

Effect of Air Pollution on Rain Water: A Case Study of Ado-Ekiti, Nigeria

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Abstract— This study investigates the effect of air pollution on rain water in Ado-Ekiti. Air pollution is becoming a global phenomenon and a source of concern to the entire world. Plants, animals, environment and public health are subjected to risks due largely to the earth that is getting warmer, ozone layer getting depleted, acid rain being recorded, all as a results of air pollution. This study was carried out in order to determine the pH level (i.e acidity and alkalinity), Total Dissolve Solids (TDS), Electrical Conductivity (E.C), Nitrate, E-Coli and Total Coliform count of the rainwater in Ado-Ekiti. The study area was classified into three environmental zones (high income, medium income and low income) based on standard of living of the residents. Fifty six samples of rainwater was collected in the three environmental zones between April and September, 2017 using small buckets that were washed and rinsed with distilled water. The collected samples were taken to the laboratory for chemical and bacteriological analysis. The results showed that the observation zone having pH in between 5.3 and 7.5 while EC fell in between 0 and 0.2 mS/cm indicating that the zones were polluted. Results of bacteriological analysis showed rainwater is free from bacteriological pollutants. It is concluded that gone are the days in the study area when rainwater can be collected for drinking purposes without treatment. Measures have to be taken in the area of efficient energy consumption and vehicular emissions control.

Keywords— Air pollution, rainwater, Ado-Ekiti, pH, TDS, EC.

I. INTRODUCTION

Rapid industrialization, unplanned urbanization, population and vehicular growth are the major causes for the increased air pollution level in the city. Exposure assessment studies carried out in the developing world on several air pollutants have been reviewed and it is known that pollutants in the outdoor and indoor environments are associated with acute adverse effects on health of human and plants, [1]. Normal air contains about 78% nitrogen, 21% oxygen, 0.93%, argon, 0.038% carbon dioxide, and several other trace gases. Changes in the

gaseous composition of earth's atmosphere have become a prime concern for today's world due to human activities [1].

Nigeria and other developing countries have experienced a progressive degradation in air quality due to industrialization, urbanization, lack of awareness, number of motor vehicles, more use of fuels with poor environmental performance, badly maintained roads and ineffective environmental regulations. Rainwater has become increasingly dirty in the passage of time because of pollution. While it is initially a product of natural distillation, the formation of rainwater involves initially nucleation on aerosol particles. When the water is condensed, it interacts with various substances in the air dissolving some of them. As the rainwater falls, it collects more impurities. In effect, the first amounts of rainwater can be much polluted but the condition improves as the raining continues, i.e., the rainwater becomes cleaner [2].

The entire process also cleans the air. Aerosols (ammonium, nitrate, and sulfate) get reduced by 30% to 73% after rainfall while the gases (ammonia, nitrogen dioxide, sulfur dioxide, and chlorine) can go down by 24% to 63%. The ability of rainwater to capture air pollutants makes it a good medium for studying the extent of pollution in a locality. Such a study was done in Singapore in 1997-1998 which showed, among others, that both formic acid and acetic acid are the major organic acids that contributed to the acidity of rainwater [3]. A longer-term research based on rainwater was done in a semi-arid region of India wherein the chemistry of the rainwater was largely affected by the wind-carried dust and soil as indicated by the good correlation between calcium and nitrate ions, calcium and sulfate ions, and sulfate and nitrate ions. This study aimed at study rainwater in five locations within Ado Ekiti metropolitan area to determine whether it is polluted or not.

II. THE STUDY AREA

Ado Ekiti is a city in southwest Nigeria (Figure 1 & 2), the state capital and headquarters of the Ekiti State. It is also known as Ado. It has a population of above 424,

340. The people of Ado Ekiti are mainly of the Ekiti sub-ethnic group of the Yorubas. Ado Ekiti (Figure 3) has four tertiary educational institutions namely: Ekiti State University, Afe Babalola University and The Federal Polytechnic Ado Ekiti and Ekiti State School of Nursing and Midwifery. It also play host to two local television and three radio stations; NTA Ado Ekiti, Ekiti State Television (ESBS), Ekiti FM, Voice FM and Progress FM Ado Ekiti. Various commercial banks and enterprises operate in Ado Ekiti. Ado Ekiti also have ninety four (94) hotels and more that fifty (50) petrol stations all running on generating sets as source of electricity between two to twenty four hours per day

The town lies between the latitude $7^{\circ} 33'$ and $7^{\circ} 42'$ North of the equator and the longitude $5^{\circ} 11'$ and $5^{\circ} 20'$ East on a low-land surrounded by several isolated hills and inselbergs, [4]. Geologically, the region lies entirely within the pre-Cambrian basement complex rock group, which underlies much of Ekiti State [5]. The temperature of this area is almost uniform throughout the year; with little deviation from the mean annual temperature of 27° C. February and March are the hottest 28° C and 29° C respectively, while June with temperature of 25° C is the coolest [6]. The mean annual rainfall is 1,367mm with a low co-efficient variation of about 10% and 117 raining days in year 2017. Rainfall is highly seasonal with well marked wet and dry season. The wet season lasts from April to October, with a break in August.

