



Comparative assessment of wellbeing of *Chrysichthys filamentosus*, *Kribia nana* and *Pegusa lascaris* from Tomaro, Ajegunle and Badagry Creeks in Lagos, Nigeria

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Abstract. An investigation was made from April to September 2018 to detect some metals (cadmium, chromium, copper, iron, lead and zinc) in the fishes like *Kribia nana*, *Chrysichthys filamentosus* and *Pegusa lascaris*, as well as in water and sediment from three creeks i.e. Badagry (Station 1), Tomaro (Station 2) and Ajegunle (Station 3) in Lagos, Nigeria. Samples were collected and analyzed according to standard methods. Most of the water quality parameters are within standard recommended limits. Iron content in *C. filamentosus* (11.57 ± 2.50 mg/kg) from station 3 was higher ($p < 0.05$) than iron content from station 2 (6.54 ± 2.88 mg/kg), while iron content in *K. nana* (8.34 ± 1.10 mg/kg) from station 3 was higher ($p < 0.05$) than that from station 1 (6.12 ± 1.04 mg/kg) and station 2 (3.62 ± 1.14 mg/kg) respectively. Zinc (5.54 ± 1.12 mg/kg) recorded from station 3 was significantly ($p < 0.05$) higher than that from station 2 (2.45 ± 0.96 mg/kg) and station 1 (3.84 ± 0.86 mg/kg). Iron content in all the fishes, cadmium in *C. filamentosus* and lead, chromium, copper in *K. nana* in stations 1 and 3 exceeded permissible limits. Condition factor (K) of most fish species was greater than 1. The Hazardous Index (HI) content in *C. filamentosus* from the three creeks and *K. nana* from stations 1 and 3 was above 1. Ecological risk factor (Er), enrichment factors (EF) and Index of geo-accumulation indicated moderate contamination of the sediment with cadmium. In conclusion, the three creeks are moderately polluted with metals but consumption of large quantity of the fish species could have high health risk. Hence, discharge of untreated metals into the water should be precluded.

Keywords: Metals, Pollution, *Kribia nana*, *Chrysichthys filamentosus*, *Pegusa lascaris*

Introduction

Fish is a very essential food source for human being. This is because fish provides Omega 3 fatty acids, vitamins, minerals and protein. Despite fish nutritional capability, consumption of fish contaminated with heavy metals brings hazard concentration concern for human consumer (Olowu *et al.* 2010). Heavy metals are high priority pollutants because of their relatively toxic and persistent nature in the environment (Wangboje and Ekundayo 2013). Apart from disrupting the aquatic environment, the biological amplification of these toxic metals in the aquatic food chain constitutes a serious threat to public health (Ndimele 2012). Indeed, Badagry Division of Lagos Western-Nigeria is blessed with several inland waters. These waters include Tomaro, Ajegunle and Badagry creeks. Recent study carried out by Ejike and Liman (2017) and Mekuleyi *et al.* (2019) revealed that Nigerian water bodies needs to be assessed periodically as a result of heavy metal pollution. To the best of our knowledge, no comparative study on the status of *Kribia nana*, *Pegusa lascaris* and *Chrysichthys filamentosus* from these three creeks has been reported. It is on this background that this study aimed to compare the condition factor (k) and length-weight relationship of *Kribia nana*, *Pegusa lascaris* and *Chrysichthys filamentosus*

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with a view to determine their wellness in the selected water bodies. The study also examined levels of some heavy metals in the selected fishes, water, and sediment from Tomaro, Ajegunle and Badagry Creeks in Lagos, Nigeria in order to determine their safety for human use and consumption.

Materials and Methods

Study area/ sampling stations: This study was carried out in Lagos State, Nigeria on three water bodies (Badagry Creek, Tomaro Creek and Ajegunle Creek) as presented in Fig. 1. These three sampling stations were selected as a result of their economic importance to Lagosian. Station 2 (Tomaro creek) is on Longitude $3^{\circ}21'7.352''\text{E}$ and Latitude $6^{\circ}27'0.520''\text{N}$ whose water drains into the Lagos lagoon through the Apapa wharf (Nwankwo *et al.* 2013) while station 1(Badagry creek) and station 3 (Ajegunle creek) lies between longitude $2^{\circ}42'\text{E}$ and $3^{\circ}22'\text{E}$ and between latitude $6^{\circ}22'\text{N}$ and $6^{\circ}42'\text{N}$ (Mekuleyi *et al.* 2019). They are bounded in the south by the Atlantic Ocean. Also, in the north, they are bounded by Alimosho Local Government Area but enclosed in the east by Apapa Local Government Area (Mekuleyi *et al.*, 2019). Specifically, sampling stations 2, 3 and 1 respectively are located in Apapa Local Government, Ajeromi-Ifelodun Local Government, and Badagry Local Government of Lagos State, Nigeria.

