AJEMATES
African Journal of Educational Management, Teaching and Entrepreneurship Studies
VOL.15 (2), May-August, 2025 https://ajemates.org

ASSESSMENT OF LEVEL OF CONTAMINATION OF RAIN WATER IN ENUGU METROPOLIS OF ENUGU STATE, NIGERIA

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ABSTRACT

The current study is based on the assessment of levels of physic-chemical contaminants in rain water in Enugu metropolis of Enugu State, the study is aimed at analyzing the physiochemical parameters as well as the content of different heavy metals in the rain water harvested from the different locations in Enugu metropolis. A total of six samples of rainwater were collected in the month of June from six out of twelve different locations identified in and around Enugu metropolis. Namely: Awkunanaw east, Achara layout, Ogui-nike, Emene, and Trans-ekulu and Newhaven. The samples were collected and analysed for physiochemical parameters such as P^H, acidity, temperature, electrical conductivity, total dissolved solids, acid radicals (NO_3^-, Cl^-, and SO_4^-) and heavy metals such as, cadmium, copper, iron, lead, nickel and zinc were tested. The results show that the parameters from all the samples were within WHO standard for portable water except for lead. This confirms that there is little or no risk of water contamination if the presence of lead metal in water is detected and adequately controlled, through filtration or other effective methods.

Keywords: Assessment, Physco-Chemical, Rain water, Contaminant, Heavy Metal.

Introduction

Water is a very important solvent that is highly beneficial to all living things. As a universal solvent, it has the capability of dissolving almost all solids and as such, an indispensible liquid that cuts across all spheres of lives and discipline. As a chemical compound, it consists of two substances/elements namely, Hydrogen and Oxygen that are chemically combined together at a ratio of 2:1. As a result, water is represented by the chemical formula of H_2O. Water is essential to living organism due to its unique properties. These properties contribute a lot to the quality of water. Once any of the properties is outside its acceptable quality, then, Water is said to be contaminated. Physical properties of water such as, temperature, colour, odour and taste, are identified using the senses. Chemically, quality water is associated with some chemical properties such as, pH, electrical conductivity, salinity, alkalinity, hardness, dissolved oxygen, heavy metals, biochemical oxygen demand and chemical oxygen demand. Water occurs in a large quantity throughout the globe in form of water bodies such as Ocean, Seas, Lakes, River, Spring, underground well, boreholes and rainwater. Water in its natural form supposed to be pure, but the purity depends on source, location and the type of pollutants associated with

water in terms of source, environmental, industrial, Agricultural, chemical activities going on continuously across the globe.

Rainfall constitutes one of the largest sources of drinking water not only in Nigeria but also in other tropical regions such as Australia and Africa (Chubaka, 2018, Nduka & Orisakwe, 2010). According to Nsi, (2007), the period of rainy season, a season of rainfall, varies from North to South, beginning effectively from April to October in the South and then, runs from June to October in the North. Rain water, has a relatively good quality for drinking water, but the development of science and technology, through industrialization, agriculture and increased human population have in major ways introduced some pollutants into our environment and affects the quality of air. When the environment is polluted, every other thing associated with it such as air, water, land also gets polluted. In the air, rain water can come in contact with particulate matters, acid anhydrides (CO_2, SO_2, NO_2) The most important pollutants that contribute to the formation of acid rain, by dissolving in water to form trioxocarbonate (iv), trioxonitrate (v) and tetraoxosulphate (vi) acids, that can introduce acid rain that can decrease the pH of water.

Water pollution has contributed to health challenges of billions of people worldwide due to no access to safe drinking water (WHO, 2011). The World Health organization has also attributed millions of deaths recorded in a year especially in Africa to water borne diseases. According to Adeyinka, Asiu and Akintayo, (2014), these water-borne diseases such as typhoid fever, diarrhea, cholera, dysenteries, hepatitis and many other gastro-intestinal diseases are due to microbial contaminations in water. In accordance with that, some other studies like (Aminu and Amadi, 2014; Bisi-Johnson, Kehinde, Saheed and Hamzat 2014, Foka, Yah, Agbortabot Bissong, 2018) carried out in Nigeria have also confirmed the presence of microbial contaminants, pathogenic bacteria and fungi and high coliform count isolated bacteria in water accordingly. Besides water borne diseases, chemically associated pollutant has the capability of introducing heavy metals into water. The level of pollution determines the level of contaminants in water. In urbanized area, where the agent of air pollution is high, there is greater probability of having more pollutants in water than in less urban areas (Bharti, Singh, Tyagi, (2017), Mielke and Paterson, (2018).

