

Investigation of Hydrochemical Characteristics of Surface Water around Canal and Creek Parts of Lagos, South - Western, Nigeria

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Abstract

Hydrochemical studies of surface water in canal and creek of Lagos, South-western part of Nigeria have been undertaken towards evaluating the pollution status of the environments. The water in these areas is large depository of not only domestic wastes but also industrial wastes from various drains or channels. In order to establish the pollution status of these two environments, the physical and geochemical analyses were carried out on the water samples. Physico-chemical analysis of twenty – one (21) water samples were equally undertaken in terms of temperature, salinity, pH, TDS, EC, Na, K, Ca, Mg, Cl, SO₄, NO₃, HCO₃, CO₃ and F. Also, some selected heavy metals such as Arsenic (AS), Cadmium (Cd), Mercury (Hg), Iron (Fe), Lead (Pb), Zinc (Zn), Cobalt (Co), Chromium (Cr), Copper (Cu) and Nickel (Ni) were also determined. The canal water is slightly alkaline, very hard fresh water, while the creek is alkaline, very hard brackish water with the following value range for canal and creek respectively: salinity (0-5) % and (12-20) %, pH (7.37-7.68) and (7.94-8.16), TDS (377-1,110) ppm and (2,000) ppm, EC (804-2,226) µms/cm and (3,999) µms/cm. The canal water is of Ca-Mg-HCO₃ water facies while the creek is of Ca-Mg-Na-SO₄-Cl water facies. The computational data using geoaccumulation indices (I_{geo}) revealed that the metal load in the water surpass their natural background especially with respect to Cd

and Hg. These metals are of significant environmental implications and thus need to be monitored and controlled.

Keywords: Hydrochemical, Heavy metals, Pollution, Geoaccumulation, Canal and Creek.

1.0 Introduction

Water which is a vital natural resource is rapidly becoming scarce in quantity and more importantly in quality especially in the developing countries Throughout the history of humanity, water has always sustained life and communities, and the quality of available water is essentially an index of the living standard. However, water of poor physico – chemical quality may give an adverse health effects, causing avoidable economic and human losses (Ayodele and Aturamu, 2011). That is why the slogan of the environmental protection movement is “all human economic and social stability rest on one base, the earth’s natural resources, destroy them and the foundation for all life is destroyed”. Since the quality of water is affected by the characteristics of the environment of circulation and occurrence, such sources as surface water are invariably exposed to anthropogenic and industrial pollutants (Elueze *et al.*, 2004). This study focuses on the assessment of the quality of surface water around Badagry creek and Isolo canal in Lagos metropolis, Southwestern Nigeria. This study is necessitated based on the fact that population growth in Lagos state is very rapid due to increase in birth rate and high rate of migration due to industrialization. Consequently, this study is born out of the need to evaluate the effects of the above realities on surface water quality in terms of physical and chemical characteristics towards deducing their pollution status.



Fig.1: A location map of Study Area

1.1 Physical and Geological Settings

The Isolo canal is located in the South-eastern part of Lagos and it runs via Oke-Afa, Ago-Okota, Agboju and finally empty into Badagry creek at FESTAC. The whole study area is located within Latitude $6^{\circ}26'N$ and $6^{\circ}33'N$ and Longitude $3^{\circ}17'E$ and $3^{\circ}21'E$. The study area experiences two main climatic seasons i.e. the wet season which spans from April to October and the dry season between November and March. The wet season is characterized by very heavy rainfall with average rainfall of about 1,700mm (Akintola, 1986) and there is little or no rainfall during the dry season. The temperature of the study area ranges between $22^{\circ}C$ - $32^{\circ}C$ which is relatively uniform. The coastal city of Lagos is characterized by low lying marshy belts with elevation barely above the sea level (Asiwaju Bello and Akande, 2001). The drainage system consists of major rivers such as River Ogun, River Magidun, River Shasha and River Oluwa which drain into Lagos and Lekki Lagoons (Ajayi, 1998). The drainage system also consists of River Opomu and Abesan to the West and Northwest boundary of the study area respectively. These rivers also flow Southerly into the Lagoon by series of creek system.