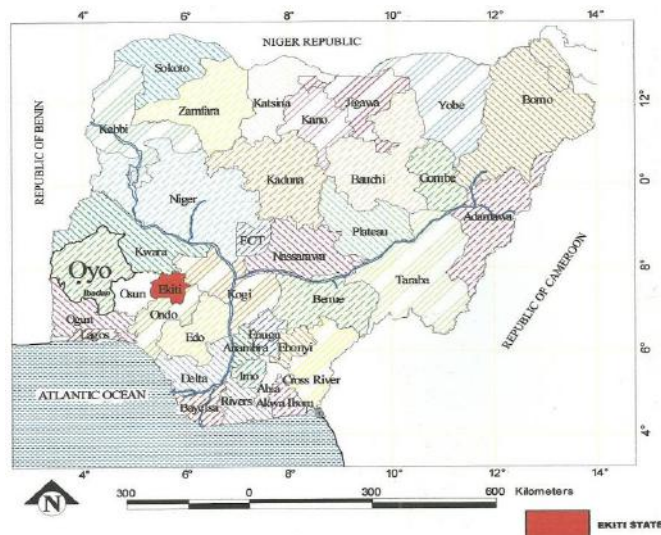


Fig.1: Map of Nigeria showing Ekiti State. Source: [7]

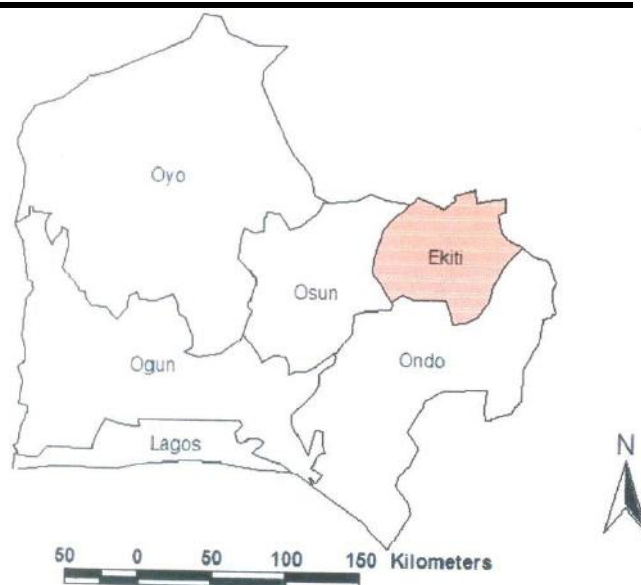


Fig.2: Map of South West Nigeria showing Ekiti State
Source: [7]

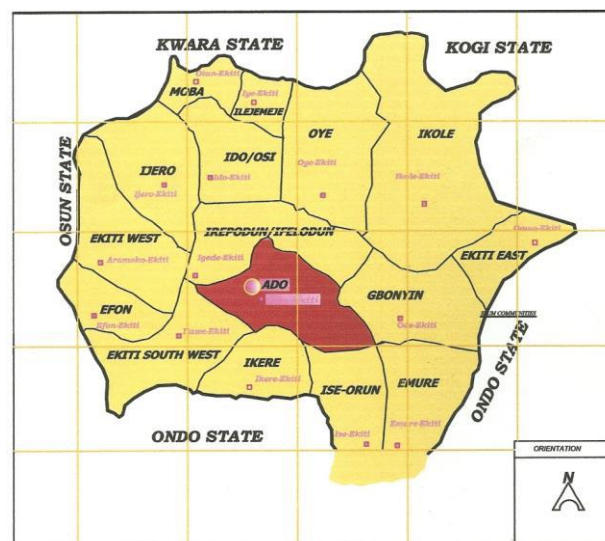


Fig.3: Map of Ekiti State showing Ado-Ekiti. Source: [7]

III. RESEARCH METHODOLOGY

A. Sample Collection Procedure

The procedures for collection of rainwater samples in the selected locations were:

- The plastic basin used for collection was washed with a soap.
- The basin was rinsed with distilled water before it was used for collecting samples each time.
- The basin was raised at least one meter above the ground level and covered with the cover lid after the collection of rainwater, so as to avoid contamination.
- The samples collected were then taken to the laboratory.