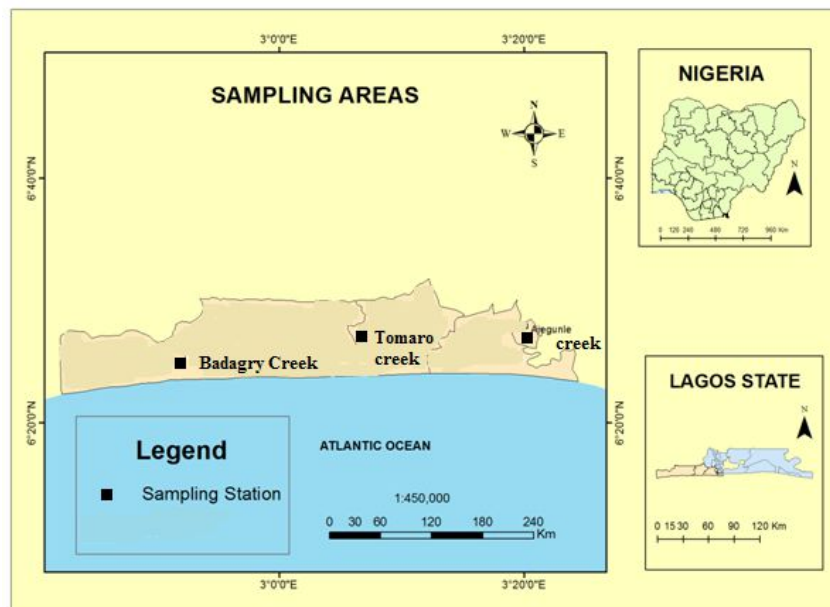


Fig. 1. Location of Badagry Creek, Tomaro Creek and Ajegunle Creek in Lagos State, Nigeria.

Collection of fish, water and sediment samples: A total of 270 fish specimens consisting 90 samples of *Kribia nana*, *Chrysichthys filamentosus*, and *Pegusa lascaris* respectively from each creek were purchased from the landing sites of stations 1- 3 between April and September 2018. Specimens were identified in the laboratory by experts at the Department of Fisheries, Lagos State University while samples of water and sediment were also collected for six months following APHA (1998).

Measurement of weight, length, and length – weight relationship and condition factor of fish samples: By using electric balance, body weight of the fish was measured to the nearest 0.1 g, while the total length was measured with measuring board to the nearest 0.1cm. The length and weight (LWR) relationship of the fish samples were calculated using the equation $W=aL^b$ (Pauly 1983). The values of constant a and b were determined via the least-square method applied to the log transformed data as $\log W = \log a + b \log L$ (Pauly 1983) where W (g) is the body weight of the fish, L (cm) is the total length, a is the intercept of the regression curve and b is the regression coefficient. The condition factor (K) was calculated via the formula: $K = 100 W / L^3$ (Pauly 1983). Where K= condition factor, W= total body weight (g), L= total length (cm).

Determination of physico-chemical parameters: Chemical Oxygen Demand (COD), Carbon dioxide (CO₂), alkalinity, total hardness, and Biochemical Oxygen Demand (BOD) were determined in the laboratory using methods described by APHA (1998). Conductivity, temperature, pH, salinity, Total Dissolved Solid (TDS), and dissolved oxygen of the water samples were measured *in-situ* by using a mercury-in-glass thermometer, HQ40D Portable Multi Meter (pH, Conductivity, Salinity, TDS, ORP and ISE for water, USA) and DO meter (Method:HACH 8157).

