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Research note

Comparative Assessment of Total Hydrocarbon Content and Bioaccumulation of Heavy Metals in *Sarotherodon Melanotheron* at Atlas Cove Area and Okobaba of Lagos Lagoon

Ayoola S. O., Olorunsanmi G. T. and Oke A.O.

Department of Marine Sciences, University of Lagos, Lagos State, Nigeria

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A B S T R A C T

Industrial waste discharge has increased the hazard of water pollution. The total hydrocarbon content and bioaccumulation of heavy metals in *Sarotherodon melanotheron* at Atlas cove area and at Okobaba end of Lagoon Lagos were assessed between November, 2014 and January, 2015. The physicochemical parameters were determined according to APHA-AWWA-WEF and heavy metals in the fish species were determined using Atomic Absorption Spectrometer. The total hydrocarbon content (THC) in the fish samples were analysed by using Soxhlet extraction gravimetric methods. The heavy metal values evaluated are Fe, Cr, Pb, Ni and Cu. The concentration of Iron (Fe) in *Sarotherodon melanotheron* was 72.72 ± 125.95mg/kg, Chromium (Cr)- 10.29 ± 4.61mg/kg; Lead (Pb)- 1.08 ± 0.23mg/kg; Nickel (Ni)- 0.39 ± 0.26mg/kg; and Copper (Cu)- 0.20 ± 0.26mg/kg at Atlas cove area while at Okobaba the concentration were;Fe-115.98±87,Cr-5.25±1.02,Pb-2.04±1.50,Ni-0.78±0.08,and Cu is 0.36±0.15mg/kg. The levels of accumulation of all the heavy metals in *Sarotherodon melanotheron* were above the WHO permissible limits. The concentration of n- alkanes in *Sarotherodon melanotheron* at Atlas cove was 164.69 ± 97.04µg/g, polycyclic aromatic hydrocarbon (PAH) was 73.58 ± 72.48µg/g, and total petroleum hydrocarbon was 526.67 ± 214.34µg/g. The average intake of polycyclic aromatic hydrocarbon through fish consumption at Atlas cove area was estimated to be 5039.94 ± 49.2mg/kg; body weight/day. The mean concentration of n-alkanes hydrocarbon in *Sarotherodon melanotheron* at Okobaba was 152.62±54.11µg/g, the Polycyclic Aromatic Hydrocarbon (PAH) was 74.4±50.30 µg/g.The carcinogenic high molecular weight polycyclic aromatic hydrocarbons (HMW-PAH) were of higher concentrations than the lower molecular weight polycyclic aromatic hydrocarbon (LMW-PAH). Therefore, Atlas cove area is more exposed to carcinogenic health risks associated with the consumption of the studied fish than Okobaba end of Lagos Lagoon. This indicates significant carcinogenic health risks associated with the consumption of black jaw Tilapia fish caught from the study areas.

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INTRODUCTION

The indiscriminate discharge of effluent into aquatic ecosystem has increased over the years, especially in developing countries like Nigeria. The contaminated environment might cause free divalent ions of many heavy metals to be absorbed by fish through their gills. The concentration of heavy metals in fish reveals the pollution status of the environment. According to literature [1], oil spills in the aquatic and terrestrial environment are results of leakages from pipelines, underground and surface fuel storage tanks, indiscriminate spills and careless disposal and mismanagement of waste and other petroleum by-products of the society. Humans are exposed to total hydrocarbon content (THC) through air, water, food, or soil. However, dietary intake has been shown to be a major route for human exposure to petroleum hydrocarbons [2, 3, 4].

Fish ingest hydrocarbons directly or indirectly from contaminated water as food and sediments. These reduce growth and damage their tissues and organs, leading to massive destruction of aquatic biota. Fish are good source of protein but frequent consumption of contaminated fish can pose risk to human health. Since fish often respond to toxicants in a similar way as higher vertebrates, they can be used to screen for chemicals that are potentially carcinogenic in humans [5]. Therefore, they are good biomonitors that indicate the presence of pollutants and also attempt to provide additional

* Corresponding author: Ayoola S. O.
E-mail: sayoola@unilag.edu.ng

information about the amount and the intensity of the exposure.

