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Assessment of the Variability of Contamination of Surface Water Quality in Afikpo Urban (A Case Study of Ogberehi Stream)

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Abstract— *Ensuring a safe and sustainable water body which the entire community depends on for their everyday water demand is of much importance for development. A thorough knowledge of the water body must be acquired before an effective water quality monitoring system is established (APHA 1995). This study looked at the variability of the contamination level of surface water quality of Ogberehi stream, Afikpo Urban. Water samples were collected from four (4) strategic stations along the Ogberehi stream. In carrying out the research, physic-chemical properties of the stream were tested in the laboratory. Physical parameters analysed include Colour, Conductivity, Odour, Taste, Temperature, and Turbidity; Chemical Parameters include pH, Hardness, Chlorides, Residual Chlorine, Calcium, Sulphate, Magnesium, Nitrate, Iron, and Total Dissolved Solids (TDS) and Biological Parameters include Coliform, E coli, Faecal Steptococcus, and Salmonela. Statistical tools such as mean, Variance, standard deviation and Coefficient of variation were used to analyze the parameters. The tests results were compared with W.H.O and NSDWQ standards for potable water. The results obtained from the analysis revealed that there is a significant difference between experimental yield and the standards of World Health Organization (WHO) and Nigeria Standard for Drinking Water Quality (NSDWQ), which implies that the stream has high concentration of pollutants and is not safe for direct consumption thus, requires treatments before use.*

Keywords— *Surface Water, Waste, Contamination, Environment, Water Quality.*

I. INTRODUCTION

Surface water quality is of great environmental concern since it is one of the major available fresh water resources for human consumption. Throughout the history of human civilization, streams have always been heavily exposed to pollutions, due to their easy accessibility to disposal of wastes. However, after the industrial revolution, the carrying capacity of the streams to process waste reduced tremendously (APHA 1995). Anthropogenic activities such as precipitation, inputs, erosion and weathering of crustal materials affect stream water quality and determine its use for various purposes. Seasonal variations in precipitation, surface runoff, inflow ground water flow, fertilizers and pesticides, soaps, detergents and pumped in and out flows also have a strong effect on the concentration of pollutants in streams (Ladipo et al. 2012 and Sidnei, et al., 1992). Inadequate solid waste management is a major environmental problem in some urban and rural areas (Smith, et al., 1999). There is no adequate designed solid waste disposal facility in Afikpo North local government, therefore posing contamination risk to both ground and surface water. The pollutant species in the dumpsites will continue to migrate and attenuate through the soil strata and after certain period of time might contaminate the surface water system if there is no action taken to prevent the phenomenon. Research wise, one of the important stages in the protection and conservation of water quality is the variability analysis of water and sediment quality of water system. The non- linear nature of environmental data makes physico-chemical variation of water quality often difficult to interpret and for this reason statistical approach is used for providing representative and reliable analysis of water quality (Salim, et al. 2014).

II. METHODOLOGY

Data on the assessment of water parameters were obtained using stratified random sampling technique or disruptive analysis. These samples were tested using the APHA method raw water test. Minimum and maximum values were computed for every physical, chemical and biological parameters for each sampling location and comparing the test results with the World Health Organization (WHO) standards for drinking water quality and the Nigerian Standard for Drinking Water Quality (NSDWQ) guideline. For data analysis Statistical tools such as Mean, Variance, Standard Deviation, and Coefficient of Variation are computed for all the selected parameters and the data are used for analysis.

Data Sources

The samples were collected from raw water from the Ogberehi stream (source); at different Stations i.e. Station A, Station B, Station C and Station D.

Parameters of Interest

Parameters of interest for the project are grouped into three; physical, chemical and biological parameters, thus:

Physical Parameters:

Colour, Conductivity, Odour, Taste, Temperature, and Turbidity

Chemical Parameters:

pH, Hardness, Chlorides, Residual Chlorine, Calcium, Sulphate, Magnesium, Nitrate, Iron, and Total Dissolved Solids (TDS)

Biological Parameters:

Coliform, E coli, Faecal Steptococcus, and Salmonela.

