Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2021, 8(12):90-98**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Determination of Physico-Chemical Parameters in Interstitial Water Samples from Bodo Creek

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Abstract The assessment of water quality, especially the physico-chemical parameters of water is important in the determination of the availability of water for various anthropogenic uses. The study monitored the water physico-chemistry (temperature, hydrogen ion concentration (pH), conductivity, dissolved oxygen (DO) and biochemical oxygen demand (BOD)) of Bodo Creek. Sample collection was done monthly for 5 months (February 2020- June 2020) at sites previously studied (pre-spill baseline studies, three years, five years, and seven years post-spill); using the same sampling methods. There was no statistically significant difference in temperature ($p > 0.05 = 0.841$), DO ($p > 0.05 = 0.412$), BOD ($p > 0.05= 0.706$) and pH ($p > 0.05 = 0.522$). There was a statistically significant difference in conductivity ($p < 0.05 = 0.025$) between the stations. Between the months, the difference in temperature was statistically significant ($P < 0.05 = 0.000$). There was no statistically significant difference in DO ($P > 0.05 =0.090$), pH ($P > 0.05 = 0.100$), conductivity ($P > 0.05 = 0.417$) and BOD ($P > 0.05 = 0.052$) between the sampled months. Results from this study would help in future assessment of physico-chemical parameters of Bodo Creek, the Niger Delta and other regions in Nigeria.

Keywords Bodo Creek, intertidal flats, tide, recommended levels and temporal variations

Introduction

Bodo community, located in the upper reaches of the Andoni-Bonny river system occupying the lower Niger Delta basin, is made up of brackish water creek network, constantly affected by crude oil spills resulting from abandoned pipelines, sabotage (criminal damage) as well as lack of oil facility maintenance [1]. In 2008, precisely on August 28th, there was a major oil spill in Bodo Creek, resulting from a fault in the Trans-Niger pipeline. For weeks, the oil continued to pour into the creeks and swamps (eventually stopped on November 7th 2008), which covered the area with a thick slick of oil that led to the death of aquatic organisms. Another significant oil spill was reported on February 2nd 2009 [2-3]. The study was carried out to determine priority physico-chemical parameters (temperature, pH, conductivity, DO and BOD) of water in Bodo Creek tidal flats. The study was also carried out to evaluate the spatio-temporal variations in water physico-chemistry in Bodo Creek.

There are reports from previous studies showing the effects of water quality on the composition of species, aggregation and distribution of aquatic plants, bottom dwelling organisms and fish [4-7]. Hydrology, biology and physico-chemical parameters of water all constitute water quality. Water hydrology deals with the study of

the movement and distribution of water in relation to the earth surface. Water biology is the aspect of water quality concerned with the form, structure, behavior, origin as well as the distribution of aquatic organisms. Water physico-chemistry is made up of the physical and chemical components of water including temperature, hydrogen ion concentration (pH), conductivity, dissolved oxygen (DO), biochemical oxygen demand (BOD), total dissolved solids (TDS), total suspended solids (TSS) and chemical oxygen demand (COD). According to Zabbey [8], physico-chemical conditions of water determine how water is available for different uses by man.

Materials and Methods

Description of the study area

Bodo Creek is located between the river estuaries of Bonny and Andoni. To determine the spatio-temporal variation in interstitial water physico-chemical parameters in the creek, four stations previously sampled before the oil spill, 3 years after the oil spill [9], 5 years after the oil spill [10] and 7 years after the oil spill [11] were re-sampled.

Sampling sites and their locations

Station 1: This station is located upstream with sandy mud as the substratum. This station is traditionally called "Sivibilagbara" and is located on the right-hand side of the main channel known as ''Dor Nwezor'' at a latitude of 4°36'29.7'' N and a longitude of 7°15'30.2''E. Dead mangrove stumps occupy the mudflat. Large scale unvegetated muddy intertidal flat characterizes the station. Under the Bonny-Bodo overhead bridge located about 40 m from the station is a landing jetty. About 60 m from the station on the opposite side of the ''Dor Nwezor'' channel, there is a human settlement.

Station 2: This station is located downstream of station 1, about 1.2 km from station 1, with sandy mud as the substratum. This station is locally called "Si Eeva", occupying a latitude and longitude of 4°36'12.7''N and 7°16'08.1''E, respectively. The riparian zone of the station is dominated by dead mangrove stumps. Toward the land, there are terrestrial plants such as mango, coconut, and palm trees.

