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The Effect Of Urban Runoff Water And Human Activities On Some Physico-Chemical Parameters Of The Epie Creek In The Niger Delta

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ABSTRACT: The Epie creek was investigated for six months from five sampling stations to determine the effects of urban runoff and human activities on some physico-chemical parameters. Variations in the physico-chemical parameters were observed from station to station both in the dry and rainy seasons. These variations were attributed to runoff water and human activities in the Epie Creek. Although the levels of most of these physico-chemical parameters were found to be within the safe limits for drinking water, the mean DO levels were generally found to be lower than septic levels and thus unsafe for fish and other aquatic organisms. The chloride, sulphate, phosphate, nitrate and ammonia levels were found to be higher during the rainy season than the dry season, suggesting that runoff water contributed to their levels in the creek. It was also observed that the levels of TDS, alkalinity, total hardness, calcium, potassium, sodium, conductivity, chloride, nitrates, sulphates, ammonia and phosphates in sections of the Epie creek traversing the Yenagoa metropolis were higher than those from the upstream sections. These higher levels were attributed to human activities in the creek. The potential risk associated with the generally low DO levels and the high nutrients have been highlighted. @ *JASEM*

Urban runoff as a contributing factor to poor river water quality of the Epie Creek has been a source of concern to the inhabitants of Yenagoa, Bayelsa State. The characteristics of any water body may indicate its level of pollution. According to Chov (1964), a great deal of information on river water quality may be evaluated from the climatic and geological conditions in the river basin. These two factors generally play a role in the quality of water available for use for different purposes. In most rivers, the normal or dry weather flow is made up primarily of water which seeps from the ground. However, most of the flow of a river is contributed during the high runoff or flood periods. During the period of high runoff, most rivers exhibit their most favourable chemical water characteristics. Chov (1964), suggests that although the river may contain extremely large amounts of suspended matter, the concentrations of dissolved substances are usually low, often only a fraction of that present during dry weather. However, there are some instances where high runoff may cause deterioration in water quality. For instance, if rain falls selectively on the watershed of a tributary which contributes poor-quality water to a comparatively good-quality river system, the water contributed may cause a transitory deterioration of the water quality in the system.

As stated by Strahler and Strahler (1973), all rainfall, wherever it occurs carries with it a variety of ions, some introduced into the atmosphere from the sea surface, some from land surfaces undisturbed by man and some from man-made sources. The ions and other substances carried into the streams or rivers via rainfall may result to pollution.

The pollution of water bodies from pollutant transport through surface runoff and uncontrolled discharge of untreated and partially treated sewage has been reported severally by Inoue *et al;* (1991), Inanc *et al.* (1998), and Martin *et al.* (1998). Some of the identified effects of runoff water on such water bodies include nutrient enrichment, deterioration of the water qualities, destruction of spawning grounds for aquatic and marine life, general fish kill, etc.

Bariweni et al. (2000), have recently reported that domestic wastes are indiscriminately dumped in the Yenagoa metropolis because of a lack of any effective and efficient domestic waste management system. The Epie creek serves as a receiver of this poorly managed waste inspite of the fact that it is being used for fishing, drinking, bathing, travelling and recreating. The Epie creek is a distributary of the Nun River in the Niger Delta and lies astride the Yenagoa metropolis which is located between latitude 4^0 50'N to 5^0 05'N and longitude $6^0$15'E to $6^0$30'E.

Given the present poor status of the domestic waste management in the metropolis, and given the chemical composition of domestic wastes and the microbial activities in wastes, at periods of high runoff from such littered waste dumps, or through the direct dumping of wastes into the creek, the quality of water in the (Epie) creek may be altered. Presently, no study has been conducted

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on this river to establish to what extent the runoff water and other human activities from the metropolis affect the water quality of the creek. This paper therefore reports the results of studies conducted on the Epie Creek to establish the effects if any of urban runoff and other activities on the water quality of the Epie creek, an important water body lying astride the capital city Yenagoa, of Bayelsa State, in the Niger Delta.

MATERIALS AND METHODS

The Epie creek was sampled once monthly for six months (December, January, February, April, May, June) from five sampling stations (A-E) (fig 1.). Sites A and E represent stations for the downstream and upstream samples respectively. Stations B and D were used to assess the contribution of urban storm runoff and other human activities from the municipality into the Epie creek. Station C was used to determine the influence if any of the Taylor creek, another distributary, which empties into the Epie creek at station C on the Epie creek. Sampling was done thrice at base flow and thrice after storm runoff events. Plastic containers were used for the collection of water samples for the physico-chemical analyses, while dark, glass-stoppered BOD bottles were used for the collection of DO and BOD samples. Creek water sampling was done from the main flow near the centre of the creek. Rainwater samples were also collected in the open air according to standard methods for analysis to assess the influence (if any) of direct precipitation into the creek on the physico-chemical parameters being investigated. DO samples were fixed in the field with wrinkler I and II reagents, while BOD samples were fixed after five days.

