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VARIATION OF THE PHYSICO-CHEMICAL PARAMETERS, NUTRIENTS AND SOME SELECTED HEAVY METALS AROUND THE WATERS OF THE TINCAN ISLAND IN LAGOS, NIGERIA

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ABSTRACT: *This study assessed the physico-chemical characteristics, concentration of heavy metals and nutrients composition of the surface water of Badagry and Tincan Island creeks adjoining the Lagos Lagoon. Sanplind was done once in a month between May and September 2019. The pH, Temperature, Salinity, Conductivity, Total Dissolved Solids, Total Suspended Solids, Dissolved Oxygen, Biochemical Oxygen Demand, Sulphate, Phosphate, Silicate, Nitrate, Calcium, Copper, Iron, Zinc, Lead, Cadmium, Manganese, Chromium and Nickel were determined usinng statndard methods. there was a significant difference ($p<0.05$) in the different parameters rececorded in the stations and the months. The DO (0.36 mg/L- 5.47mg/L) was lower than the WHO recommended 5mg/L for water quality assessment with a significant difference ($p<0.05$) recorded across the stations and months. The BOD values varied significantly across all the stations and the months with up to 211mg/L in station 1 in September thus depicting a severe deterioration of the creek. The concentrations of the heavy metals in the water samples were within the safe limit but posits potential human and fisheries health implications from continuous usage.*

KEYWORDS: nutrients, physicochemical parameters, heavy metals, creeks, pollution.

INTRODUCTION

Pollution is a principal problem in the marine ecosystem in today's world (Useh *et al.*, 2015). Human activities have introduced the various discharge of pollutants into the marine environment which has endangered the health of the marine population and destroying the quality of the environment by making the water bodies unhealthy for human use (Akankali and Davies, 2020). Pollution in the marine environment has a wide array of implications for human health (Davies and Okonkwo, 2021). Most seafood, particularly fish can get contaminated and affected humans when they are consumed. Also, the use of marine water resources for recreation could pose serious health hazards as a result of pollutant effects (Akankali and Davies, 2018). Water pollution affects rivers, oceans, lakes, and drinking water for humans and some sources of water pollution include marine dumping, industrial waste, atmospheric deposition, underground storage leakages, eutrophication, and global warming (Akankali *et al.*, 2019). The direct contaminants that bring

about pollution in water are a wide spectrum of chemicals and physical, pathogens, or sensory changes which include the increased temperature and water discolouration (Agarin *et al.*, 2020).
The waters around Tincan Island are important water bodies that serve as a viable resource for artisanal and commercial fishing as well as for transportation. It receives inputs from Ajegunle Creek, Tincan Island Creek, Badagry Creek, Porto-Novo Creek, FESTAC Creek as well as the Tomaro and Lighthouse Creek (Agarin *et al.*, 2020). The adjoining waters are heavily contaminated due to the wanton activities of sand miners, dredgers, the discharge of untreated sewage, and the relatively unregulated activities of ships and other vessels (Davies and Okonkwo, 2021). From observations derived from the field expeditions, it can be opined that the major pollution source in the study area include the discharge of raw sewage, wood shavings, sand and gravel extraction, dredging, hydrocarbon, and spent oil discharge and industrial wastes. Meanwhile, chronic inputs of heavy metals from many anthropogenic activities such as seaport, industrial and related activity are developing highly contaminated sediments in the environment. Thus, metal pollution raised concerns about toxic effects in marine organisms/ecosystems and the potential for bioaccumulation down the food chain with possible human health risks. However, enterprises center on marine environments are playing vital role in the economy of many countries, therefore, such activities cannot be stopped but sustainable approaches may be developed to reduce/combat polluting contaminants. (Sharifuzzaman *et al.*, 2016). Therefore, there is a need to assess the concentrations of heavy metals and nutrients composition in the study area. This can be achieved when there is a continuous environmental impact study in the area to ascertain the effect of land-based anthropogenic stressors and the need for prompt and effective policy implementation on the effect of these contaminations.

LITERATURE/THEORETICAL UNDERPINNING

The waters around Tincan Island are important water bodies which serve as a viable resource for artisanal and commercial fishing as well as for transportation. It receives inputs from the Ajegunle Creek, Tincan Island Creek, Badagry Creek, Porto-Novo Creek, FESTAC Creek as well as the Tomaro and Lighthouse Creek. The adjoining waters are heavily contaminated due to the wanton activities of sand miners, dredgers, discharge of untreated sewage and the relatively unregulated activities of ships and other vessels. These anthropogenic activities impact the aquatic fauna and flora community which are crucial primary producers because a healthy population of this important set of organisms is essential to maintain the balance in the ecosystem.

