# Comparative Study of Heavy Metals Composition in Industrial and Non-Industrial Areas of Ogun State

**Oguntade B.K[1*] Ajibode C.P[1]**
[1]Department of Science Laboratory Technology
School of Pure and Applied Sciences, Federal Polytechnic, Ilaro
*Corresponding author:ejire7072@gmail.com +2348050440530

**ABSTRACT**

As a result of the scarcity of portable water, the harvesting of rainwater has been favorable as an alternative source of water supply by most communities in Nigeria. This study was carried out to investigate and compare the physicochemical properties of rainwater from selected industrial (Sango-Ota), and non-industrial (Ilaro) locations in Ogun State. Rainwater samples were collected from nine (9) different locations between the months of July – October 2010. Parameters determined include pH, Temperature, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Total Solids (TS), Hardness, Chloride, $Cu^{2+}$, $Zn^{2+}$, $Ni^{2+}$, $Pb^{2+}$ and $Fe^{2+}$. The average results obtained for the industrial areas were 5.26, 26.25$^0$C, 1.26mg/l, 0.69mg/l, 1.58mg/l, 0.09CaCO3/50ml, 61.44mg/100ml, 0.15mg/l, 0.933mg/l, 0.11mg/l, 0.20mg/l, 3.80mg/l respectively. While those from non-industrial are 6.39, 27.87$^0$C, 0.69mg/l, 0.46mg/l, 0.98 mg/l, 0.08CaCO3/50ml, 35.86mg/100ml, 0.17mg/l, 0.82mg/l, 0.09mg/l, 0.19mg/l, 3.72mg/l respectively. All the parameters analyzed in the samples except pH, Cu and Zn fell within the WHO allowable limits for drinking water. Keywords: Rainwater, Pollution, Industrial area, ions, WHO.

## INTRODUCTION

One of the fundamental human rights is access to clean and affordable water. Water is essential to life and it is also a life foundation to social-economic development of any country (Olowoiya & Omotayo, 2010). As a result of the increasing population, urbanization and industrial growth, the security of water supply have become a major concern worldwide (Haque, Rahman, & Samali, 2016). Report has it that on a daily basis, Nigerians are faced with the problem of obtaining water for domestic purposes and other uses (Oyedotun & Dare, 2012), and less than 30% of the population has access to adequate drinking water (Ezemonye, Isueken, & Emeribe, 2016). Advancement in science and technology which brought improved standard of living, has also incidentally introduced some pollution into our environment (Hou, Takamatsu, Koshikawa, & Hosomi, 2005). In developing countries, one of the most important causes of ill health and sicknesses, is the consumption and usage of contaminated polluted water (Olorunfemi, 2007).

As a result of the increase in water demand, the collection of rainwater for non- potable or irrigation uses as well as ground water recharge is now being considered in many urban areas. Rainwater harvesting which has been in existence for a long period of time is being encouraged and promoted in countries like India, Australia, Brazil and China (Olowoiya & Omotayo, 2010). Rainwater is usually considered a safe and suitable source of potable water

particularly in locations where traditional, high-quality freshwater supplies are absent (Adeniyi, Olabanji, & State, 2005; Chakraborty & Gupta, 2018). In Nigeria, most communities lack treated pipe-borne water, therefore roof-intercepted rainwater and collection of free- fall rain are the major sources of potable water supplies during the rainy season

