Self Purification of a Freshwater Stream in Ile-Ife: Lessons for Water Management

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ABSTRACT Stream flow samples were collected with distances downstream over a river stretch of 6.5km. The rivers transcend different land use pattern and took it source from a large refuse dump in the central market (Ogbe market) Ile-Ife before flowing into a dam. Seven sampling points were carefully selected downstream the channel. The examined water parameters were sodium (Na^+), calcium (Ca^+), potassium (K^+), magnesium (Mg^+), phosphorous (P), Nitrate (No_3^-), water hardness, ph and suspended particles. Descriptive and inferential methods were employed on the study. Chemical parameters highly varied with distances downstream. A comparison of the chemical parameters at sampling point 1 and 7 shows that Mg^+, Ca^+, Na^+, P, No_3^-, water hardness, suspended particles reduced at the rivers mouth (dam) correlation statistics further shows that only Ca^+, P, No_3^- and suspended particles actually showed evidences of self purification. Further, Ph and Na^+ in the river actually exceeded the WHO highest permissible drinking water standard. The paper calls for further research in the area of monitoring water quality.

1. INTRODUCTION

Running water is capable of purifying itself with distances through a process known as self-purification. This is the ability of rivers to purify itself of sewage or other wastes naturally. It is produced by certain processes which work as rivers move downstream. These mechanisms can be inform of dilution of polluted water with influx of surface and groundwater or through certain complex hydrologic, biologic and chemical processes such as sedimentation (behind obstruction), coagulation, volatilization, precipitation of colloids and its subsequent settlement at the base of the channel, or lastly due to biological uptake of pollutants. On the other hand, certain streams are capable of adding-up more materials as they flow downstream from riparian inputs (see: Ongley; 1987; 1991). The extent of self purification in any stream depend on certain factors some of which are: temperature; level of river; river velocity; amount of inorganic compound in the stream and the arrow; distribution and types of aquatic weeds along the channel. In a study of the assessment of water quality a ropical Nigeria city Ajibade (2004) has reported variation in stream water quality; he further observed that none of the water quality parameters met the WHO standard for drinking water.

Quality of water is of paramount impor-tance because of its role to human health, aquatic life, ecological integrity and sustainable economic growth. Indeed, without good quality water sustainable development and environmentally sound management of water resources will be meaningless. For example, on a global scale, water borne disease is estimated to be responsible for about 3 million deaths and also to render sick a billion people (World Bank, 1993). In Nigeria, alone, in 1991 a total of 72,000 cholera cases were reported. Besides, there were evidences that other water borne related diseases such as hepatitis; diarrhoea; dysentary; cholera are also on the increase. For instance, water diarrhoea alone is responsible for about 300,000 deaths (see: Sadiq, 1991 and William 1991). The coverage of potable water in the country was 20% in 1985, this rose to 30% in 1991, in the same urban areas. It rose from 30% in 1985 to 50% in 1991. Presently, the average water consumption per day is about 36 litres per capita day (LPCD) as against the recommended 90LPCD in the Nigeria National Rolling Plan of 1993-1995. In real terms, service level in some rural areas in the country is about 10 and 30LPCD respectively as against the recommended standard of 60 and 120 LPCD respectively (Nigeria, 1994). Consequently, people particularly in rural areas resort to various unhygienic sources of water supply like ponds; rivers; rain and hand dug wells. Numerous cases of water borne diseases have been documented

in the country. For example, there are increasing evidences of fresh outbreak of cholera; diarrhoea; guinea worm and other water borne diseases. Indeed, a survey by the Federal Ministry of Health (FMOH) in 1989 showed outbreak of cholera in Katsina, Kaduna, Kano, Bornu, Plateau, Benue, Cross-River, Akwa Ibom, Lagos and Delta states, all in Nigeria.