According to Agarin *et al.* (2020), there will be changes in the biotic species type and abundance which can eliminate numerous intolerant aquatic species due to these activities. A healthy phytoplankton community maintains the integrity of an aquatic food web. This is because it forms the bulk of the nutrients required by higher trophic organisms. When phytoplankton communities are threatened, the aquatic biodiversity endemic in the area are at risk of depletion or extinction.
The contamination of aquatic environment with heavy metals has continued to gain attention around the globe giving their indestructible and toxic properties. Fish constitute a significant component of food all over the world giving their contribution to solving the global food problem and making available cheap proteins, vitamins, minerals and rich trace elements for the common

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man (Akinhanmi *et al*., 2021). The consumption of sea foods especially fish has increased globally in recent years particularly with the awareness of its nutritional and therapeutic benefits. In addition to being important source of protein, fish are enriched with vitamins, essential minerals and unsaturated fatty acids (Davies *et al.*, 2017).). When heavy metals are in fish it can invalidate their beneficial values. Several detrimental effects of heavy metals to human health have been well-known for long time (Akankali and Davies, 2020).). This includes serious threats like renal failure, liver damage, cardiovascular diseases, and even death (Al-Busaidi *et al*., 2011).
In the quest to maintain the biological integrity of the waters around the Tincan Island, the need to study the variation of the physico-chemical parameters, nutrients and heavy metals around the waters of the Tincan Island is of prime importance.

MATERIALS AND METHODS

Description of the study area

The Badagry and Tincan Island creeks are sheltered tidal creeks located inland along the lower part of the western Lagos Harbour at Apapa and Tincan island. The sampling stations are located at Latitude N6°26’19’’ and Longitude E3°21’25’’ (station 1), Latitude N6°26’13’’ and Longitude E3°20’5’’ (station 2), Latitude N6°25’43’’ and Longitude E3°20’0’’ (station 3) and Latitude N6°25’46’’ and Longitude E3°21’54’’ (station 4). The creeks are fed by seawater at high tide and associated waste namely domestic wastes, municipal wastes, and sewage sludge from the environment.

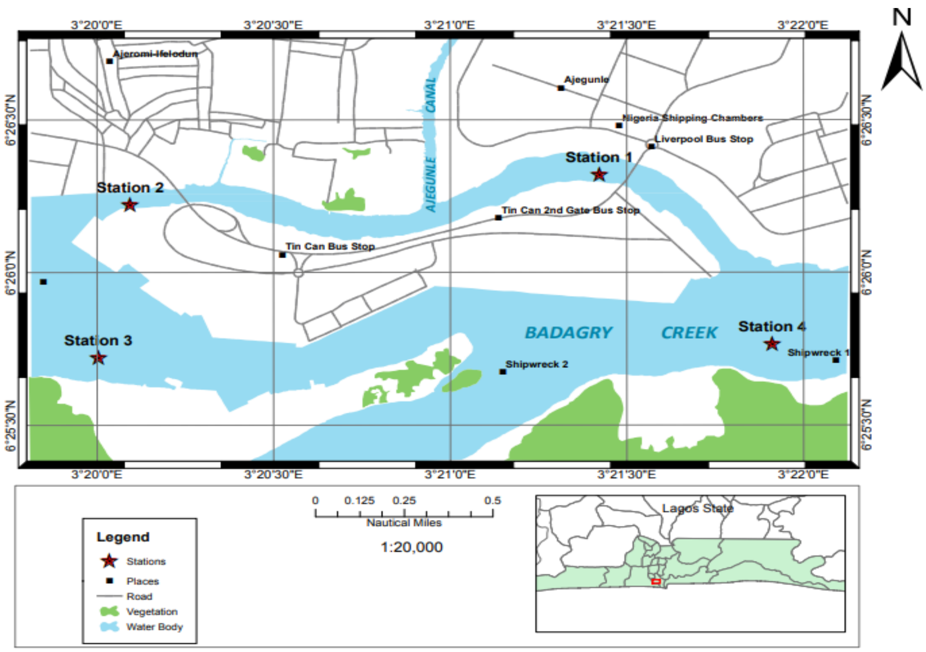

Figure 1: Tincan Island area showing the Ajegunle and Badagry Creeks

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Table 1: Geographic coordinates of stations

Sampling Stations	Coordinates
Station 1	N6°26'19'' E3°21'25''
Station 2	N6°26'13'' E3°20'5''
Station 3	N6°25'43'' E3°20'0''
Station 4	N6°25'46''E3°21'54''

Collection of Water Samples

The sampling station was sampled once a month for five months (May to September 2019). Water samples were collected each time using 75cl plastic containers with each indicating the month of collection at the study site. The plastic bottles were dipped into the water to collect the water samples and were taken to the laboratory for physical and chemical analysis.

Determination Of Heavy Metals

The Calcium (Ca) content was estimated using the EDTA Titrimetric Method (APHA, 1998). Copper (Cu), Iron (Fe), Zinc (Zn), Lead (Pb), Cadmium (Ca), Manganese (Mg), Chromium (Cr), Nickel (Ni) were determined using the Atomic Absorption Spectrophotometer (AAS) method.

Determination of physical parameters

Surface water samples were collected using Schott glass bottles. The air temperature was taken using a mercury-in-glass thermometer. The pH, Surface Water Temperature, Salinity, Conductivity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS) of the water were measured using an in-situ Handheld Multimeter (Milwaukee Model pH600 and Laboratory Benchtop meter 860033-model). while the Dissolved Oxygen (DO) was measured using Winkler's method. Transparency would be measured using a 20cm diameter Secchi disc. Biochemical Oxygen Demand (BOD) was determined by the 5-day BOD test (APHA, 2005). Turbidity was measured using a 20cm diameter Secchi disc. Total alkalinity was determined in accordance with American Society for Testing and Materials (ASTM D 1067B). Chemical Oxygen Demand **(**COD) is determined by using the Closed Reflux Method 5220C with a higher concentration of potassium dichromate solution. Total hardness was determined using the method recommended by APHA 2340C (1995) standards.

