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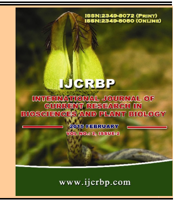

Original Research Article

Water Quality Evaluation and Heavy Metals Concentration of Kolo Creek, Imiringi, Bayelsa State

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Abstract

The levels of the pollutants lead, copper, cadmium and Nickel (Pb, Cu, Cd and Ni) and other selected physicochemical variables were investigated in Kolo creek, Bayelsa State, Nigeria in order to determine the status of the creek and the possible impact on human health. Surface water samples were collected at depths of 15-25cm with pre-rinsed containers. Samples were collected monthly for 4 months from 5 stations. Samples were investigated for Pb, Cu, Cd and Ni and for biochemical oxygen demand (BOD_5), dissolved oxygen (DO), turbidity and pH. Data were subjected to statistical analysis using the SPSS software and analysis of variance (ANOVA) was employed at 95% confidence limit to check for differences between stations in measured variables. Means and standard deviations were also computed. Result reveal that there were significant seasonal differences ($p<0.05$) in physicochemical variables of temperature, conductivity and turbidity. There were also significant seasonal differences ($p<0.05$) in all physicochemical parameters between sample stations. There were no significant differences ($p>0.05$) in all heavy metals except Pb which showed a significant difference ($p<0.05$) between seasons. There were significant differences ($p>0.05$) between stations in heavy metals characteristics. Results from physiochemical analysis obtained, revealed that DO, turbidity and pH were above national and international standards. Based on the observations from this study, it can be concluded that Kolo creek is under serious threat from oil prospecting and other human activities around the creek and thus a need for a proper waste management plan.

Keywords

Heavy metals
Kolo Creek
Water Quality

Introduction

Kolo Creek, Bayelsa State, Nigeria is a non-tidal fresh water system that empties into the River Nun. The Creek is summed by a number of water bodies which are natural and artificial including ponds, borrow pits and tributaries which drain into it. The region is characterized by tropical rainforest and fresh water swamps. It is surrounded by oil fields, which are connected to the Kolo Creek Flow Station along the creek. There is also a power generating plant (Gas turbine) behind the flow station. These industrial activities discharge their effluents into the creek. The creek provides the only source for portable water, fish and other forms of aquatic life for people living in the catchment.

Water which is a delicate part of the environment, when polluted can be totally deoxygenated that life in it becomes impossible (Mellanby, 1980). Water bodies in the Niger Delta have been heavily polluted due to recurrent incidence of oil activities and this has adversely affected aquatic lives in the area (Akpofure et al., 2000). Studies by Asuquo et al., (1997) have shown that concentrations of heavy metals have increased in the Cross River systems as a result of man's activities and this may result in fish and shellfish having concentrations of metals that may be harmful to man (Chinda et al., 2004). Toxic metals accumulate in the body through the food chain, water and air (Tsoumbaris and Tsoukali-Papadopoulou, 1994). The global call for safe portable water for all has led to the regular analysis of ground and surface waters by several workers in Nigeria. However, the necessity for good quality surface fresh water for the increasing high populations in the Niger Delta region cannot be overemphasized.

This study was therefore geared towards the investigation of physicochemical characteristics and metal contents of the creek in order to determine the suitability of creek for use.

Materials and methods

Study stations

Five study stations were situated at specific coordinates on the creek. The station coordinates and physical characteristics of the stations are given below:

Station 1: The station has coordinates of 04 ^{o} 53' 22.6"N - 006 ^{o} 22' 46.7''E. It is situated in the densely populated part of the creek.

Station 2: The station has coordinates of 04 ^{o} 54' 42.0''N – 006 ^{o} 21' 41.1''E. It is situated near a make-shift market

Station 3: The coordinates of this station is 04^{o} 55' 06.8''N – 006 ^{o} 24' 11.1''E. It is situated near a car wash facility and is a point for bathing.

Station 4: The coordinates of this station are 04 ^{o} 50' 25.1''N – 006 ^{o} 21' 17.1''E. The station is located downstream where there are no visible direct human interference.