Digestion and analysis of heavy metals: Samples earlier frosted were defrosted at 25°C which was attained in 5 h. The digestion of all metals were done and analyzed in accordance with APHA (1998) procedures. The heavy metals (cadmium, chromium, copper, iron, lead and zinc) in water samples were determined in the laboratory using Buck Scientific Atomic Absorption Spectrophotometer (VGP 210 model, USA). Similarly, sediments were dried with crucible for 12 min and sieved with 0.5 mm sieve prior to digestion while the metal content of the digested sediment samples was determined using Atomic Absorption Spectrophotometer. Twenty samples of whole fresh *C. filamentosus*, *K. nana* and *P. lascaris* were selected from each sampling station, weighed and oven-dried at 105°C for 28 h. Dried samples were grounded into powder with ceramic mortar and pestle and 3 g of each sample was digested (APHA, 1998). The concentration of the metals was calculated in mg/L for water sample and mg/kg for sediment and fish specimens (APHA 1998).

Calculation of daily intake (DI) of metals in fish: Copat *et al.* (2012) divulged that EDI can be calculated using the formula:

$$DI = \frac{E_F \times E_D \times F_{IR} \times C_F \times C_M}{W_{AB} \times T_A} \times 10^{-3}$$

Where, E_F = Exposure frequency 365 days/year; E_D = Exposure duration, equivalent to verge life time (65 years) (Ali and Hau, 2001); F_{IR} = Fresh food ingestion rate (g/person/day) being taken as 48/g/person/day (Ali and Hau, 2001); C_F = Conversion factor = 0.208; C_M = Heavy metal concentration in the fish stuffs (mg/kg d-w); W_{AB} = Average body weight (bw) of consumer (adult) was taken as 60kg (Copat *et al.* 2012); T_A = Average exposure of time for non-carcinogens which is equal to (EF x ED) as used by Wang *et al.* (2005).

Calculation of Hazard Quotient (HQ) of metals in fish and Hazard Index(HI) : According to USEPA (1989), HQ is given as:

$$HQ = \frac{EDI}{RFDO}$$

Where, EDI = Estimated daily intake, RFDO = the reference oral dose of individual metal (mg/kg/day).

The hazard index (HI) developed by Guerra *et al.* (2010) is expressed as:

$$HI = \sum HQ \text{ of metals} \\ = HQCd + HQCr + HQCu + HQFe + HQPb + HQZn$$

Ecological Risk Factor(Er): Ecological Risk Factor (Er) was calculated according to Hakanson (1980) as $Er = Tr \times CF$

Where, Tr is the standard toxic-response factor for a given contaminant, and CF is the contamination factor. $Er < 40$ = low potential ecological risk, $40 \leq Er < 80$ = moderate potential ecological risk, $80 < Er < 160$ = considerable potential ecological risk, $160 \leq Er < 320$ = high potential ecological risk and $Er \geq 320$ = very high ecological risk (Hakanson 1980).

Calculation of Contamination Factor, Index of geo-accumulation (I_{GEO}) and Enrichment Factor (EF): These pollution indexes factors were calculated following methods described in Mekuleyi *et al.* (2019).

Statistical analysis: Excel 2007 was used to compute data for Length-weight relationship of the sampled fish species. In order to determine the kind of allometry exhibited by fish species, slopes of length-weight regressions were compared to 3 using student t- test as opined by (Kumolu-Johnson *et al.*, 2010). Values of metals in the samples across the creeks were computed by SPSS (Version 20) and tested by one-way Analysis of Variance (ANOVA) while Fisher's LSD at 95% ($p \leq 0.05$) confidence level was used to separate the means. Also, formulae reported in literatures were used to calculate the pollution indexes.

Results

Comparison of heavy metals concentration and physico-chemical properties of the creeks:

Heavy metal concentrations recorded in water sample at sampling stations 1-3 as shown in Table I were not different. In like trend, parameters like carbon dioxide (CO_2) (8.12 ± 1.64 mg/L, 7.48 ± 2.15 mg/L), dissolved oxygen (DO) (7.65 ± 1.07 mg/L, 7.43 ± 0.88 mg/L) from station 2 and 3 respectively; pH (5.38 ± 0.44 , 6.36 ± 0.24) and salinity (0.106 ± 0.074 ppt, 0.040 ± 0.020 ppt) from station 3 and 1 respectively did not show any significant difference (Table II). Station 1 contained the highest conductivity (255.10 ± 45.41 μ s/cm), CO_2 (12.56 ± 3.29 mg/L), total hardness (246.25 ± 15.92 mg/L) and chemical oxygen demand (COD) (184.46 ± 15.12 mg/L); but the peak biochemical oxygen demand (BOD) (213.48 ± 24.48 mg/L) and total dissolved solid (TDS) (147.89 ± 8.74 mg/L) was obtained in station 3. On the other hand, the highest pH (7.52 ± 0.88), salinity (14.28 ± 1.18 ppt), temperature ($28.20 \pm 1.25^\circ$ C) and alkalinity (80.44 ± 6.02 mg/L) were obtained from station 2.