The following physico-chemical parameters were assessed using standard methods (APHA et al., 1976): pH, conductivity, total dissolved solids (TDS), turbidity, alkalinity, total hardness, five day biochemical oxygen demand (BOD_5), dissolved oxygen (DO), magnesium, calcium, sodium, potassium, phosphates, sulphates, ammonia, nitrate, chloride and temperature. pH was measured with the OORNING pH meter Model 7. The conductivity and total dissolved solids were determined with the Lovibond conductivity meter (Type cm-21). Turbidity was assessed with the Horiba water checker. Total hardness and calcium levels of samples were determined by complexometric titration with standard EDTA as titrant and Erichrome Black T as indicator (APHA, 1976). The Azide modification method (APHA, 1976) was used to assess the DO and BOD_5 levels in the Epie creek. Magnesium was determined by calculation from the EDTA calcium and total hardness titration (APHA, 1976). Sodium and potassium were measured using the flame photometer method (APHA, 1976). Using a spectronic 21D photometer, phosphate was measured by the stannous chloride method; sulphate by the turbidimeter method; ammonia by the phenol-hypochlorate method and nitrate by the Brucine method. The chloride content of the water samples was determined by the Argentometric method. Water temperature was measured with a mercury thermometer.

RESULTS AND DISCUSSION

The average results obtained for the five sampling stations during the dry (December, Jaunary, February) and rainy seasons (April, May, June) for the 18 physico-chemical parameters are shown in table 1. The range, mean and standard deviations of the results are shown in table 2.

Results from table 2 show that the mean pH, conductivity, TDS, BOD_5 Alkalinity, Total hardness, Calcium, Magnesium, Potassium, Sodium and temperature levels of the creek were generally higher in the dry season than in the rainy (wet) season. The lower values of these parameters suggest that the runoff water only contributes to dilution of the parameters in the rainy season. Results also show that the pattern of dominance of the major cations based on the mean values was $Ca^{++}>Na^{+}>Mg^{++}>K^{+}$ during the dry season and $Ca^{++}>K^{+}>Na^{+}>Mg^{++}$ in the wet season. This was found to be consistent with the dominance pattern of some African Rivers where Ca^{++} was found to be the dominant cation (Imevbore, 1970). The results also indicated that relatively more K^{+} was released from land sources during the rainy season in preference for the retention of Na^{+} and Mg^{++}. Decomposing vegetable matter have been reported to rapidly release potassium (K^{+}) (Tesarova, 1976; Ezeala, 1984). Although, the generally low cation concentrations are consistent with the findings of Ajayi and Osibanjo (1981) in freshwaters of the coastal regions of Nigeria, the values for pH, turbidity, BOD_5, alkalinity, total hardness, calcium, potassium and sodium of the Epie creek show some variations from some other Nigerian Rivers in the Niger Delta as shown in table 3.

The spatial mean DO levels in sections of the Epie creek were generally found to be below septic levels. Although the seasonal mean values are within the safe limits of 3-7mg/l for drinking water (WHO, 1993 - table 3), the values are lower than the level of 5mg/l required for the survival of fish and other aquatic life (Hodges, 1973). The average DO level of 4.45mg/L recorded in the wet season is higher than the value of 3.35mg/L obtained in the dry season. This is inspite of any dilution effects in the wet season. The observed seasonal fluctuation may be due to the effect of temperature on the solubility of oxygen in water. At high temperature, the solubility of oxygen decreases while at lower temperatures, it increases (Plimmer, 1978).

Table 2 also shows that, the spatial mean BOD_5 levels ranged between 1.53-6.77mg/L in the dry season and 0.31-4.29mg /l in the rainy season. The seasonal means were 4.28mg/L in the dry season and 2.25mg/L in the wet season. The average value in the wet season is lower than the safe limit of 4mg /l for drinking water (Tom, 1975). BOD_5 was found to be higher in the dry season than the rainy season. This is perhaps due to the lower volume of water in the Epie creek during the dry season. Moore and Moore (1976) reported that BOD_5 has been a fair measure of cleanliness of any water on the basis that values less than 1-2 mg/L are considered clean, 3mg/L fairly clean, 5mg/L doubtful and 10mg/L definitely bad and polluted. The results therefore show that the Epie creek is cleaner in the rainy season than the dry season.

