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Water Quality Index of Kolo Creek, Bayelsa State, Nigeria

[1]EBUETE, AW; [2*]BARIWENI, PA

Department of Geography and Environmental Management, Niger Delta University,
Wilberforce Island, Bayelsa State, Nigeria.
**** Corresponding Author Email:*** *perekibinabariweni@ndu.edu.ng; +2348035085317; ebuetewilliams@gmail.com; +2348038890102*

ABSTRACT: The Kolo Creek was assessed to determine the impact of human activities on the water quality using the Water Quality Index. Water samples were collected from six sample sites (A-F) during the dry and wet seasons and assessed for physicochemical and biological parameters. Results from the study showed a mean e-coli level of 39.83±2.93 (Cfu); mean pH of 7.23±0.37 in the dry season and 6.78±0.18 for the wet season; and mean DO levels of 7.58±1.00mg/l during the dry season and 9.29±2.67mg/l during the wet season indicating that the Kolo Creek was biologically polluted but physicochemical potable for domestic use. However, combined physicochemical and biological classification with the water quality index ranked the creek water as medium (Class III) and not good for consumption. The water quality index was affirmed as a good single measure of water quality.

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Water is a dynamic medium containing living, non – living components, organic and inorganic soluble as well as insoluble substances that constitute a support system for living organisms (Al-Mashagbah, 2015). In fact, water stands to be the second most important natural resource for all forms of life after air and is a valuable natural asset which forms the major constituent of the ecosystem (Balan *et al.,* 2012). Despite its abundance, the quality and accessibility of potable water remains a global challenge especially in the rural and semi-rural communities in the developing countries (Ohwo and Abotutu, 2014). Freshwater that is available for drinking, agricultural and domestic purposes is known to be exposed to an array of contamination from uncontrolled human activities (Oribhabor, 2015). The type and severity of water contamination is often directly related to human activity, which can be quantified in terms of the intensity and type of land use in the catchment areas of a water body. With growing human population, increasing urbanisation, industrialisation and environmental degradations, lakes, streams and rivers are increasingly threatened from chemical and biological pollutants. The Kolo Creek is one of the inland water bodies in the Niger Delta receiving organic and chemical wastes arising from anthropogenic activities within the catchment area**.** Numerous studies have been carried out to assess its water quality (NEDECO, 1961; Inegite *et al.*, 2010; Gobo *et al.*, 2013; Aghoghovulia and Ohimain, 2014; Ogamba *et al.*, 2015; Seiyabor and Ayibaefie, 2017 and Ogamba *et al.*, 2017). None of these studies has generally classified the water quality from the Kolo Creek, because the indices used are either the physico-chemical or biological parameters. This study is aimed at assessing the general water quality of the Kolo Creek using Water Quality Index for missing parameters. Over the last couple of decades, Water Quality Index, which was first developed by Horton in 1965 has been successfully applied in water quality assessment studies in various region of the world under various names such as Weighted Arithmetic Water Quality Index (WAWQI), National Sanitation Foundation Water Quality Index (NSFWQI), Canadian Council of Minister of the Environment Water Quality Index (CCMEWQI), Oregon Water Quality Index (OWQI) etc. (Cude, 2001; Chaturvedi and Bassin, 2010; Sing *et al.*, 2013a; Fadaei and Gafari, 2015). The uniqueness of the use of the water quality index is that it provides the composite influences of individual water quality parameter on the overall quality of water (Sing *et al.*, 2013b). Accordingly, water with a quality index range of 90 – 100 is classed I and its quality is described as excellent, 70 – 90 is classed II and its quality is described as good, 50 – 70 is classed III and its quality described as medium, 25 – 50 is classed IV and its quality is described as bad and 0 – 25 is classed V and its quality described as very bad (Deepika and Sing, 2015). Information on the quality of surface water using water quality index in most streams and rivers in Nigeria is scanty, hence the need for this study.