Table I. Comparison of heavy metals concentration in water sample from the three creeks

Heavy Metals	Station 2	Station 3	Station 1
Cd (mg/kg)	0.100±0.004 ^a	0.008±0.005 ^a	0.004±0.001 ^a
Cr(mg/kg)	0.008±0.003 ^a	0.013±0.009 ^a	0.006±0.004 ^a
Cu(mg/kg)	0.39±0.74 ^a	0.60±0.47 ^a	0.41±0.18 ^a
Fe(mg/kg)	1.23±0.39 ^a	1.48±0.45 ^a	1.65±0.35 ^a
Cu(mg/kg)	0.39±0.74 ^a	0.60±0.47 ^a	0.41±0.18 ^a
Zn (mg/kg)	0.86±0.36 ^a	1.38±0.49 ^a	0.69±0.26 ^a
Pb(mg/kg)	0.083±0.050 ^a	0.175±0.162 ^a	0.058±0.043 ^a

Mean ± SD values with same superscript in the row are not significantly ($p > 0.05$) different.

Station 1 = Badagry Creek, Station 2 = Tomaro creek and Station 3 = Ajegunle creek

Table II. Physico-chemical parameters of the sampled creeks in Lagos, Nigeria

Parameters	Station 2	Station 3	Station 1
Conductivity(μs/cm)	152.87±25.60 ^a	210.28±31.57 ^b	255.10±45.41 ^c
TDS(mg/L)	138.49±11.25 ^a	147.89±8.74 ^b	144.97± 10.38 ^c
CO ₂ (mg/L)	8.12±1.64 ^a	7.48±2.15 ^a	12.56±3.29 ^b
Total Hardness(mg/L)	214.48±3.46 ^a	196.45±8.89 ^b	246.25±15.92 ^c
COD(mg/L)	61.62±12.34 ^a	168.41±22.63 ^b	184.46±15.12 ^c
Alkalinity(mg/L)	80.44±6.02 ^a	37.64±3.66 ^b	32.55±4.82 ^c
Temperature(°C)	28.20± 1.25 ^a	25.59±1.99 ^b	26.73± 1.85 ^c
BOD(mg/L)	20.98±4.84 ^a	213.48± 24.48 ^b	209.80±28.17 ^c
DO(mg/L)	7.65±1.07 ^a	7.43±0.88 ^a	5.87±0.84 ^b
pH(mg/L)	7.52±0.88 ^a	5.38±0.44 ^b	6.36±0.24 ^b
Salinity(ppt)	14.28±1.18 ^a	0.106±0.074 ^b	0.040±0.020 ^b

Mean ± SD values with same superscript in the row are not significantly ($p > 0.05$) different.

Station 1 = Badagry Creek, Station 2 = Tomaro creek and Station 3 = Ajegunle creek

Sampling station 2 had the lowest conductivity (152.87±25.60 μs/cm), TDS (138.49±11.25mg/L), COD (61.62±12.34mg/L) and BOD (20.98±4.84mg/L). However, station 1 had the lowest DO (5.87±0.84mg/L), salinity (0.040±0.020ppt) and alkalinity (32.55±4.82mg/L), while the lowest CO₂ (7.48±2.15mg/L), temperature (25.59±1.99°C), and pH (5.38±0.44) were recorded in station 3.

Comparison of heavy metals in *C. filamentosus*, *K. nana* and *P. lascaris*: In comparison of the metals in fish, the results showed that values of copper, chromium, cadmium and lead in the three sampled fishes are not different ($p > 0.05$) across the sampling stations. Iron content in *C. filamentosus* (11.57±2.50mg/kg) from station 3 was significantly ($p < 0.05$) higher than iron content recorded from station 2 (6.54±2.88mg/kg) (Table III). Similarly, iron content in *K. nana* (8.34±1.10mg/kg) from station 3 is higher than that from station 1 (6.12±1.04mg/kg) and station 2 (3.62±1.14mg/kg). In like manner, value of Zn (5.54±1.12mg/kg) in *C. filamentosus* recorded from station 3 was significantly ($p < 0.05$) higher than that from station 2 (2.45±0.96mg/kg) and station 1 (3.84±0.86mg/kg).