Station 3: This station is located downstream of station 2, about 955.58 m from station 2. There is a large expanse of unvegetated sandy intertidal flats in this station. Located on the left of "Dor Nwezor" main channel, opposite a small fishing settlement known as ''Kozo'' occupying a latitude of 4°35'55.3''N and a longitude of 7°16'33.8''E. Traditionally this station is called ''Kozo''. Towards the land are terrestrial plants such as palm trees and mango. Kozo is located about 30 m away from the small fishing settlement. Station 3 is the most elevated of all the stations.

Station 4: This station is located 994 m downstream of station 3, occupying a latitude of 4° 35'32.4''N and a longitude of 7°16'56.6''E. The site is characterized by a sandy mud substratum. The unvegetated sandy intertidal flat at this station is massive. This station is known as Sigberebala traditionally. Fishing activity goes on along the main channel of "Dor Nwezor".

Field and Laboratory Procedures

Samples were collected from the designated stations every month for five months (February 2020 – June 2020). The monthly sample collection was done at low tide because during this period, the intertidal flats were exposed. The sample was collected during spring and neap tide to be an actual representative. A 30 cm × 30 cm quadrat was randomly thrown to dig sediments with a spade, to allow interstitial water enter the dug-out holes. The dug-out hole was limited to 20 cm depth. Interstitial water samples in the infauna dug-out holes was collected and analyzed as follows for the physico-chemical parameters:

A hand held digital multimeter (Go n DO multimeter CTS-406) was used in measuring temperature, pH and conductivity in-situ. The probe was dipped about 5cm into the interstitial water, allowed for an interval of 2 minutes for stability; the reading of temperature was to the nearest 0.1^{o}C. Dissolved oxygen (DO) was measured with a Milwaukee DO meter (MW 600). One amber 250ml BOD bottle (Winchester bottle) per station was used to collect the interstitial water, transported in ice-chest to the laboratory for BOD analysis.