Determination of nutrients

Nitrate– Nitrogen (NO_3^-) concentration of each sample was determined using the Colorimetric Method 4500D (APHA, 1998) using an APHA/HACH DR 2010, Phosphorus (PO_4^-) This was determined using the Colorimetric Method (Stannous Chloride Method 4500-PD). Sulphate and Silica (S_iO_2) were determined using the Turbidimetric Method 4500 E (APHA, 1998).

Determination of Cation Content

Calcium (Ca^{2+}) content was estimated using the EDTA Titrimetric Method (APHA, 1998). Magnesium (Mg^{2+}) was estimated using the titrimetric method. The AAS was set in direct readout mode. Mg (mg/L) = Total hardness – Calcium concentration x 0.244.

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Statistical Analysis
The Duncan (1955) Multiple Range Test was used to separate differences among means. Differences were considered significant at ($P<0.05$).

RESULTS/FINDINGS

Physicochemical Parameters,
pH
The pH value ranged between a minimum of 5.94 in September and a maximum value of 7.63 in the month of August. The mean pH value for the sampling period was 7.25 ± 0.33.

Salinity (‰).
The salinity values during the sampling period varied due to the influence of rainfall. The lowest salinity value was recorded in the month of September with a value of 1.5 ‰ while the highest salinity of 15.02 ‰ was recorded in the month of May. The mean salinity value for the sampling duration was 7.28 ± 3.95 ‰.

Chloride (mg/L)
The chloride values ranged between 810.4 mg/L and 8250.2 mg/L. The lowest value (810.4 mg/L) was recorded in the month of September while the highest value (8250.2 mg/L) was recorded in the month of May. The mean value during the sampling period was 3971.24mg/L ± 2178.69 .

Conductivity (μ S/cm)
Conductivity showed a distinct variation during the sampling period. The minimum value of 2760 μ S/cm was recorded in September and the maximum value of 24900 μ S/cm was recorded in the month of May. The mean conductivity for the sampling duration was 12583.03 ± 6450.97 μ S/cm

Acidity (mg/L)
Acidity values ranged between 8 mg/L and 76 mg/L. The minimum value, 8 mg/L occurred in the months of June and July while the maximum value, 76 mg/L was recorded in the month of September. The mean values during the sampling period were 22.25mg/L ± 18.26 .

Alkalinity (mg/L)
The alkalinity values ranged from between 52mg/L and 308.1mg/L. The highest value (308.1mg/L) was recorded in the month of September while the lowest value 52mg/L was recorded in the months of June and July. The mean value during the sampling period was 113.45mg/L ± 63.72 .

Total Hardness (mg/L)
The highest value of total hardness (2775.1mg/L) was recorded in the month of May while the lowest value (269.4mg/L) was recorded in the month of September. The mean value, for the total hardness, was 1331.37mg/L ±729.87 .

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Dissolved Oxygen (mg/L)

The Dissolved oxygen values ranged from between 0.36 mg/L to 5.47 mg/L. The lowest value 0.36mg/L was recorded in the month of September while the highest value (5.47 mg/L) was recorded in the month of May. The mean value of dissolved oxygen was 4.41mg/L ±1.35 .

Biological Oxygen Demand (mg/L)

The lowest value of Biological Oxygen Demand (5 mg/L) was recorded in the month of September while the highest value (211 mg/L) was also recorded in the month of September. The mean value for the sampling period was 33.15mg/L ± 4 6.68 .

Chemical Oxygen Demand (mg/L)

The values showed major variation. The highest and lowest value of Chemical Oxygen Demand was recorded as 1769 mg/L and 19mg/L both were observed in the month of September. The mean value for Chemical Oxygen Demand during the sampling period was 201.20mg/L ± 417.01 .

Total Suspended Solid (mg/L)

The values of the total suspended solids ranged between 1mg/L and 48mg/L. The lowest and highest value were both recorded in the month of May while the mean value for the sampling duration was 13.25mg/L ± 11.76.

Total Dissolved Solids (mg/L)

Total dissolved solids showed variations from May 2018 to September 2018. The values ranged between 1569.2mg/L and 15189mg/L. The lowest value 1569.2mg/L was recorded in the month of September while the highest value 15189mg/L was recorded in the month of May. The mean value for the sampling duration was 7606.80mg/L ± 3965.78.

NUTRIENTS

Nitrate (NO_3) (mg/L)

The nitrate concentrations showed variations ranging between a minimum of 1.7 mg/L which was recorded in the month of August and a maximum of 5.74 mg/L which was recorded in the month of May. The mean value for nitrate during the sampling period was 3.11mg/L ± 1.33 .