Heavy metals are found in marine environment that occur because of pollution which is due to the discharge of untreated wastes into water bodies by industries and runoffs. [6]. Many pollutant are found in crude oil due to its geological proximity most especially heavy metals, since they play important role in biological systems, whereas mercury, lead and cadmium are toxic, even in trace amounts. The essential metals can produce toxic effects at high concentrations and when they bioacumulate in organism. Contamination with heavy metals and non–degradable pollutants are serious threat because of their concentration and bioaccumulation in the food chain [7]. Bioaccumulation is the gradual build up over time of a chemical in a living organism. Bioaccumulation occurs when an organism absorbs a toxic substance at a rate greater than it is lost. The longer the biological half-life of the substance the greater the effect, even if environmental levels of the toxin are not very high [8]. However, zooplankton might then consume them. One zooplankton that has eaten ten phytoplankton may have ten times the toxic substances level as the phytoplankton and this result in bioaccumulation in the organism. [8]. However, the zooplankton may be slow to metabolize or excrete the toxic substances because some of the heavy metals are non-degradable hence, they build up or bio accumulate within the organism. A fish might then eat ten zooplankton and the level of toxicant will be 100 times when phytoplankton is consumed. This multiplication would continue throughout the food chain and food web. The biomagnified amount might cause serious damage to organisms higher during the energy flow in the food chain [7, 8].

Organism especially fish accumulate heavy metals directly from water and food also from suspended particulate materials and sediment. The contaminant residues in fish may multiplied in food chain and pyramid of biomass. Several studies [9, 10, 11, 12, 13] have indicated that fish are able to accumulate and retain heavy metals from their environment depending upon magnitude and duration of exposure. Adeyeye *et al.*, [14] also showed that the concentration of metals was a function of fish species physiology as some fishes accumulate toxic substances than other.

However,public health point of view,attention has been drawn on the necessity of measuring the accumulation of heavy metals and total hydrocarbon co ntent which pose serious health hazards to humans. Though there are studies on the level of hea vy metals and total hydrocarbon content in fish species; however, none of the research works was on as sessment of total hydrocarbon content and bioaccumulation of heavy metals in *Sarotherodon melanotheron* at Atlas cove area of Lagos state and Okobaba of Lagos Lagoon. The subjective of this research is to compare the quality of the water, the level of heavy metal concentration and to also investigate the level of Total hydrocarbon content (THC) in *Sarotherodon melanotheron* at Atlas cove area and Okobaba of Lagoon. Also estimate the dietary intake of Polycyclic Aromatic Hydrocarbon (PAH) through consumption of *Sarotherodon melanotheron* at Atlas cove and Okobaba .

MATERIALS AND METHODS

Description of study sites

The Atlas cove area lies South West of Lagos city. The area is notable for Atlas cove oil depot, a facility of Pipelines and Products Marketing Company Limited (PPMC), a subsidiary of Nigerian National Petroleum Corporation (NNPC) that was constructed in 1981(Adeofun and Oyedepo, 2011). The study area and adjoining sea fall within Oil Prospecting License (OPL) blocks which make it vulnerable to both inland and offshore oil spill disasters. The neighbouring communities include Tarkwa bay, Store, Abagbo and Ebute oko communities. Most people in this area are fishermen. The other study area is Oko Baba end of the lagoon serves as a permanent store for different sizes of logs. They are suspended in water and pulled out when needed. Also, wood shaving and saw dusts are disposed there on a daily basis. This alters the sediment composition of the area. Most benthic macro-invertebrates are sediment specific; therefore, some of them are totally wiped out by the disposal. It also reduces the biodiversity and the food available for the fishes in this area to feed on. Wood waste from Okobaba Sawmill industry is a persistent source of pollution to the Lagos Lagoon. Sludge beds of sawdust or wood shavings and particulate wood waste accumulate at the Okobaba end of the Lagos Lagoon [15]. Anthropogenic impacts at this location are from logging and sawmilling which generate organic waste such as sawdust and particulate wood waste. Figure 1 shows the Atlas cove area, Lagos while figure 2 shows the Oko Baba end of the Lagos Lagoon.

Experimental procedures

Water and fish samples were collected between 10:00 hr and 13:00 hr every Thursday for three consecutive months (November, 2014; December, 2014 and January 2015) from the two locations.

Determination of physicochemical parameters

Air and surface water temperatures were measured using a mercury-in-glass thermometer. Salinity was measured using Refractometer while Total dissolved solids (TDS) was measured using a Handheld Total Dissolved Solids meter (LaMotte) models TDS 6 PLUS. Dissolved oxygen (DO), pH, Biochemical oxygen demand (BOD), Total suspended solids (TSS) were determined according to APHA-AWWA-WEF [16].

