mean and standard deviation of 0.47 ± 0.22 mg/kg. Lead concentrations ranged from 0.04 to 0.10 mg/kg, having a mean and standard deviation of 0.06 ± 0.02 mg/kg. Nickel concentrations ranged from 0.57 to 1.13 mg/kg, with a mean and standard deviation of 0.90 ± 0.23 mg/kg. The total hydrocarbon content ranged from 1.06 to 4.73 mg/kg, with a mean and standard deviation of 3.03 ± 1.46 mg/kg (Table 2).

Table 2:-Mean concentrations values (mg/kg) of heavy metals in the muscles of C. gariepinus from the three stations of the Iboe River.

Metals	UAC	Mkpanak	Iwuokpom	Mean	WHO 1985	GESAMP
Zn	0.63 ± 0.54^{a} (0.13 – 1.18)	0.74 ± 0.54^{a} (0.24 – 1.35)	0.97 ± 0.68^{a} (0.33-1.82)	0.78±0.57 (0.13-1.82)	10-75	-
Cd	0.15 ± 0.13^{a} (0.03 – 0.29)	0.37 ± 0.06^{a} (0.27 – 0.42)	0.33 ± 0.30^{a} (0.06 – 0.63)	0.28 ±0.20 (0.03-0.63)	2.0	-
Cr	0.16 ± 0.11^{a} (0.05-0.33)	0.42 ± 0.17^{b} (0.21-0.62)	0.47 ± 0.22^{c} (0.21-0.71)	0.35±0.21 (0.05-0.71)	0.15	-
Pb	0.01 ± 0.01^{a} (0.00-0.03)	0.03 ± 0.23^{b} (0.00-0.06)	0.06 ± 0.02^{c} (0.04-0.10)	0.04±0.03 (0.00-0.10)	2.0	-
Ni	0.44 ± 0.27^{a} (0.12-0.75)	0.79 ± 0.43^{a} (0.36-1.33)	0.90 ± 0.23^{a} (0.57-1.13)	0.71±0.37 (0.12-1.33)	0.6	-
THC	2.31 ± 0.26^{a} (1.95-2.62)	3.03 ± 1.46^{a} (1.06-4.73)	3.14 ± 0.75^{a} (2.01-3.81)	2.82±0.98 (1.06-4.73)	-	25

1. Mean values with different superscript are significantly different at $P < 0.05$
2. Values are in mean ± standard deviation
3. Ranges are in parenthesis ( )

The distribution of heavy metals and total hydrocarbon content in C. gariepinus across the 3 sampling stations is shown in Table 2. Statistically, ANOVA indicated significant difference in the mean concentrations of chromium and lead ($p < 0.05$), insignificant difference in zinc, cadmium, nickel and total hydrocarbon content ($p > 0.05$) of C. gariepinus between the 3 sampling stations. During the study, the overall mean concentration of heavy metals in C. gariepinus muscles were 0.78 ± 0.57 mg/kg (Zn), 0.28 ± 0.20 mg/kg (Cd), 0.35 ± 0.21 mg/kg (Cr), 0.04 ± 0.03 mg/kg (Pb), 0.7 ± 0.37 mg/kg (Ni) and 2.82 ± 0.98 mg/kg (THC). The muscles of fish in this study showed metal accumulation in the decreasing order of Zn> Ni> Cr> Cd> Pb. The mean Cr and Ni in the muscles of the fish were higher than the WHO and GESAMP acceptable limits (Table 2).

Principal component analysis

The summary of the principal component analysis plots for heavy metals, THC, total length and weight of C. gariepinus from Qua Iboe River is shown in Figure 2. In component 1, principal component analysis revealed very high positive loading values of 0.963, 0.979, 0.993, 0.980 and 0.996 for condition factor (CF), cadmium, chromium, nickel and THC respectively. A slightly high positive loading values of 0.769 and 0.821were also recorded for zinc and lead respectively, while a high negative loading values of -0.865 and -0.820 were recorded for total length and weight of fish. All loadings in component 1 resulted in a total variance of 83.46% (Fig 2).

In component 2, no high positive loading values were observed for all analysed parameters, resulting in a low total variance of 16.54%. Also, PCA revealed the clustering of nickel, chromium, total hydrocarbon content, cadmium and condition factor within one group, while zinc, lead clustered separately, very close to the cluster of nickel, chromium, total hydrocarbon content, cadmium and condition factor. The third group consisted of the total length and weight of fish, which were very far away from the main groups (Fig 2).

