Quality Studies of Rainwater in Uyo Municipality, Nigeria

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Abstract — Some Uyo municipalities in Nigeria are facing environmental threats due to rainwater pollution cause by a new phase of several developments going on in the City. Therefore, the objective of this study is to evaluate the levels of heavy metals in the atmosphere to fically determine the rainwater composition and to provide a background for the chemical characteristics of rainwater in some selected Municipalities in Uyo. The rainwater samples were simultaneously collected from six locations which ranges from sample A to F, (A: Nwaniba by Nsikak eduok Junction, B: Ibom connection, C: Nepaline by Aka road, D: Nwaniba junction by Oron road, E: Ikpa junction by Ikot Ekpene road and F: Barracks road by CKS junction). Samples were collected in the rainy season period of April to August and analyzed for physicochemical and heavy metal parameters. The samples were analyzed using standard procedures and instruments which indicated the following ranges of results Pb <0.001 to 0.05 mg/L, Cd <0.001 to 0.05 mg/L, Fe 0.077 to 0.991 mg/L, SO_4^{2-} 1.00 to 250 mg/L, PO_4^{3-} 0.01 to 0.15 mg/L, SO_3^{-} 0.10 to 10.00 mg/L, temperature 27.70 to 28.90 ^{0}C, pH 5.90 to 6.80, alkalinity 32.00 to 500 mg/L, chloride 22.70 to 250 mg/L, DO 12.20 to 17.10 mg/L, BOD_5 2.50 to 6.00 mg/L, total hardness 8.00 to 500 mg/Las $CaCO_3$, suspended solids 10.00 to 500 mg/L, dissolved solids 0.04 to 1000.00 mg/Land total solids 10.04 to 1500 mg/L. In comparison of the results obtained with World Health Organization standard for potable water indicates that sample A, B, D and E are acidic while sample B, C, D, E and F contains excess concentration of Fe. The result of research shows that all the rainwater gotten from the sampling locations contains diverse forms of pollutant.

Keywords: Rainwater, heavy metals, physicochemical parameters, Acid rain, Uyo municipality, Water quality, Nigeria.

1 Introduction

WATER is one of the most important natural resources needed for life, plants and animals for survival. Rainwater as one of the resources of water results from a systematic process of rain formation. Rain is formed when the heat from the sun causes water to evaporate from water bodies and vegetation, the water vapour that results, condenses to form cloud droplets which gradually form layer water droplets and overtime falls as rain [1]. Due to anthropogenic activities in the environment, rain water can be acidic. The chemical composition of atmospheric precipitation is closely related with the degree of air pollution in urban, industrial and rural ecosystems. It is well known that due to the dynamic nature of the atmosphere, metals in particle form can be deposited in areas far away from their original sources [2].

Rainwater dissolves gases of the atmosphere and contains particulate in dust and smokes, when it runs off over the ground it carries silts which are dissolved rocks containing calcium and magnesium as clays [3]. Acid rain is defined as having a pH lower than that of pure water in equilibrium with CO_2 in the atmosphere, which is a pH of 5.6 [4]. Rainwater has a tendency to be somewhat aggressive towards materials with which it comes in contact, be they natural materials such as soil and rocks or man-made substances such as metal product [5]. Warran, [6] noted that man's activities has increased the qualities and distribution of heavy metals in the atmosphere, on land, rivers, lakes, seas and streams. Therefore, the work is aimed at evaluating the levels of heavy metals in the atmosphere to determine the rainwater composition and to provide a background for the chemical characteristics of rainwater in some selected municipalities in Uyo.

2 Materials and Methods

2.1 Materials

The equipment used on this research analytical work were pipettes 25 ml, mercury in-glass centigrade thermometer, pH meter (Hach model), steam bath, white polyethylene bottle, oven, dessicator, weighing balance, flame emission photometer (FEP), atomic adsorption spectrometer (AAS) Unicam 969 solar system 1998 and unicam 8625 UV/VIS spectrometer.

2.2 Reagents

The reagents used were all Analar grades from British Drug House (BDH) 0.02M $AgNO_3$, 0.01M EDTA, CO_2 free NaOH, 0.02M HCl, NH_3/NH_4Cl buffer, $MnCl_2$ solution, 0.05M potassium hydrogen phthalate, 0.0125M $Na_2S_2O_3.5H_2O$ starch solution, Eriochrome Black T indicator, Brucine sulphate, stock nitrate solution, stock phosphate vanadate-molybdate, gelatin $BaCl_2$, Conc. HC, H_2SO_4, HNO_3.