Phosphate-Phosphorus (PO_4) (mg/L)

The phosphate-phosphorus concentration showed variations from May to September. The highest concentration (5.01 mg/L) was recorded in the month of May while the lowest concentration (0.29 mg/L) was recorded in the months of June and July. The mean value for phosphate during the sampling period was 0.71mg/L ±1.10

Sulphate (SO_4^{2-}) (mg/L)

The sulphate concentration varied widely ranging from a minimum of 91.1mg/L to a maximum of 1020.7mg/L. The minimum concentration (91.1rng/l) was recorded in the month of September while the maximum concentration (1020.7mg/L) was recorded in May. The mean value for sulphate during the sampling period was 531.54mg/L ± 306.92 .

Silica (mg/L)

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Silica concentration showed variations ranging from the lowest value 1.6 mg/L which was recorded in the month of August while the highest value (8.27mg/L) was recorded in the month of May. The mean value for the sampling was 5.51mg/L ±1.86 .

MAY

Parameters	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Mean ± SE**
Physico-Chemical					
pH	7.16	7.25	7.29	7.48	7.295 ± 0.30
Conductivity (µS/cm)	10420	24900	24100	23500	20730 ± 0.23
TSS (mg/L)	48	1	2	2	13.25 ± 11.76
TDS (mg/L)	6252	15189	14701	14100	12561 ± 1.25
Turbidity (NTU)	7.27	4.29	6.72	4.56	5.71 ± 10.87
Salinity (ppt)	5.8	15.02	14.51	14.11	12.36 ± 3.74
Acidity (mg/L)	66.2	16	22.1	12.9	29.3 ± 6.99
Alkalinity (mg/L)	308.1	144	132.1	122.2	176.6 ± 9.91
Total Hardness (mg/L)	1039.2	2775.1	2667.6	2582.2	2266 ± 6.38
DO (mg/L)	1.31	5.03	5.47	5.39	4.3 ± 1.24
BOD5 (mg/L)	94	13	9	8	31 ± 4.53
COD (mg/L)	826	34	32	42	233.5 ± 3.68
Chloride (mg/L)	3016.8	8250.2	7975	7755.3	6749.3 ± 4.32
Nutrients					
Nitrate (mg/L, as NO_3^-)	2.87	4.83	5.68	5.74	4.78 ± 1.26
Sulphate (mg/L)	376	1020.7	1001	970.1	841.95 ± 6.53
Phosphate (mg/L, as PO_4^{3-})	5.01	0.38	0.39	0.32	1.525 ± 1.02
Silica (mg/L)	8.27	3.85	3.92	3.65	4.9225 ± 1.81
Cations					
Calcium (mg/L)	57.42	159.53	152.81	149.3	129.77 ± 4.13
Magnesium (mg/L)	217.5	577.51	555.4	587.11	484.38 ± 1.84
Heavy Metal					
Sodium (mg/L)	1756.2	4605.3	4451.1	4328.1	3785.2 ± 3.62
Potassium (mg/L)	48.22	135.12	130.3	126.25	109.97 ± 0.04
Zinc (mg/L)	0.126	0.017	0.005	0.006	0.0385 ± 0.21
Iron (mg/L)	0.143	0.169	0.007	0.009	0.082 ± 0.00
Copper (mg/L)	0.0016	0.0005	0.0007	0.0005	0.0008 ± 0.00
Cadmium (mg/L)	0.0009	0.0004	0.0006	0.0005	0.0006 ± 0.00
Lead (mg/L)	0.0006	0.0006	0.0007	0.0008	0.0007 ± 0.00
Chromium (mg/L)	0.0026	0.001	0.0016	0.0013	0.0016 ± 0.00
Manganese (mg/L)	0.126	0.006	0.008	0.004	0.036 ± 0.03
Nickel (mg/L)	0.0011	0.0005	0.0009	0.0005	0.0008 ± 0.00