The above positions is further complicated by the nature of water management system in this part of the world. For instance, in Nigeria, the state owns the water resource, and other hydraulic infrastructures. Public official decides who gets the water and how much to be changed. Water supply lacked a market-based approach which is more effective and less wasteful. The end result of this is that these water outfits are inefficient and almost crippled with lack of fund. It should be noted that the most common treatment given to water is chlorination, although a very important process, but still a minor segment of water treatment. Indeed, other segments of water treatments are totally forgotten. This explains the poor quality of water not only in untreated streams but also of piped water on this environment.

However, since majority of the inhabitants in this locality have no access to treated water, people generally lives directly on polluted streams where quality of water depended solely on the extent of natural cleansing. The river under study takes its source from a highly polluted source and empties ills water into a (University) dam. There is therefore a need to determine evidences (if any) of the processes of self purification and also identify which of the water chemistry variable are affected by the processes and also examine the portability of the water of the study area with a view to making recommendations for the purposes of water resources management in the study area. As a result of these problems, majority of the people on this part of the world do not have access to potable water.

2. THE STUDY AREA

The choice of river Ogbe is because it is a stream segments drawing an urban environment and later flowing into a dam, from where the water is pumped for various uses. The study area is Ile-Ife, Osun State, Nigeria. Located on the intersection of longitude $4^{O}3'E$ and $7^{O}28'N$. It is the headquarters of Ife Central Local Government Area; it has a population of 185,256 (NPC, 1992) (See Fig 1).

Temperature is high throughout the year (about $37^{O}C$). Rainfall is about 1,500mm (NMO, 1962) with a large percentage falling in the rainy season (April-November). The other months are usually dry and rainless.

River Ogbe is a tributary of river Opa which in turn contribute water to river Shasha. The river flows into the Obafemi Awolowo University dam (5ha). The flow pattern exhibited by the streams is highly patterned along the incidences of rainfall. The river exhibits higher velocity and greater volume during rainy season, but almost dries up during the dry season.

The city of Ile-Ife is compacted together with high density. The city generally lack planning and order in its detailed layout. The Palace or the *Afin* is located at the centre of the town.

Table 1: Land use characteristics of the sampling points along river Ogbe Ile-Ife

Sampling points	Landuse characteristics	Description of sample points
1.	Refuse Dump (market) urban residential area	Sabo market.
2.	Urban built up area	Oluwasanmi house
3.	Boundary of built-up area	End of the urban built up area
4.	Perennial crops, farmland tree crops i.e. cocoa, kola nuts, oranges, banana stomps.	The point is located to the right hand side of Oluwasanmi road (OAU), enroot the University Campus.
5.	Arable farming, farmlands yams, cassava	Located close to road seven gate (OAU campus) below the right hand tributary of the Ogbe river.
6.	Residential/Arable, farming, grove junior staff quarters (part) modern housing types.	Below the confluence
7.	Burnt Buds/patches of farmland	Mouth of the University Dam.

Source: Author.

Farming and buying and selling form and important activity with the market located at the centre of the town. There is low level of manufacturing activities. Because of the size of the town, consumption pattern and the peoples attitude huge amount of domestic waste is generated which are not properly disposed off. These are dumped indiscriminately along streets, open spaces and river channels.

Two major land use patterns are discernible in the study area. These are namely agricultural and urban (See Table 1 and Fig. 1).
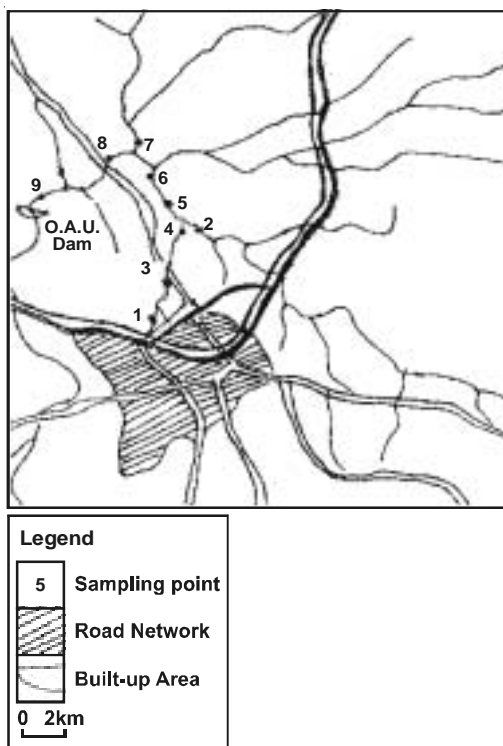