Station 5: This station located closest to the gas turbine. It has coordinates of 04 ^{o} 51' 49.5''N – 006 ^{o} 20' 68.4''E.

Collection of samples

Collection of physico-chemical samples: Sub-surface water samples were collected at depths of 15-25cm with pre-rinsed containers. Samples were collected monthly for 4 months from 5 stations. One litre (1L) plastic containers were used for the collection of samples for physico-chemical analysis. Dark coloured reagent bottles measuring 125ml were used in collecting water sample for biological oxygen demand (BOD_s) and dissolved oxygen (DO) analysis. The samples for the determination of DO were fixed at the spot with 1ml of $MnSO_4$ and alkaline iodideazide solutions.

Collection of heavy metal samples: Heavy metal samples were collected with one litre plastic containers and treated with 2ml concentrated nitric acid (HNO_3) in order to stabilize the oxidation state of the metals.

Analyses of samples

Dissolved oxygen: Dissolved oxygen was measured by the use of the Winkler Iodometric method. This method is based on the oxidizing properties of oxygen.

Biochemical Oxygen Demand (BOD_5): BOD_5 was determined after the samples were incubated in the dark for five days. The Dissolved Oxygen content of the samples was determined using the above Winkler Iodometric method.

The BOD_5 was then determined from the calculation below:

$$BOD_5 = DO - DO_5$$

pH, temperature, electrical conductivity and turbidity: The above physicochemical parameters were measured insitu by the use of a U10 Horiba water checker. This was done by introducing water at each station into the metal container of the equipment. The probe of the U10 Horiba water checker was then put into the container and the water checker then switched on to measure each parameter one at a time. The readings of each parameter were displayed electronically on a display screen as bright red lights.

Sulphate: Sulphate determination was done using the turbidimetric method (APHA, 1985).

Phosphate: Phosphate was determined using the stannous chloride method (APHA, 1998).

Nitrate: Nitrate measurement was done by the brucine method (APHA, 1998).

Statistical analysis

Data were subjected to statistical analysis using the SPSS software. Means and standard deviations were calculated for sampled variables. Analysis of variance (ANOVA) was employed to compare means at the 95% confidence limit.

Results and discussion

The results of the study are captured in Tables 1, 2, 3 and 4. The Tables show the results of the analysis of physiochemical parameters and heavy metal concentrations. Means and standard deviation for both spatial and seasonal variations for the surface water sample and the result of the ANOVA are presented as superscripts of the means. These results are compared with the Federal Ministry of Environment and International Standards for maximum limits.

Among the physico-chemical parameters analyzed, conductivity, Temperature and turbidity showed significant differences between the wet and dry seasons. Temperature was higher in the dry season than in the wet season. This variation may be association with the differences in seasonal depth. The difference in temperature may also be due to reduced sun-shine during the rainy season as compared to the dry season. Alagoa (2012) also observed similar reduction in temperature in Taylor creek during the rainy season. Another reason may also be the increased dilution of the creek by additional precipitation by cooler rain water.

Table 1. Spatial variation (mean and standard deviation) of pyhsico-chemical variables of water over the study period.

Stations	1		2		3		4		5		NS	IS
Parameters	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
PO_4 (mg/L)	0.21^{a}	±0.21	0.08^{b}	±0.06	0.12^{c}	±0.04	0.15^{ad}	±0.05	0.17^{d}	±0.05		5.00
NO_3 (mg/L)	2.31^{a}	±2.44	3.60^{b}	±2.93	2.26^{a}	±2.70	2.00^{d}	±0.54	1.62^{e}	±0.97	20.00	10.00
Conductivity	17.5^{a}	±5.00	12.5^{b}	±5.00	22.50^{c}	±5.00	27.50^{d}	±0.96	32.50^{e}	±28.72		400.00
Temp. (°C)	30.5^{a}	±1.29	31.7^{b}	±0.96	29.75^{ac}	±1.26	28.75^{c}	±0.96	27.75^{c}	±0.96		
Turb.(NTU)	19.25	±9.94	3.50^{b}	±1.73	5.75^{c}	±2.99	10.25^{d}	±7.37	10.25^{d}	±13.89	1.00	
DO (mg/L)	4.08^{a}	±0.90	2.78^{b}	±0.82	3.19^{c}	±0.67	3.10^{c}	±0.68	3.20^{c}	±0.65	7.50	6.00
BOD (mg/L)	2.40^{a}	±1.05	1.38^{b}	±1.22	1.55^{b}	±0.74	1.00^{c}	±0.39	1.35^{b}	±1.10	10.00	
Ph	6.00^{a}	±0.34	6.00^{a}	±0.67	5.87^{a}	±0.24	6.04^{a}	±0.33	6.21^{a}	±0.28	6.90	7.00