The city of Lagos falls within the Dahomey basin of South-western Nigeria. It is a coastal city on the Gulf of Guinea, North of Atlantic Ocean

in the Western part of Nigeria. It is low lying area with several points coinciding with, or virtually close to the sea level. The area is bounded in the South by the Atlantic Ocean and in the west by the border between Nigeria and Benin republic. There are two broad distinct geological formations: The Cretaceous-Tertiary succession of Abeokuta Group to Ilaro formation and The Quaternary formation of the coastal plain sand (Recent alluvium), (Omatsola and Adegoke, 1981; Adekeye *et al.*, 2005)

The geology of the Lagos area is characterized by a continuous alternating of clayey and sandy horizons. These horizons show some lateral continuity in some places but are discontinuous in most places. The stratigraphic variation along the coastline (East-West), at the topmost unit is made up of sands of various types grading into clay, sandy-clay, coarse gravelly and conglomeratic sand and shale at basal levels. At the hinterland (Northern) section, the lithology varies from reddish lateritic clay horizon at the top, grading into sands, clay, sandy clay and shale at deeper levels.

2.0 Materials and Methods

The fieldwork was carried out between 7th and 9th of November, 2017. A total of twenty - one (21) samples were collected which stretch across both the canal and the creek. The coverage areas include FESTAC, Mile 2 and Kirikiri for the Badagry creek and Ago- Okota and Oke- Afa for the Isolo canal. The sample locations were adequately established with the use of Global Positioning System (GPS). The physical and chemical parameters such as temperature, depth, time, pH, conductance, salinity, refractive index and Total Dissolve Solids (TDS) were determined on the field using Salinometer, pH meter, Refractometer, Multicomponent device and Timer. The water samples were collected for every location in three (250ml capacity) airtight plastic bottles that was previously cleaned and rinsed with detergent and distilled water. The water samples were preserved by keeping them under low temperature (below 4c°) to prevent deterioration by bacteria. Each and every sample bottle was adequately labelled to avoid mix up. These were then taken to the Laboratory for analyses and determination of the major ions and heavy metals concentration in the water samples using AAS and IC-PMS respectively. The chemical analyses were carried out at Institute of Oceanography laboratory, Victoria Island, Lagos.

Table 1: Physical Parameters of water samples in the study area

S/No	Location	Description	Coordinate	TDS (ppm)	EC (µmS/cm)	Temp (°C)	Salinity (‰)	Refractive Index	pH	Water Depth	Time
1	L1	Coconut Creek	6°26'00.5"N 3°19'14.2"E	2000	3999	31.4	20	1.3370	8.16	0.93m	10.45am
2	L2	Kirikiri creek	6°27'0.5"N 3°18'14.2"E	2000	3999	32.2°	20	1.3370	8.06	1.50m	11.117am
3	L3	Festac-Agboju creek	6°28'35.1"N 3°17'31.3"E	2000	3999	32.4°	12	1.3350	7.94	0.5m	11.50am
4	L4	Ago-Okota canal	6°30'34.6"N 3°18'03.8"E	1110	2226	32.3°	5	1.3340	7.68	1.80m	12.25pm
5	L5	Isolo canal	6°31'3653"N 3°19'02.3"E	377	761	33°	0	1.3330	7.48	1.50m	2.05am
6	L6a	Oke Afa canal	6°32'12.6"N 0°03.8"E	804	399	33.5°	0	1.3330	7.37	1.50m	2.45pm
7	L6b	Oke Afa borehole	6°31'36.5"N 3°19'02.3"E	2441	218	32°	0	1.3330	7.63	0.22m	3.30pm