2.3 Sampling Methods

Methods used are an acceptable method by Association of Official Analytical Chemist AOAC and the procedures as recommended by the manufacturers of the instuments. Sampling of the rain water were carried out using plastic funnel of 30cm diameter fitted onto one litre capacity polyethylene bttle placed on a stool that is six feet above the ground level and it was sited in an open space away from obstruction. To avoid dry deposition the funnels in all sample

locations were washed with distilled water every morning and evening and three polyethylene bottle with funnel were sited from each other at the same location and the rainwater collected as a composite representative sample of that location.

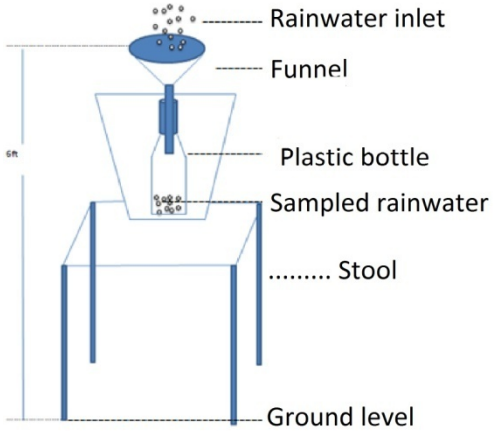

Figure 2.1
Schematic diagram of rainwater sampling

2.3 Study Area

Six samples of the rainwater used in this study were freshly harvested from Uyo municipality of Akwa Ibom State, Nigeria a famous commercial and oil producing area in Niger Delta, Nigeria. The Local Government Area occupies a landmass of approximately 168 square kilometres and having a coordinate of N5^0 023′ 2309″ E7^0 923′8892″. The sample location were carefully choosed to cover the municipality as shown in **Figure 2.2** and taken to the laboratory for analyses.

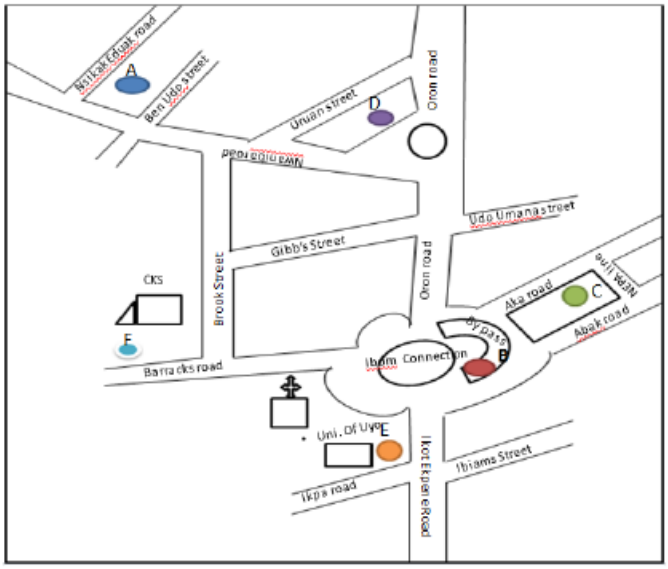

Figure 2.2 Map of the sampling locations in Uyo municipality
Where the sample locations as indicated in the map are:

A Nwaniba by Nsikak Eduok junction
B Ibom connection
C Nepa-line junction by Aka Road
D Nwabiba junction by Oron Road
E Ikpa Road by Ikot Ekpene Road
F Barracks Road by CKS junction