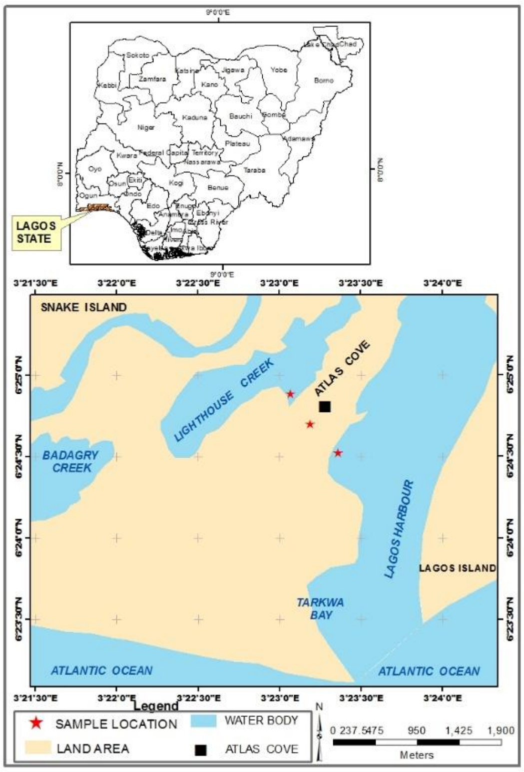

Figure 1: Atlas cove area, Lagos State

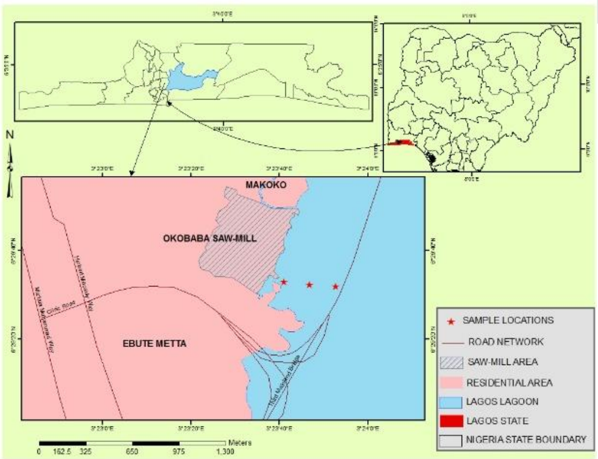

Figure 2: The Oko Baba end of the Lagos Lagoon.

Collection of fish samples

Sarotherodon melanotheron (black jaw Tilapia) were collected monthly from Lighthouse creek by the local fishermen with the use of hook and line. The samples of *Sarotherodon melanotheron* were also collected with cast net by local fishermen from the water body at the Oko Baba end of the Lagos lagoon. The fish samples were then wrapped in sterile aluminum foil and properly labeled. They were stored in deep freezer at about -20°C until digestion of fish samples were carried out.

Atomic Absorption Spectrophotometer (AAS) analysis

Heavy metal concentrations (Nickel, Chromium, Lead, Copper and Iron) for all extracts were determined using Agilent Technologies 200 series AA Atomic Absorption Spectrophotometer (AAS) as described by AOAC [17].

Total Hydrocarbon Content (THC) Extraction

The fish samples were dried on aluminum foil by heating in an oven at 50ºC for 48hours to constant weight. The total hydrocarbon content extraction of fish samples was determine by using a soxhlet apparatus for 8h using a mixture of n-hexane and dichloromethane according to UNEP [18] and WHO [19]. The total hydrocarbons in the extract were determined using UV spectrophotometer model DREL 3000 at a wavelength of 450 nm against blank of n-hexane.

Statistical analysis

The obtained data were analysed with SPSS package (version 16.0) and subjected to Descriptive Statistics and Simple student t-test, to test whether there is significant differences between the mean values of the two sampling stations.

RESULTS AND DISCUSSION

The data obtained for physicochemical parameters at Atlas cove and Oko Baba from November, 2014 to January, 2015 are represented in Tables 1 and 2. The concentrations of heavy metals in *Sarotherodon melanotheron* at two locations were presented in Tables 3 and 4. There was no significant difference ($P > 0.05$) between the mean values of heavy metal concentrations (Ni, Cr, Pb, Cu and Fe) in *Sarotherodon melanotheron* at the two stations. The Total Hydrocarbon Content (THC): n- Alkanes (table 5), Polycyclic Aromatic Hydrocarbon (PAH) (Tables 6 and 7 for Atlas cove and Okobaba respectively) and Total Petroleum Hydrocarbon (TPH) in *Sarotherodon melanotheron* are presented in Tables 8 and 9 for Atlas cove and Okobaba respectively. There was significant difference ($P < 0.05$) between the mean values of n- Alkanes in *Sarotherodon melanotheron* between Atlas cove and Okobaba end of Lagoon. Significant difference ($P > 0.05$) was not observed between the mean values of n- Alkanes, PAH and TPH in *Sarotherodon melanotheron* for three months in the stations.