NB: TDS = total dissolved solids

Table 2: Results of Chemical Analysis of the water samples in the study area

	SAMPLE LOCATION AND DESCRIPTION	Na (mg/L)	Mg (mg/L)	K (mg/L)	Ca (mg/L)	Cl (mg/L)	SO ₄ (mg/L)	NO ₃ (mg/L)	HCO ₃ (mg/L)	CO ₃ (mg/L)	F (mg/L)
BADAGRY CREEK	LOC 1 COCONUT	6000	4500	150	1500	7978	1596	223	36	27	0.75
	LOC2 KIRIKIRI	4700	4580	126	1270	6025	1302	231	64	42	0.69
	LOC 3 FESTAC-AGBOJU	3500	4625	38	875	4654	930	235	34	63	0.60
	MAXIMUM	6000	4625	150	1500	7978	1596	235	34	63	0.75
	MINIMUM	3500	4500	38	875	4654	930	223	36	27	0.60
	MEAN	4733	4568.33	121.33	1215	6219	1276	229.67	61.33	44	0.68
	S.D.	1250	63.31	31.33	316	1670.50	333.80	6.11	24.11	18.08	0.08
ISOLO CANAL	LOC 4 AGO-OKOTA	28	70	70	210	10	2	145	30	60	1.20
	LOC 5 OKE-AFA i	32	60	3	240	12	3	145	92	70	1.50
	LOC6 OKE-AFA ii	36	90	9	270	15	3	202	96	68	1.56
	MAXIMUM	36	90	70	270	15	3	202	96	70	1.56
	MINIMUM	28	60	3	210	10	2	145	30	60	1.20
	MEAN	32	73.3	29	240	12.3	2.66	175.67	89.33	66	1.42
	S.D.	4.0	15.3	35.5	30	2.5	0.58	28.75	3.33	5.29	0.19
BOREHOLE	LOC 7 OKE-AFA iii	72	190	18	540	30	6	196	490	360	235
	WHO 1996	200	150	15	200	600	400	100	600	120	1.5
	MPL 2006	200	150	72	200	600	400	100	600	120	1.5

Table 3: Results of Heavy metals in Canal and Creek water samples in the study area.

	SAMPLE LOCATION AND DESCRIPTION	As	Cd	Hg	Pb	Zn	Co	Cr	Cu	Ni	
		Ppm	ppm	Ppm	Ppm	Ppm	Ppm	Ppm	Ppm	Ppm	
BADAGRY CREEK	LOC 1 COCONUT	1.020	1.012	1.130	10.240	4.230	0.021	0.021	0.023	0.002	0.300
	LOC 2	1.064	1.074	1.125	12.070	5.410	0.019	0.023	0.021	0.003	0.302
	KIRIKIRI										
	LOC 3	1.130	1.139	1.120	13.120	6.440	0.017	0.025	0.020	0.004	0.305
	FESTAC-AGBOJU										
	MAXIMUM	1.13	1.14	1.13	13.12	6.44	0.02	0.03	0.03	0.004	0.31
	MINIMUM	1.02	1.01	1.12	10.24	4.23	0.02	0.02	0.02	0.002	0.30
	MEAN	1.07	1.08	1.13	11.81	5.36	0.02	0.02	0.02	0.003	0.30
	STANDARD DEVIATION	0.06	0.06	0.01	1.46	1.11	0.002	0.002	0.003	0.001	0.003
ISOLO CANAL	LOC 4	0.030	0.497	1.010	4.200	0.010	0.018	0.045	0.020	0.005	0.905
	AGO-OKOTA										
	LOC 5	0.030	1.103	0.890	9.400	0.010	0.306	0.032	0.020	0.006	1.200
	ISOLO										
	LOC 6	0.030	1.450	0	16.240	0.010	0.129	0.025	0.020	1.870	1.905
	OKE-AFA I										
	MCWR	0.001	0.0001		0.5	0.003	0.015			0.003	
	MAXIMUM	0.03	1.45	1.01	16.21	0.01	0.31	0.05	0.02	1.87	1.91
	MINIMUM	0.03	0.50	0.00	4.20	0.01	0.02	0.03	0.02	0.01	0.91
	MEAN	0.03	1.02	0.63	9.94	0.01	0.15	0.03	0.02	0.63	1.34
	STANDARD DEVIATION	0	0.48	0.55	6.02	0	0.15	0.01	0.0	1.08	0.51
	WHO MPL	0.1	0.003	0.001	0.30	0.01	3.0		0.05	2.0	0.02