Fig. 1. Ile-Ife showing the sampling points

3. MATERIALS AND METHOD OF STUDY

After a preliminary assessment of the river channel, 7 sampling points were chosen at intervals (10km; 0.1km, 0.6km, 1.4km, 2.6km, 3.7km, 6.4km) from the source to the point closer to the rivers mouth at the University dam site.

The samples from the selected water points were taken during the dry season of March 1990. Samples were taken in plastic water bottles. 9 parameters were tested. These are Sodium (Na^+),

Calcium (Ca^+), Potassium (K^+), Magnesium (Mg^+), Phosphorous (P), water hardness, pH and suspended particles and Nitrate (No_3^-).

Na^+ K^+ were analyzed using a flame analyzer while Mg^+ and Ca^+ were analyzed using atomic absorption spectrometer. The PH was determined by glass electrode PH meter, No_3^- by chlorimetric method using phenol disulphonic acid, water hardness by volumetric method using soap solution. A suspended particle was analyzed by filtration method and phosphorous by bray method.

The inferential method employed is the product moment linear correlation statistics which was used to test the strength of the association between water chemical characteristics and distances downstream the river channel.

4. RESULTS

4.1 Descriptive Characteristics of Chemical Parameters

The results of the descriptive statistics shows that the means of the chemical parameters vary from one parameter to the other (Table 2). For example, it ranges from 317mg/L for water hardness 154mg/L for Na^+, while suspended particles is 0.06mg/L. On the extent of the variation between each of these chemical parameters and their mean the result of the standard deviation vary from one parameter to the other. This ranges from 135mg/L for Na^+ to 0.7mg/L for suspended particles. On the relative deviation from one sample point to the other, the result of the coefficient of variation showed that four parameters (Mg^+, Ca^+, K^+, suspended particles No_3^-) are heterogeneous with coefficient greater than 33%. The implication of the above is that these parameters vary on the nature of their occurrences. This point to the fact that water chemistry properties along the channel is highly variable. High variability in stream water quality has equally been reported by Ajibade (2004) in a study of the assessment of water quality in Nigeria. This therefore suggests that there is a need for close monitoring of chemical parameters for the purposes of water resource management in the study area.

4.2 Spatial Characteristics of Water

All the chemical parameters vary in the concentration especially as shown in Table 2. The value of Na^+ decreased from 152.1mg/L to

42.0mg/L in sampling point 3. This later increased to 67mg/L and rose to 4mg/L at the rivers mouth. Mg^+ decreases from 0.16mg/L to 0.13mg/L at the rivers mouth, the value decreased to 0.6mg/L. Ca^+ had an initial value of 1.40mg/L this decreased to 1.30mg/L at sample point 6 and later 1mg/L at sample point 7 [see Figs. 2(a-c)].

K^+ at the source was 3.76mg/L, it went down to 0.97mg/L on sample point 3 and to 1.49mg/L at sample point 4. This eventually rose to 6.10mg/L and 10.4mg/L at sample point 6 and 7 respectively (see Fig. 2d). The increase may possibly be from riparian inputs. Water hardness had an initial value of 380mg/L, this changes to 348mg/L, 362mg/L before getting to sample point 6. At the mouth of the stream (sampling point 7) 27mg/L was recorded (Fig. 2e). Suspended particles decreased from 0.20mg/l to 0.01mg/L at the mouth (see Fig. 2f). pH initially was 8.40 (Fig. 2g), it changed to 8.50 at the second sample point and later 8.80 in sample point 6. This changed to 9.50 at the mouth of the river. No_3^- initially was 36mg/L, it went down to 7.20mg/L on sampling point 4. In sampling point 5 it has increased to 12.2mg/L. This later reduced to 4.0mg/L (Fig. 2h). Finally, phosphorous decreased from 3.40mg/L at the source to 2.30mg/L in sample point 3. In sampling point 4, it increased to 2.60mg/L , afterwards it consistently decreased to 1.30mg/L (Fig. 2i). The high variability in concentration of water chemistry is as a result of land use changes coupled with the impact of self purification processes, which has either increased of decreased concentration of water chemical parameters in the study area. Ajibade (2004) reported a similar trend in Nigeria.