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JUNE					
Parameters	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Mean ± SE**
Physico-Chemical					
pH	7.18	7.33	7.35	7.44	7.325 ± 0.30
Conductivity (µS/cm)	11780	13930	13900	10660	12568 ±0.23
TSS (mg/L)	10	6	12	12	10 ± 11.76
TDS (mg/L)	7068	8497.3	8618	6182	7591.3 ± 1.25
Turbidity (NTU)	10.84	9.82	6.66	14.07	10.348 ± 10.87
Salinity (ppt)	6.7	8.05	8.01	6.03	7.1975 ± 3.74
Acidity (mg/L)	16.5	8	10	8.5	10.75 ± 6.99
Alkalinity (mg/L)	148.1	52	96	80.2	94.075 ± 9.91
Total Hardness (mg/L)	1186	1502	1484	1062.2	1308.6 ± 6.38
DO (mg/L)	4.43	5.12	5.49	4.92	4.99 ± 1.24
BOD5 (mg/L)	49	24	18	18	27.25 ± 4.53
COD (mg/L)	362	45	41	40	122 ± 3.68
Chloride (mg/L)	3644.2	4422.1	4368.2	3264.1	3924.7 ± 4.32
Nutrients					
Nitrate (mg/L, as NO_3^-)	4.64	2.01	2.89	2.55	3.0225 ± 1.26
Sulphate (mg/L)	928.2	534	536.3	384.2	595.68 ± 6.53
Phosphate (mg/L, as PO_4^{3-})	0.6	0.29	0.38	0.32	0.3975 ± 1.02
Silica (mg/L)	6.52	6.51	6.22	7.25	6.625 ± 1.81
Cations					
Calcium (mg/L)	66.31	80.7	79.81	56.52	70.835 ± 4.13
Magnesium (mg/L)	247.9	315.9	312.2	223.8	274.95 ± 1.84
Heavy Metal					
Sodium (mg/L)	2030	2462.1	2432	1806	2182.5 ± 3.62
Potassium (mg/L)	62.13	76.11	75.21	55.24	67.173 ± 0.04
Zinc (mg/L)	0.109	0.081	0.007	0.007	0.051 ± 0.21
Iron (mg/L)	0.104	0.113	0.027	0.039	0.0708 ± 0.00
Copper (mg/L)	0.0012	0.0008	0.0007	0.0007	0.0009 ± 0.00
Cadmium (mg/L)	0.0009	0.0004	0.0005	0.0006	0.0006 ± 0.00
Lead (mg/L)	0.0008	0.0008	0.0015	0.0007	0.001 ± 0.00
Chromium (mg/L)	0.0022	0.0019	0.002	0.001	0.0018 ± 0.00
Manganese (mg/L)	0.034	0.01	0.006	0.009	0.0148 ± 0.03
Nickel (mg/L)	0.0004	0.0004	0.0007	0.0008	0.0006 ± 0.00

		JULY				
Parameters	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Mean ± SE**	
Physico-Chemical						
pH	7.18	7.33	7.35	7.44	7.325	± 0.30
Conductivity (µS/cm)	11780	13930	13900	10660	12568	± 0.23
TSS (mg/L)	10	6	12	12	10	± 11.76
TDS (mg/L)	7068	8497.3	8618	6182	7591.3	± 1.25
Turbidity (NTU)	10.84	9.82	6.66	14.07	10.348	± 10.87
Salinity (ppt)	6.7	8.05	8.01	6.03	7.1975	± 3.74
Acidity (mg/L)	16.5	8	10	8.5	10.75	± 6.99
Alkalinity (mg/L)	148.1	52	96	80.2	94.075	± 9.91
Total Hardness (mg/L)	1186	1502	1484	1062.2	1308.6	± 6.38
DO (mg/L)	4.43	5.12	5.49	4.92	4.99	± 1.24
BOD5 (mg/L)	49	24	18	18	27.25	± 4.53
COD (mg/L)	362	45	41	40	122	± 3.68
Chloride (mg/L)	3644.2	4422.1	4368.2	3264.1	3924.7	± 4.32
Nutrients						
Nitrate (mg/L, as NO_3^-)	4.64	2.01	2.89	2.55	3.0225	± 1.26
Sulphate (mg/L)	928.2	534	536.3	384.2	595.68	± 6.53
Phosphate(mg/L,asPO_4^{3-})	0.6	0.29	0.38	0.32	0.3975	± 1.02
Silica (mg/L)	6.52	6.51	6.22	7.25	6.625	± 1.81
Cations						
Calcium (mg/L)	66.31	80.7	79.81	56.52	70.835	± 4.13
Magnesium (mg/L)	247.9	315.9	312.2	223.8	274.95	± 1.84
Heavy Metal						
Sodium (mg/L)	2030	2462.1	2432	1806	2182.5	± 3.62
Potassium (mg/L)	62.13	76.11	75.21	55.24	67.173	± 0.04
Zinc (mg/L)	0.109	0.081	0.007	0.007	0.051	± 0.21
Iron (mg/L)	0.104	0.113	0.027	0.039	0.0708	± 0.00
Copper (mg/L)	0.0012	0.0008	0.0007	0.0007	0.0009	± 0.00
Cadmium (mg/L)	0.0009	0.0004	0.0005	0.0006	0.0006	± 0.00
Lead (mg/L)	0.0008	0.0008	0.0015	0.0007	0.001	± 0.00
Chromium (mg/L)	0.0022	0.0019	0.002	0.001	0.0018	± 0.00
Manganese (mg/L)	0.034	0.01	0.006	0.009	0.0148	± 0.03
Nickel (mg/L)	0.0004	0.0004	0.0007	0.0008	0.0006	± 0.00