Table 4: The estimated index of Geoaccumulation (Igeo= Log (Cm/1.5*Bm) for the Creek and Canal water samples in the study area

	SAMPLE LOCATION AND DESCRIPTION	As	Cd	Hg	Fe	Pb	Zn	Ce	Cr	Cu	Ni
BADAGRY CREEK	LOC 1 COCONUT	-1.404	2.17	5.24	-12.95	-2.15	-12.29	-10.62	-12.55	-15.20	-8.55
	LOC 2	-1.34	2.26	5.23	-12.71	-1.79	-12.43	-10.49	-12.89	-14.61	-8.54
	KIRIKIRI										
	LOC 3	-1.26	2.34	5.22	-12.59	-1.54	-12.59	-12.37	-12.87	-14.20	-8.53
	FESTAC-AGBOJU										
	MAXIMUM	-1.26	2.34	5.24	-12.59	-1.54	-12.29	-10.37	-12.55	-	-8.53
										14.20	
	MINIMUM	-1.40	2.17	5.22	-12.95	-2.15	-12.59	-10.62	-12.87	-	-8.55
										15.20	
	MEAN	-1.33	2.26	5.23	-12.75	-1.83	-12.44	-10.49	-12.74	-	-8.54
										14.67	
ISOLO CANAL	STANDARD DEVIATION	0.07	0.09	0.007	0.18	0.30	0.15	0.13	0.17	0.30	0.012
	LOC 4	-6.49	1.14	5.07	-14.24	-10.87	-12.51	-9.52	-12.87	-	-6.696
										13.87	
	AGO-OKOTA										
	LOC 5	-6.49	2.29	4.891	-13.07	-10.87	-8.42	-10.01	-12.87	-	-6.55
										13.61	
	ISOLO										
	LOC 6	-6.49	2.69	0	-12.29	-10.87	-9.67	-10.37	-12.87	-	-5.89
										5.33	
	OKE-AFA I										
	MAXIMUM	-6.49	2.69	5.07	-12.29	-10.87	-8.42	-9.52	-12.87	-	-5.89
										5.33	
	MINIMUM	-6.49	1.14	0	-14.24	-10.87	-12.51	-10.37	-12.87	-	-6.96
										13.87	
	MEAN	-6.49	2.04	3.32	-13.20	-10.87	-10.20	-9.97	-12.87	-	-6.46
										10.94	
	STANDARD DEVIATION	0	0.80	2.88	0.98	0	2.00	0.43	0	4.86	0.54

3.0 Discussion of Results

Physical Results

The salinity values of the water samples as shown in Table 1, indicates medium salinity for the creek water and very low to negligible salinity for the canal water. It could be observed that salinity increases seaward and this could be attributed to oceanic influence which is the main source of Na and Cl. The pH of the water was observed to be increasing in the seaward direction, though the values of both the creek and the canal still

fall within the WHO (2006) maximum permissible values of 6.5 or 9.5. Total Dissolved Solids (TDS), according to the WHO standard (2006), the TDS values for the creek water samples were excessive while the canal water samples were within the permissible limit except at Ago - Okota which is excessive. In accordance with the USGS classification, the creek water samples are slightly saline while the canal water samples are fresh water. Based on the UNESCO classification (1973), the hazard level of the water samples is moderate for the creek water and low for canal water samples.

The creek water could be regarded as highly mineralized while there is low mineralization in the canal waters. Also, Electrical conductance (Ec), in accordance with Wilcox quality classification (1955) in terms of Agricultural usage (i.e. irrigation), the creek water samples are unsuitable while the canal water samples range from permissible to doubtful. However, classification based on the California Fertilizer Committee Classification (1975) with respect to hazard level, the creek water is of high hazard while the canal water is moderately hazardous and this can be compared with the recent work of Yusuf *et al.*, (2014) that reported the canal water to be unpolluted with respect to Zn, Cu, As, Ni, Co, Cr, Cd, Pb, and Fe while Hg is the only pollutant in canal water.

