European Journal of Scientific Research
ISSN 1450-216X Vol.41 No.3 (2010), pp.383-390

http://www.eurojournals.com/ejsr.htm

Physico- Chemical Properties of Rain Water Collected from Some Industrial Areas of Lagos State Nigeria

R.R. Dinrifo
Corresponding Author, Department of Agricultural Engineering
School of Engineering, Lagos State Polytechnic, Ikorodu

S.O.E. Babatunde
Department of Agricultural Engineering
School of Engineering, Lagos State Polytechnic, Ikorodu

Y.O. Bankole
Department of Agricultural Engineering
School of Engineering, Lagos State Polytechnic, Ikorodu

Q.A Demu
Department of Agricultural Engineering
School of Engineering, Lagos State Polytechnic, Ikorodu

Abstract

This study was carried out to determine the physico-chemical properties of rain water from four different industrial sites in Lagos State Nigeria. Rain water samples were collected from four locations (viz Ikeja, Oshodi, Odongunyan, and Imota) of Lagos Metropolis, during the months of May, July and September 2009 and the rainwater samples were taken to the laboratory and analysed. The first three locations were industrial layouts while the last one was a rural, non-industrialised community on the outskirt of Lagos.

The result of analyses on the rainwater samples indicated that at the four locations (i.e Ikeja, Oshodi, Odongunyan, and Imota) the average values were: colour (7.0, 9.0, 6.7 and 5.0 Hazen units); turbidity (0.2, 0.25,0.18 and 0.16 NTU); chloride (15,13.3, 14.3 and 11.1 mg/l); total hardness (21.3, 20.0, 20.0, 15.1 mg/l) respectively. The PH values of the samples show that rain water from the three industrial locations showed slight acidity (ie P^H < 6.5), particularly for the month of May 2009, which for the year under consideration marked the onset of the rainy season after a spell of dryness. This shows that it is possible to have acidic rain in these locations and thus suggestive of immediate corrective actions.

Keywords: Rainwater, Pollution, emissions, acidity, Lagos State

1. Introduction

Rainwater is an important source of fresh water especially for those who live in rural areas, where water use is limited due to scarcity or where surface and underground water quality is poor. In many areas, rainwater is still considered as a safe and suitable source of potable water, and it is commonly used as such (Vikaskumar *et al*, 2007). Developments in science and technology have brought improved standard of living, but have also unwittingly introduced some pollution into our environment. Substances are regarded as pollutants if they are present in concentration toxic to man, animals or plants, have an odour or in some other ways that irritate our senses (Wooven, 1974). These include emissions and effluent outflow from factories, refineries, waste treatment plant, oil or gases of varying quality and quantity directly into the atmosphere. As noted by Ayodele and Abubakar (1998) the concentrations of pollutants correlated with the industrial activities of metropolis. These chemicals are mostly odourless, colourless and tasteless and most importantly, are health hazards. The massive increase in chemical utilization due to recent development in science and technology has greatly increased different contaminant present in water generally, regardless of its source. In an industrial area, there is possibility of acidic rain.

Acid rain is formed through a complex process of chemical reaction involving air pollution (Kemp, 1971). The most important pollutants that contribute to the formation of acid rain are nitrogen oxide and sulphur-dioxide, which react with moisture in the atmosphere, to form nitric and sulphuric acid. The sulphur and nitrogen compounds that contribute to acid rain primarily come from manmade source, such as industries, utilities, automobiles, and other form of transportation and industrial process, such as melting. Acid rain has recently become a serious environmental problem in many industrialized countries including Japan, in Europe and in the northeast areas of the United States and Canada (Adachi, *et al* 1990).

Many researchers including Evans *et al* (2006), Yasunori and Akira (1981), Nicole and Mason (2001) and Susumu *et al* 2001) have considered the effect of acid rain on human health. These acid pollutants can be deposited in a dry form through dust. Pollutant that contributes to acid rain may be carried hundred of miles before being deposited on the earth. Because of this, it is sometimes difficult to determine the specific sources of these acid rain pollutants.