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AUGUST						
Parameters	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Mean ± SE**	
Physico-Chemical						
pH	7.22	7.26	7.34	7.63	7.3625	± 0.30
Conductivity (µS/cm)	11490	16315	16855	8730.3	13348	± 0.23
TSS (mg/L)	12	3	4	17	9	± 11.76
TDS (mg/L)	6894	9952.4	10450	5063.4	8090	± 1.25
Turbidity (NTU)	15.57	7.67	8.35	22.31	13.475	± 10.87
Salinity (ppt)	6.52	9.41	9.8	4.91	7.66	± 3.74
Acidity (mg/L)	34.5	19.5	18	18.2	22.55	± 6.99
Alkalinity (mg/L)	228.2	128.5	120	88	141.18	± 9.91
Total Hardness (mg/L)	1151	1744	1818.2	868.7	1395.5	± 6.38
DO (mg/L)	4.71	4.73	5.17	4.77	4.845	± 1.24
BOD5 (mg/L)	37	20	7	19	20.75	± 4.53
COD (mg/L)	129	38	40	58	66.25	± 3.68
Chloride (mg/L)	3536.7	5132.3	5350	2665.3	4171.1	± 4.32
Nutrients						
Nitrate (mg/L, as NO_3^-)	2.01	1.7	3.7	2.62	2.5075	± 1.26
Sulphate (mg/L)	416.4	620	656	313	501.35	± 6.53
Phosphate (mg/L, as PO_4^{3-})	2.25	0.38	0.29	0.28	0.8	± 1.02
Silica (mg/L)	3.43	1.78	1.6	5.12	2.9825	± 1.81
Cations						
Calcium (mg/L)	64.12	93.17	97.12	46.21	75.155	± 4.13
Magnesium (mg/L)	240.44	366.17	382.1	182.14	292.71	± 1.84
Heavy Metal						
Sodium (mg/L)	1969.1	2852.2	2979.1	1474	2318.6	± 3.62
Potassium (mg/L)	60.03	88.21	92.04	45.21	71.373	± 0.04
Zinc (mg/L)	0.101	0.102	0.005	0.014	0.0555	± 0.21
Iron (mg/L)	0.17	0.102	0.072	0.07	0.1035	± 0.00
Copper (mg/L)	0.0007	0.0006	0.0007	0.0008	0.0007	± 0.00
Cadmium (mg/L)	0.0005	0.0007	0.0006	0.0007	0.0006	± 0.00
Lead (mg/L)	0.0009	0.0005	0.0008	0.0005	0.0007	± 0.00
Chromium (mg/L)	0.0012	0.0014	0.001	0.003	0.0017	± 0.00
Manganese (mg/L)	0.02	0.03	0.012	0.009	0.0178	± 0.03
Nickel (mg/L)	0.0005	0.0006	0.0005	0.0006	0.0006	± 0.00

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SEPTEMBER					
Parameters	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Mean ± SE**
Physico-Chemical					
pH	5.94	7.17	7.34	7.32	6.9425 ± 0.30
Conductivity (µS/cm)	2760	4710	2920.2	4420.1	3702.6 ± 0.23
TSS (mg/L)	30	28	33	31	30.5 ± 1.76
TDS (mg/L)	1569.2	2826	1712	2696.2	2200.9 ± 1.25
Turbidity (NTU)	39.2	25.02	42.7	35.31	35.558 ± 0.87
Salinity (ppt)	1.5	2.5	1.6	2.41	2.0025 ± 3.74
Acidity (mg/L)	76	28	22	25.5	37.875 ± 6.99
Alkalinity (mg/L)	72.3	55.5	56.5	61	61.325 ± 9.91
Total Hardness (mg/L)	353.3	463.8	269.4	426.5	378.25 ± 6.38
DO (mg/L)	0.36	3.77	3.89	3.65	2.9175 ± 1.24
BOD5 (mg/L)	211	5	9	13	59.5 ± 4.53
COD (mg/L)	1769	19	21	40	462.25 ± 3.68
Chloride (mg/L)	810.4	1365.4	865.1	1305	1086.5 ± 4.32
Nutrients					
Nitrate (mg/L, as $NO3^-$)	1.29	1.77	3.01	2.79	2.215 ± 1.26
Sulphate (mg/L)	91.1	157	96	148	123.03 ± 6.53
Phosphate (mg/L, as$PO_4^{3-)}$	0.66	0.4	0.49	0.24	0.4475 ± 1.02
Silica (mg/L, as $SiO2^-$)	5.8	6.78	5.85	7.22	6.4125 ± 1.81
Cations					
Calcium (mg/L)	14.85	24.9	15.51	23.9	19.79 ± 4.13
Magnesium (mg/L)	52.5	97.5	56.11	89.03	73.785 ± 1.84
Heavy Metal					
Sodium (mg/L)	454.14	760.04	484.1	729.12	606.85 ± 3.62
Potassium (mg/L)	13.5	23.6	14.56	22.54	18.55 ± 0.04
Zinc (mg/L)	0.018	0.009	0.015	0.015	0.0143 ± 0.21
Iron (mg/L)	1.104	0.111	0.085	0.088	0.347 ± 0.00
Copper (mg/L)	0.0011	0.0005	0.0008	0.0007	0.0008 ± 0.00
Cadmium (mg/L)	0.0008	0.0006	0.0006	0.0006	0.0007 ± 0.00
Lead (mg/L)	0.0013	0.0008	0.0009	0.0007	0.0009 ± 0.00
Chromium (mg/L)	0.0016	0.0005	0.0044	0.0028	0.0023 ± 0.00
Manganese (mg/L)	0.04	0.006	0.086	0.005	0.0343 ± 0.03
Nickel (mg/L)	0.0001	0.0004	0.0005	0.0006	0.0006 ± 0.00

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CATIONS

Calcium (mg/L)

For the duration of the sampling period, calcium values ranged from 14.85mg/L to 159.53mg/L. The minimum value of 14.85mg/L was recorded in the month of September while the highest value was recorded in the month of May. The mean value for Calcium during the sampling period was 73.28 ± 42.28 mg/L.