Chemical Results

The results of the cations concentration in the water samples are shown in Table 2 above. Based on the WHO standards (2006) for the various cations, the creek water samples are contaminated with respect to the four major cations {Na, Ca, Mg and K} analysed while reverse is the case in the canal water with an exception of calcium. Also, the creek water samples are polluted by Cl, SO₄ and NO₃, while the canal water samples are only contaminated by NO₃ when compared with WHO standard (2006). The Total Hardness (TH) for both creek and canal water can be rated to be very high and thus not suitable for both domestic and industrial usage.

Generally, the major ionic concentrations in the Creek water are higher than the Canal water with the exception of bicarbonate and carbonate (Fig. 2). Both Canal and Creek water have comparable high values of NO₃, which were generally above 200ppm. The observed high nitrate value is an indication of anthropogenic input. The mean cationic and anionic

concentrations from both media are in the following order: Canal water: Cations $\text{Ca} > \text{Mg} > \text{K} > \text{Na}$, Anions $\text{NO}_3 > \text{HCO}_3 > \text{CO}_3 > \text{Cl} > \text{SO}_4$ Creek water: Cations $\text{Na} > \text{Mg} > \text{Ca} > \text{K}$, Anions: $\text{Cl} > \text{SO}_4 > \text{NO}_3 > \text{HCO}_3 > \text{CO}_3$.

Whereas, the heavy metal concentrations in the waters of both the canal and Creek revealed higher enrichment with respect to Cd, Hg, Fe and Ni. However, As and Pb are found at elevated concentration in the creek only (Fig 3). The order of enrichment of the heavy metals in the waters is as follow:

Creek water: $\text{Fe} > \text{Pb} > \text{Hg} > \text{Cd} > \text{As} > \text{Ni} > \text{Co} > \text{Cr} > \text{Zn}$

Canal water: $\text{Fe} > \text{Ni} > \text{Cd} > \text{Fe} = \text{Cu} > \text{Zn} > \text{As} = \text{Co} > \text{Cr} > \text{Pb}$

Hydrochemical Facies

There are two distinct hydrochemical facies identified. The creek water is Earth-Alkaline (with high alkali component) with chloride as the predominant anion while the canal is Earth-Alkaline with HCO_3 as the predominant anion as shown in Piper Trilinear Diagram (Figure 4).

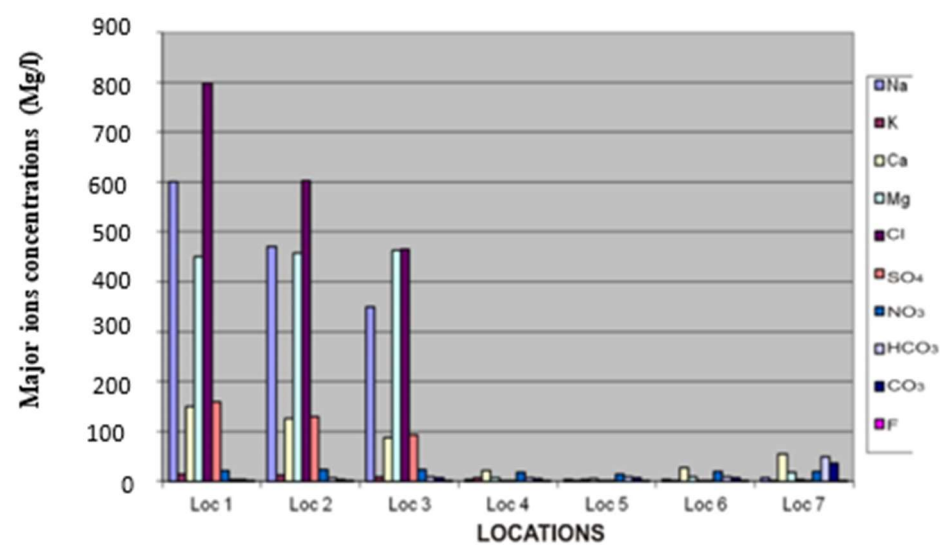


Fig. 2: Histogram of major ions concentrations in the creek, canal and borehole water