Heavy metallic elements are naturally-occurring transition elements with high atomic numbers and densities higher than the density of water by at least five times [(Tchounwou, Yedjou, Patlolla, & Sutton, (2012) and Izah, Chakrabarty, & Srivastav, (2016)]. Heavy metals are classified into essential and non-essential. Some of the essential elements such as zinc, cobalt, copper, manganese and molybdenum are useful to human growth, development and reproduction but can still be harmful according to (Izah et al, 2016), when the concentration exceeds the tolerable limit for living organism. While on the other hands, the non-essential elements, such as Cadmium, lead and mercury could be

harmful to organism, even if present at a very low concentration. These heavy metals are taken by organisms through water, air, food (Walter and Silliker, 2019) including vegetables and fruits, and therefore could be detrimental to human beings, because it builds, and gradually causes disease condition on different parts of human system such as liver, blood, hGeart, kidney (Woyessa, Kassa, Demissie & Srivastava, 2015).

Reports from some researchers showed that some heavy metals cause toxicity as well as deficiency of other trace metals in the body. Cadmium has the tendency to substitute copper and iron in cytoplasmic membrane (Iwegbu, Nwozo, Overah, Bassey & Nwajei, 2013). The presence of cadmium, leads to liver, kidney, skeletal and kidney and lung damage and even death (Izah, et al, 2016; Muhammad, Ashiru, Ibrahim, Salawu, Muhammad, & Muhammad, 2014; Garba, Udam, Babando & Galadima 2015). Iron deficiency, causes fatigue; shortness of breath, difficulty in thinking, liver damage (Salako, Adekoyeni, Adegbite & Hammed, 2016) and also lung disease and siderosis as reported by (Izah, et al, 2016 and Muhammad et al, (2014). Short term exposure to high concentration of nickel, results to symptoms as nausea, abdominal discomfort, cough and high exposure may lead to pneumonia and death, cancer of lungs, nose, throat (Genchi, Carrocci & Catalano, 2020), including other disease conditions that can affect kidney, bones, thyroid glands (Salako, et al, 2016).

Many researchers have investigated the occurrence of toxic metals in different water sources and in different parts of the world. In South China coastal water, Ong & Kamaruzzaman, (2009) discovered, Pb and Cu. (Gutierrez, Rubio-Anas, Quintana, Ortega, & Gutierrez, 2008), confirmed the presence of heavy metal in San Pedro River that might affect human health and ecosystem. The concentration of heavy metals in water sample detected in Malasia, were found to be below the detection limit (Ismail & Saleh, (2012). Alomary (2013) discovered the following: As, Ba, Cd, Pb, Cr, Fe, Zn, Ni and Se in drinking water in Irbid (Jordan) but within the WHO standard for drinking water. Batayneh, (2010) found some heavy metals at a concentration that might affect human health as well as that of the ecosystem from Yarmouk Basin in Jordan. In Romania, some heavy metals were also detected but in the range of few micro grams per liter (Voica, Kovacs, De helean, Ristoiu & Lordache 2012). Recent studies have assessed the quality of rainwater in different regions. For instance, a study in South Africa found that rainwater harvesting systems can be a viable alternative to traditional water sources, but require proper maintenance to ensure water quality (Mkhize et al., 2020). Another study in India found that rainwater quality was affected by atmospheric pollution and recommended regular monitoring and treatment (Kumar et al., 2019). Okoye, E., Onuorah, S., Okoye, L., Eleanya, L., Agu, G., Okafor, U., & Egudu, N. (2024), also revealed that physicochemical parameters and some heavy metals were within acceptable limits, except for Fe (0.01-0.72 mg/L) and Pb (0.01-0.25 mg/L). Total bacterial counts ranged from 1.2×10^4 to 6.8×10^4 CFU/100mL, indicating high

contamination. While there are studies on water contamination in various regions, more localized research is needed to understand specific contamination profiles in different areas, such as Enugu Metropolis. Further investigation is required to determine the long-term effects of exposure to contaminated water and heavy metals on human health.