TABLE 1: Monthly variation in Physicochemical Parameters of water samples at Atlas cove area, Lagos

PARAMETERS	NOVEMBRR	DECEMBER	JANUARY	MEAN±SD
Air Temperature	31.0±1.5	32.0±1.3.	28.6±1.4	30.56±1.61
Water Temperature	31.2±1.0	30.5±3.2	28.6±0.8	30.39±2.00
pH	6.83±0.7	7.10±0.6	7.3±0.5	7.08±0.50
Dissolved Oxygen (mg/L)	4.3±2.0	6.4±1.9	4.4±2.3	5.04±2.02
BOD(mg/L)	1.50±0.8	2.3±1.3	0.8±0.2	1.52±1.21
Total Suspended Solids(mg/L)	1.1.±0.8	0.7±1.0	0.8±1.3	0.41±1.05
Total Dissolved Solids(mg/L)	6047.33±0.4	10452.0±0.6	14900.33±0.4	10466.56±9021.34
Salinity (‰)	5.7±9.0	12.3±8.8	17.0±8.4	11.78±9.85

TABLE 2: Mean and Standard Deviation Values of Physico-Chemical Parameters of water samples at Oko Baba end of Lagoon.

PARAMETERS	NOVEMBR	DECEMBER	JANUARY	MEAN±SD
Air Temperature	28.43±0.75	29.13±0.85	28.17±0.76	28.57±0.78
Water Temperature	30.93±1.66	30.7±1.67	30.67±2.08	30.76±1.80
pH	7.07±0.12	7.13±0.15	7.3±0.1	7.16±0.12
Dissolved Oxygen (mg/l)	6±6	5.6±4.87	3.97±3.44	5.19±4.77
BOD(mg/l)	0.50±0.75	1.47±2.20	2.47±3.44	1.48±2.13
Total Suspended Solids(mg/l)	0.09±0.04	0.04±0.01	0.06±3.44	0.06±1.16
Total Dissolved Solids(mg/l)	2593.33±722.86	5946.67±1428.89	11946.67±3.44	3322.96±718.39
Salinity (‰)	7.067±0.12	7.13±0.15	7.3±3.44	7.16±1.24

TABLE 3: heavy metals concentration in *Sarotherodon melanotheron* at atlas cove area, Lagos

Heavy metals	Concentration (mg/kg) in *Sarotherodon melanotheron*					
	Nov	Dec	Jan	MEAN ± SD	FEPA limit	WHO Limit
Ni	0.61 ± 0.24	0.47 ± 0.02	0.10 ± 0.06	0.39 ± 0.26	0.5	-
Cr	5.37 ± 2.66	10.99 ± 2.96	14.50 ± 1.00	10.29 ± 4.61	0.15	0.05
Pb	0.82 ± 0	1.27 ± 1.52	1.16 ± 0	1.08 ± 0.23	1.5	0.05
Cu	0.02 ± 0	0.09 ± 0.09	0.50 ± 0.49	0.20 ± 0.26	3.00	0.05
Fe	218.15 ± 146.05	ND	ND	72.72 ± 125.95	0.30	0.10

ND= Not detected

TABLE 4: Mean concentration of Heavy Metals in the tissues of *Sarotherodon melanotheron* from Oko Baba. Values are presented in Means ± S.D. (mg/kg)

HEAVY METALS	MONTHS				PERMISSIBLE LIMITS	
	NOVEMBER	DECEMBER	JANUARY	MEAN± SD	FEPA LIMIT	WHO LIMIT
Nickel	0.85±0.36	0.69±0.02	0.79±0.50	0.78±0.08	0.5	-
Chromium	6.33±3.46	5.14±0.91	4.29±2.39	5.25±1.02	0.15	0.05
Lead	3.61±1.94	1.90±1.73	0.62±0.91	2.04±1.50	2.00	0.05
Copper	0.49±0.21	0.4±0.02	0.19±0.11	0.36±0.15	3.00	0.05
Iron	52.52±60.53	215.61±91.03	79.82±138.25	115.98±87.35	0.30	0.10

TABLE 5: n- alkane components in *Sarotherodon melanotheron* at atlas cove area, Lagos and Oko baba end of Lagos Lagoon