2.4 Sample Preservation and Analysis

Water samples for Dissolved Oxygen (DO) and Biochemical oxygen Demand (BOD) were collected in brown amber bottles, in each case the bottles were carefully filled without trapping air bubbles. For DO samples (200 ml each) and 2 ml of $MnCl_2$ solution was added followed by the addition of 2 ml alkali iodide oxide reagent well below the surface of the water using separate dropping pipettes. The excess solution was allow to overflow, the bottle stoppered with air to exclude air bubbles and mixed by inverting the bottles a number of time until supernatant water was obtained and precipitate then allowed to settle [7]. pH and temperature were taken insitu and samples for heavy metals were acidified using nitric acid to avoid the growth of micro fauna and microflora while samples for other parameters were preserved in the field in ice packed cooler and taken to the laboratory for analysis. All parameters were measured using standard methods [7]. Quality control procedures were performed for at least every three samples tested, procedural blanks and blank spikes, sample duplicates and spikes. The parameters analysed were suspended solids (SS), dissolved solids (DS), total solids (TS), dissolved oxygen (DO), biochemical oxygen demand (BOD), alkalinity, total hardness (TH), chloride (Cl^-), sulphate (SO_4^{2-}), nitrates (NO_3^-), phosphates (PO_4^{3-}), pH, temperature, hydrocarbon (THC), lead (Pb), cadmium (Cd) and iron (Fe). The result of the analyses were compared to the WHO stardard for potable water.

3 Results and Discussion

Rainwaters analysed from various location were presented in table 3.1.

Temperature

In water, temperature increases or decreases the rate of a chemical reaction depending on its level in a water sample. In Figure 3.1 of this study temperatures ranges from 27.70 to 28.90 ^{0}C with a mean of 28.25 ^{0}C indicating sampling location of A and B to be of highest value (Table 3.1), this is within the ambient temperature range as prescribed by [8] and [9].

pH

pH is an indicator of the acidity or alkalinity of a solution. The WHO [8], [10] and NSDWQ [9] standard for drinking water is 6.5 to 8.5 from the result pH has a range of 4.52 to 6.80 which indicates sample A, B, D and E are below the WHO standard signifying that rainwater from those locations are slightly acidic but sample F is within the standard range with value of 6.80 (table 3.1).

Total Hardness

Hardness result in scale deposition particularly on heating and can cause corrosion to pipes. The degree of hardness in water affects its acceptability to the consumer in terms of taste and scale deposition. In this study hardness ranges from 8.00 to 84.00 mg/Lwith mean of 24.67 mg/L (Table 3.1) which shows low level of hardness comparing with WHO standard of 500mg/L [8] and [11].

Phosphate

Phosphate is essential for plant growth and excess of it can lead to algae bloom. The concentration of PO_4^{3-} ranges from 0.01 to 0.07 mg/Lwith mean of 0.037 mg/L (Table 3.1), it can deduced that its has no significant effect due to its negligible concentration [8].

Sulphate

Suphate occur in rainwater due to the release of industrial effluent into the environment through gas flaring which is the rampant and the most effective practice in Nigeria. Increase in sulphate is due to the incomplete combustion of fossil fuel and gaseoline in automobile. SO_4^{2-} concentration in the study area ranges from 1.00 to 13.00 mg/Lwith mean of 6.67 mg/L (Table 3.1). Comparing the concentration of SO_3^- with WHO standard of 250 mg/LWHO [8] and [12], it indicates that the level of SO_4^2 in the rain water samples are negligible.

Chloride

The presence of chloride ions in rainwater helps to control algae bloom and bacteria production and is also required by the body for good health as in sodium chloride (NaCl) which is used as a measure of salinity. The samples from the study area has a slight increase in variation of parameter value with respect to sampling location as shown in Fig. 3.1 and the concentration ranges from 22.70 to 31.2 mg/L with mean of 26.98 mg/L (Table 3.1). This result is lower than WHO [8], [13] and NSDWQ [9] standard of 250 mg/L and therefore has no significant effect on the environment.