B. Rainwater Sample Analysis

Water samples were collected from different locations within the study area. Records were taken for every

sample collected. Every container was identified by attaching appropriate inscription of the location where the samples were collected. Records made include; Source of sample, Date sample was collected and Sample number. The rainwater samples were taken to the laboratory within four hours for the following analysis; pH, Electrical - Conductivity, Total Dissolved Solids, Nitrate, E-Coli, and Total Coliform Count.

C. Chemical Test Procedures

By simple analysis of rainwater using pH-Meter, TDS-Meter and Conductivity meter for the measurement of pH, TDS of rainwater, and electro conductivity. We can predict whether studied locations are polluted or not

D. Determination of pH (Hydrogen potential) value

Aim: To determine the hydrogen potential (pH) of the samples

Apparatus and materials: Glass beaker, pH meter, distilled water, Standard buffer solution (pH4 and pH7)

Method: The reagents (buffer solution of pH4.0 and pH7.0) were prepared and were used to calibrate the pH meter. This was done by placing the electrode in the beaker containing the buffer solution. When the pH meter did not show the pH value of the buffer solution, the calibration knob is used to adjust it to the exact value. The electrode was then taken from the buffer solution, washed with distilled water and wiped with soft tissue. The sample was then poured into a beaker washed with distilled water, and the electrode of the pH meter placed in the beaker containing the sample to measure the pH value. A stable value on the meter was then recorded.

E. Determination of EC (Electro conductivity)

Aim: To determine the electro conductivity of the samples

Apparatus and materials: Glass beaker, portable EC meter, distilled water, tissue paper and Potassium chloride.

Method: The EC sensors was first washed with distilled water and wiped dry with tissue paper then inserted into a beaker containing KCl reagent for calibration. The meter was then rinsed in distilled water before using it to measure the conductivity. Readings are performed by an amperometric sensor. An alternating voltage is applied to the sensor and the amount of current that passes between the two stainless steel pins is dependent upon the amount of pollutants present

F. Determination of TDS (Total dissolved solids)

Aim: To determine the total dissolved solids in the samples

Apparatus and materials: Glass beaker, portable TDS meter, distilled water, tissue paper.

Method: In the determination of TDS of rainwater, TDS meter is used. Wash the electrode of TDS Meter with the help of distilled water, thereafter, electrode of the TDS

meter was dipped into the rainwater sample and the readings were taken.

G. Determination of Nitrate

Aim: To determine Nitrate in the sample.

Apparatus and materials: Glass beaker, Test tube, Acid reagent, Nitrate Nitrogen comparator, Tissue paper.

Method: The test tube was rinsed and filled with the sample to the 2.5 ml line which was then diluted to the 5 ml line with the Mixed Acid Reagent. The mixture was then mixed. After 2 minutes. A 0.1 g spoon was used to add one level measure and after waiting for 10 minutes, the test tube was inserted into the Nitrate Nitrogen Comparator. The sample color was matched to a color standard and result was record in mg/l (ppm)

H. Determination of Total Coliform

Aim: To determine Total Coliform in the sample.

Apparatus and materials: 1.0 ml each of the samples, incubator, auto colony counter electronic machine and nutrient agar

Method: 100 ml of the sample was filtered through thin acetals membrane sheet with openings less than 0.5 mm so that the bacteria present in the sample were trapped. The filter was later raised with the nutrient agar and incubated at a temperature of 37°C for a period between one and five days, in which the bacteria start to grow in the nutrient agar (which acts as the nutrient medium). Visible colonies are produced.

IV. RESULTS AND DISCUSSION

A. Results

The Tables 1 – 5 show results of rainwater analysis from the five sampling locations. Each table show results of pH, TDS, EC, Nitrate, Total coliform count, and E-coli. In this study, the analyzed rainwater samples met the requirements for safe drinking water in terms of physicochemical composition and the microbiological parameter except of some samples which had a pH lesser than 5.6 and considered to be acidic according to [8].