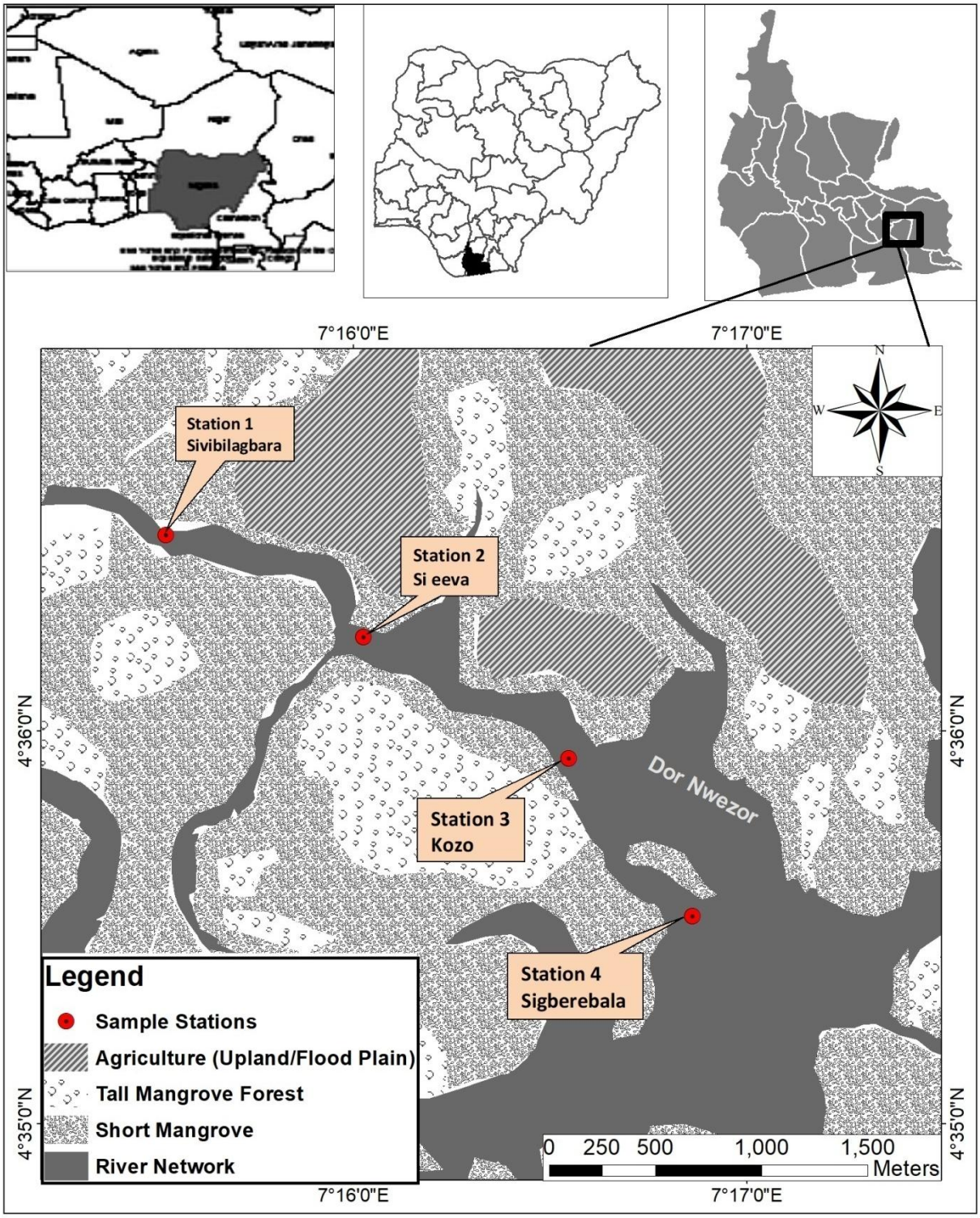

Figure 1: Map of Bodo Creek showing sampled station

Statistical Analysis

Analysis of Variance (ANOVA) in SPSS version 22 at 95% confidence limit was used to show the variation in physico-chemical parameters between stations and months.

Results

Table 1: Variations in spatial mean and ranges of physico-chemical parameters in Bodo Creek interstitial water (February 2020 – November 2020)

Parameter	Station 1	Station 2	Station 3	Station 4	P-Value
Temp.(^{o}C)	30.50	31.21	31.46	31.90	0.841
	(30.1-32.3)	(30.4-34.6)	(30.3-34.8)	(28-34.9)	
pH	7.34	8.42	8.36	8.16	0.522
	(3.5-9.5)	(7.7-9.4)	(7.8-9.3)	(7.4-9.2)	
Cond.(ms/cm)	9.83^b	8.93^a	9.46^{ab}	9.87^b	0.025
	(9.71-9.85)	(8.3-9.83)	(8.35-9.8)	(9.62-10.1)	
DO	3.10	3.14	2.50	1.72	0.412
	(1.9-4.2)	(0.5-5.8)	(0.6-4.5)	(0.8-2.8)	
BOD	1.22	2.06	2.14	2.78	0 .706
	(0.4-4.1)	(0.3-5.0)	(0.3-5.0)	(0.6-4.5)	

*Means with different superscript in the same column are significantly different (p<0.05)

**Means with the same superscript in the same column are not significantly different (p>0.05)

From table 1, the range for temperature was 27.3^{o}C-34.9^{o}C, there was no statistically significant difference (P > 0.05 = 0.841) in temperature, between the stations. The range for hydrogen ion concentration (pH) was 3.5-9.5; there was no significant difference (P > 0.05 = 0.522) in pH. Conductivity ranged between 8.29 and 10.1, there was a statistically significant difference (P < 0.05 = 0.025) in conductivity. There was no statistically significant difference in dissolved oxygen (DO); the range for DO was between 0.5mg/l and 5.8mg/l. There was no statistically significant difference (P > 0.05 = 0.706) in Biochemical oxygen demand (BOD), with a range of 0.3mg/l to 5mg/l.

Table 2: Temporal variation in mean and ranges of physico-chemical parameters in Bodo Creek interstitial water (February 2020 – November 2020)

Month	Temp. (^{o}C)	DO (mg/L)	pH	Cond. (ms/cm)	BOD(mg/L)
Feb.	30.90^a	1.50^a	7.05^a	9.10	4.33^b
	(30.03-31.8)	(0.6-1.9)	(3.5-8.6)	(8.29-9.86)	(4-4.2)
Mar.	33.15	9.98^b	7.75^{ab}	9.85	0.45^a
	(32.3-34.8)	(2.3-5.8)	(7.4-8.1)	(9.76-9.93)	(0.3-0.6)
Apr.	30.99^b	2.30^{ab}	9.35^b	9.48	1.68^a
	(30.1-32.1)	(0.5-3)	(9.2-9.5)	(8.88-9.85)	(0.6-5)
May	33.65^c	3.33^{ab}	9.95^{ab}	9.68	1.40^a
	(31.7-34.9)	(0.8-4.5)	(7.4-8.2)	(9.33-9.85)	(0.3-4.5)
June	27.65^a	1.98^{ab}	8.25^{ab}	9.58	2.40^{ab}
	(27.3-28)	(0.8-3.3)	(8.0-8.6)	(8.3-10.1)	(0.5-4.3)
P-Value	0.000	0.090	0.100	0.417	0.052