Comparison of length-weight relationship, condition factor and Hazard Index of the sampled fishes: Only *C. filamentosus* from station 2 exhibited positive allometry whose b value was 3.10. All the R² values of the examined fish species are below 1.0 while mean condition

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factors (K) of the fish species was between 0.68 (in *C. filamentosus* from station 3) and 1.98 (in *K. nana* from station 1) (Table IV). The mean body weight of *C. filamentosus* significantly ($p < 0.05$) differs across the three creeks with the highest mean body weight (26.84 ± 4.17 g) recorded in station 2 and least (19.65 ± 4.06 g) in station 1 (Table IV). The Hazard Index (HI) of *C. filamentosus* from stations 2, 3 and 1 respectively are 1.18, 2.06 and 1.81 respectively. The HI values calculated for *K. nana* are 0.63, 1.42 and 1.05 from station 2, 3 and 1 respectively, while HI of 0.72, 0.02 and 0.59 were calculated for *P. lascaris* collected from stations 2, 3 and 1 respectively (Table IV).

Table III. Comparison of heavy metal contents (mg/kg) in fish species from the three creeks

Location	Fish Species	Cd	Cr	Cu	Fe	Pb	Zn
Station 2	<i>C. filamentosus</i>	0.002 ± 0.001	0.42 ± 0.01	0.18 ± 0.06	6.54 ± 2.88^b	0.56 ± 0.03	2.45 ± 0.96^b
		0.001 ± 0.001	0.01 ± 0.01	0.04 ± 0.01	3.62 ± 1.14^c	0.36 ± 0.01	1.48 ± 0.22^c
	<i>K. nana</i>	0.001 ± 0.001	0.01 ± 0.01	0.04 ± 0.01	3.62 ± 1.14^c	0.36 ± 0.01	1.48 ± 0.22^c
		0.001 ± 0.001	0.01 ± 0.01	0.04 ± 0.01	3.62 ± 1.14^c	0.36 ± 0.01	1.48 ± 0.22^c
	<i>P. lascaris</i>	0.000 ± 0.000	0.00 ± 0.00	0.02 ± 0.01	4.20 ± 0.32^d	0.30 ± 0.01	1.32 ± 0.11^d
Station 3	<i>C. filamentosus</i>	0.105 ± 0.002	0.33 ± 0.01	0.55 ± 0.36	11.57 ± 2.50^{ab}	0.53 ± 0.02	5.45 ± 1.12^{ab}
		0.105 ± 0.002	0.33 ± 0.01	0.55 ± 0.36	11.57 ± 2.50^{ab}	0.53 ± 0.02	5.45 ± 1.12^{ab}
	<i>K. nana</i>	0.004 ± 0.001	0.00 ± 0.00	0.22 ± 0.02	8.34 ± 1.10^{ac}	0.32 ± 0.01	2.18 ± 1.10^c
		0.004 ± 0.001	0.00 ± 0.00	0.22 ± 0.02	8.34 ± 1.10^{ac}	0.32 ± 0.01	2.18 ± 1.10^c
	<i>P. lascaris</i>	0.001 ± 0.001	0.00 ± 0.00	0.00 ± 0.00	5.18 ± 1.20^d	0.14 ± 0.01	1.58 ± 0.95^d
Station 1	<i>C. filamentosus</i>	0.008 ± 0.002	0.03 ± 0.01	0.78 ± 0.03	10.65 ± 2.42^{ab}	0.26 ± 0.02	3.84 ± 0.86^{bb}
		0.008 ± 0.002	0.03 ± 0.01	0.78 ± 0.03	10.65 ± 2.42^{ab}	0.26 ± 0.02	3.84 ± 0.86^{bb}
	<i>K. nana</i>	0.001 ± 0.001	0.01 ± 0.01	0.34 ± 0.02	6.12 ± 1.04^{bc}	0.18 ± 0.01	1.39 ± 0.92^c
		0.001 ± 0.001	0.01 ± 0.01	0.34 ± 0.02	6.12 ± 1.04^{bc}	0.18 ± 0.01	1.39 ± 0.92^c
	<i>P. lascaris</i>	0.001 ± 0.001^a	0.01 ± 0.01	0.17 ± 0.01	3.48 ± 1.12^d	0.11 ± 0.01	1.28 ± 0.64^d

Mean \pm SD values with no superscript/ same in the row = not significant ($p > 0.05$) difference.