STATIONS	Mean±SD
Atlas cove area	164.69 ± 97.04
Oko baba	152.62±54.11

TABLE 6: polycyclic aromatic hydrocarbon (PAH) components in *Sarotherodon melanotheron* at atlas cove area, Lagos

Concentration (µg/g) in *Sarotherodon melanotheron*			
Components	**November**	**December**	**January**
Naphthalene (Estd + Istd)	2.64 ± 0	ND	2.47 ± 0
Acenaphthylene	0.29 ± 0.29	0.07 ± 0.02	0.09 ± 0.01
Acenaphthene	0.79 ± 1.23	0.10 ± 0.12	0.37 ± 0.20
Fluorene	0.29 ± 0.25	0.09 ± 0.08	0.17 ± 0.15
Phenanthrene	0.76 ± 0.08	0.54 ± 0.14	0.49 ± 0.05
Anthracene	0.74 ± 0.25	0.44 ± 0.22	0.20 ± 0.08
Fluoranthene	5.16 ± 2.08	6.57 ± 3.45	0.64 ± 0.70
Pyrene	0.20 ± 0.24	0.20 ± 0.09	0.44 ± 0.34
Benzo (a) anthracene	2.55 ± 2.83	0.45 ± 0.10	0.44 ± 0.25
Chrysene	0.29 ± 0.09	1.29 ± 1.37	0.69 ± 0.53
Benzo (b) fluoranthene	7.69 ± 5.84	6.32 ± 1.33	7.42 ± 2.29
Benzo (k) fluoranthene	11.77 ± 8.21	2.76 ± 1.72	3.75 ± 0.34
Benzo (a) pyrene	2.59 ± 1.64	1.54 ± 0.24	1.24 ± 0.07
Dibenz (a,h) anthracene	28.69 ± 40.66	3.71 ± 2.04	3.44 ± 2.13
Indeno (1,2,3,-cd) pyrene	16.812 ± 25.87	2.15 ± 1.58	2.80 ± 1.15
Benzo (g,h,i) perylene	76.02 ± 113.31	5.35 ± 3.20	7.21 ± 2.21
Total	157.27	31.58	31.87
Mean ± SD	73.58 ± 72.48		

ND= Not detected

TABLE 7: Individual Polycyclic Aromatic Hydrocarbon (PAH) content in Black Jaw Tilapia; *Sarotherodon melanotheron* from Oko Baba

	Concentration in µg/g		
COMPONENTS	**NOVEMBER**	**DECEMBER**	**JANUARY**
Naphthalene (Estd + Istd)	ND	2.464712±0	ND
Acenaphthylene	0.12±0.05	0.284±0.18	0.0915±0.04
Acenaphthene	0.434±0.47	0.00325±0.01	0.223±0.24
Fluorene	0.436±0.19	0.284±0.18	0.00246±0.003
Phenanthrene	0.7281±0.31	0.313±0.13	0.533±0.31
Anthracene	0.796±0.66	0.232±1.20	0.158±0.09
Fluoranthene	4.10±3.89	10.4±8.62	0.232±0.10
Pyrene	0.532±0.32	0.191±0.21	0.258±0.13
Benz (a) anthracene	0.370±0.27	1.16±0.68	0.535±0.23
Chrysene	0.4.79±0.31	0.324±0.15	0.400±0.19
Benzo (b) fluoranthene	0.715±0.43	7.27±3.03	5.97±2.78
Benzo (k) fluoranthene	9.16±7.80	6.76±3.47	2.56±1.13
Benzo (a) pyrene	2.62±1.42	2.71±1.54	1.39±0.58
Dibenz (a,h) anthracene	8.13±8.56	26.9±21.30	2.94±2.203174
Indeno (1,2,3,-cd) pyrene	4.99±4.54	13.1±11.02	2.26±1.34
Benzo (g,h,i) perylene	40.2±38.42	52.0±49.05	6.84±4.70
TOTAL	73.8±47.39	125±96.26	24.4±12.42
Mean±SD (Nov-Jan)	74.4±50.30		

ND = not detected

TABLE 8: Total petroleum hydrocarbon (tph) in *sarotherodon melanotheron* at atlas cove area, lagos

Concentration (µg/g) in *Sarotherodon melanotheron*			
Component	**November**	**December**	**January**
TPH	773.48 ± 428.54	419.18 ± 42.01	387.33 ± 32.10
Total	773.48	419.18	387.33
Mean ± SD	526.67 ± 214.34		

TABLE 9: Total Petroleum Hydrocarbon (TPH) content in Black Jaw Tilapia; *Sarotherodon melanotheron* from Oko Baba