Magnesium (mg/L)

For the duration of the sampling period, magnesium values ranged from 52.5mg/L to 587.11mg/L. The minimum value (52.5mg/L) was recorded in the month of September while the highest value (587.11mg/L) was recorded in the month of May. The mean value for magnesium during the sampling period was 280.16 ± 158.32 mg/L.

HEAVY METAL CONCENTRATION

Copper (mg/L)

Copper values ranged from 0.005mg/L to 0.0016mg/L. The minimum concentration (0.005mg/L) was recorded in the month of May and September and while the maximum concentration (0.0016mg/L) was recorded in the month of May. The mean value during the sampling period was 0.00 ± 0.00 mg/L.

Zinc (mg/L)

Zinc values varied between a minimum concentration of 0.005mg/L in the month of May and August while a maximum concentration of 0.012mg/L in the month of May. The mean value for Zinc recorded was 0.04 ± 0.05 mg/L.

Cadmium (mg/L)

Cadmium showed variations with values ranging from 0.004mg/L to 0.009mg/L. The minimum value (0.004mg/L) was recorded in the month of May, June, and July while the maximum value (0.009mg/L) was recorded in the month of May. The mean value of cadmium during the sampling period was 0.00 ± 0.00 mg/L.

Lead (mg/L)

Lead showed variations with values ranging from 0.0005 to 0.0015 mg/L. The minimum value (0.0005mg/L) was recorded in the month of August while the maximum value (0.0015 mg/L) was recorded in the month of June and July. The mean value of Lead during the sampling period was 0.00 ± 0.00 mg/L.

Chromium (mg/L)

Chromium showed variations with values that were constant throughout the sampling period. The mean value of Chromium during the sampling period was 0.00 ± 0.00 mg/L.

Manganese (mg/L)

Manganese showed variations with values ranging from 0.004 to 0.126mg/L. The minimum and maximum values were recorded in the month of May. The mean value of manganese during the sampling period was 0.02 ± 0.03 mg/L.

Nickel (mg/L)

Nickel showed weekly variations with values ranging from 0.004 to 0.0011mg/L. The minimum value of 0.0004 mg/L was recorded in the month of June, July, and September while the maximum

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value (0.0011mg/L) was recorded in the month of May. The mean value of Nickel during the sampling period was 0.00 ± 0.00 mg/L.

DISCUSSION

The variation of the water chemistry and heavy metal concentrations in the present study was significantly different across the stations ($p<0.05$) and months. This can be attributed to the influences of the peak rainy season. Rains and anthropogenic activities have an impact on water physic-chemical concentration (Onyena and Okoro, 2019). The pH value recorded across the months was slightly acidic to alkaline. Most aquatic organisms are known to be affected by pH due to their metabolic activities that are pH-dependent (Hendriks *et al.,* 2015). Low pH values or acidic water are known to allow toxic elements and compounds such as heavy metals to become mobile, thus creating conditions that are hostile to aquatic life (Okonkwo *et al*., 2021). While the optimal pH range for sustainable aquatic life is pH 6.5 - 8.5 (WHO, 2006; USEPA, 2009), the acidic September recorded (pH≥5.94) represented the high influx of rain, hydrocarbon content, and wood and gravel shavings in the water. The acidic concentration was lower compared to the studies of Onyena and Okoro, (2019) sampled from some creeks adjoining the Lagos Lagoon which recorded pH≥6.5≤7.2. The increase in acidity and alkalinity in the study stations in September shows the study stations to be an urbanized area characterized by anthropogenic input, land drainage pollution, and anthropogenic accumulation.

Mean Salinity value of 7.28 ± 3.95 ‰ indicated the study station to be brackish environment. This high-water salinity resulted in the increased conductivity values of up to approximately 25000 μ S/cm. The Total Dissolved Solids obtained during the study period were also high across the creeks (1569.2 - 15189mg/L) and above USEPA standard for marine waters. This also indicates that solids in this environment were less of suspended solids (Okoro *et al.*, 2021). The total suspended solids were 1-48mg/L. This concentration agreed with the studies of Nkwoji *et al* (2019) who also observed that land-based pollutants affected the water chemistry and benthic macroinvertebrates community of the Lagos lagoon and Okoro *et al.* (2021). The TDS values were higher than the United States Environmental Protection Agency in Marine Water and WHO guidelines for water quality and fisheries of 1000mg/L. This further illustrates the study stations to contain quantifiable amounts of organic matter.