Table.1: Physicochemical and Bacteriological Analysis of Rainwater Samples at Dalimore

Date	pH	TDS (pp m)	EC (mS/c m)	Nitrate (mg/L)	Coliform Count (cfu/ml)	E-coli Count
18-06-17	5.3	6.4	0.1	0.2	0	0
30-06-17	6.5	0	0	0.48	0	0
05-07-17	6.5	0	0	0.29	0	0
14-07-17	6.5	0	0	0.32	0	0
16-07-17	7.2	0	0	0.21	0	0
17-07-17	7.8	6.4	0.1	0.53	0	0
Average	6.63	2.2	0.03	0.34	0	0

WHO	6.50-	600	1000	50	1	0
Standard	8.50					

Table.2: Physicochemical and Bacteriological Analysis of Rainwater Samples at Fajuyi

Date	pH	TDS (ppm)	EC (mS/cm)	Nitrate (mg/L)	Coliform Count (cfu/ml)	E-coli Count
18-06-17	6.6	6.4	0.1	0.15	0	0
30-06-17	6.8	0	0	0.27	0	0
01-07-17	6.5	0	0	0.42	0	0
05-07-17	6.7	0	0	0.13	0	0
14-07-17	6.6	0	0	0.81	2	0
17-07-17	5.9	0	0	0.24	0	0
Average	6.52	1.07	0.02	0.34	0.33	0
WHO Standard	6.50-8.50	600	1000	50	1	0

Table.3: Physicochemical and Bacteriological Analysis of Rainwater Samples at Ilokun

Date	pH	TDS (ppm)	EC (mS/cm)	Nitrate (mg/L)	Coliform Count (cfu/ml)	E-coli Count
02-06-17	6.3	0	0	NC	NC	NC
04-06-17	6.2	0	0	NC	NC	NC
06-06-17	6.3	0	0	NC	NC	NC
07-06-17	6.2	0	0	NC	NC	NC
09-06-17	6.8	0	0	NC	NC	NC
11-06-17	6.7	0	0	NC	NC	NC
13-06-17	6.4	0	0	NC	NC	NC
14-06-17	7	0	0	NC	NC	NC
18-06-17	6.8	0	0	NC	NC	NC
19-06-17	6.6	0	0	NC	NC	NC
20-06-17	6.7	0	0	NC	NC	NC
Average	6.55	0	0	NC	NC	NC
WHO Standard	6.50-8.50	600	1000	50	1	0

*NC = Not conducted

Table.4: Physicochemical and Bacteriological Analysis of Rainwater Samples at Bawa Estate

Date	pH	TDS (ppm)	EC (mS/cm)	Nitrate (mg/L)	Coliform Count (cfu/ml)	E-coli Count
11-06-17	6	0	0	0.31	0	0
14-06-17	6.3	0	0	0.19	0	0
16-06-17	6.4	0	0	0.24	0	0
18-06-17	6.6	0	0	0.13	0	0
19-06-17	6.9	0	0	0.17	0	0
24-06-17	6.5	0	0	0.32	0	0
24-06-17	6.7	0	0	0.21	0	0
30-06-17	5.1	0	0	0.17	0	0
01-07-17	5.7	0	0	0.22	0	0
Average	6.24	0	0	0.22	0	0
WHO Standard	6.50-8.50	600	1000	50	1	0

Table.5: Physicochemical and Bacteriological Analysis of Rainwater Samples at GRA

Date	pH	TDS (ppm)	EC (mS/cm)	Nitrate (mg/L)	Coliform Count (cfu/ml)	E-coli Count
29-05-17	6.14	6.4	0.1	NC	NC	NC
31-05-17	6.42	0	0	NC	NC	NC
06-06-17	6.1	0	0	NC	NC	NC
07-06-17	6.5	0	0	NC	NC	NC
12-06-17	6.87	0	0	NC	NC	NC
14-06-17	6.9	0	0	NC	NC	NC
19-06-17	6.6	0	0	NC	NC	NC
Average	6.5	1.07	0.02	NC	NC	NC
WHO Standard	6.50-8.50	600	1000	50	1	0

*NC = Not conducted

B. Discussion

The above tables show the result of the water samples tested for all five locations and the average values for each parameter.

C. Physical parameters

The pH of water samples from all locations ranged from 5.10 – 7.80, with Dalimore, Fajuyi, Ilokun, Bawa and G.R.A having an average pH of 6.63, 6.52, 6.55, 6.24 and 6.50 respectively. The rainwater in the area is normal, except for the one that in Bawa on 30/06/2017 that was 5.10 and Dalimore on 18/06/2017 which was 5.30 below 5.60 which is considered to be an acidic rain according to [9], who reported that the reference level commonly used to compare acid precipitation to natural precipitation is pH 5.6 (the pH that results from the equilibrium of atmospheric carbon dioxide with precipitation). The rain of 01/07/2017 was 5.70 while the rest were above 6.00.