Table 2: Seasonal range, mean and standard deviation of some physico-chemical parameters of the Epie creek (1999-2000)

S/No.	Parameter	Dry Season			Wet Season		
		Range	Mean	STD	Range	Mean	STD
1	pH	7.4-7.57	7.46	0.08	6.9-7.33	7.05	0.2
2	Conductivity (μs/cm)	78.33-89.33	84.78	4.69	47.73-54	50.35	2.66
3	TDS (mg/L)	55-62	59.33	3.09	33-37.83	35.11	2.02
4	Turbidity (NTU)	11.67-19.67	14.89	3.45	16.67-28	23.89	5.12
5	DO (mg/L)	1.76-5.68	3.35	1.68	1.38-9.06	4.45	3.32
6	BOD_5 (mg/L)	1.53-6.77	4.28	2.15	0.31-4.29	2.25	1.63
7	Chloride (mg/L)	1.65-4.62	2.75	1.33	3.62-4.28	3.95	0.27
8	Alkalinity (mg/L)	30-37.33	33.55	3.0	15.33-22	18.67	2.72
9	Total Hardness (mg/L)	3.27-5.27	4.14	0.84	2.27-3.36	2.68	0.48
10	Calcium (mg/L)	5.47-7.53	6.51	0.84	3.20-4.84	4.25	0.75
11	Magnessium (mg/L)	2.29-3.6	3.11	0.59	1.77-2.98	2.52	0.54
12	Potassium (mg/L)	2.55-3.33	2.92	0.32	2.55-3.35	2.86	0.35
13	Sodium (mg/L)	3.27-5.27	4.14	0.84	2.27-3.36	2.68	0.48
14	Phosphate (mg/L)	0.10-0.23	0.19	0.07	0.09-0.47	0.33	0.17
15	Sulphate (mg/L)	1.98-2.66	2.25	0.30	2.22-6.27	4.44	1.68
16	Nitrate (mg/L)	0.02-0.27	0.16	0.10	0.14-0.28	0.20	0.06
17	Ammonia (mg/L)	0.003-0.1	0.05	0.04	0.15-0.21	0.18	0.03
18	Temperature (^{0}C)	28.7-305	29.73	0.76	27.3-29.3	28.27	0.82

S/No.	Parameter	Source	April	May	June	Mean
1.	pH	River	6.93	7.33	6.90	7.05
		Rain	6.60	6.80	6.60	6.67
2.	Conductivity ([illegible]	River	61.33	56.33	43.04	50.35
		Rain	9.20	10.00	10.00	9.73
3.	TDS (mg/l)	River	49.00	32.00	30.33	37.11
		Rain	6.40	7.00	7.50	6.97
4.	Turbidity (NTU)	River	17.33	31.00	23.33	23.89
		Rain	0.00	0.00	0.00	0.00
5.	Chloride (mg/l)	River	5.27	3.61	2.96	3.95
		Rain	3.95	2.96	2.96	2.29

6.	Alkalinity (mg/l)	River	24.67	14.00	17.33	18.67
		Rain	8.00	6.00	6.00	6.67
7.	Total hardness (mg/l)	River	19.20	8.58	16.00	14.59
		Rain	1.92	1.92	7.70	3.85
8.	Calcium (mg/l)	River	5.82	3.33	3.6	4.25
		Rain	0.83	0.83	0.80	0.82
9.	Magnesium (mg/l)	River	3.26	1.28	3.03	2.52
		Rain	0.27	0.27	1.70	0.75
10.	Potassium (mg/l)	River	3.00	3.18	2.40	2.86
		Rain	0.10	0.50	0.00	0.20
11.	Sodium (mg/l)	River	3.6	2.38	2.07	2.68
		Rain	0.40	0.25	0.00	0.22
12.	Phosphates (mg/l)	River	0.39	0.34	0.29	0.33
		Rain	0.06	0.06	0.00	0.04
13.	Sulphates (mg/l)	River	10.87	2.46	0.00	4.44
		Rain	0.24	1.19	0.24	0.56
14.	Nitrates (mg/l)	River	0.23	0.10	0.24	0.19
		Rain	0.52	0.03	0.13	0.23
15.	Ammonia (mg/l)	River	0.18	0.05	0.31	0.18
		Rain	0.34	0.00	0.18	0.173