Mean \pm SD values with different superscript in the row = significant ($p < 0.05$) difference.

Station 1 = Badagry Creek, Station 2 = Tomaro creek and Station 3 = Ajegunle creek

Table IV. Length-weight relationship, K and HI of fish species collected from the three creeks

Creek(s)	Species	Mean Total Length(cm)	Mean Body Weight(g)	K	R ²	b	HI
Station 2	<i>Chrysichthys filamentosus</i>	16.58 ± 2.15	26.84 ± 4.17	1.28	0.80	3.10	1.18
Station 3	<i>C. filamentosus</i>	15.78 ± 1.69	22.86 ± 2.34	0.68	0.69	1.84	2.06
Station 1	<i>C. filamentosus</i>	14.26 ± 1.57	19.65 ± 4.06	1.45	0.54	0.31	1.81
Station 2	<i>Kribia nana</i>	11.46 ± 0.29	13.48 ± 0.46	1.86	0.28	0.64	0.63
Station 3	<i>K. nana</i>	10.72 ± 0.66	12.44 ± 0.57	1.76	0.25	0.59	1.42
Station 1	<i>K. nana</i>	10.50 ± 0.47	12.11 ± 0.42	1.98	0.32	0.54	1.05
Station 2	<i>P. lascaris</i>	13.45 ± 0.65	14.49 ± 1.26	1.35	0.14	0.26	0.72
Station 3	<i>P. Lascaris</i>	12.52 ± 0.86	13.98 ± 1.30	0.88	0.27	0.16	0.02
Station 1	<i>P. lascaris</i>	12.52 ± 0.86	13.94 ± 1.50	0.99	0.17	0.18	0.59

R² = Coefficient of determination, b = slope of regression line, K = condition factor, HI = hazard index; Station 1 = Badagry Creek, Station 2 = Tomaro creek and Station 3 = Ajegunle creek

Comparison of heavy metal content in sediment across the creeks: The copper content in the sediment from stations 2 and 1 were significantly lower than that obtained at station 3 ($10.88 \pm 3.54 \text{ mg/kg}$). The lead values ($1.16 \pm 0.14 \text{ mg/kg}$) in sediment from station 1 was significantly lower than lead recorded from both station 2 and 3. On the opposite, the values of iron and zinc in the sediment from the three creeks significantly ($p < 0.05$) differs but values of cadmium and chromium was not different ($p > 0.05$) (Table V).

Table V. Comparison of heavy metals concentration in sediment from the three creeks

Heavy Metals	Station 2	Station 3	Station 1
Cd (mg/kg)	0.97 ± 0.12^a	1.64 ± 0.62^a	0.88 ± 0.37^a
Cr(mg/kg)	1.64 ± 0.86^a	1.75 ± 0.26^a	1.24 ± 0.42^a
Cu(mg/kg)	8.19 ± 4.26^a	10.88 ± 3.54^b	7.74 ± 1.70^a
Fe(mg/kg)	527.14 ± 89.67^a	1432.24 ± 116.23^b	1164.02 ± 84.62^c
Zn (mg/kg)	11.28 ± 3.44^a	20.94 ± 2.66^b	13.74 ± 1.27^c
Pb(mg/kg)	4.18 ± 2.36^a	3.44 ± 1.05^a	1.16 ± 0.14^b

Mean \pm SD values with same superscript in the row are not significantly ($p > 0.05$) different.

Station 1 = Badagry Creek, Station 2 = Tomaro creek and Station 3 = Ajegunle creek

Pollution Index Model: The EF values for station 3 are: 0.622, 0.393, 0.489, 1.000, 0.303 and 0.683 for cadmium, copper, iron, lead and zinc respectively. On the other hand, values of 0.334, 0.278, 0.348, 1.000, 0.102 and 0.448 were calculated for cadmium, chromium, copper, iron, lead and zinc respectively from station 1. The highest I_{GEO} value recorded at stations 2, 3 and 1 respectively was for cadmium whose values are (0.649, 1.097 and 0.589) respectively. On the contrast, the lowest I_{GEO} values recorded in stations 2, 3 and 1 respectively are iron (0.002), lead (0.035) and lead (0.012). The peak CF and Er respectively was obtained in cadmium and their values were (1.213, 36.390) at station 2, (2.050, 61.50) at station 3 and (1.100, 33.000) at station 1 (Table VI). Station 2 was the control sites with constant EF values for all the metals.