MATERIAL AND METHODS

Study Area: Kolo Creek lies within latitude $04^{0}24'26.893''$ and $04^{0}\ 59'05.094''$ North and longitude $06^{0}\ 14'59.190''$ and $06^{0}\ 20'47.701''$ East. The full length of the Kolo Creek is about 85km, covering a total area

**** Corresponding Author Email:*** *perekibinabariweni@ndu.edu.ng; Tel: +2348035085317*

of about 1,625 square kilometers (NEDECO, 1961; Eli, 2012). Kolo Creek is located at the central part of the Niger Delta and transverses about twenty-one (21) communities including Okarki; Otegue II, Ibelebiri, Oruma/Yibama, Otuasega, Imiringi, Emeyal 1 and 2, Kolo 1, 2 and 3, Otuegila, Otakeme, Otuabagi, Ewoma/Otuabi, Otuogidi, Ogbia Town, Otuabo/Abobiri, Ekpenkiri, Akakumama, and Bukiri (Gobo *et al.,* 2013) (Figure 1). The main human activities along the creek include flood plain farming, sand mining, oil palm processing, cassava processing, open defeacation, etc. These activities are known to influence water quality (Izonfuo and Bariweni, 2001; Ayotunde and Bariweni, 2017).

Sampling design and method of data Collection: Water samples were collected from six (6) sampling points labelled A (Okarki); B (Otuasega); C (Imiringi); D (Kolo 2); E (Otuabagi) and F (Ogbia Town) (Figure 1) purposively selected to assess the variation in anthropogenic activities and classify the water quality of the Kolo Creek using Water Quality Index. Samples were collected monthly for a year and analysed by standard methods of APHA (1995) for their physico-chemical and biological characteristics. All sampling locations were geo-located using GARMIN 76 hand held GPS equipment. Water Quality Index (WQI) for missing parameter (phosphate) was determined using Equation 1**,** following the method of Srivastava and Kumar (2013).

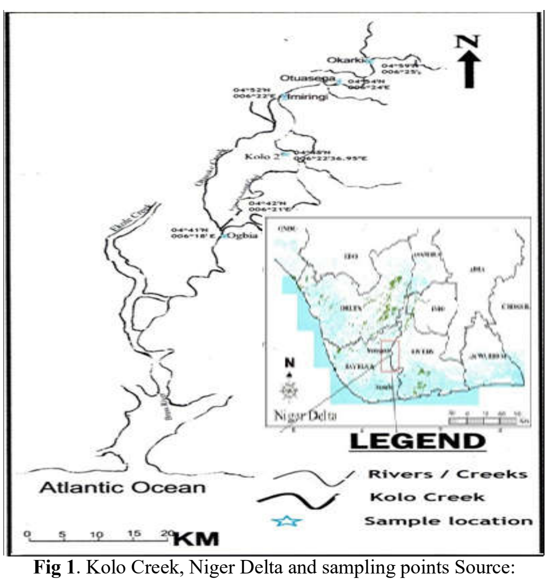

Fig 1. Kolo Creek, Niger Delta and sampling points Source: Adapted from Eli (2012)

$$WQI_{MP} = \sum \frac{WYQY}{WY}$$

$WQI_{MP} = \Sigma\ WYQY / WY$ (1)

Where: WQI_{MP} = Water Quality Index for Missing parameters, Σ = Summation, WY = Weighting Factors of Available Parameters, QY = Q-values of available parameters.

Results obtained from physicochemical and microbiological parameters were transferred to a weighting curve/ chart from which numerical values were obtained. The numerical value or Q-value, which is multiplied by a "weighting factor (Table 1, Equation 1), gives an indication of how good or bad the water quality is when summed up; where a value of 100 is Very Good and 1 is Very Bad.