	Concentration in µg/g		
	NOVEMBER	**DECEMBER**	**JANUARY**
TPH	810.13±259.83	437.24±182.56	236.08±196.43
TOTAL	810.13±259.83	437.24±182.56	236.08±196.43

The physical and chemical analysis of water is an important factor employed in the assessment of the quality of water. Air and water temperatures were high throughout the study period and only slightly varied. The air temperature ranged from 28.6±1.4 to 31.0±1.5^{0}C while the water temperature ranged from 28.6±0.8 to 30.39±2.0ºC. This shows that the temperature in the tropics is usually high [20] and points to depletion of the ozone layer. However, rainfall rather than temperature is the limiting factor which determines the environment in the tropics [21, 22].

At the stations most especially Okobaba which is directly by the saw mill, the dissolved oxygen was low throughout the period of sampling. This indicates the extent of pollution caused by the disposal of wood wastes into this area of the lagoon. Based on this result, it is safe to assume that there is no aerobic life at all in this part of the water body. However, some locations stations had higher values of dissolved oxygen. This shows the presence of life as we move away from the water bank where the sawmill industry is located.

Oxygen is a bye product of photosynthesis and the more the primary production, the more the Dissolved oxygen (DO) production. The highest value of dissolved oxygen recorded may be attributed to abundance of algae in this water body compared to the other water bodies. Biochemical oxygen demand recorded in two stations (November to January) indicates survival of only tolerant anaerobs in the water body. The variations in the physicochemical characteristics reported in this study agree with earlier records of Nwankwo *et al*. [23].

The highest value of Total suspended solids recorded at atlas cove in November could be as a result of operational discharge of petroleum products. Total dissolved solids showed an increase throughout the sampling period at the three locations. The Total dissolved solids were high in the three stations due to the introduction of derived materials from adjourning wetlands, recruitment from flood waters and dissolution of some particles in the water bodies. This is in accordance with the works of Nwankwo *et al*. [23].

The pH value was slightly acidic at atlas cove and to slightly alkaline at Okobaba end of Lagoon. pH values increased with reduction in rainfall values throughout the sampling period for the two stations. According to Nwankwo *et al*. [23], high pH levels observed in the coastal waters of Nigeria has been linked to the buffering effects impacted by tidal inflow of seawater. The salinity values varied during the sampling period. Salinity increased in both Stations during the sampling months and the highest salinity value was recorded in January at Atlas cove. This could be as a result of reduced freshwater incursion and the fact that Atlas cove experiences greater seawater incursion from the Atlantic Ocean.

Living organisms require specific amounts of some heavy metals; some of these metals are essential for animal tissue metabolism but may be hazardous for human metabolism especially when their concentration is high [24] .Trace metals such as cadmium, lead and mercury have no known beneficial effect on organisms and their accumulation over time in the bodies of humans can cause certain illnesses [25]. Fish take up heavy metals from the surrounding aquatic environment through the gills during the process of respiration or through the intestinal wall with ingestion of metals absorbed in the food.

The level of accumulation of Lead (Pb) in *Sarotheron melanotheron* was below the FEPA permissible limit but above WHO permissible limit at Atlas cove area while Pb was higher above FEPA and WHO at Okobaba end of Lagoon while that of Nickel (Ni) was above FEPA permissible limit in the two stations . The level of accumulation of Chromium (Cr) was far above WHO and FEPA permissible limits for the three months in all the stations. Bioaccumulation of Copper (Cu) was below WHO limit for the three months but above FEPA limit in all the stations. Bioaccumulation of Iron (Fe) was above FEPA and WHO limits. Murtala *et al*. [6] detected high value at downstream Ogun coastal water and were also above the recommended limit but not as high as those recorded in the study area. Ayoola and Dansu [26] reported lower concentrations of Cadmium (Cd), Chromium (Cr), Lead (Pb) and Zinc (Zn) in *Chrysichthys nigrodigitatus* and *Pythonichthys macrurus* collected at Makoko fishing site compared to the current study; the concentrations of heavy metals in the fish samples were above WHO permissible limit. Hence, the consumption of fish caught around the Atlas cove and Okobaba may pose risk to human health.

The concentration of n- Alkanes in *Sarotheron melanotheron* where higher in the two stations. The values were higher than those recorded by Olaji *et al*. [27] in four species of Degele community, Sapele, Delta. There was significant difference ($P < 0.05$) between the mean values of n- Alkanes in *Sarotherodon melanotheron* for three months of the stations. The observed difference in n- Alkanes concentration for the three months may be attributed to differences in feeding preference and general habit.