4.3 Self Purification

A comparison of the values of chemical parameters at the source (sampling point 1) and at the mouth (sampling point 7) (see Table 4) shows that seven parameters (i.e. Mg^+, Ca^+, water hardness, suspended particles, No_3^-, P and PH) out of the 9 parameters under study decreased in their concentration at the mouth of the river (see Table 4). This might be due to processes such as coagulation, sedimentation, and volatilization (see: Ongley, 1991). Hence, water properties are likely to be present in lower concentration in in the water of the dam (although such investigation is beyond the scope of this study). The other two parameters must have added into their concentration probably from riparian inputs or plants senescence along the river channel (Ongley, 1991). This consequently suggests a need to examine the concentration of these two parameters in some details for the purpose of environmental management.

In a further analysis, the result of the linear correlation (Table 4) between water values and distances downstream shows that four parameters Ca^+, No_3^-, P and suspended particles) actually decreased with distances downstream with correlation values of -0.60; -0.66; -0.70 respectively, while other parameters (Mg^+, K^+, PH, No_3^- and water hardness increased with distances downstream having correlations values of 0.90; 0.70; 0.90 and 0.30 respectively and therefore indicating a high correlation value. One can therefore conclude that artificial purification efforts at the water works (O.A.U dam) should be directed towards controlling the concentration of Mg^+, K^+, PH, No_3^- and water hardness which increased with increases in distance downstream. This will be more important at a future date, when the pollutant loadings in the water body might have increased particularly due to anthropogenic influence in the study area. Lernlerc,(1964) , Kalinin, (1971) and Ongley (1991) all reported that flowing streams changes in quality with distances downstream . Ajibade (2004) further confirmed this in a similar study in Nigeria.

Table 2: Sampling points and water chemical parameters

Sample points	Na^+	Ca^+	K^+	Mg^+	P	pH	Water hardness	Suspended particles mg/L	No_3^-
1	152	1.40	3.76	0.16	3.40	8.40	380	0.02	36
2	61	1.30	1.23	0.13	2.60	8.50	322	0.01	15
3	45	1.10	0.91	0.13	2.3	8.80	348	0.04	12
4	67	1.20	1.49	0.13	0.11	8.80	362	0.02	7.20
5	148	0.70	0.69	0.13	2.10	8.80	380	0.01	17
6	410	1.0	6.92	0.09	1.30	9.40	258	0.01	2.40
7	137	1.0	10.4	0.06	1.30	9.50	270	0.01	4.0

All values apart from Ph in Mg/L.

4. 4 River Potability

A comparison of the values of water chemistry at the rivers mouth with WHO (1971) drinking water standard (Table 5) shows that two out of the nine parameters (Na^+ and PH) exceeded the WHO (1971) maximum permissible limit of drinking water standard. Also, these two parameters have bee found to increase with distances downstream with correlation values of +0.90 and +0.30 respectively. Other water parameters fell short of the required limits. Excess concentration of Na^+ may probably be from riparian inputs from the surrounding farmlands, this has been noted to aggravate hypertension in adults and also to elevate blood pressures in children (WHO, 1978). The high PH can be indicative of the extent of chemical pollution from the riparian land use, inform of leachates from chemical fertilizers and forms of herbicides from farmlands. Therefore, treatment work at the University waterworks should be directed towards reducing the concentration of these two parameters.