Dissolved oxygen regulates the existence, diversity, behavioural, and physiological of aquatic organisms (Okoro *et al.*, 2021). The mean value of dissolved oxygen was recorded as 4.41 ±1.35 mg/L which was lower than the W.H.O standard of 5 mg/L. The low level of dissolved oxygen of 0.36mg/L recorded in September in the study stations depicted a high level of organic pollution. This low dissolved oxygen was attributed to being a result of the discharge of untreated organic wastes and nutrient inputs from sewages, sand mining, dredging, and the relatively unregulated activities of ships (Davies and Okonkwo, 2021). The Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand values showed that organic matter contents in the study creeks were high. The range values of COD were between 19 to 1769mg/L. The high disparity in dissolved organic matter concentration varies from one site to another suggests the discharge of sewage containing varying amounts of substances at different points in a given time. The high values of COD (201.20 ± 417.01 mg/L) in the study months are above 10-40 mg/L permissible limit and thus a reflection of the level of contamination occurring during the period of research. A measure of the effect of pollution on receiving water and the biologically oxidizable matter for deoxygenating water gives the total Biochemical oxygen demand (Jaiswal *et al*., 2019). The BOD values (5- 211 mg/L) recorded in this study were higher than those (0.7 - 34mg/L) reported for some Nigerian waters (Onojake *et al.,* 2017; Okonkwo *et al*., 2021). September recorded greater concentrations of BOD than other study months. This is an indication of the influx of organic pollutants from other adjoining creeks during rains. The high BOD could be attributed to the high level of organic substances from the effluent discharge into the creeks that receive influxes mostly occasioned by the rains thus implying the presence of a high concentration of aerobic microbes which acted on the biodegradable wastes and accordingly depleted the optimum dissolved oxygen (Nkwoji *et al.,* 2019). The BOD values recorded in some of the sample locations were not within the WHO 28-30mg/L limit. The high BOD is linked with the low dissolved oxygen obtained in the study and thus may lead to the physiological stress of aquatic organisms, asphyxia, and eventual death (Ajibare, 2014).

The high calcium and magnesium values detected in the study reflect the elevated levels of total hardness on the content of the water. The concentration of total hardness is far higher than the permissible limit of 150mg/L (SON, 2007). The total hardness of the studies 269.4mg/L - 2775.1mg/L correlates with the studies of Onyema, (2015). This hardness of the water in the study stations is an indication of the ability of the water to tolerate high soap concentrations.

Nutrients including nitrogen and phosphorus are key elements in aquatic ecosystems. They occur as nitrate and phosphates. The result of nitrate concentrations from the study ranged from 1.7 - 5.74 mg/L while phosphate-phosphorus was between 0.29 - 5.01 mg/L. Sulphate concentrations recorded a high range of values between 91 - 1020.7mg/L higher than the results of Okoro *et al*., (2021) that recorded a range of values of 11-240mg/L. The elevated nutrient concentrations and water nutrient input could be a result of the discharge from wastes from the septic systems and drainage systems coming from the human-populated Lagosian living in the surroundings of the sampling locations, as well as agricultural fertilizers and industrial wastes that seeped into the water bodies (Onyena and Okoro, 2019; Okoro *et al.*, 2021). The phosphate and nitrate were exceptionally high in May and can be attributed to the ability of the creek to accumulate nutrients from different anthropogenic sources during this period. These phosphates and nitrates are the essential limiting nutrients for eutrophication, and the results of the study indicate relatively high nutrient load; there is thus evidence of nutrient enrichment, decay, and sedimentation. The high levels of the nutrient in the study location contributed to the decrease in dissolved oxygen levels in the creeks.

The heavy metals concentrations recorde in this study was <1mg/L which is within the USEPA and WHO standards. This also agrees with Davies and Okonkwo (2021) who also reported a low level of heavy metals around the water samples from ajegunle creek in lagos.

This level of heavy metals obtained in the studied Creek could be attributed to activities such as domestic, cement bags washing, sewage and industrial wastes that took place within and around the Creek leading to some form of dilution. Although the results of this recorded very low significant values, the high alkalinity, acidity, nutrients, TDS, BOD, and COD with low dissolved oxygen content indicating deteriorating water quality. Agricultural effluent, ship wastes, industrial and domestic wastes discharge into creeks, rivers, stormwater channels, and lagoon are usual practices in Lagos state and are the main reasons for the pollution status in the study stations.

CONCLUSION

The decline in the physical, chemical quality and increase in the nutrient level observed in this study is worrisome and has been ascribed to the consistent accumulation of organic matter, ship discharges, hydrocarbon spills, contaminants, and pollution going on at the time of research. The relative increase in phosphate and nitrates depict an environmentally stressed ecosystem which resulted in the low values of dissolved oxygen concentrations. Variations also contributed to the high levels of concentrations in the parameters studied with alkalinity and acidity having high values in September, while phosphates and nitrates had higher concentrations in September. It can be deduced that different study stations differed with the level of concentrations due to the type of anthropogenic stressors occurring in the stations. Although these metals occurred in low concentrations during the study period and was within the USEPA and WHO standards, the occurrence of metal contamination in excess of natural loads might become a problem of high concern as time goes by. Moreover, through dominant inputs of most trace metals through rivers and land run-off, metals are introduced into the aquatic environment which do not remain in the water column but also become more concentrated in the surface film or become adsorbed onto suspended particulate which later precipitate out on the bottom. Water serves as a source of food and habitat to organisms and man hence, periodic monitoring and preventive measures are necessary to save the creeks from eutrophication and future degradation. Adequate legislation and proper management may also help prevent indiscriminate discharge of large quantity of toxic heavy metals into the creek.

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