Statement of Problem

The problem of this study emanated from the global public health threat posed on people by unsafe water. This has tried to place people at risk for a host of different water related diseases earlier identified from the literature. In Enugu State, rainwater is a major source of drinking water during rainy season. A lot of activities going on in the environment try to introduce air pollutants in rainwater. The trigger factor for the presence of pollutants in rainwater is generated from such activities as: burning of domestic and agricultural wastes, fossil fuel, fumes from exhaust pipes, fermentation and decomposition processes. Some of these pollutants found in air are decomposed to more soluble compounds in the presence of sunlight and during acid rain. When the rain water is consumed over time without treatment, it might cause a lot of health problems to human beings. That brought about the need for the assessment of physico-chemical parameters of rain water in different locations in Enugu metropolis to ascertain the level of contaminant in Enugu metropolis.

Purpose of the Study

The purpose of the study is to assess the level of physic-chemical properties of rain water in different locations in Enugu State. Specifically, the study sought to;

1. To assess the level of contamination of rainwater in Enugu metropolis using some physico-chemical parameters.
2. To find out the level of contamination of some toxic metals in rain water from the sampled areas.
3. To compare the result of the analysis of water to the value stipulated by World health organization for portable water.

Materials and Method

Sample location. The rain water used was gotten from Enugu metropolis. Enugu metropolis consists of three local governments: Enugu East, Enugu North and Enugu South. The sample was drawn from the 12 locations were clustered around the three local government areas

Sample and sampling technique: Stratified and simple random sampling techniques were used for the study. The towns were stratified into 3 different local government areas. Out of twelve locations, simple random sampling was used to sample six locations out of twelve, from where the 6 water samples were collected. 2 samples were drawn from each of the three local government areas making it a total of 6 sampled locations.

Sample Collection: Rain water samples were collected in six (6) different place locations: (Awkunanaw east, Achara layout, Ogui-nike, Emene and Trans-ekulu, Newhaven) in Enugu Metropolis in June, 2020.The sample collected were carefully carried out in order to minimize the chances of contamination. The containers used for the

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VOL.15 (2), May-August, 2025 https://ajemates.org

collection were placed on top of high stool in an open environment, in different sampled locations, at the same time, using the same method of collection process. After the collection, the samples were tightly covered, labeled according to locations and kept in the refrigerator prior to analysis.

Water Samples Preparation: Six liters of Water samples were collected and concentrated under a sand bath in an oven. The water sample was mixed with 4 ml concentrated nitric acid and digested for few minutes. 8 milliliters of hydrogen peroxide were added and heated until complete oxidation. The sample was cooled, filtered and the filtrate diluted with deionized water to a required volume, kept at 4 ^{0}C in the refrigerator prior to laboratory analysis.

Physico-chemical Analysis: Water samples were analyzed using standard methods (American Public Health Association, (APHA) 1998); p^H, temperature, electrical conductivity, total acidity, total dissolved solid was measured on site using their respective appropriate equipment. Conductivity was measured using Electrical conductivity meter (DDB-303A Digital), p^H with (Orion Star A321 Portable) p^H meter, temperature by mercury in glass thermometer, TDS. Heavy metal Concentrations were measured with gravimetric method. Buck Scientific Atomic absorption spectrophotometer (AAS), GBC Avanta 2.02 was employed for the determination of heavy metals in water. The reagents used were of analytical grade and the samples were analyzed in triplicates after which the average values were determined. $(SO_4)^{2-}$, NO_3^-, Cl^- were determined using a standard photometric method.

Results and Discussion

Results

Table 1 shows the results of the analysis of the physicochemical parameter of samples of rain water harvested from sampled areas.

Table 1: physicochemical properties of the rain water samples.