Table 1: Weighing Factors of Water Quality Parameters

Parameters	**Weight Factor**
Dissolved Oxygen (DO)	0.17
Total Coliform	0.16
Potential d'Hydrogene (pH)	0.11
Biological Oxygen Demand	0.11
Temperature	0.11
Nitrates	0.10
Turbidity	0.08
Total Dissolved Solute (TDS)	0.07

Source: Srivastava and Kumar, 2013

RESULTS AND DISCUSSION

Results of the mean seasonal physicochemical and biological characteristics of the Kolo Creek are presented in Table 2. Results of the individual parameters showed that Dissolved Oxygen (DO) levels were more variable in the wet season than the dry season. The observed seasonal mean levels of 7.58±1.00mg/l during the dry season and 9.29±2.67mg/l during the wet season, which accounted for 10.14% seasonal difference, were above the recommended permissible limit of 3.0-7.0mg/l for drinking water (Nigerian Industrial Standard (NIS), 2007; WHO, 2011). The values obtained agree with the results of Inengite *et.al.*(2010); Williams and Odokuma (2014); and Daka *et al.* (2014) for the Kolo Creek. The mean result of the Total-Coliform count for both seasons were above permissible limit of 10 CFU/100ml (NIS, 2007; WHO, 2011). It was observed that the presence of coliforms in the creek decreased downstream (A>B>C>D>E>F). The values obtained from this study compare with the findings of Dami *et.al.*(2012). Data regarding the mean Hydrogen ions concentration (pH) of the Kolo Creek showed a mean of 7.23±0.37 in the dry season and 6.78±0.18 for the wet season. The observed seasonal mean pH levels, which were within the recommended range of 6.5-8.5 for drinking water (NIS, 2007; WHO, 2011) were found to be similar to those of Inengite et. al. (2010); Gobo, *et al* (2013); and Aghoghovwia and Ohimain (2014). The mean Biochemical Oxygen Demand (BOD_5) recorded for the dry season was 0.97±0.20mg/l and 0.23±0.11mg/l for the wet season. This accounted for a 61.34% seasonal difference in the mean BOD_5 values. These results were within the permissible limit (NIS, 2007; WHO, 2011) and agrees with those of Ogamba and Ebere (2017) for the Kolo Creek. Results concerning the turbidity levels showed a mean seasonal variation of 0.38±0.61NTU for the dry season and 2.68±0.52NTU for the wet season. The observed values were below NIS (2007) and WHO (2011) permissible value of 5.00 NTU. The results were similar to the report of Seiyaboh *et al.* (2016) on the Kolo Creek. The mean seasonal Total Dissolved Solids result were within the recommended value of (500 Mg/l) by the National guideline and standards for water quality in Nigeria (NIS, 2007) and the WHO (2011) specified limit for drinking water. The results were similar to those of Inengite *et al.,* (2010); Aghoghovwia and Ohimain (2014).

Table 2: Mean seasonal Physicochemical and biological characteristics of the Kolo Creek

	Dry Season				Wet Season				Standard
Parameters	MIN	MAX	MEAN	STD	MIN	MAX	MEAN	STD	
DO (mg/l)	6.00	8.80	7.58	1.00	4.00	10.81	9.29	2.67	3.0 – 7.0 (WHO, 2011)
E-Coli (cfu)	6.00	59.00	32.00	21.62	37.00	45.00	39.83	2.93	10 (WHO, 2011)
PH	6.80	7.70	7.23	0.37	6.50	6.90	6.78	0.18	6.5 – 8.5 (WHO, 2011)
BOD (mg/l)	0.68	1.20	0.97	0.20	0.08	0.40	0.23	0.11	3.0 (WHO, 2011)
Temperature (^{0}C)	31.00	32.00	31.43	0.46	28.30	28.40	28.35	0.05	
Nitrates (mg/l)	96.00	100.00	98.83	1.60	86.00	92.00	87.50	2.26	9.1 (WHO, 2011)
Turbidity (NTU)	0.00	1.60	0.38	0.61	2.40	3.60	2.68	0.52	5.00 (WHO, 2011)
TDS (mg/l)	91.00	168.00	121.00	29.93	45.80	64.40	50.00	7.11	500 (WHO, 2011)