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Experimental Set Up

Field Observation

Water samples were collected from the four sampling points along the Ogberehi stream (source); at different Stations i.e. Station A, Station B, Station C and Station D, poured in a sampling bottle avoiding floating materials. The stoppers of the sample containers were closed properly to prevent outside contamination. The container was labeled describing the name of the sample, date, time, sampling point and conditions under which it was sampled (Wetzel, et al 1979). Between the times a sample is collected and analyzed in the laboratory, physical, chemical and biochemical reactions may take place in the sample container leading to changes in the intrinsic quality of the sample making it necessary to prevent or minimize these changes with suitable preservatives such as alcohol and mercuric chloride. Highly unstable parameters such as pH, temperature, free carbon dioxide, dissolved oxygen, etc. are measured at the sampling site. The preservation procedure includes keeping the samples in the dark, adding chemical preservatives, lowering the temperature to retard reactions, or combination of these.

TABLE 1.1 Preservation methodologies followed

Experiment	Preservative	Max Holding Time
pH	None	6 hours
Iron	2ml conc. nitric acid/l	6 months
B. O.D	Cool, 4°C	4 hours
Calcium	Cool, 4°C	7 days
Chloride	Cool, 4°C	7 days
COD	Cool 4°C	24 hours
Dissolved oxygen	Fix on site	6 hours
Fluoride	Cool, 4°C	7 days
Magnesium	Cool, 4°C	7 days
Nitrate	Cool, 4°C	24 hours
Dissolved solid	Filter on site using 0.45µm filter	24hours

Source: Analytical methods manual, water quality branch, environment Canada 1981.

Laboratory Procedure

The physico-chemical analysis of water samples followed the standard limnology method of APHA (1995) and National Environmental Engineering and Research Institute (NEERI 1986). **pH** was measured with a pH meter (model Nagpur 3015 Jenway), using pH buffer solution of 4.0, 7.0 and 9.0.

Turbidity was determined using spectro-photo metric method at 420nm.

Total alkalinity was determined using titrimetic method (APHA, 1995) with a $0.2nH_2504$ and methylated orange indicator.

Nitrate – nitrogen was measured using the brucine method (APHA, 1995).

Conductivity was determined using a conductivity meter (Jenway model 4010).

Total hardness by titrimetric method using Ethylene Diamine tetracetic acid (EDTA) (APHA 1975)

Dissolved Oxygen (DO) and Biochemical Oxygen Demad (BOD) were determined using gravitmetric method.

Calcium and magnesium were determined using EDTA titration method chlorides using argentometric method

Sulphate using turbidimetric method using spectrophotometer at 420nm and Nitrate using phenol Di sulfonic Acid method using spectrophotometer at 410.

Temperature was determined using mercury thermometer.

Colour was measured using visual comparison method.

Odour and taste were determined using the sense organs for taste and smell

Calcium, magnesium and iron were determined using Atomic absorption spectrophotometer (AAS) (Ademoroti, 1996)

Analytical Tool

Data for physico-chemical parameters of water samples were presented as Mean values, Standard Deviation (SD) and Coefficient of Variation (CV) for variations of the observed water quality parameters.

The four samples are Source, Station 1, Station 2, Station 3 and Station 4 denoted as Sample 1, Sample 2, Sample 3 and Sample 4

Formular

Mean, $\bar{x} = \dfrac{\sum x}{n}$

Where $x =$ individual variables

$n =$ number of samples

Variance $= \dfrac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + (x_3 - \bar{x})^2 + (x_4 - \bar{x})^2}{n - 1}$

Standard deviations $= \sqrt{Variance}$

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}\left(x - \bar{x}\right)^2}{n-1}}$$

Coefficient of variation, $\gamma = \dfrac{\sigma}{\bar{x}}$ expressed in percentage (%)

Coefficient of variation CV = Standard Deviation / Mean

CV**%**

Biological Parameter

1. Coliform: No significant count
2. E – coli: No significant count
3. Faecal streptococcus: No significant count
4. Salmonella: No significant count

III. Result and Discussion

Seventeen physico-chemical parameters of water samples were determined and analysed by prescribed standard methods given in APHA 1995.