Parameter	Awk-east	Achara Layout	Ogui-nike	Emene	Tras-ekulu	Newhaven	WHO. Std.
P^H	6.80	6.37	5.69	6.89	6.45	5.89	5.8-8.5
Acidity	0.592	0.424	0.890	0.549	0.435	0.387	100
Temperature (^{0}C)	23	22	24	25	24	20	23
Con ductivity (µs/cm)	32	34	38	36	34	24	900
Total dissolved solids (mg/l)	80	79	65	209	85	68	500
Nitrates (NO_3^-) mg/l	2.927	2.847	2.840	4.184	2.920	2.807	10
Chloride (Cl^-) mg/l	136	148	130	149	145	124	250
Sulphate (SO_4^-) mg/l	87.8	132.7	139.9	129.2	102.9	112.8	500

NF = Not Found.

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Table 2 shows the results of heavy metal analysis from the sampled locations:

Metals	Awk-east	Achara layout	Ogui-nike	Emene	Trans Ekulu	Newhaven	WHO Std
Cadmium	NF	NF	NF	NF	NF	NF	0.003
Copper	NF	NF	NF	NF	NF	NF	1.00
Iron	NF	NF	NF	NF	NF	NF	0.30
Lead	0.035	0.166	0.029	0.099	0.105	0.084	0.05
Nickel	NF	NF	NF	NF	NF	NF	0.07
Zinc	NF	NF	NF	NF	NF	NF	0.05

NF= Not Found

Discussion

The results of physicochemical analyses presented in Table 1 showed that the p^H values of the samples ranged from 5.69-6.89. This is in agreement with the previous works of, (Malassa Al-Rimawi, Al-Khatib and Al-Qutob, 2014) and Ikhioya, Osu and Obuzor (2015) with a p^H range of 6-8.5 and (Sazakli, Alexopoulos, and Leotsinidis, 2007) with a range of 7.3- 8.8, all of which falls within the W.H.O limit with a range of 5.8-8.5. Contrarily, Isoken and Isoken, (2017) recorded a p^H range of 5.29- 9.79 and (Engwa, Tagbo, Richard and Unaegbu 2015), with pH of 2.0-6.3 which are slightly higher and completely lower respectively than the acceptable pH ranges by WHO. The low p^H value of below 6.5, results to acidic water (Erica, 2019) and it is more likely to be contaminated with pollutant making it unsafe for drinking.

Acidity increases the capacity of the water to attack geological materials. Slight acidity of rain water suggest that the water was susceptible to some degree of trace metal pollution, possibly through atmospheric deposition as a result of change in climate, burning of fossil fuels and municipal activities.

The temperature value of the samples falls within the WHO limit except for ogui-nike and Trans-ekulu which have 24^0C each and Emene which has 25 ^{0}C and is slightly above the WHO standard, this slightly disagrees with the report of the study of Isoken and Isoken, (2017) who recorded a temperature range of between, 27.1 - 30.35, this may be attributed to the domestic and industrial activities going at such locations and which is likely to pose health risk to the individuals.

The electrical conductivity estimates the total amount of dissolved ions or the total dissolved salts in water. High conductivity values in rain water can be as a result of accumulation of various particles of dust in the air from industries and household activities. It can affect the survival of plant due to high salinity. The electrical conductivity value of samples ranges from 24-38, this is in agreement with the works of Isoken and Isoken, (2017) which recorded low Electrical Conductivity values of less than 100µs/cm for all the samples analyzed

which is within WHO standard. Engwa et al (2015) in disagreement recorded higher electrical conductivity with a range of 240-1700 for about 11samples out of the whole samples analyzed. This signifies high mineralization and charged by dissolved salts together with impurities.

Similarly, the total dissolved solids were detected in all the locations but they were all within the WHO admissible limit. The nitrate, chloride and sulphate values ranged from 2.807 to 4.184, and 124-149 and 87.8-139.9. The result showed that all samples had low nitrate value when compared to WHO limit. Just like the work of Isoken and Isoken, (2017). Nitrate detected in the rain water might be attributed to the burning of fossil fuels and flaming of petroleum, gas into the atmosphere.