Lagos remains Nigeria’s most industrialised city. Many of the factories in Lagos freely release their effluents and emissions to the environment. In the neighbourhoods of these industrial centres, some forms of farming activities take place. The farmers and horticulturists in the areas depend on rainfall and the water harvested by the usual methods of rainwater harvesting (RWH). Earlier studies by Uzomah and Sangodoyin and Ojolo *et al* reported a higher than normal levels of sulphites and nitrites in the rainwater samples from some of these industrial areas. Beside farming and horticultural activities, the quality of rainwater has the potential to affect aquaculture (Adewolu *et al* 2009). There is a need therefore, to investigate the effects of these pollutants on the rainfall occurring in the vicinity of these industries. Such study may form the basis for the recommendation of remedial actions. In this study, rainwater samples from four locations namely Ikeja Industrial Estate, Oshodi Industrial Area, Odongunyan Industrial Complex and Imota rural community were collected in order to check for the physical and chemical properties.

2. Materials and Methodology

2.1. Description of Study Site

Nigeria is located approximately between latitude 4° and 14° North of the equator, and between longitudes 2° 2' and 14° 30' east of the Greenwich meridian (Babatola, 2002). The climate, which affects the quality and quantity of the country's water resources, results from the influence of two main wind systems: the moist, relatively cool monsoon wind which blows from the south-west across the Atlantic Ocean towards the country and brings rainfall, and the hot, dry, dust-laden harmattan wind which blows from the north-east across the Sahara desert with its accompanying dry weather and dust-laden air. The mean temperature is generally between 25 and 30 °C (77 and 86 °F), although because of the moderating influence of the sea the mean daily and annual maximum temperatures increase from the coast towards the interior. Lagos State is located on the latitude 6.3^0N and longitude 3.3^0E at the south western part of the country. It has a maximum temperature that ranges between 27^0C to 36^0C during the dry season and 20^0C to 25^0C during raining season (National Climatological agency, Oshodi, Lagos, 2008).

Three of the four sites (i.e Ikeja, Oshodi and Odongunyan) chosen for this research work were among the main industrial centres in Lagos. The fourth location (Imota) was a in a rural non-industrialised suburb on the outskirt of Lagos State.

2.2. Collection of Rain Water Samples

Samples of rain*water* were collected in the four (4) different places (i.e Ikeja, Oshodi, Odongunyan, and Imota) of Lagos Metropolis. Care was taken to ensure that samples were representative of water to be examined and that no accidental contaminations occur during sampling. Sample collectors were trained and made aware of the need to send the samples to the laboratory for analysis without delay. Rainwater samples were collected in clean plastic containers by placing the container on a raised platform in an open environment in other to ensure that the water have no contact with any object before getting into the container. The samples were analysed on the same day of collection to preclude possible chemical reactions that may occur in the samples.

2.3. Physical Analysis

The most important of the senses used in these analyses is that of sight. Physical analyses for samples were done on site. This is because some of these characteristics are subject to changes with time. The parameters measured were: - colour, turbidity, odour, taste, and conductivity.

2.3.1. Temperature

Immediately after each rain event, the temperature of the rainwater was determined using mercury in glass thermometer.

2.3.2. Turbidity

Turbidity in water is caused by the presence of suspended particles, dissolved organic and inorganic matter and microscopic organisms.

A turbidimeter (HACH 2100Q Portable Turbidimeter, HACH, Colorado) was used to determine the turbidity of the water samples.

2.3.3. Odour and Taste

Samples were collected in odour free glassware. Tests were performed only on samples which are known to be sanitary acceptable for ingestion.

2.3.4. Colour

Colour in water could be due to several form of pollution- including decaying of organic matter, vegetable or soil origin. It may also due to the presence of colloidal iron and manganese. Colour is P^H dependant

The colour of the samples was observed by filling a matched Nessler tube to mark 50ml with the water to be examined and comparing it with the standards (distilled water). The tube was looked vertically downward toward white surface placed at an angle that light is reflected upward through the columns of liquid. The tubes were placed in the comparator (Nessleriser Dis. NSA) and the true colour was read.

The results of colour determinations were expressed in whole number and recorded as Hazen units (1 Hazen unit is equivalent to a solution of potassium chloroplatinate containing 1 part per million of platimum) or Alpha platinum cobalt standardized.

2.4. Chemical Analysis

The following tests were carried out on the water samples: P^H value, magnesium hardness, acidity, chloride, and chlorine, free CO^2, salinity, hardness and total alkalinity.