Discussion:-

Condition factor can be used to explain the general health of a fish and differs according to the prevailing factors in an environment, age of the fish, sex of the fish, and also its reproduction period (Yilmaz et al., 2007). Heavy metals are capable of causing a decline in the condition factor of fish due to loss of appetite or excessive use of energy reserves in order to compensate requirements (Sanchez et al., 2008; Alberto et al., 2005). The condition factors of C. gariepinus from the study area varied across sampling stations, but generally reflected a partial good health conditions, probably due to the level of contaminants introduced into the River (Sanchez et al., 2008). The variations in the condition factor across stations in this study corroborated with the findings of Blackwell et al. (2000), who also observed variations in the condition factor of fish between locations.

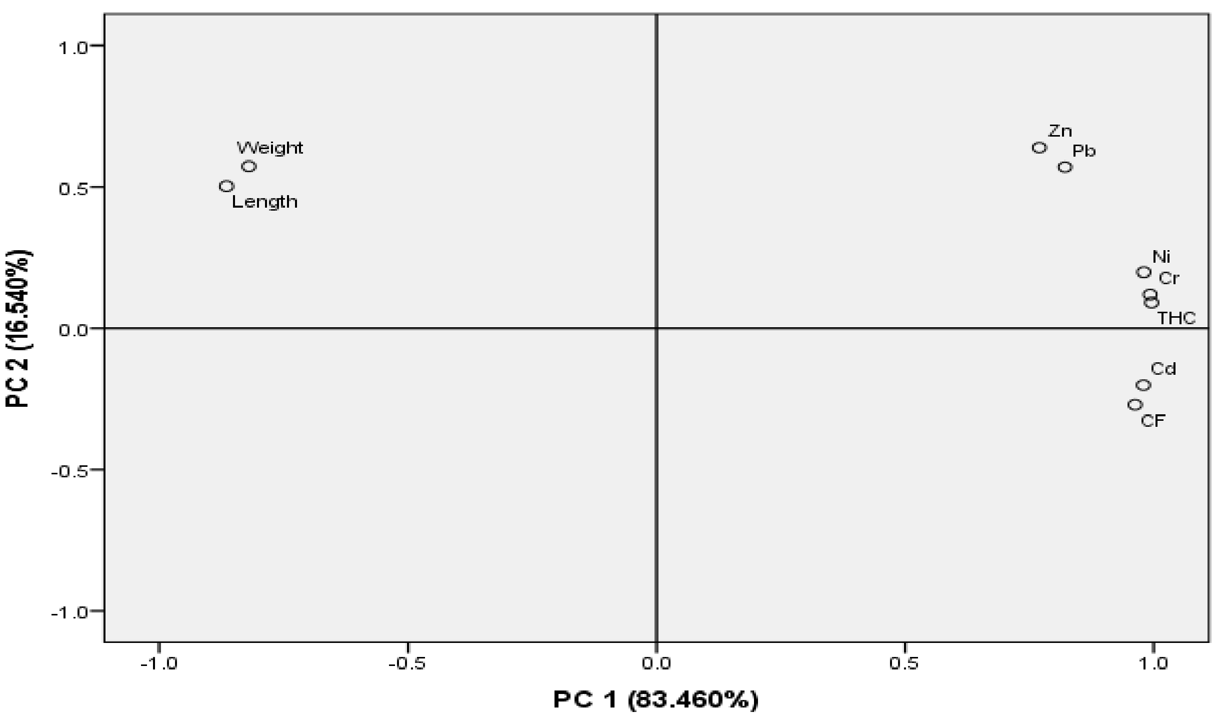

Fig 2:-Principal component analysis plots for heavy metals, total hydrocarbon content, condition factor, total length and weight of C. gariepinus from Qua Iboe River

The present study revealed variations in the levels of THC across sampling stations, though UAC beach (control station) had the least THC levels. The levels of THC were higher in the other 2 sampling stations, due to the intense level of human activities compared to the minimum activities observed in the control station. The higher concentration of metals and THC in fish from the 2 other sampling stations could also be due to intensive activities that introduces waste into these stations; including manual and accidental oil spills, sprays and oil paints, household refuse, chemicals used in carpentry (wood work), sewage sludge, grease and oil from mechanic workshops, and grease and fuel discharge from engine boats. The mean THC of fish from Qua Iboe River during the present study were lower than the findings of Ekpenyong and Udofia (2015) for Chrysicthys nigrodigtatus and Ethmalosa fimbriata, but higher that the findings of Omeregie et al. (2016) for C. gariepinus from Osse River in Edo State. The discrepancies in the levels of the measured THC between the compared studies could be due to the difference in rate of the introduction of hydrocarbon contained waste into the Rivers. The mean THC in C. gariepinus from Qua Iboe River was within the GESAMP acceptable limit.