Source: Researcher fieldwork, 2017

Table 3: Q-Values of Water Quality Parameters in Sampled Stations

Parameters	**Q- Values For all Stations**											
	A		**B**		**C**		**D**		**E**		**F**	
	Dry	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
DO	3	3	3.5	4	4	6	4.5	8	4.5	8	4.7	9
E-Coli	52	35	53	56	55	54	53	52	65	56	64	52
PH	90	75	92	75	94	75	92	75	89	70	88	68
BOD	97	95	100	96	97	96	100	97	99	97	100	99
Temperature	1.9	39	2.7	39	2.7	39	1.9	39	1.9	39	1.9	39
Nitrates	96	86	98	86	99	87	100	87	100	87	100	92
Turbidity	98	88	98	88	99	78	98	79	99	78	99	70
TDS	74	85	77	84	81	84	83	84	85	86	87	83

Source: Fieldwork, 2017.

Table 4: Summary of Computed WQI across Stations for two seasons

WQI	**Station**											
	A		**B**		**C**		**D**		**E**		**F**	
	Dry	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
ΣQ_Y	55.9	53.9	57.2	54.3	57.9	53.6	57.9	53.8	59.6	53.9	59.6	53.12
ΣW_Y	0.91		0.91		0.91		0.91		0.91		0.91	
ΣWQI	61.4	59.2	62.8	59.7	63.7	58.9	63.6	59.1	65.5	59.3	65.5	58.22
$\bar{x}$	$\bar{x}\Sigma DQI_{mp}$ = 63.74 and $\bar{x}\Sigma WQI_{mp}$ = 58.22; $\bar{x}\Sigma WDQI_{mp}$ = ($\bar{x}\Sigma DQI_{mp}$ + $\bar{x}\Sigma WQI_{mp}$/ 2) = 60.97											

Sources: Fieldwork, 2017

Where: x∑DQI = Sum of water quality index during the dry season, x∑WQI = Sum of water quality index during the wet season, x∑WDQI = Sum of water quality index during the dry and wet season

Results of all the individual parameters as observed in the study appear to indicate that the kolo creek water quality were within acceptable limits except for those of total coliforms and the DO levels. The water quality may therefore be classified as polluted on the basis of an individual water quality characteristics. As stated earlier, the WQI classifies water quality according to the degree of purity by incorporating multiple water quality parameters into mathematical equation that rates the health status of water with a single number **(**Ayobahan *et al.,* 2014). Result obtained from conversion of raw data to Q-values is presented in Table 3 and the summary of the WQI is presented in Table 4. Results from the summary classified water quality of the Kolo creek as Class III, which is scientifically described as "Medium". The water quality status from the computed water quality index also revealed slight quality differences from source to mouth in an order of F>E>C>D>B>A during the dry season and B>E>A>D>C>F during the wet season (Table 4). Obviously, water quality of the Kolo Creek was practically determined by the types of anthropogenic activities operating within its catchment indicating the variation in impact of human activities on water quality with the seasons. The percentage differences between the dry season and the wet season samples accounted for 4.52% which was very minute compared to the differences in anthropogenic activities. Mustapha and Aris (2011); Eli (2012); Rim-Rukeh and Agbozu (2013); Etim *et al.* (2013); Olowe *et al.* (2016); Seiyaboh and Izah (2017); had linked types and severity of water contamination to the human activities, which can be quantified in terms of the intensity and types of land use of the area.

Conclusion: The results from this study has demonstrated the usefulness of the water quality index in providing the composite impact of individual water quality parameter on the overall quality of water. Therefore, instead of using just the physicochemical or biological parameters in assessing water quality, a combination of these is recommended using the water quality index.

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