*Means with different superscript in the same column are significantly different (p<0.05)

**Means with the same superscript in the same column are not significantly different (p>0.05)

From table 2, there was a significant variation in temperature (P < 0.05 = 0.000); temperature ranged from 27.3^{o}C to 34.9^{o}C. There was no statistically significant difference (P > 0.05 = 0.100) in hydrogen ion concentration (pH). pH ranged from 3.5 to 9.5. There was no statistically significant difference (P > 0.05 = 0.417) in conductivity, with a range of 8.29ms/cm to 10.1ms/cm. There was no statistically significant difference (P > 0.05 = 0.090) in DO and BOD (P > 0.05 = 0.052) with ranges of (0.5mg/l-5.8mg/l) and (0.3mg/l-4.5mg/l) respectively.

From figure 2, temperature was at its peak at station 3 and was least at station 1. Temperature peaked in May and was minimum in June (Figure 7). Hydrogen ion concentration (pH) was at its peak at station 2 and least at station 1 (Figure 3). The value for pH was lowest in February and peaked in April (Figure 8). Conductivity peaked at station 4 and minimum value at station 2 (Figure 4). From Figure 9, conductivity was maximum in March and minimum in February. Dissolved oxygen (DO) peaked at station 2 and was least at station 4 (Figure 5). Dissolved oxygen (DO) peaked in March and was minimum in February (Figure 10). BOD was least at

station 1 with a peak at station 4 (Figure 6). Biochemical oxygen demand (BOD) peaked in February and was least in May (Figure 11).

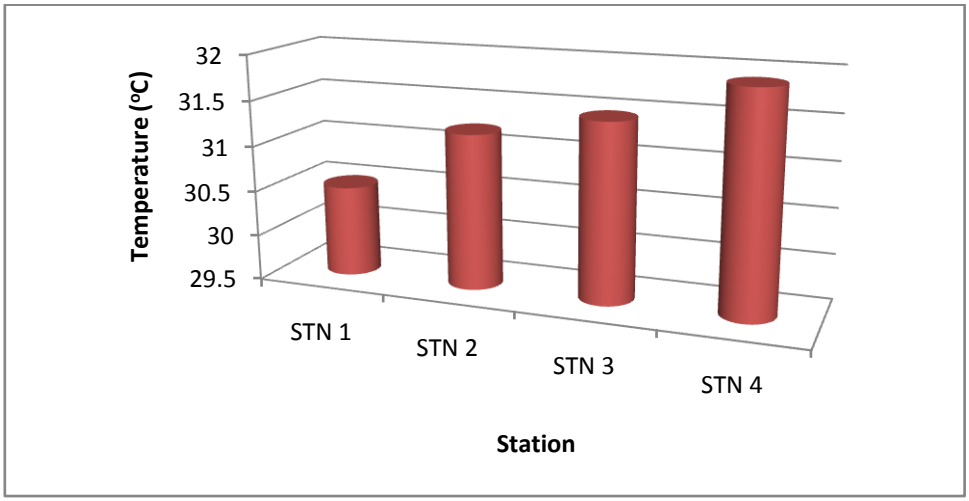

Figure 2: Spatial variations of temperature in Bodo Creek (February 2020- June 2020)

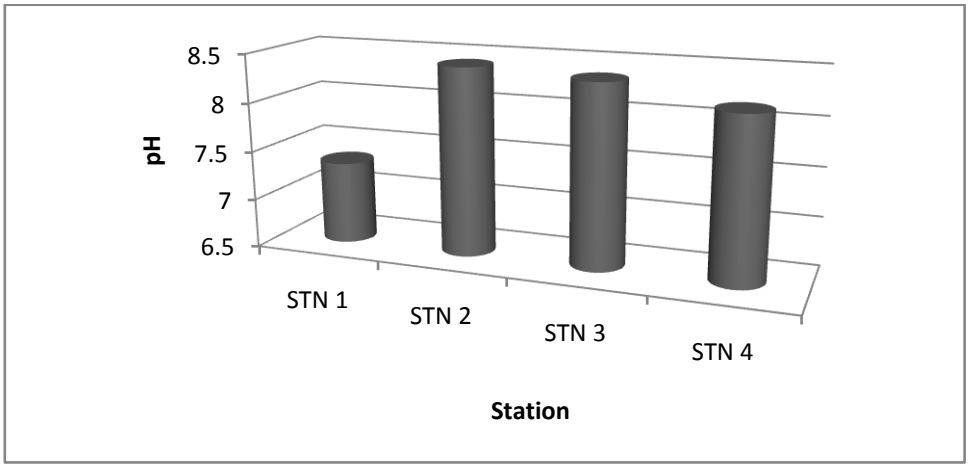

Figure 3: Spatial variations of pH in Bodo Creek (February 2020- June 2020)