N.B. Parameters are measured in triplicates

The mean turbidity, DO, chlorides, sulphates, phosphates, nitrates and ammonia levels of the Epie creek were lower in the dry season than in the wet season. This means that runoff water contributes a significant proportion of these constituents into the Epie creek. The mean levels for chloride, phosphates, sulphates, nitrates and ammonia were found to be significantly lower than the safe limits for drinking water of 200-600mg/l for chlorides; 0.5mg/l for phosphates; 200-400mg/l for sulphates; 45mg/l for nitrates; and 0.5mg/l for ammonia both in the dry and wet seasons. (WHO, 1963; WHO, 1971; FEPA, 1991 - table 3). Although the levels of phosphates present in the Epie creek were found to be lower than the safe limits for drinking water, they were found to be higher than the range of 0.01-0.03mg/ l for phosphorus normally found in uncontaminated streams (USDASCS, 1975). The ammonia levels were also found to be high when compared to the value of 0.10mg /l classification for high free ammonia usually present in streams (USDASCS, 1975). The mean nitrates, ammonia, phosphates and chloride levels in sections of the Epie creek traversing the Yenagoa metropolis were generally found to be higher than the levels of the upstream section (table 1). This suggests that human activities in the metropolis greatly influence the quality of the Epie creek. Phosphates and nitrates are important ingredients to plant blooms and the eutrophication of lakes and streams. Their increased levels in addition to the relative abundance of potassium when compared to other Nigerian rivers may therefore be responsible for the high rate of plant growth observed in the Epie creek (Plate 1). It is worthy of note that the increased turbidity in the Epie creek during the wet season is in agreement with the observation of Chov (1964), who observed that turbidity was usually higher during periods of high runoff. Turbidity of the water affects the fish and other aquatic organisms mostly due to light obstruction. Welch (1952) stated that many organisms smother in prolonged conditions of very high turbidity by a clogging of their respiratory mechanisms.

Results from table 4 show that rainwater also contributed to the amount of nitrates present in the Epie creek. This is because the mean level of nitrate present in rainwater (0.23mg/l) was found to be higher than those found in the river water (0.20mg/l). High nitrates in rainwater may be due to gas flaring which is a predominant feature in the Niger delta area, in which the Epie creek is located.

Plate 1: Plant blooms in Epie Creek

The Taylor creek which empties into the Epie creek at station C appears to have no significant effect on most of the physico-chemical parameters investigated. However the DO values of 6.83 and 5.22mg/L recorded for the dry and wet seasons respectively at station C are much higher than the mean values of 3.35 and 4.45mg/L for the Epie creek. This effect is no doubt of apparent advantage to fish and other aquatic organisms downstream.

The turbidity at station C is higher than the mean turbidity in the wet season. The turbidity at station C is however lower than the mean turbidity during the dry season. The turbidity recorded at station C can be attributed to the Taylor creek.

CONCLUSION

It can be concluded from the results of this study that water quality in the Epie creek is presently to a large extent safe from a physico-chemical point of view for human consumption. However, the low DO levels indicated that the creek cannot support the lives of fish and other aquatic organisms. This is no doubt not good for the economic life of the local fisherman and the inhabitants who may rely on fish and other aquatic organisms for their source of protein. Also, increased nutrients especially nitrates and phosphates have the implication of increasing plant bloom, a situation which may lead to eutrophication in future. This is in addition to the health risk (methemoglobinemia, asphyxiation etc.) associated with high levels of nitrate in drinking water. There is therefore a dire need to properly manage wastes in the metropolis and control as well as monitor other human activities in general in order to ensure that runoff water will have a minimal effect on the Epie creek.

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Station / Season	pH		Conductivity (μσ/χμ)		TDS (mg/l)		Turbidity (NTU)		DO (mg/l)		BOD_5 (mg/l)		Chloride (mg/l)		Alkalinity (mg/l)		Total hardness (mg/l)	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
A	7.57	7.33	78.33	54	55	37.83	11.67	16.6	5.68	9.06	4.53	4.29	1.65	4.28	33.33	22	3.27	3.36
B	7.4	6.9	86.67	47.73	61	33	13.33	28	2.61	2.91	1.53	2.15	1.99	3.62	37.33	18.67	3.87	2.42
C	7.6	6.8	87.33	40	61.33	28.33	11.33	41.3	6.83	5.22	4.37	3.38	1.66	3.29	27.33	12.67	4.0	2.53
D	7.4	6.93	89.33	49.33	62	34.5	19.67	27	1.76	1.38	6.77	0.31	4.62	3.95	30	15.33	5.27	2.27
E	7.36	6.67	48	25.33	33.6	17.83	17.33	38.8	5.07	2.15	2.77	1.69	1.98	2.96	26.67	10	2.32	1.76
Mean	7.46	7.05	84.78	50.35	59.33	35.11	14.89	23.8	3.35	4.45	4.28	2.25	2.75	3.95	33.55	18.67	4.14	2.68