2.4.1. P^H Test

The P^H of water was taken as a measure of the degree of acidity or alkalinity of water and its logarithm of the reciprocal of the hydrogen-ion concentration. Pure water at 24ºC is balanced with respect to H^+ and OH^-.

10mls of water sample was placed in test tubes and 20mls of bromothymol blue solution was added to each test tube, then a glass electrode was dipped into the solution then dipped into the P^H meter to test the P^H of the water sample.

2.4.2. Chloride Test

100ml of water sample was measured into a conical flask and 1 ml of potassium chromate solution was added as an indicator. The mixed solution was then titrated against silver nitrate. The end point was indicated by the solution changing from yellow to red. The same procedure was carried out for distilled water as blank.

2.4.3. Total Acidity

100m1 of water sample was poured into a conical flask and two (2) drops of phenolphthalein indicator were added. The resulting solution was titrated against 0.02N sodium hydroxide solution until a pink colour was obtained which indicated end point.

2.4.4. Total Alkalinity

The alkalinity of water is a measure of its capacity to neutralized acids. In natural waters, the alkalinity is related to the bi-carbonates HCO_3, carbonate CO_3 and hydroxide OH concentration. 100m1 of water sample was poured into a conical flask and three (3) drops of methyl orange indicator was added. The resulting solution was titrated against sulphuric acid until the appearance of orange colour was obtained.

2.4.5. Total Hardness

100m1 of water sample was measured into a conical flask and two (2) drops of crichrome black-1 indicator were added and mixed properly. Then 2ml of ammonium chloride (NH_4Cl) and ammonium hydroxide (NH_40H) buffer solution were added and mixed properly. The resulting solution was titrated against standard ethylene-di amine tetra-acetic acid (EDTA) solution and the volume at the end point was recorded.

2.4.6. Calcium Hardness

To 100m1 of sample 2ml of sodium hydroxide buffer solution was added while mixing so as to avoid excess of buffer solution. 0.4g of murexide (ammonium purpate) indicator was added and the solution was titrated against sequestric acid until the colour changes from pink to purple. After taking the burette reading, one or two drops of the sequestric acid were added to make sure that no further change in colour occurs.

2.4.7. Residual Chlorine

The concentration of residual chlorine was estimated by matching colours. The comparator cells were washed with the water samples and consequently filtered. A tablet each of diethyl-p-phenylene diamine (DPP) was added to the water samples impacting some degree of colouration after standing for about 5 minutes. The cells were then placed one at a time, in the comparator and the standard chlorine disc rotated until the colours matched. The number indicated on the matched colour disc indicates the residual chlorine in mg/l.

2.4.8. Nitrate Test

A few drops of water sample was taken in an evaporating dish, then two drops of diphenyl amine were added to sulphuric acid in a conical flask. The content of the flask was poured into the evaporating dish and the solution was heated. Blue colour indicates the presence of nitrate. The absorbance of the mixture was read on a spectrophotometer at 520nm.

2.4.9. Carbon (IV) Oxide

To 10ml of rain water sample in a measuring cylinder was added 4 drops of phenolphthalein. The colourless solution was then titrated with 0.045 M of sodium carbonate solution. It was stirred gently with iron rod and sodium carbonate was added in bits. A faint pink colour that remains for at least 30 seconds indicates the presence of carbon (IV) oxide. The quantity of CO_2 was calculated as

$$CO_2(mg/l) = \frac{NaCO_3 \times N \times 22 \times 100}{volume \cdot of \cdot sample}$$

3. Result and Discussion

3.1. Temperature

The average temperature of the three sampling periods for the four samples collected from these locations (Ikeja, Oshodi, Odongunyan and Imota) conform with world Health organization standard which range from 20-32^{0}c.

3.2. Colour

The average colour of the water for the four samples for the period (May, July and September) were 6.0, 9.0, 6.7 and 5.0 Hazen units for Ikeja, Oshodi, Odungunyan and Imota respectively .

3.3. P^H Value

The P^H values of the samples show that rain water from the three industrial locations showed slight acidity. Comparatively, the P^H of the sample from Imota fell within the range. This shows that it is possible to have acidic rain in these locations and thus suggestive of immediate corrective actions. Particularly for the month of May 2009, this for the year under consideration marked the onset of the rainy season after a spell of dryness. The first flush of rain water that occurs at the beginning of rains usually contains a high proportion of the pollutant load. The main cause of this phenomenon is the deposition and accumulation of pollutant during dry periods. As noted by Muhammad and Han (2000), the longer the dry period, the greater the probabilities of higher pollutant load in the first rain.