The variation in the concentration of selected parameters are shown in table 1.2 and the statistical method employed to ascertain the degree of variation i.e. The mean, standard deviation, and coefficient of variation of all the parameters are shown Table 1.3. It is evident that the concentrations of all the parameters in the sources samples were high. The reason for these changes could be from natural processes and anthropogenic activities such as, Agriculture, urban runoff, construction, physical changes to stream channels, habitat degradation, careless, or uninformed household management,

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sediments, nutrients, pesticides, pathogens (bacteria and viruses), salts, oil, grease, toxic chemicals and heavy metals. Various chemicals and biological reactions in water depend to great extent on temperature.

TABLE 1.2. WHO and NSDWQ guidelines and the results of all the four samples

			Standards		Samples			
	Characteristics	Units	WHO	NSDWQ	Station 1	Station 2	Station 3	Station 4
					Sample1	Sample 2	Sample3	Sample4
	PHYSICAL PARAMETERS							
1.	Colour		Acceptable to consumers	Acceptable to consumers	No abnormal change	No abnormal change	No abnormal change	No abnormal Change
2.	Conductivity	µS/cm	1250	1000	29.8	10.4	12.0	10.0
3.	Odour		Acceptable to consumers	Acceptable to consumers	No abnormal change	No abnormal change	No abnormal change	No abnormal Change
4.	Taste		Acceptable to consumers	Acceptable to consumers	No abnormal change	No abnormal change	No abnormal change	No abnormal Change
5.	Temperature	^oC	$20^o – 25^o$	$20^o – 25^o$	20^o	20^o	20^o	20^o
6.	Turbidity	NTU	5	5	9.0	0.9	2.5	1.5
	CHEMICAL PARAMETERS							
7.	Calcium s	Mg/l	200	75	80	6.5	6.7	6.5
8.	Fluoride	Mg/l	1.5	1.5	1.8	0.7	0.9	0.8
9.	Hardness	Mg/l			18.2	4.0	10.0	10.0
10.	Iron	Mg/l	0.3	0.3	0.4	0.02	0.08	0.06
11.	Magnesium	Mg/l	0.5	0.20	0.7	0.03	0.05	0.04
12.	Nitrate	Mg/l	50	50	40	21	23	22
13.	pH		6.5-8.5	6.5-8.5	6.0	7.8	7.2	7.3
14.	Residual chlorine	Mg/l	0.35-0.5	0.2-0.25	0.00	0.00	0.00	0.00
15.	Sulphate	Mg/l	250	100	120	2.5	3.01	3.00
16.	Total dissolved solid	Mg/l	500	500	11.0	2.5	8.0	6.00
17.	Chloride	Mg/l	250	250	62	1.8	2.1	2.0
			BIOLOGICAL PARAMETERS					
18.	Coliform	Count/ml	0/100ml	0	0	0	0	0
19.	E- coli	Count/ml	0/100ml	0	0	0	0	0
20.	Faecal streptococcus	Count/ml	0/100ml	0	0	0	0	0
21.	Salmonella	Count/ml	0/100ml	0	0	0	0	0

TABLES 1.3. Summary of the Statistical Values from the Four Samples

S/N	Characteristics	Mean	Variance	S.D	C.V. (%)
1.	Colour	----------	----------	----------	----------
2.	Conductivity	15.55	90.997	9.54	61.35
3.	Odour	--------	----------	----------	----------
4.	Taste	---------	----------	----------	----------
5.	Temperature	----------	----------	----------	----------
6.	Turbidity	3.475	14.0025	3.742	107.7
7.	Calcium	24.925	1348.1225	36.72	147.31
8.	Fluoride	1.05	0.2567	0.50663	48.25
9.	Hardness	42.2	34.01	5.8318	55.28
10.	Iron	0.14		0.1752	125.1
11.	Magnesium	0.205	0.10897	0.3301	161.1
12.	Nitrate	26.5	81.668	9.037	34.1
13.	PH	7.075	0.5825	0.76323	10.788
14.	Residual Chlorine	0.0	0.00	0.00	0.00
15.	Sulphate	32.143	3430.72	58.573	182.23
16.	TDS	6.875	12.7292	3.5678	51.895
17.	Chloride	16.975	901.1016	30.017	176.8
18.	Coliform	----------	----------	-------	----------
19.	E-Coli	----------	----------	--------	----------
20.	F.Streptococcus	----------	----------	----------	----------
21.	Salmonella	----------	----------	----------	----------

The pH of the samples varies between 6.0 to7.8 from station 1 to station 4, 7.2 to 7.3. It is observed that pH of all the samples were high, but on an average pH of all the samples were in desirable limit as prescribed for drinking water standards. It is known that pH of 6.5- 8.5 does not cause any health hazard reported by (Pujari and Sinha 1999).