In the research work by Nkpaa *et al*. [4] on concentrations of PAH in *Tilapia queneesis* and *Liza falcipinis* collected from Kaa, B-Dere and Bodo City in River state, the exposure pathways of According to GESAMP [28], fish tend to concentrate PAHs in their tissues when exposed to petroleum, but they do not retain it indefinitely, leading to these compounds not accumulating in very high concentration in edible tissues. According to Olaji *et al*. [27], the accumulation and depuration of PAHs in fish can be influenced by various factors including route and duration of exposure, lipid content of tissues, environmental factors, differences in species, age, and sex, and exposure to other xenobiotics.

The less carcinogenic polyaromatic hydrocarbon of lower molecular weight (LMW-PAHs) (Naphthalene, Acenaphthylene and Acenaphthene) and the more carcinogenic high molecular weight (HMW) PAHs (Benzo (a) anthracene, Benzo (b) fluoranthene, Benzo (k) fluoranthene, Benzo (a) pyrene and Indeno (1, 2, 3,-cd) pyrene) were detected in *Sarotherodon melanotheron* for the three months in the two stations. This contradicts the report by Olaji *et al*. [27] on *Clarias gariepinus*, *Heterobranchus longifilis*, *Oreochromis niloticus* and *Liza falcipinnis* of Degele community. Only the low molecular weights PAHs (LMW-PAHs) were detected in the fishes from the community; the high molecular weight PAHs (HMW-PAHs) was not detected. Rose *et al*. [3] also did not detect Benzo (a) pyrene in any of the fish and invertebrate samples from Lagos lagoon. There was no significant difference ($P > 0.05$) between the mean values of PAH in *Sarotherodon melanotheron* for three months in the two stations. PAH concentrations in the fish samples analyzed exceeded the European Union (EU) recommended limit of 2μg/kg (0.002μg/g) for fish as cited by Nkpaa *et al*. [4].

The ratio of high molecular weight PAHs (HMW-PAHs) to low molecular weight PAHs (LMW- PAHs) has been used to characterize the origin of PAHs in the environment. According to Abrajano *et al*. [29], petrogenic sources are derived from petroleum, such as natural oil seepage and oil spills while pyrogenic sources are derived from the combustion of petroleum, automobile tire, and wood and vehicle emission. PAHs may then be transported from their points of release to the coastal environment via surface runoff and atmospheric deposition. Rocher *et al*. [30] reported that petrogenic sources of PAHs show characteristically higher proportion of LMW- PAHs such as naphthalene and acenaphthenes while pyrogenic PAHs have characteristically higher proportion of HMW- PAHs such as pyrene and benzo (a) pyrene. The sources of PAH in the studied area were both petrogenic and pyrogenic sources. The more carcinogenic high molecular weight (HMW) PAH (Benzo (a) anthracene, Benzo (b) fluoranthene, Benzo (k) fluoranthene, Benzo

(a) pyrene and Indeno (1, 2, 3,-cd) pyrene) were of higher concentrations than less carcinogenic polyaromatic hydrocarbon of lower molecular weight (LMW PAHs) (Naphthalene, Acenaphthylene and Acenaphthene). This indicates that the source of PAH in Atlas cove area and Okobaba end of Lagoon is more of pyrogenic than petrogenic sources. According to Berto *et al*. [31], the predominance of HMW-PAHs may be due to the fact that LMW-PAHs are preferentially degraded during PAH transport and burial into sediments. This agrees with sources of PAHs in fish analyzed from three coastal water of Ogoni land, Rivers State as reported by Nkpaa *et al*., [4]. In this study, the concentration of Total Petroleum Hydrocarbon (TPH) in *Sarotheron melanotheron* for the sampling months ranged from 387.33 to 773.48µg/g at Atlas cove area and 236.08±196.43 to 810.13±259.83 at Okobaba end of Lagoon. The values were higher than TPH in aquatic plants from Degele community which ranged from 44.0 to 79.0µg/kg as reported by Olaji *et al*. [32]. The average dietary intake concentration of PAH through consumption of *Sarotheron melanotheron* at the studied area (Atlas cove, Lagos) was higher than that reported by Olaji *et al*. [26] at Degele community. It also exceeded that reported by Dhananjayan and Muralidharan [2] in India and Moon *et al*. [33] in Korea. The consumption of *Sarotheron melanotheron* at the rate of 68.5g/day may adversely affect human health. Thus, people in the study areas who consume larger quantities of *Sarotheron melanotheron* could be at a greater carcinogenic health risk.