Table VI. CF, EF, I_{GEO} and Er in sediment from the three Creeks in Lagos, Nigeria

Location	Ecological Index	Cd	Cr	Cu	Fe	Pb	Zn
Station 2	EF	1.000	1.000	1.000	1.000	1.000	1.000
	I_{GEO}	0.649	0.004	0.037	0.002	0.042	0.024
	CF	1.213	0.016	0.228	0.014	0.049	0.081
	Er	36.390	0.032	1.140	NA	0.245	0.081
Station 3	EF	0.622	0.393	0.489	1.000	0.303	0.683
	I_{GEO}	1.097	0.004	0.049	0.006	0.035	0.044
	CF	2.050	0.018	0.302	0.038	0.040	0.150
	Er	61.50	0.036	1.510	NA	0.200	0.150
Station 1	EF	0.334	0.278	0.348	1.000	0.102	0.448
	I_{GEO}	0.589	0.003	0.035	0.005	0.012	0.029
	CF	1.100	0.012	0.215	0.031	0.014	0.098
	Er	33.000	0.024	1.075	NA	0.070	0.098

CF= Contamination Factor, EF= Enrichment Factor, I_{GEO} = Geochemical Accumulation (I_{GEO}) and Er= Ecological Risk Factor. Station 1 = Badagry Creek, Station 2 = Tomaro creek and Station 3 = Ajegunle creek

Discussion

The biological, chemical and physical parameters of water affect the desirability of water for any specific use (Boyd 1982). Anyanwu (2012) explained that quality of any water body is controlled by its physical, chemical and heavy metal factors. For the present study, most of the water quality parameters were very conducive for the fish when compared to WHO (2004) and FEPA (2007) permissible limits. Studies have shown that dissolved oxygen (DO) is an important factor limiting abundance, distribution, composition and survival of aquatic organisms (Etim *et al.* 2013). DO tends to reduce in concentration when effluents containing cations compete for binding sites with the hydroxyl group in water molecule to form other compounds thereby depleting the water body of its dissolved oxygen (Pollock *et al.* 2007). According to Okorafor *et al.* (2013), DO level of 1 to 5mg/L will slow down the growth of fishes when continuously exposed, while levels below 1mg/L are reportedly fatal to fish when exposed for more than a few hours. Water parameters such as alkalinity, hardness, BOD, conductivity and COD in this study were lower than that reported in Owudu creek in Niger Delta, Nigeria and in Gangetic Delta Region, West Bengal, India respectively (Friday *et al.* 2013). However, the water parameters reported from River Okpokwu in Benue State, Nigeria was higher than that obtained in this study.

Different authors have highlighted the importance of different water physico-chemical parameters. For instance, Ajit and Padmakar (2012) and Ani *et al.* (2016) reported that water temperature controlled the metabolism and physiology of fishes as well as its productivity. Kara *et al.* (2004) revealed that temperature above 30°C can cause regression in growth of aquatic organisms and decay in plants. Lawson (2011) disclosed that higher temperature increases toxicity of pesticides and heavy metals, and susceptibility of organisms to toxicants. Temperature is known to impact several chemical and biological characteristics and greatly influence DO, Alkalinity, EC and pH (Matta *et al.* 2017). As defined by Ekpo *et al.* (2012), conductivity is a measure of the total amount of ions present in a water body which is useful in approximating the chemical richness of the water. Alkalinity is important to fish and aquatic life because it buffers against rapid pH changes. Total dissolved solids (TDS) is described as the total amount of mobile charged ions, including minerals, salts or metals dissolved in a given volume of water in mg/L. TDS in aquatic systems may be related to the geo-chemistry of the system and the allochthonous load it carries and constitute an important parameter in describing the chemical density of water as a fitness factor (Taskeena *et al.* 2017).