The present study clearly revealed variations in the bio-accumulation of heavy metals across sampling stations, with the control station having the least heavy metals concentration. This could be due to the intense anthropogenic activities in the other 2 stations, which allowed for the introduction of huge contaminants into these stations of the River. In the present study, the mean concentration of zinc, cadmium, chromium, lead and nickel were lower than the findings of Nzeve et al. (2014) for C. gariepinus and Oreochromis spirulus from Masinger reservoir, Kenya; Ekeanyanwu et al. (2010) for Tilapia muscle from River Okumeshi Delta State. The mean cadmium concentration in the present study was higher than the findings of Ogamba et al. (2016) and Nkwoko and Egwonwa (2015) for C. gariepinus. The mean concentration of lead in the present study is lower than the findings of Ogamba et al. (2016) for C. gariepinus muscles from River Nun. The muscles of C. gariepinus in this study showed a decreasing heavy metals trend of Zn> Ni> Cr> Cd> Pb, which did not corroborate with the trend of Cr> Mn> Pb> Ni> Zn> Cu in Clarias anguillaris reported by Jonathan and Maina (2009). The variations in the heavy metals concentration and trend in the fish between the compared studies could be due to the difference in fish species, feeding habit, intensity of human activities, biology and physiology, metabolism and ecological needs and type of contaminants introduced (Canli et al., 1998); differences in geographical location, capture season, size, age and feeding habit (Farkas et al., 2003); differences in trophic levels, sampling location (Asuquo et al., 2004) and the period of retainment in water and biological activity of the metal (Ekpo et al., 2008; Ndimele et al., 2011). The mean concentration of Chromium and Nickel were above the WHO allowable limits. This means that the species under study is polluted with chromium and nickel, and consumption of this fish species can result to health problems.

Principal component analysis (PCA) of heavy metals, THC, condition factor, total length and weight of C. gariepinus samples were extracted into 2 principal components (PC), each of which was used in interpreting the sources of contaminants and their relationship with the condition factor of the fish. In component 1, principal component analysis revealed very high positive loading values for condition factor (CF), cadmium, chromium, nickel and THC; a slightly high positive loading values for zinc and lead, and a high negative loading values for total length and weight of fish. This denotes that the chromium, cadmium, THC, nickel, zinc and lead contaminants were introduced from the intense activities within the study area. Also, PCA revealed the clustering of nickel, chromium, THC, cadmium and condition factor within one group, while zinc, lead clustered separately, but very close to the cluster of nickel, chromium, total hydrocarbon content, cadmium and condition factor. The third group consisted of the total length and weight of fish, which were very far away from the main groups. This denotes that nickel, chromium, THC, cadmium contaminants were strongly related to the condition factor, while zinc, lead were slightly related to the condition factor, meaning an increase in these contaminants (nickel, chromium, THC, cadmium) will impact hugely on the condition factor of the fish, thereby possibly lowering the condition factor. The total length and weight of the fish had no influence on the condition factor as shown by PCA.

Conclusion:-

In conclusion, the study revealed variations in the heavy metals, THC and condition factor of fish across the 3 sampling stations. The study also revealed higher concentration of heavy metals and THC in Mkpanak and Iwuokpom beaches compared to the control, due to higher level of contaminants introduced. The condition factor of the fish indicated a partially healthy fish. The fish samples were polluted with chromium and nickel. Principal components analysis revealed that chromium, cadmium, THC, nickel, zinc and lead contaminants were introduced from the intense activities within the study area. It also revealed that nickel, chromium, THC, cadmium, zinc, lead had a huge negative influence on the condition factor of the fish. The total length and weight of the fish had no influence on the condition factor as shown by PCA.

Ethical Consideration:-

The authors ensured that all ethical and other basic principles underlying behavior and advancing welfare for the use of animals in research, including handling, relevant laws and regulations were considered before proceeding with the research. Permission was also received from the relevant bodies for the use of fish for this experiment.

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