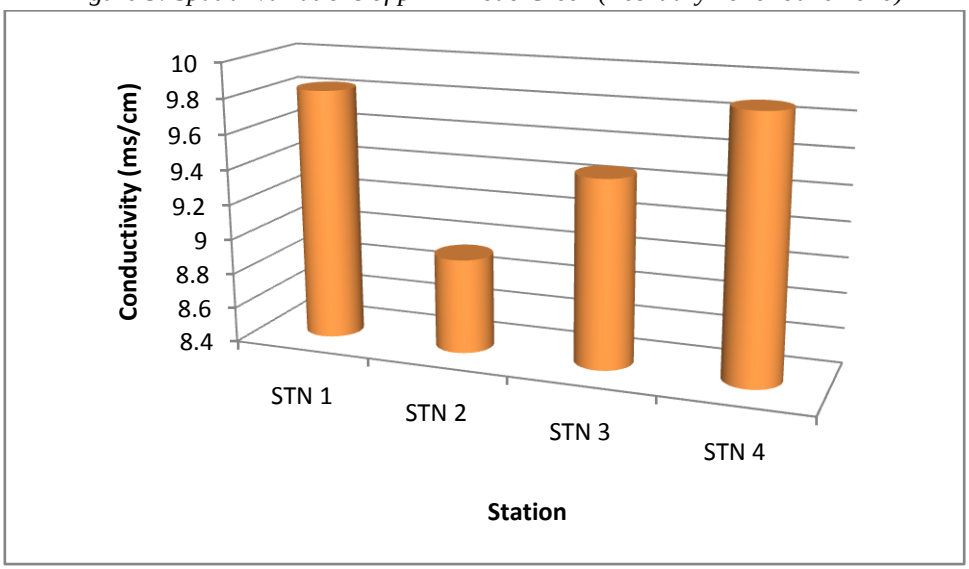

Figure 4: Spatial variations of Conductivity in Bodo Creek (February 2020- June 2020)

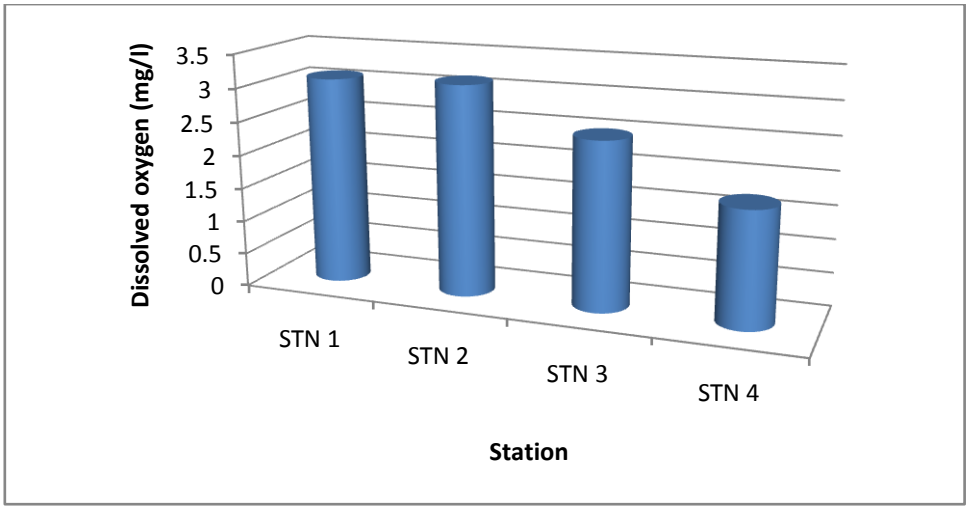

Figure 5: Spatial variations of DO in Bodo Creek (February 2020- June 2020)