And when an enquiry was made in the Bawa location, it was made known that they had not had electricity supply for some days before the day it rained and most houses, hostels and shops had to use their Generating sets with must have increased the CO₂ content in the air causing a rise in the pH. With the construction work going on in Fajuyi as at when this study was carried out, it is believed that the pollution created as a result of the construction must have caused the pH of the sample collected that day to drop to 5.9.

Dalimore is a commercial location with high level of pollution generated as a result of vehicular activities and generating sets. But because pollutants are easily dispersed, it is believed that pollutants generated from the construction site in Fajuyi had dispersed to Dalimore on 18/06/2017

But this also showed that the rain within Ado-Ekiti is not acidic in comparison to research work by [10], which showed that the pH of four industrial areas of Lagos state namely: Ilupeju, Costain, Ikeja and Ikorodu were 4.94, 4.20, 4.22 and 4.30 respectively.

The range for the total dissolved solids for all the location ranged between 0.0 – 6.4 mg/l and which reflected in the conductivity of the samples. The values gotten is within range of the value of 5.25 ± 1.2 mg/l reported by [11] in physicochemical and trace metal levels of rain water for Ile-Ife, South-western Nigeria. This value makes the rainwater in ado someway safe for drinking assuming other parameters are in the green. As water with a total dissolved solids (TDS) level of less than about 600 mg/l is generally considered to be good and drinking water becomes significantly and increasingly unsafe at TDS levels greater than about 250 mg/l [12].

D. Chemical parameter

The levels of Nitrate in all locations were considerably low compared to the WHO limits for Nitrate in rainwater.

No health based guideline value has been derived for Nitrate [12].

E. Bacteriological parameter

There was no presence of E-coli in all samples and a Total coliform count of 2cfu/ml in samples from Fajuyi which was within limits.

V. CONCLUSION

Rainwater appears to be one of the most promising alternatives for supplying freshwater even in a polluted area hence it is collected from an open space. The chemical quality of open space harvested rainwater in Ado-Ekiti is quite satisfactory with no parameter being detected above the corresponding maximum allowable concentration for drinking purposes according to WHO standard. Since this research focused on “Effect of Air Pollution on Rainwater in Ado-Ekiti”, not all the physico-chemical analysis and microbiological composition needs be checked to know what effect air pollution would have on rainwater. In general, examination of the physicochemical composition of the rainwater is a prerequisite before its utilization for drinking purposes.

The physicochemical quality of the rainwater samples examined in this study indicates that at Ado-Ekiti is unpolluted in terms of rainwater according to WHO standards. Even though there are increasing vehicular activities, deforestation, increase in use of Generating set for power supply, bush burning, e.t.c going on daily in the study area, the findings indicated that the rainwater was still not affected which shows that pollution or gas emissions might travel far away from its source or can settle on roof, leaves etc and do not always remain on the air. Which makes the authors conclude that except for rare occasions, Ado-Ekiti does not experience what is termed “Acidic rain” and with the low level of Nitrogen ion present in the rainwater, “Eutrophication” would be nothing to worry about.

VI. RECOMMENDATION

Because rainwater harvesting as an alternative source of water for domestic use is an age long popular practice as public water supply are not always available and consistent [9] and rainwater harvesting is a simple and low cost technique that involves the capturing and storing of rainwater from roof catchments or directly for domestic, agricultural and environmental purposes [9].

In order to curb the effect of air pollution on rainwater within the state capital, the following measures could be considered so as to reduce the amount of air pollution generated within the state capital:

- i. Awareness should be made on air pollutions. Residents within the study area need to be educated on air pollution, the sources and its effects. If people are self-aware and knowledgeable

about air pollution, some activities causing air pollution such as bush burning, burning of tire by vigilantes, burning of refuse instead of disposing it properly though Ekiti State Waste Management Authority (EKSWMA) would be reduced. This would also make people switch from using artificial indoor product that causes pollution to a natural product. For example, swapping insecticides for lemon peels soaked in water to kill mosquitoes, or using baking soda and onions to kill cockroaches.

- ii. Sensitization on the need for residents and shops or office owners to plant trees and flowers around their premises and have smaller trees in pots or flowers in pots placed in their premises.
- iii. Source reduction happens to be the most effective way of reducing air pollution; a shift to clean energy (e.g. Solar, Inverter, etc.). Instead of using a generating set which its long term cost is almost equal to that of a solar power unit, a solar or an inverter should be used because they are eco-friendly when compared to a generating set which produces pollutants e.g. CO₂, Unburned hydrocarbon.

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