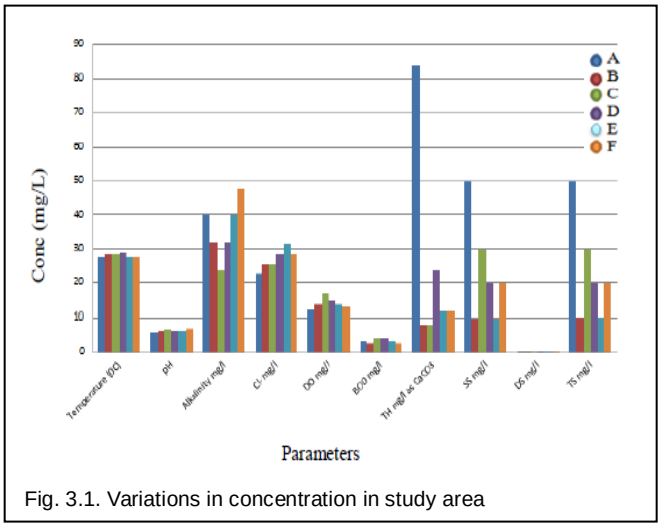

Fig. 3.1. Variations in concentration in study area

Nitrates

Nitrate is a naturally occuring ion which is part of the nitrogen cycle. It occur due to animal waste as a result of ammonia oxidation. The WHO [14] set a standard of 10 mg/l for NO_3^- which from the result the concentration has a range of 0.10 to 0.20 mg/L with a mean of 0.13 mg/L indication a low concentration as compared with WHO limit. Figure 3.2 indicates a stable variation in concentration 0f 0.10 mg/L at sample loaction B, C, D and F while A and E are of the same value of 0.20 mg/L. This result is lower than WHO [8] of 20 - 45 mg/L and NSDWQ [9] standard of 50 mg/L and therefore has no significant effect on the environment.

Alkalinity

This occurs due to the presence of bicarbonate, carbonate and hydroxide. The concentration of alkalinity ranges from 24.0 to 48.0 mg/L with mean of 36.0 mg/L, as shown in Figure 3.1 sample F and C has the highest and lowest concentration respectively. This result is lower than WHO [8] and NSDWQ [9] standard of 100 mg/L and therefore has no significant effect on the environment.

Dissolved Oxygen

Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement) and as a waste product of photosynthesis. Environmental impact of total dissolved solids gas concentration in water should not exceed 110% (above 13-14 mg/L) as started by [15]. This study indicates that DO ranges from 12.30 to 17.10 mg/L with mean of 14.15 mg/L (table 3.1).

Biochemical Oxygen Demand

This is the measure of oxygen needed by microorganisms for breaking down of organic matter. The result of this study shows the range of 2.50 to 4.10 mg/L with mean of 3.267 mg/L. The result of the study area are not above the WHO standard of 6.0 mg/L (table 3.1).

Total Suspended Solids

Total suspended solids causes water to be cloudy. TSS in this study area ranges from 10.0 to 50.0 mg/L with mean of 23.33 mg/L. This result is lower than WHO [8] standard of 500 mg/L and therefore has no significant effect on the environment (table 3.1).

Total Dissolved Solids

This describes the inorganic salts and smal amounts of organic matter present in solution in water. TDS in this study has a mean of 0.053 mg/L and ranges from 0.04 to 0.08 mg/L. According to WHO [14] standard of 1000 mg/L the result of the area is negligible because it has no significance to the water quality (table 3.1).

Total Solids

This indicates the general pollution potential. Total solids ranges from 10.08 to 50.06 mg/l with mean of 23.386 mg/L and WHO [8] standard limit of 500 - 1000 mg/L indicates that the concentration of TS in the study area is below the WHO standard limit (table 3.1).

Heavy metals

Iron if present in water in large quality could make water bitter and unpalatable for drinking. From the study iron ranges from 0.078 to 0.991 mg/l with mean of 0.693 mg/l indicating a high concentration of iron in location B, C, D, E and F while location A as shown in Figure 3.2 is below the WHO limit of 0.3 mg/l in drinking water. As stated by WHO [16] iron stains laundry and plumbing fixtures at levels above 0.3 mg/litre; there is usually no noticeable taste at iron concentrations below 0.3 mg/litre and concentrations of 1–3 mg/litre can be acceptable for people drinking anaerobic well water (table 3.1).

TABLE 3.1
RESULT OF SOME HEAVY METALS AND PHYSIOCHEMICAL PARAMETERS OF RAINWATER FROM DIFFERENT SAMPLING POINTS IN UYO MUNICIPALITY, NIGERIA WITH NATIONAL AND WHO STANDARDS