(Mean±SD) SD- Standard deviation. NS- National standard. IS- International standard.
Source: Field work and FDA, 1993.
Means with the same letter superscripts along the same column are not significantly different.

The results for PO_4 showed that phosphate was generally lower than specified standards (FEPA, 1991). The ranges were similar to values recorded previously in some Nigerian inland water bodies (Ekweozor and Agbozu, 2001). The concentrations were shown to be slightly lower in the dry season than in wet season, because of influx of phosphates in runoff waters in the rainy season (Egborge 1994). NO_3 values ranged from 0.30-6.28mg/L, which were lower than the specified standard of 10mg/L (FEPA 1991). Nitrate values were higher in dry season than wet season. This may be attributed to rain fall and runoff from back swamps during the wet season and may have contributed to the observed depletion of nitrate in the wet season.

Table 2. Seasonal variation (mean and standard deviation) of physicochemical variables of water over the study period

Parameters	Seasons			
	Wet		Dry	
	Mean	SD	Mean	SD
PO_4 (mg/L)	0.16[a]	±0.13	0.13[a]	±0.06
NO_3 (mg/L)	2.17[a]	±2.13	2.54[a]	±2.01
Conductivity	18.00[a]	±7.89	27.10[b]	±18.29
Temp. (°C)	28.90[a]	±1.52	30.50[a]	±1.58
Turbidity (NTU)	13.40[a]	±19.61	6.20[a]	±6.05
DO (mg/L)	3.01[a]	±0.66	3.53[a]	±0.88
BOD (mg/L)	1.55[a]	±0.98	1.52[a]	±1.01
pH	6.02[a]	±0.43	6.03[a]	±0.33

Source: Field work; (Mean±SD) SD- Standard deviation; Means with the same letter superscripts along the same column are not significantly different.

Table 3. Spatial variation (mean and standard deviation) of heavy metals in water over the study period.

Stations	1		2		3		4		5	
Parameters	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pb (mg/L)	0.012[a]	±0.013	0.021[b]	±0.019	0.008[a]	±0.015	0.015[a]	±0.03	0.000[c]	±0.000
Cu (mg/L)	0.001[a]	±0.002	0.001a	±0.002	0.005[b]	±0.003	0.005[b]	±0.002	0.003[ab]	±0.004
Cd (mg/L)	0.003[a]	±0.000	0.004[ab]	±0.001	0.005[b]	±0.003	0.003[a]	±0.002	0.005[b]	±0.001
Ni (mg/L)	0.005[a]	±0.005	0.002[b]	±0.003	0.005[a]	±0.004	0.007[c]	±0.009	0.001[b]	±0.003

Source: Field work; (Mean±SD.) SD- Standard deviation. Means with the same letter superscripts along the same column are not significantly different.

Table 4. Seasonal variation (mean and standard deviation) of heavy metals of water over the study period.

Parameters	Seasons			
	Wet		Dry	
	Mean	SD	mean	SD
Pb (mg/L)	0.004[a]	±0.014	0.018[b]	±0.019
Cu (mg/L)	0.002[a]	±0.002	0.004[a]	±0.003
Cd (mg/L)	0.004[a]	±0.001	0.004[a]	±0.002
Ni (mg/L)	0.00 3[a]	±0.003	0.005[a]	±0.007

Source: Field work; (Mean±SD.) SD- Standard deviation. Means with the same letter superscripts along the same column are not significantly different.