Station / Season	Calcium (mg/l)		Magnesium (mg/l)		Potassium (mg/l)		Sodium (mg/l)		Phosphate (mg/l)		Sulphate (mg/l)		Nitrate (mg/l)		Ammonia (mg/l)		Temperature ^0C	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
A	6.52	4.72	2.29	2.98	2.55	2.68	3.27	3.36	0.10	0.09	2.10	2.22	0.02	0.17	0.04	0.15	30.5	29.3
B	5.47	4.84	3.45	1.77	2.87	3.35	3.87	2.42	0.25	0.47	1.98	4.84	0.19	0.14	0.003	0.21	30	28.2
C	6.37	3.06	3.92	2.7	2.33	1.9	4.0	2.53	0.17	0.28	0.99	3.53	0.17	0.16	0.02	0.14	29.7	28.7
D	7.53	3.20	3.6	2.82	3.33	2.55	5.27	2.27	0.23	0.44	2.66	6.27	0.27	0.28	0.1	0.18	28.7	27.3
E	3.31	3.34	9.07	2.15	2.27	1.89	2.32	1.76	0.15	0.24	2.06	6.82	0.12	0.14	0	0.16	27.7	27.3
Mean	6.51	4.25	3.11	2.52	2.92	2.86	4.14	2.68	0.19	0.33	2.25	4.44	0.16	0.20	0.05	0.18	29.73	28.27

N.B: MEAN - mean value for stations A, B, and D

S/No	Parameter	Epie Creek		Imo River	Streams around Port Harcourt	Zambezi River	New Calabar River	Upper Ogun River	International Permissible Standards
		Dry season	Wet season						
1	pH	7.46	7.05	6.0	5.6-6.0	7.8		6.9-7.9	70-8.5 (WHO, 1971; FEPA, 1991)
2	Conductivity (µs/cm)	84.78	50.33			121.57		31-131	400-1250 (Mento..., 1986)
3	TDS (mg/L)	59.33	35.11	2.7			4.32-4013.9		500 (WHO, 1971; FEPA, 1991)
4	Turbidity (NTU)	14.89	23.89	2.1	<1.0				NS
5	DO (mg/L)	3.35	4.45			7.9	3.4-9.1	4.94-7.62	3-7 (WHO, 1993)
6	BOD_5 (mg/L)	4.28	2.25	0.25	0.15-0.92		0.15-4.95		4 (TOM, 1975)
7	Chloride (mg/L)	2.75	3.95			5.2			200-600 (WHO, 1971; FEPA 1991)
8	Alkalinity (mg/L)	33.55	18.67			55		65.6-77.9	100 (EEC)
9	Total Hardness (mg/L)	26.46	14.59	0.25	0.01-0.25	47.43			100-500 (WHO, 1963)
10	Calcium (mg/L)	6.51	4.25	0.30	0.37	10.77	0.38		75-200 (WHO, 1971; FEPA, 1991)
11	Magnesium (mg/L)	3.11	2.92	0.19	0.40	4.24	0.89		50-150 (WHO, 1971; FEPA, 1991)
12	Potassium (mg/L)	2.92	2.86	0.60	0.84	2.0	1.43		10 (EEC)
13	Sodium (mg/L)	4.14	2.68	0.59	0.78	5.63	1.20		120-400 (MORGAN, 1990)
14	Phosphate (mg/L)	0.19	0.33	0.16	<1.0	0.23			0.5 (WHO, 1963)
15	Sulphate (mg/L)	2.25	4.44	0.16	0.13-0.16	4.81			200-400 (WHO, 1971; FEPA, 1991)
16	Nitrate (mg/L)	0.16	0.20	0.10	0.054	0.13			45 (WHO, 1971; FEPA, 1991)
17	Ammonia (mg/L)	0.05	0.18	0.22	0.156-0.23	0.09			0.5 (WHO, 1971; FEPA, 1991)
18	Temperature (^{0}C)	29.73	28.27			24			NS

Source: Imo River and Streams around Port Harcourt (Ogan, 1988); Zambezi (Hall *et al*., 1977); New Calabar River (Odokuma and Okpakwasihi, 1996); Ogun River (Adebisi, 1981).

NS - No specification