However, for other months considered, except the sample from Ikeja all the samples were within the WHO range. This was probably due to the fact that most of the accumulated pollutants must have been washed down back to the surface as a result of frequent rainfall occurring in the period.

The average P^H value for all the period (May, July and September) for the whole sample fell within range of W.H.O standard for drinking water.

3.4. Turbidity and Total Hardness

Turbidity is a measure of the cloudiness of water. It is used to indicate water quality. Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria and dissolved chemicals.

The mean hardness of the four samples was 21.3, 20, 20, and 13.7 respectively. This fell below the W.H.O standard which ranges between (100-300 mg/l).

3.5. Calcium Hardness

It was observe that the calcium available in the rain*water* was below the W.H.O standard for drinking which is (20-200mg/l). Although, it has no side effect medically, the calcium should be increased to fall within the W.H.O standard for drinking water.

3.6. Total Acidity

The average total acidity of the samples was 18.3, 20.7, 17.3, and 10.7 respectively, for the four locations. The values conform to the W.H.O standard.

3.7. Carbon (IV) Oxide

For the month of May (2009) all the locations showed high level of CO_2 in the rain water. Although this is still within the WHO upper limit, it however showed that there were appreciable emissions of this gas. Carbon (IV) oxide is a colourless, odourless, and poisonous gas. It is produced in large amount when the carbon in fuel is burnt incompletely. This could be traced to the use of electricity generators to provide power for the industries, beside the ones coming from the automobiles in the environment. If carbon (ii) oxide if inhaled, it competes with oxygen for the haemoglobin in the blood and thus causing a reduction in the amount of oxygen that is carried to the body.

4. Conclusion

This study considered the physico-chemical properties of rain water from four different industrial sites in Lagos State Nigeria. Rain water samples were collected from four locations (viz Ikeja, Oshodi, Odongunyan, and Imota) of Lagos Metropolis, during the months of May, July and September 2009. The analysis carried out on the four samples of rain*water* showed that only the samples from Imota, for the period conformed to W.H.O standard. The other three locations (i.e. Ikeja, Oshodi, and Odongunyan) which were industrial areas in Lagos State did not conform to W.H.O standard in terms of P^H, chloride, total alkanility, and salinity. This shows that the rainwater from the industrial areas was contaminated by the emission of the industries and possibly emissions from automobiles.

Table 1: Physical and Chemical Properties of Rainwater Samples

S/N		IKEJA			OSHODI			ODONGUNYAN			IMOTA			WHO
		May	July	Sept	May	July	Sept	May	July	Sept	May	July	Sept	STANDARAD
1.	Temperature (ºC)	27	28	27	28	28	28	27	28	27	27	27	27	20 – 32
2.	Colour (Hazen unit)	8	5	8	10	7	10	5	5	10	5	5	5	5-35
3.	Turbidity (*NTU)	0.15	0.25	0.18	0.20	0.25	0.31	0.15	0.18	0.20	0.16	0.18	0.16	0.25
4	P^H value	6.2	6.7	7.1	6.3	6.9	6.5	6.4	7.1	7.2	6.5	6.9	6.7	6.5-9.5
5	Residual chlorine (mg/l)	0.1	0.3	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1-0.5
6	Chloride (mg/l)	17	12	16	17	11	12	15	13	15	16	10	5	200-300
7	Free CO_2 (mg/l)	48	32	8	45	41	10	23	18	12	11	8	8	6-60
8	Total Acidity (mg/l)	19	22	24	11	25	25	17	21	24	16	10	16	47-146
9	Total Hardness (mg/l)	25	22	17	24	20	16	27	20	13	20	13	12	100-300
10	Calcium Hardness (mg/l)	19	17	11	18	16	13	22	15	10	16	10	6	20-200
11	Magnesium Hardness (mg/l)	60	65	66	60	45	35	55	50	30	40	35	25	80-100
12	Total Alkalinity (mg/l)	36	20	27	38	24	27	29	18	23	18	36	37	30-50
13	Nitrite (mg/l)	36	40	34	20	40	30	20	22	10	20	20	30	50

*Nephelometric Turbidity Units.

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