Biochemical Oxygen Demand (BOD) is the amount of oxygen utilized by microorganisms in stabilizing organic matter (Ewebiyi *et al.* 2015). They asserted that unpolluted waters usually have BOD value of 2.00 mg/L or less, while those receiving wastewaters may have value as high as 10 mg/L. Turbidity is a measure of the reduction of transparency due to dissolved and suspended particulate matter in the water column (Matta *et al.* 2017). Water hardness is not a pollution parameter but represents the quality of water in terms of calcium, magnesium, carbonate, sulphate, chlorate and nitrate (Matta *et al.* 2017) and water quality with less than 75mg/L of CaCO₃ is considered soft, while above 75mg/L of CaCO₃ is hard water. Therefore, it's cleared that the three creeks examined in this present study are hard waters.

In the present study, all metals in water samples (except lead and cadmium) were within the standard limits. El-Sayed *et al.* (2011) have reported that though heavy metals are natural constituents of the Earth's crust however they can bio-accumulate along the food chain in soils, water and sediment causing different types of ailments and diseases. *C. filamentosus* and *K. nana* from the three creeks contained lead, cadmium, iron concentrations that were above the standard permissible limit. Similarly, *C. filamentosus* collected from stations 1 and 3 consist of chromium and copper level that exceeded recommended limits in fish. Range of recommended standard permissible limits of metals such as zinc, lead, copper, iron, cadmium and chromium, in fish has been documented (WHO 2003). The present findings as regard metal concentration in fish is similar to the record of metals in *C. nigrodigitatus* from Ibaka and Ifiayong fishing sites in Akwa Ibom State, Nigeria (Akpanyung *et al.* 2014) but exceeded that which was recorded in *E. fimbriata* from Cross River Estuary (Udo and Ndunobong 2016). However, all the metals obtained in fish during this study was lower than that reported in *Clarias gariepinus* and *Oreochromis niloticus* (Ejike and Liman 2017). Various deleterious effects of high concentration of heavy metals in fish have been reported in literatures such as Mekuleyi *et al.* (2019) and Duruibe *et al.* (2007).

The assessment of concentrations of metals in the sediments during this present study revealed that content of iron and lead was not below the USEPA (2018) recommended maximum permissible limit. Contrary to the present findings, Okorafor *et al.*, (2013) found out that all metals examined in sediment from Intertidal Regions of Calabar River were within permissible limits. They attributed this outcome to tidal influence which resulted in thorough mixing of the effluent in the large water body and thus minimizing the impact on the receiving water body. Mekuleyi *et al.* (2019) opined that sources of lead and iron pollution in water sediment include metallic pipes, batteries of pumping equipment, automobile emissions, as well as drainage of lead compounds from crop farms treated with agro-chemicals. The values of ecological risk factor (Er) for cadmium and copper (at stations 1 and 2), and copper (at station 3) in this study indicated low potential ecological risk of the habitats. However, the Er value recorded for cadmium in station 3 implies moderate potential ecological risk. Comparatively, all the Er values in this study were below that reported by Hashim *et al.* (2015). The values for enrichment factors in this study indicate that there is a minimal enrichment of the metals in the sediments. Okorafor *et al.* (2013) have reported similar results. However, Igbinsosa *et al.* (2012) which work on Shanomi Creek in Niger Delta reported EF value that was lower than what was recorded in this study. Furthermore, the values of contamination factor (CF) and Igeo values for this study indicated that the sediment was moderately contaminated. Apart from *C. filamentosus* and *P. lascaris* in station 3 and *P. lascaris* in station 1 most of the fish sampled in this study had mean $K > 1$ and this means that they are in good state and condition in their respective habitats. Similar findings of fish with k factor above 1 has been reported by Imam *et al.* (2010), Ahmed *et al.* (2011), and Kumolu-Johnson and Ndimele (2011). Majority of the fish had negative allometry growth pattern and this indicated that the fish becomes thinner with increase in length (King 2007). The HI content in *C. filamentosus* from the three creeks and *K. nana* from stations 1 and 3 was higher than 1. According to Zodape (2014), HI value that is above 1 poses public health concern. Therefore, the implication of HI values exceeding 1 in this study is that consumption of large quantity of the fish species by individual person could lead to health problem as opined by Zodape (2014).

From the findings in this study, it could be concluded that the three habitats (creeks) are suitable for the fish, although the creeks are contaminated with low levels of heavy metals. More so, the values of the condition factors implied that the fish are in good status while most of them exhibited negative allometric growth pattern. However, HI index divulged that high health risk may occur if human consume large quantity of the sampled fish species.

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COMPARATIVE ASSESSMENT OF WELL-BEING OF *C. FILAMENTOSUS*, *K. NANA* AND
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