Heavy Metals Analysis

The results of the heavy metal analyses presented in Table 2, showed that, all the heavy metals analyzed were not detected in the samples except Lead with a range of values between 0.029-0.166, which is higher than the W.H.O acceptable standard (0.05) for drinking water. This result was similar to that of Engwa, et al (2015) who observed that, the presence of lead was, well above the permissible level and Nduka and Orisakwe (2011) who noticed that most metals analyzed were not detected. The presence of Lead in the environment may be attributed to the activities associated with industrial and urban areas, such as burning of fossil fuels and from exhaust fumes of motor car, because lead is a major component of anti-knock ingredients (TEL) in petrol. Similar with the present study, Uduosoro and Unanaowo, (2015) detected the presence of lead, but on the contrary also discovered Ni, Cd and Fe, in rain water, in Uyo metropolis. Isoken and Isoken, (2017) in disagreement with the present study, reported the presence of Ni, Cu, Zn, Cd in addition to, Pb in some of the study areas under consideration. Other researchers from different countries had in various water samples in different locations identified so many other heavy metals in different proportions that ran contrary to the present work. Chubaka (2018) also identified Zn, Cu, Cd in addition to Pb, from rain water in South Australia. Most of the researchers' findings were either completely or partly in compliance with the findings of this present study.

Findings

Based on the result of physico-chemical properties in table, 1 above, the following findings were made:

1. The values for all the physico-chemical properties of the rain water, analyzed in all the locations were all within the WHO standard except for lead, (see, table 1).
2. The temperatures of water collected from Achara layout and Newhaven were 2^{o} and 3^{o} below the WHO standard while those collected from Ogui-nike, Trans-ekulu and Emene, were, 1^{o}, 1^{o} and 2^{o} above the WHO standard.
3. From the heavy metal analyses presented in Table 2. It was found that all the heavy metals analyzed were not detected in the samples except

Lead with a range of values between 0.029-0.166, which is higher than the WHO acceptable standard (0.05) for drinking water.

The study's findings have implications for teachers, students, and government:

Teachers - Incorporate water quality and conservation into curriculum, using local examples and case studies; Conduct projects and activities that promote rainwater harvesting and sustainable water management practices and encourage students to participate in water-related extracurricular activities

Students- They should learn about importance of water quality and conservation, and how to protect rainwater sources from pollution; Participate in projects and activities that promote rainwater harvesting and sustainable water management practices and develop skills and knowledge to monitor and analyze water quality, and identify potential sources of pollution. Government should develop and implement policies to regulate and monitor rainwater quality, and promote sustainable water management practices; provide funding and support for research and projects on rainwater harvesting and water conservation and educate the public about importance of water quality and conservation, and promote behavior change through awareness campaigns

Conclusion

The parameters of the rain water assessed from all the sampled locations met the WHO drinking water standard except for lead metal. It has been observed from the literature that the purity of water is dependent on a lot of factors such as, sources, location, morphological, biological, environmental, and anthropogenic, physical, chemical and so many other peculiarities with respects to the area of the study. The rain water assessed from the designated places were relatively safe for drinking and for other domestic activities, if the activities that introduce lead and other particulate matters into the environment could be urgently checkmated. The results obtained from the analysis of the samples, revealed that the quality of rain water in (Awkunanaw east, Achara layout, Ogui-nike, Emene and Trans-ekulu, Newhaven) had been assessed by comparing the level of each parameter with the standard limit as prescribed by WHO. And they were found to be within the permissible limits with the exception of lead. The study's findings highlight the need for regular monitoring and assessment of rainwater quality, and for public education and awareness campaigns to promote water conservation and protection of rainwater sources. By working together, we can ensure that rainwater remains a safe and sustainable source of drinking water for communities in Enugu metropolis, Nigeria.

Recommendations

Based on the findings of the study, the following recommendations were made.

1. Government should enact laws that should prohibit the use of leaded fuel and honestly follow it up by adequate monitoring through the ministry of environment.
2. Researchers should be encouraged to carry out similar assessment on a

regular basis, and at different locations in the state, to find out the levels of other harmful chemical elements or pollutants on the rainwater so that adequate solution should be proffered.

3. The result of this kind of study should be made available to the government through the ministry of Education. From there, a strong committee can be set up, to carry out enlightenment campaign, on the dangers associated with air pollutants normally generated through different kinds of burning and their deadly effect on rainwater. They should make sure that the report goes down to different grassroots, using different media, such as, radio, whatsApp messages, heads of schools, chairmen of local governments, ward councilors, down to traditional rulers in different villages.
4. Filtration methods using granulated activated carbon method should be introduced, and explained to the people, as a cost-effective method of rain water treatment before drinking. It is affordable and more importantly can be improvised using locally available materials.

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