Table 3: Descriptive characteristics of water samples

Variable	Na^+ mg/L	Mg^+ mg/L	Ca^+ mg/L	K^+ mg/L	Water hardness mg/L	Susp-ended particles mg/L	pH	No_3^- mg/L	P mg/L
Mean	154	0.12	2.53	3.63	317.	0.06	8.89	12.8	2.21
Standard deviation	135	0.03	8.86	3.23	44.78	0.07	0.05	10.3	0.70
Coefficient of variation %	87.66	25	350	88.98	14.78	116	0.61	80.46	31.67

Source: Authors Computation.

Table 4. Self purification attributes of water samples

S. No.	Chemical parameters	Value at source (sampling point 1)	Value at the mouth (sampling point 7)	Differences in values of water samples (pt. 1 & 7)	Correlation analysis
1.	Mg^+	0.16mg/l	0.06mg/l	+0.1	0.90*
2.	Ca^+	1.40mg/l	1.0mg/l	+0.4	-0.60*
3.	K^+	3.76mg/l	10.30mg/l	-6.54	0.70*
4.	Na^+	152.3mg/l	136.6mg/l	+110	0.30
5.	P	3.40mg/l	1.30mg/l	+21	-0.70/
6.	No_3^-	36mg/l	4.0mg/l	+32	-0.66*
7.	Water Hardnes4	380mg/l	270mg/l	+110	0.75*
8.	Suspended particles	0.20mg/l	0.01mg/l	+0.19	-0.66*
9.	pH	8.40	9.50	-1.1	0.90*

Source: Author's Computation
*Significant at 0.05 level

Table 5: Drinking water standard

| Chemical Parameters	Values at the Rivers Mouth (sampling point 7)	WHO (1971) Drinking Water standard Highest permissible limit	Maximum permissible limit
Mg^+	0.06mg/l	150mg/l	150mg/l
Ca^+	1.0mg/l	75mg/l	200mg/l
K^+	3.76mg/l	-	not stated
Water Hardness	270mg/l	100mg/l *	500mg/l
Suspended particles	0.01mg/l	5 units	25 units
pH*	9.50	7.0-8.5	6.5-9.2
No_3^-	4.0mg/l	45mg/l	not stated
phosphorous	1.30mg/l	not stated	not stated
Na^+	136.6mg/l	100mg/l	not stated