CONCLUSION

The level of accumulation of Lead (Pb), Chromium (Cr), Copper (Cu), Iron (Fe) and Nickel (Ni) in *Sarotheron melanotheron* were above the WHO permissible limit for the three months at the stations. Hence, the consumption of fish caught around the Atlas cove may pose risk to human health. The levels of concentration of contaminants in fish reflect the state of contamination of the environment and therefore the observed levels of Total hydrocarbon content (THC) in fish species from this study indicate that the study areas were contaminated with petroleum hydrocarbon. Also, high molecular weight Polycyclic aromatic hydrocarbons (PAHs) were predominant over low molecular weight PAHs, indicating that PAH contamination in coastal waters of the study areas are mainly from pyrogenic sources. Therefore, Atlas cove area and Okobaba end of Lagoon are more exposed to carcinogenic health risks associated with the consumption of the studied fish. Hence, continuous monitoring of the environment and public enlightenment will help prevent the increase of total hydrocarbon content in these areas.

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Persian Abstract

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چکیده

دفع زباله های صنعتی خطر آلودگی آب را افزایش داده است. مقدار کل محتوی هیدروکربن و زیست باره فلزات سنگین در سارترودون ملانورتون در منطقه خلیج اطلس و در انتهای مرداب آکوبابا لاگوس بین نوامبر ۲۰۱۴ و ژانویه ۲۰۱۵ مورد ارزیابی قرار گرفت. پارامترهای فیزیکوشیمیایی با توجه به APHA-AWWA-WEF و فلزات سنگین در گونه¬های ماهی با استفاده از اسپکترومتر جذب اتمی تعیین گردید. مقدار کل محتوی هیدروکربن (THC) در نمونه¬های ماهی با استفاده از روش¬های وزنی استخراج سوکسله مورد تجزیه و تحلیل قرار گرفت. مقادیر فلزات سنگین ارزیابی شده عبارتند از آهن، کروم، سرب، نیکل و مس. غلظت آهن (Fe) در سارترودون ملانورتون ، 125.97 ± 72.72 mg / kg، کروم (Cr) ۴,۶۱ ± 10.29 mg / kg ؛ سرب (Pb) 1.08 ± 0.23 mg/kg؛ نیکل (Ni) 0.26±0.39 mg/kg؛ و مس (Cu) 0.20 ± 0.26 mg / kg در محدوده خلیج اطلس بود در حالی که در آکوبابا غلظت آهن ۱۱۵,۹۸ ± ۸۷، کروم ۵,۲۵ ± ۱,۰۲، سرب ۲,۰۴ ± ۱,۵۰، نیکل ۷۸,۰۸ ± ۰,۰۸ و مس ۰,۳۶ ± ۰,۱۵ mg / kg بود. سطوح انباشت تمام فلزات سنگین در سارترودون ملانورتون بالاتر از حد مجاز WHO بود. غلظت ان-الکان¬ها در سارترودون ملانوترون در خلیج اطلس ۱۶۴,۶۹ ± ۹۷,۰۴ µg / g، هیدروکربن آروماتیک چند حلقه¬ای (PAH) 72.48 ± 73.58 µg / g و کل هیدروکربن نفتی ۵۲۶,۶۷ ± ۲۱۴,۳۴ µg / g بود. میانگین مصرف هیدروکربن¬های چند حلقه¬ای آروماتیک از طریق مصرف ماهی در محدوده خلیج اطلس ۴۹,۲ ± ۵۰۳۹,۹۴ میلی گرم / کیلوگرم؛ وزن بدن/ روز بود. میانگین غلظت هیدروکربن ان-آلکان در سارترودون ملانوترون در اکوبابا ۱۵۲,۶۲ ± ۵۴,۱۱ µg / g و هیدروکربن آروماتیک چند حلقه¬ای (PAH) 74.4±50.30 µg/g بود. هیدروکربن¬های آروماتیک چند حلقه¬ای با وزن مولکولی بالا و سرطان¬زا (HMW-PAH) از غلظت¬های بالاتری از هیدروکربن آروماتیک چند حلقه¬ای با وزن مولکولی پایین (LMW-PAH) برخوردار بود. بنابراین، محدوده خلیج اطلس بیشتر در معرض خطرات سرطان¬زایی مرتبط با مصرف ماهی مورد مطالعه نسبت به تالاب آکوبابا در انتهای لاگوس قرار دارد. این موضوع نشان دهنده خطرات سرطان زایی مرتبط با مصرف ماهی تیلاپیا آرواره سیاه گرفته شده از مناطق مطالعه شده می¬باشد.