The specific Conductivity of all the samples under study varies between 29.8 to 10.4 mohm/cm in station 1, 12.0 to10.0 between station 2 to station 4. The maximum permissible limit of this parameter for drinking water is 300mohm/cm but average specific conductivity exceeds this limit because of its high values. This is due to floods containing high electrolytes in water the conductivity of samples increase drastically in the stream.

The standard total dissolved solids in the water should be below 1000mg/l to consider it as non saline and values of

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water above this limits makes it non-palatable (reported by Pujari and Sinha 1999). The permissible limit of TDS of drinking water is 500mg/l (WHO). This observation shows that the TDS is higher in source sample and other samples were low in comparison to WHO and NSDWQ recommendation and are non-saline and palatable.

Hardness has no known adverse effect on health (reported by Pujari and Sinha, 1999). However maximum permissible level has been prescribed for drinking water is 500mg/l by WHO. According to same classification water having hardness up to 75mg/l is classified as soft water 76-150mg/l is moderately soft water 151-300mg/l as hard water on the basis of this observations the results shows that, water from source were moderately hard level, reservoir moderately soft from station 1 sample was moderately soft and from station2 to station 4, soft.

The present investigation shows the concentration of calcium in the water samples varied significantly, with coefficient of variation of 147.31%.

According to Ohle, 1956, the waters above 25mg/l are classified as calcium rich. Thus, as per the recommendations of Ohle, (1956) all of the water samples are calcium rich.

The observed values of magnesium were between 0.7 to 0.03mg/l in the station 1 and station 2 and 0.05 to 0.04 in station 3 and station 4 and the coefficient of variation in this observations show that maximum content of magnesium occurred in station 4. According to WHO and NSDWQ standards, the desirable maximum permissible values of magnesium content for drinking water are 0.5mg/l and 0.2mg/l respectively. Results of present investigation show that the magnesium contents does not exceed the limit as prescribed by WHO and NSDWQ.

The range of the values of iron varies from station 1 to station 4 having 0.4mg/l at source; 0.02 at reservoir 0.08 at pipeline and 0.06 at tap. With coefficient variation % of 125% these valves are acceptable for drinking water according to WHO set limits (0.3mg/l) except the value for source sample which has a high concentration of iron (0.4mg/l).

The range of nitrate (21-40) and fluoride (0.8-1.8) with mean value of 26.5 and 1.05 respectively the coefficient of variation % of nitrate is 34.1% and fluoride 48.25% indicate that they are within the acceptable limit of WHO and NSDWQ 1.5 and 1.5 respectively.

The sulphate concentration of the samples varies between 120 to 2.5 3.07 to 3.00 from station 1 to station 3 showing significant variation. And high concentration of sulphate shows that the water contains shale, or the industrial wastes, weathering of rocks, dry deposition.

And the concentration of other samples did not vary much and are within the limit of WHO (2002) and NSDWQ (2007) standard for drinking water quality.

Total Coliform (including faecal coliform and E-coli), Faecal streptococcus and Salmonella were seen to be zero mg/l which indicates that they are not health threat in themselves. Other potentially harmful bacteria may be present though they are naturally present in the environment, and come from human and animal faecal waste which are not one of the sources of contamination of the Ogberehi stream.

IV. Conclusion

There were significant variations in water parameters from the Ogberehi Streams catchment areas of all the water samples collected and analysed for the purpose of this study. The variations could not be attributed to season but as a result of natural processes and anthropogenic activities. Domestic wastewaters, particularly those containing detergents, contribute to the higher levels of, calcium and magnesium in the water column. Fluoride, chloride, sulphate and iron concentrations indicate the presence of anthropogenic pollutants such as fertilizer runoff. The nitrate-N and organic nitrogen concentrations had spatial distributions that increased from the upstream to downstream, mainly due to the contributions of agricultural runoff, natural soluble salts, point source nutrients and sewage discharge.

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