*All values apart from pH in Mg/l.
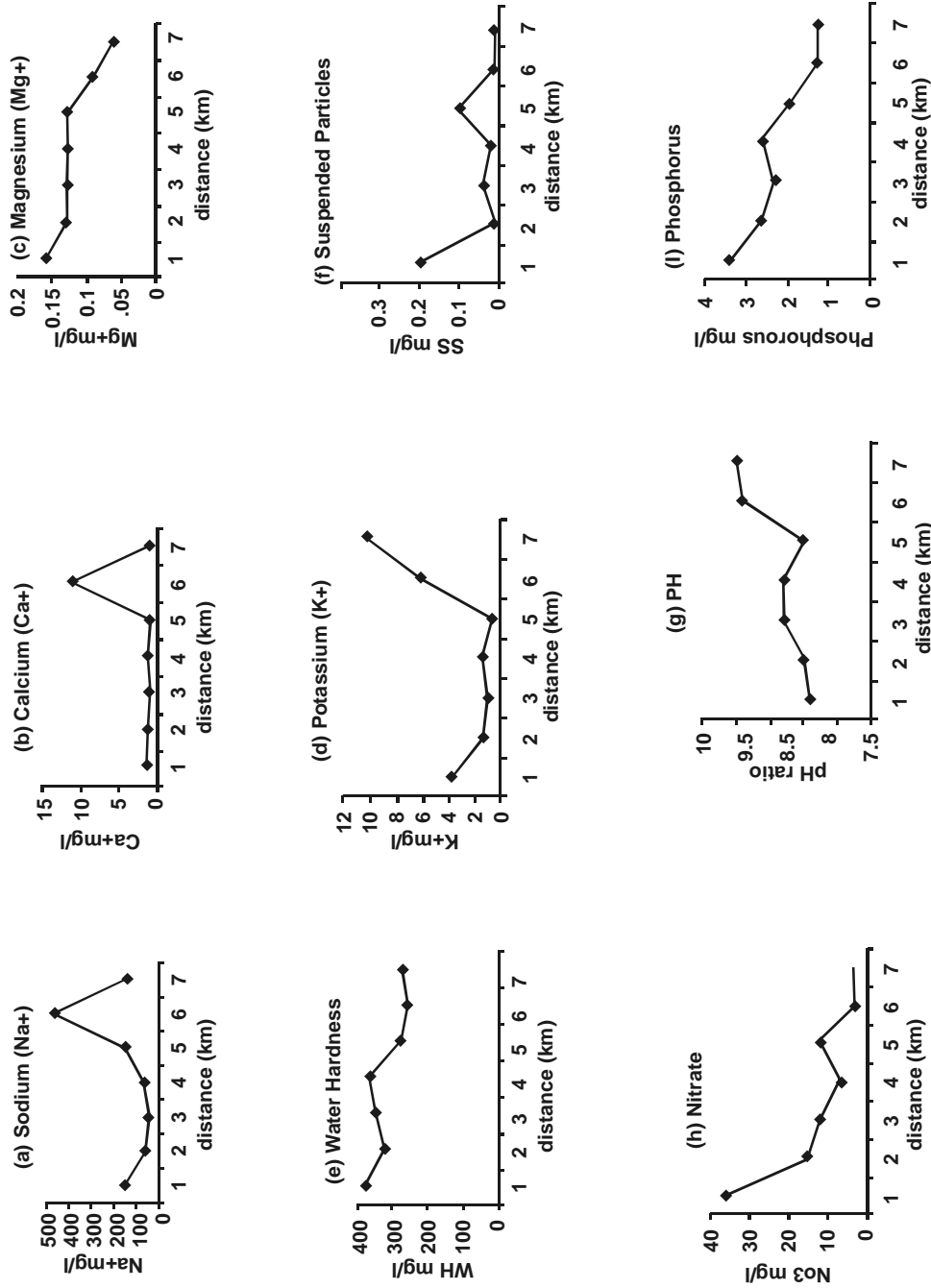
Fig. 2 (a-i.): Graphical Representation of the Self – Purification Mechanisms in River Ogbe; Ile -Ife

5. SUMMARY AND WATER RESOURCE IMPLICATION

The results of the study shows that water chemical parameters vary in both relative and absolute terms. This is clearly shown by the descriptive statistics. For example, the means of the water chemical parameters vary from 154mg/l for Na^+ to 0.06mg/l for suspended particles. Furthermore, the standard deviation also ranges from 135mg/l for Na^+ to 0.031mg/l for Mg^+. The coefficient of variation also ranges from 116% for suspended particles to 0.61% for PH. The extent of variability suggests a need for a close monitoring of the chemical parameters for the purposes of water resource management in the study area.

Furthermore, the processes of self-purification can be said to operate in study area since as all the chemical parameters examined except Ph and K^+ reduced in their concentration at the mouth of the river (sample point7) compared to their initial concentration in sample point 1. Although, when the water parameters along the sample points were correlated with distances, only Ca^+, P, No_3^- and suspended particles showed indication of a decrease in concentration downstream. This therefore suggests a need for further investigation especially in the area of monitoring more frequently the water chemical parameters with a view to preventing the build-up of some water properties and also preventing endangering lives of man and aquatics in the study area.

Other parameters such as Mg^+, K^+, Na^+, Water hardness, Ph appeared to have gain more materials downstream probably from the riparian land use comprising mainly farmlands. Hence, purification efforts along the channel should be directed to the control of these parameters. For example, Na^+ in the study area was found to exceed WHO (1971) drinking water standard. On the state of potability of water in the stream, a comparison with WHO (1971) drinking water standard showed that only Ph and Na^+ exceeded the maximum permissible limit of WHO (1971). Therefore, water treatment effort at the University dam apart from any other thing should be directed towards examining and reduction of the concentration of Na^+ and Ph.

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