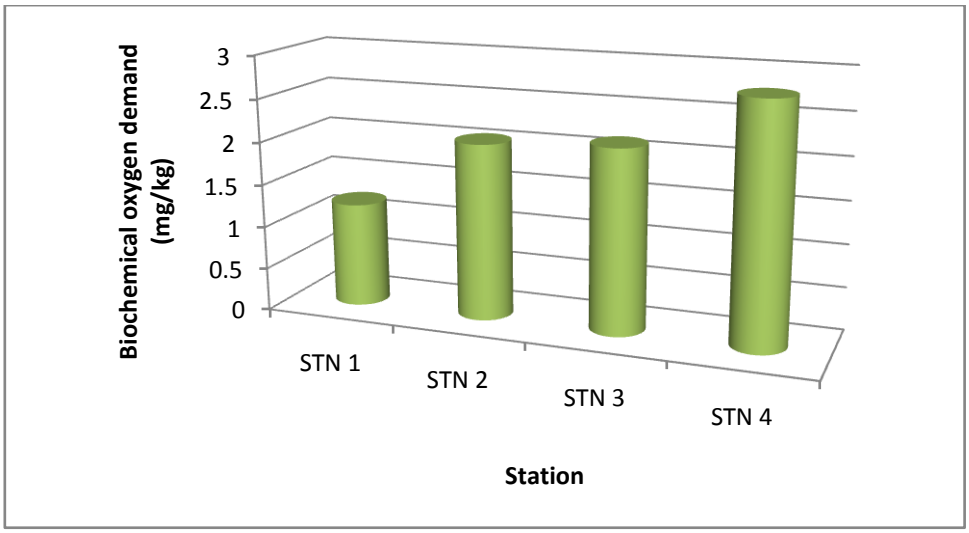

Figure 6: Spatial variations of BOD in Bodo Creek (February 2020- June 2020)

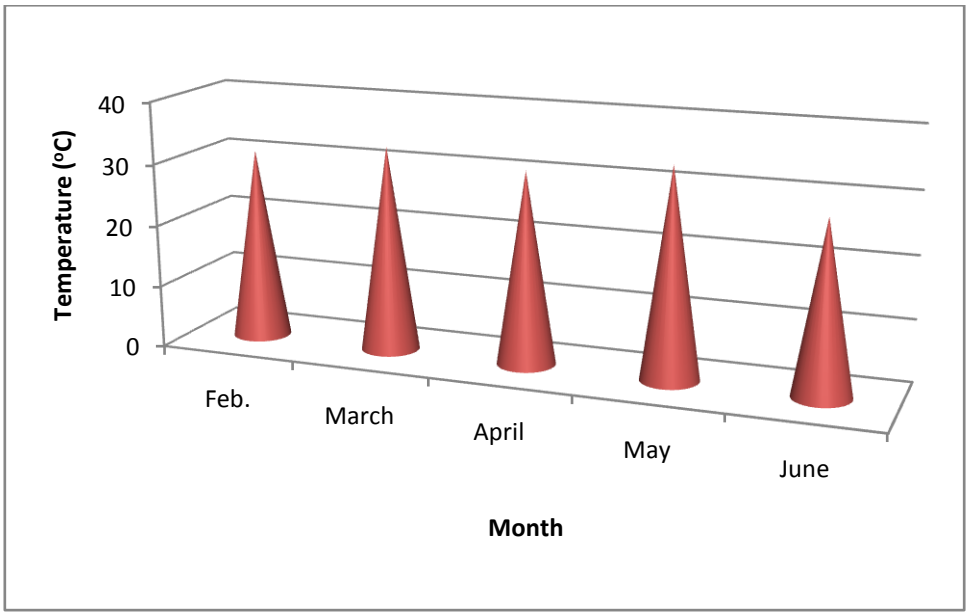

Figure 7: Temporal variations of temperature in Bodo Creek (February 2020- June 2020)

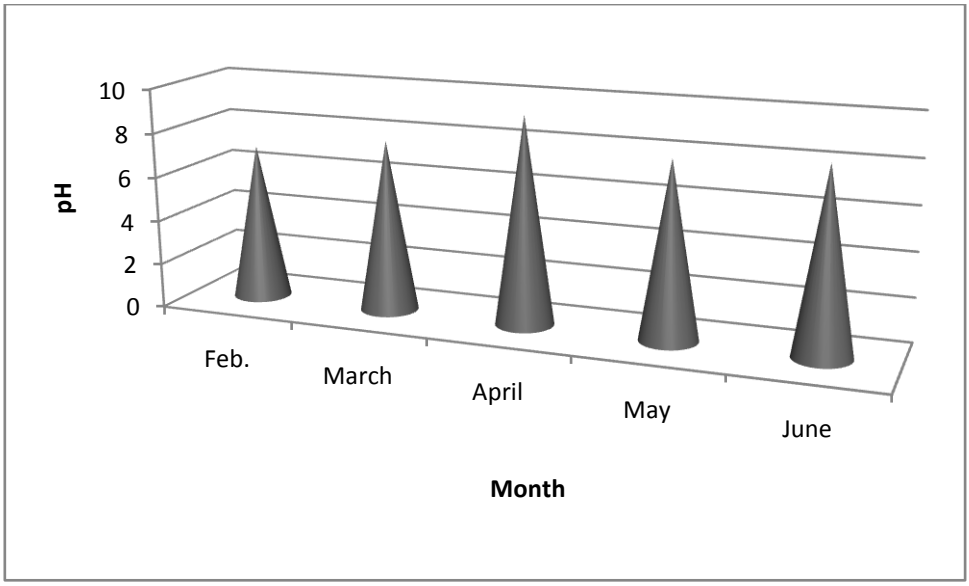

Figure 8: Temporal variations of pH in Bodo Creek (February 2020- June 2020)