Conductivity values were generally low compared to 1000spcm^{-1} of characteristic freshwater (Egborge, 1994). The mean levels of 12.50 to 32.50spcm^{-1} recorded in this study were slightly lower than those of other fresh water environment in the Niger Delta (Horsfall and Spiff, 1998). Temperature values were within national and internationally recommended standards. Mean turbidity values ranging between 5.75 and 19.25NTU were higher than the desired limit of 1.0NTU for drinking water. The high values may be as a result of continuous discharge of oily wastewaters from the flow station.

DO mean values of 2.78 – 4.08mg/L may not be suitable for aquatic life as they were by far lower than FEPA recommended standards of between 7.5mg/L (Appendix I). However, BOD mean values of 1.00 – 2.40mg/L from the various stations indicate good water quality (Appendix III). The pH range was between 5.87 and 6.21. The results indicated that the samples were slightly acidic and this may be associated with the effects of acid rains that are commonly related to gas flaring at flow station/oil field areas (Ekweozor and Agbozu, 2001).

Pb mean values with ranges between 0.100 and 0.021mg/L were relative within the range of international standards for drinking water of 0.01mg/L. The value for Station 2 with 0.02mg/L was above the recommended stand for drinking water (FEPA, 1991). This relatively high concentration could be associated with its presence in crude oil (Lolomari, 1993). Cu mean values between 0.001 and 0.005 mg/L were below the maximum level allowed for effluent discharge. For Cd, Stations 2, 4 and 5 exceeded the international standard of 0.003mg/L for drinking water. Mean values ranged between 0.003 and 0.005mg/L. Cadmium is widely distributed in low levels in the environment, and not essential for humans, plants and animals (FDA, 1993). Recorded values for Ni were generally lower than the FEPA and international standards. The mean values of 0.001 to 0.005mg/L do not pose any environmental threat in the sampled area. Generally metal concentrations were higher in dry season than in wet season due to dilution of the body by rainwater.

Conclusion/Recommendation

Generally, the physiochemical parameters analysed for surface waters revealed that the parameters vary greatly. The average mean concentrations of the parameters studied are lower when compared with World Health Organization International and FMEN national standards. The levels in some samples including DO, Pb and Cd were close to or exceeded the recommended limits for drinking water. The physiochemical parameters did not show significant spatial variations but varied seasonally between dry season, higher than wet season with exception of phosphate, turbidity and BOD. As a result of the continuous activities of the flow station, there will be continuous discharge of wastewater into the aquatic ecosystem, and pollution of the water body will continue. It is therefore recommended that companies operating in the area should adopt improved waste management plan to reduce the levels of pollutants discharged into the environment. Gas flaring in the Niger Delta should as much as possible be reduced to the minimum.

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APPENDICES

Appendix I

Natural Water Quality Standard for Human Consumption (FEPA, 1991).

Parameter	Permissible Limit
Ph	6.5 – 8.5
Colour (TCU)	15 (Colourless)
Odour (TNU)	3.5 (Odourless)
Taste	Tasteless
Turbidity	1mg/l
Dissolved Oxygen	7.5mg/l

Appendix II

Specific Dissolved Oxygen (DO) Concentration for Cold Water Biota and Warm Water Biota (MOEE, 1994).

Temperature (°C)	Cold Water Biota (DO) in mg/l	Warm Water Biota (DO) in mg/l
0	8	7
5	7	6
10	6	5
15	6	5
20	5	4
25	5	4

Appendix III

BOD Levels for Water Quality Standards as indicated by EPA (1997).

BOD Level (mg/l)	Water Quality
1 – 2	Very good: Not much organic waste present in water.
3 – 6	Fair: Moderately clean
6 – 9	Poor: Somewhat polluted. Indicative of organic matter.
100 or greater	Very Poor: Very polluted and contains organic waste.