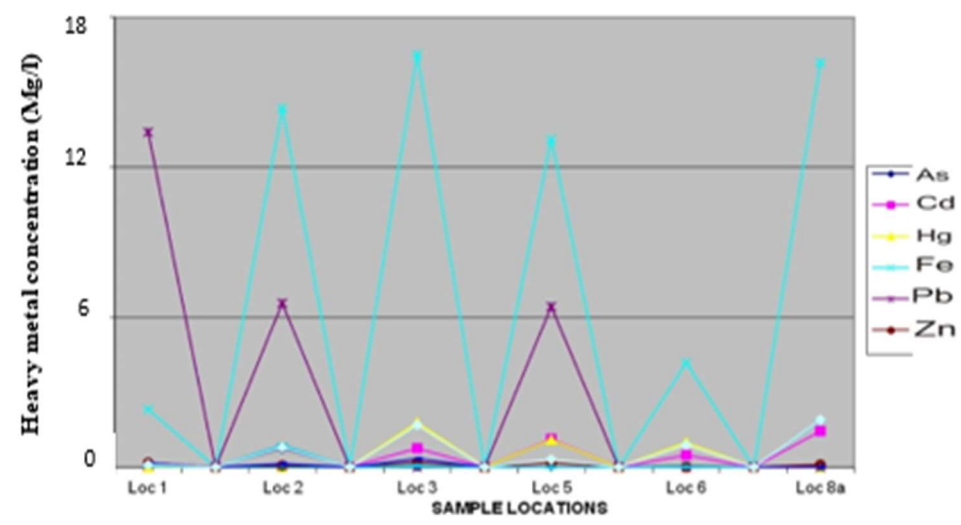


Fig. 3. Heavy metal concentration of the creek and canal water

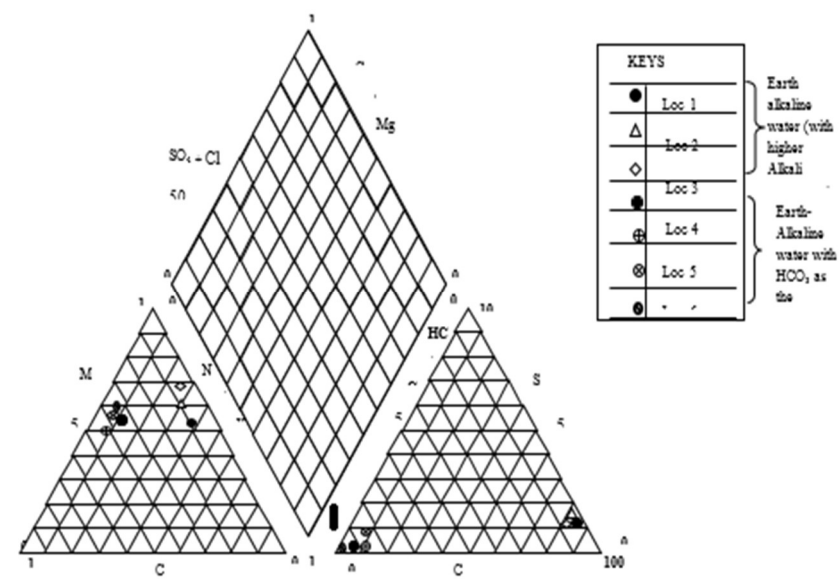


Fig.4: A Piper Trilinear diagram showing water types in the creek, canal and boreholes water in study Area

4.0 Conclusion and Recommendation

This study concluded based on the results of physical and chemical analyses that the creek water samples are polluted with respect to the four major cations analysed namely Na, Ca, Mg and K but are not with respect to the canal water samples with an exception of calcium. Also, the creek water samples are polluted with Cl, SO₄ and NO₃, while the canal water samples are only polluted by NO₃ when compared with WHO (2006) standards. It is also observed from this study that the two water bodies (Canal and Creek) are polluted as a result of anthropogenic effluents. Therefore, the concentrations of Hg and Cd in both water is at alarming rate and this calls for concern. Hence there is need for effective monitoring of the industrial and the domestic effluents from the environment. This will also go a long way in preventing unforeseen endemic situations resulting from toxic metal accumulations.

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