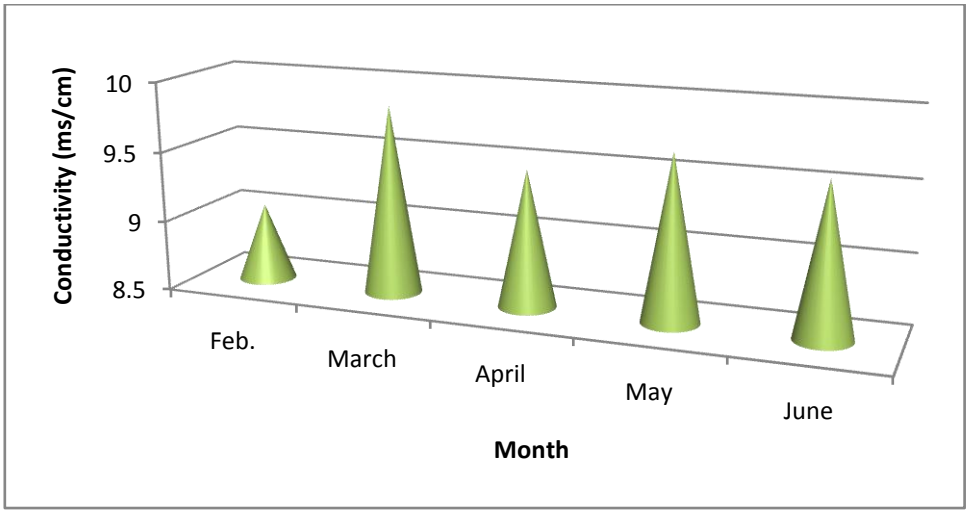

Figure 9: Temporal variations of conductivity in Bodo Creek (February 2020- June 2020)

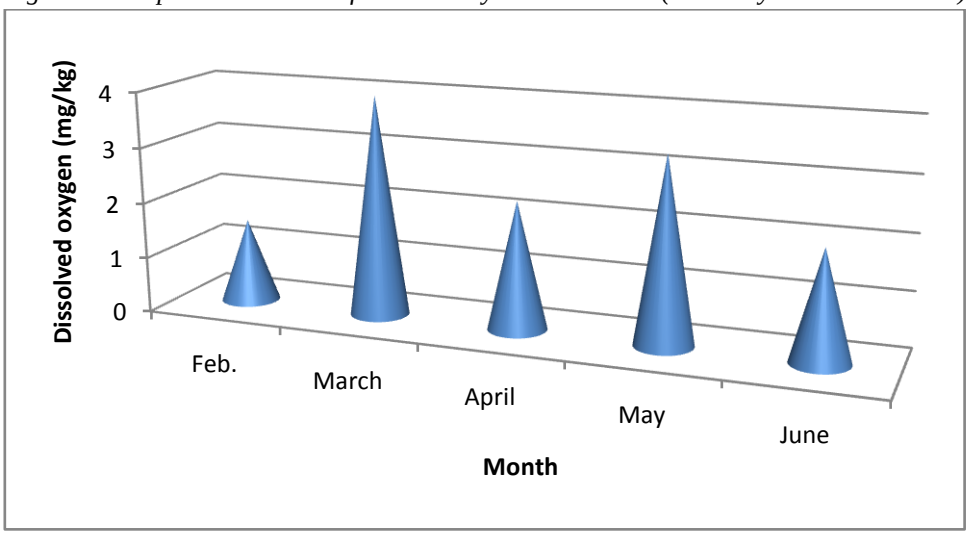

Figure 10: Temporal variations of DO in Bodo Creek (February 2020- June 2020)