Parameters	A	B	C	D	E	F	WHO (2008)	NSDWQ (2007)
Pb mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	
Cd mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Fe mg/L	0.078	0.777	0.749	0.783	0.785	0.991	0.3	0.3
SO_4^{2-} mg/L	7.00	3.00	13.00	1.00	11.00	5.00	<250	
PO_4^{3-} mg/L	0.01	0.02	0.04	0.03	0.07	0.05		
NO_3^- mg/L	0.20	0.10	0.10	0.10	0.20	0.10	20 – 45	50
Temperature (^{0}C)	27.70	28.50	28.60	28.90	27.90	27.90	Ambient	Ambient
pH	5.90	6.20	6.60	6.30	6.40	6.80	6.5-8.5	6.5-8.5
Alkalinity mg/L	40.00	32.00	24.00	32.00	40.00	48.00	100	100
Cl^- mg/L	22.70	25.60	25.60	28.40	31.20	28.40	200-600	250
DO mg/L	12.30	13.90	17.10	14.70	13.80	13.10		
BOD mg/L	3.20	2.50	4.00	4.10	3.30	2.50		
T-H mg/L as $CaCO_3$	84.00	8.00	8.00	24.00	12.00	12.00	100-500	150
TSS mg/L	50.00	10.00	30.00	20.00	10.00	20.00	500	500
TDS mg/L	0.06	0.08	0.04	0.04	0.04	0.06	500	500
TS mg/L	50.06	10.08	30.04	20.04	10.04	20.06	500-1500	1000

NSDWQ = Nigeria Standard for Drinking Water Quality, WHO = World Health Organization, Pb = Lead, Cd = Cadmium, Fe = Iron, T-H = Total Hardness, TSS = Total Suspened Solid, TDS= Total Dissolved Solid, TS = Total Solids

Cadmium is release to the environment in wastewater, and diffuse pollution is caused by contamination from fertilizers and local air pollution. Contamination in drinking-water may also be caused by impurities in the zinc of galvanized pipes and solders and some metal fittings. Cadmium in Uyo municipality were below detectable limits <0.01 mg/L which is negligible when compared with WHO standard of 0.003 mg/L (table 3.1).

Lead in rainwater of Uyo municipality is <0.01 mg/L below detectable limit and it is negligible compared to WHO limit of 0.01 mg/L of lead in drinking water (table 3.1).

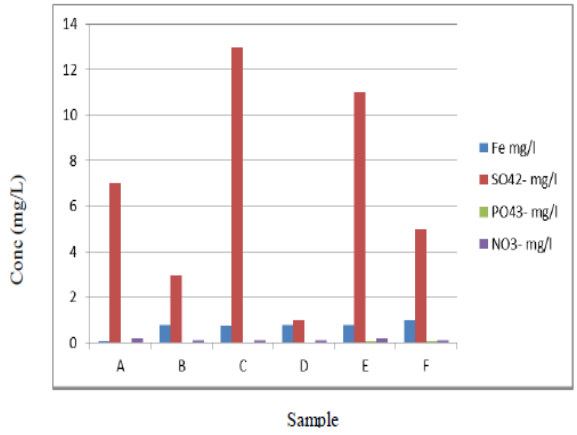

Fig. 3.2. Variations in concentration of Fe, SO_4^{2-}, PO_4^{3-} and NO_3^-. In various samples

4 CONCLUSION AND RECOMMENDATION

Water is essential for life and living things in all ecosystems cannot do without water. Any water meant for consumption should be properly treated to meet the standard of potable water and it must be odorless, colorless, tasteless, transparent and free from some suspended solids. Ions such as iron, sulphates, nitrates and phosphates should be at minimum concentration if not total absent to avoid harm or accumulation to avoid harm. The accumulative effect of these chemicals should be considered depending on the time it takes to accumulate.

Rainwater quality studies is important because it gives information about the level of air pollutant and its effects on global warming and contamination to the environment as a result of pollutant by oxidation of oxides of nitrogen and sulphur in a humid atmosphere forming suphuric acids and nitric acids result to acid rain.

The slight acidity in Uyo municipality may be attributed to fumes from exhaust of automobiles and domestic activities while the iron concentration is due to incomplete combustion by automobiles.

Petrol boosters should be used in reducing harmful exhaust emission besides reducing fuel consumption. Fuel gas scrubbers can be installed in power plants smoke stacks. These scrubbers spray a mixture of water and limestone into the exhaust which traps the sulphur dioxide and prevents it from escape to the environment. Rain water should be well boiled before drinking in order to reduce the hardness and also destroy the bacteria present in it. Gas flaring should be

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avoided where possible and constants monitoring of different parameters cannot be over emphasized.

Awareness should be carried out by government to companies and individuals on how to reduce emission of pollutants to the environment through seminar, jingles, billboards and the media.

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