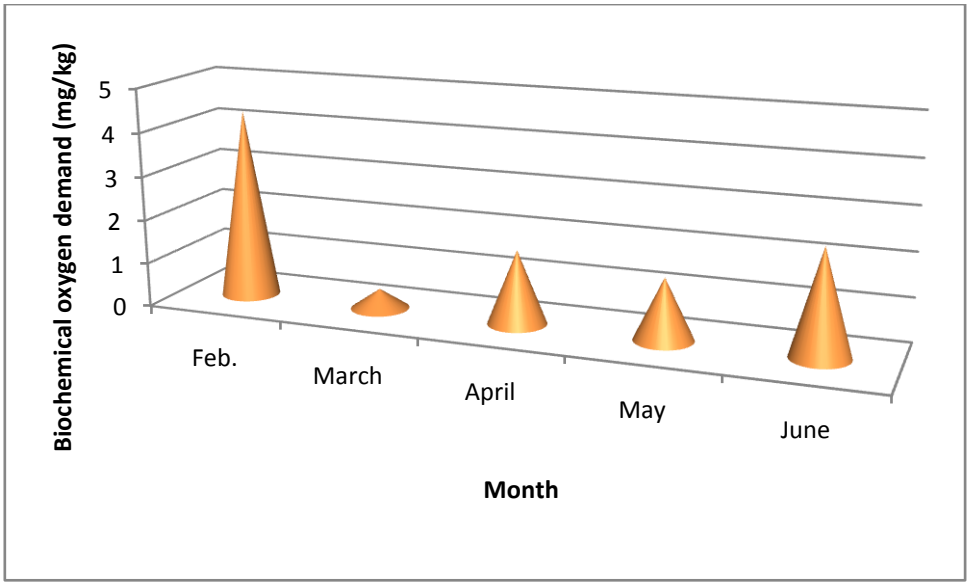

Figure 11: Temporal variations in BOD in Bodo Creek (February 2020- June 2020)

Discussion

Lowest temperature at station 1 could be indicative of limited influence of sun heating on the sediment at the station. Temperature values increased downstream between the intertidal flats (stations 1- 3), there was a peak mean temperature at station 3 and a sudden fall in temperature at station 4. In an earlier study by Zabbey [9], he reported that during low tide, the temperature of exposed pore water may fall suddenly or rise too high in rains or when the sun is shining respectively. Station 3 was the most elevated station. This could have been responsible for the peak temperature at station 3. An increase in air temperature results in increase in intertidal flat temperature [12-13]. The mean monthly temperatures (27.3^{o}C-34.9^{o}C) for 5 months were comparable with the seasonal pattern in the Niger Delta. This is in conformity with earlier studies in the Niger Delta that a long rainy season is a main characteristic of the Niger Delta [9, 14]. Although maximum temperature was reported in May, an earlier study in the sampled stations by Zabbey [9] documented peak temperature in March; where it was noted that the "interpretation of environmental data summarily taken to be monthly representation should be done with caution", this was validated by the maximum temperature reported in May for this study, against the maximum value for temperature in March, in the reported study. According to McLusky [15], this alteration/changes is usually the situation for changing estuarine and brackish water ecosystems, where ecological parameters fluctuate based on tide, day, season, etc. Egborge [16] reported that changes in dissolved solids, especially mineral salts, is a factor affecting conductivity, which indicates how fresh or otherwise is the water body. In this study, the least conductivity was at station 2, while an earlier study by Zabbey [9] in the same sampled stations reported least conductivity at station 3. Low conductivity at station 2 could be due to groundwater seepages. Conductivity of the creek was in conformity with the range applicable for brackish water. The pH in this study fluctuated between acidity and alkalinity (Tables 1 and 2). Earlier studies on pH in Bodo Creek reported alkaline values [7,17]. Low dissolved oxygen (DO) concentration at station 4, could be indicative of decaying organic matter presence, leading to the production of toxic gases including hydrogen sulphide and methane [18]. Peak BOD value at station 4, could be indicative of highest levels of organic pollution in the station, in comparison with stations 1, 2 and 3. There was an inverse relationship between dissolved oxygen (DO) and biochemical oxygen demand. For example; station 4 with highest BOD recorded the least dissolved oxygen (DO) concentration.

In comparison with WHO [19] recommended standard of physico-chemical parameters for aquatic lives' survival, temperature was slightly above the recommended value. pH was below (very acidic) and DO was below the recommended value. Conductivity was above the recommended value, while BOD was within the value recommended.

Conclusion

Most of the physico-chemical parameters were not within the values recommended for the survival of aquatic lives. This shows that the biodiversity in Bodo Creek are living in an environment that does not support their optimum survival, growth and reproduction. Thus, improved water physico-chemistry of Bodo Creek would result in a better environmental quality for improved aquatic biota. Results from this study would help in future assessment of the physico-chemical parameters of Bodo Creek, the Niger Delta and other regions in Nigeria.

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