One of the most important environmental problems in the world is water pollution. It has been documented that 70% to 80% of all illnesses in developing countries are related to water contamination. Several researchers have reported that rainwater can contain a significant amount of pollutants such as heavy metals, nutrients and pathogens (Evans, Coombes, & Dunstan, 2006). Waterborne toxic chemicals such as heavy metals, pose a great threat to the safety of water supplies. The occurrence of metal ions in water may be natural from anthropogenic sources and from leaching of ore deposits, which mainly include solid waste disposal and industrial effluents. (Nouri, Mahvi, Babaei & Ahmadpour, 2006). They also originate from fossil fuel combustion and vehicular exhausts. Heavy metals contamination of aqueous media is a worldwide environmental problem due to their toxic effects and accumulation through the food chain (Zwain, Vakili, & Dahlan, 2014). Cr, Cu, Hg, Zn, Pb and so forth can cause damage to nerves and liver and also block functional groups of vital enzymes and bones (Awwad, Fouda, & Ibrahium, 2013). Due to these harmful environmental effects, the chemistry of rainwater has been considered as an issue of global concern during the last three decades (Vet et al. 2014) and has been widely investigated in urban and non-urban environments (Bisht al., 2016; Pu et al., 2017; Rao et al., 2016; Wu et al., 2016; Xiao, 2016; Roy et al., 2016).

Therefore in determining the potential success of potable use of rain water in the study area, the possible problems associated with its quality must be assessed. This study aims at investigating the physico-chemical composition and heavy metals (Cu, Zn, Ni, Pd and Fe) concentration in rainwater collected from industrialised and non-industrialised areas.

## MATERIALS AND METHODS

### Study area

The two locations chosen as study areas have no public water supply system except private dug-well and bore hole, while the majority who cannot afford these rely on available rainwater because it is cheap and accessible in the raining season.

Sango is geographically located between Latitudes $6^0$ 42' & 27.82" North of the equator and Longitude $3^0$ 15' & 21.61" East of the Greenwich Meridian. It is a town located in the western part of Ogun State and it is the capital of the Ado-Odo/Ota Local Government Area. It is bordered by Lagos state and it remains one of the most industrialized towns in Nigeria, housing a large number of factories and industries that freely release their effluents and emissions into the environment. This represented the industrialised study area.

Ilaro is a town in Yewa South Local Government Area of Ogun State. It is geographically located between Latitudes $6^0$ 53' & 20.44" North of the equator and Longitude $3^0$ 00' & 50.98" East of the Greenwich Meridian. It is the headquarters of the Yewa South Local Government and is only about 100km from Ikeja, the capital city of Lagos State. This is chosen because of the non-availability of industries to serve as the non-industrialized area.

### Sampling of Rain Water

A random sampling method was adopted in selecting samples from sampling sites from July – October 2010. Rainwater samples were collected roof-top run off . The rainwater collectors consisted of polythene funnel and a polythene bottle. Before placement of the samplers, the funnels and bottles were cleaned with detergent solution, and soaked in 1M HNO3 for 24hrs. Finally, all the apparatus were rinsed thoroughly with distilled water. The funnels were mounted on the bottles and both placed 2m above the ground and about 3cm away from trees or canopy. Rainwater samples were retrieved weekly from mid July –Mid October except when the water levels were extremely high or low (then sampling intervals were shortened or lengthened respectively). At the sampling site, insects in the funnel and debris were carefully removed while the bottles were rinsed with the remaining rainwater to remove any dust. The temperature and pH of the rainwater sample were measured on site immediately after collection with a mercury thermometer and Elico Li 120 digital pH meter respectively. The collected samples were transported to the laboratory, and refrigerated at $4^o$ C prior to other chemical analyses.

**Chemical Analysis**

In the laboratory, rainwater samples were analyzed for, total suspended solids (TSS), total dissolved solid (TDS), total solid (TS), hardness, chloride and heavy metal analysis. The Total Suspended Solids (TSS), Total Dissolved Solid (TDS), Total Solid (TS), hardness and chloride were all determined using standard methods (Ademoroti, 1996).

**Metal Analysis**

10ml of each rainwater sample was acidified by mixing with 20ml concentrated HNO3 in a conical flask and digested to about 5ml. The digest was made up to 25ml with distilled water in a 25ml standard flask and then filtered into a thoroughly cleaned plastic. The digested filtrates were analyzed for Pb, Cu, Zn, Fe and Ni using the Flame Atomic Absorption Spectrophotometer (FAAS), Buck Scientific 210 VGP model using appropriate lamps for the metals. All reagents used are of analytical grade.

**RESULTS AND DISCUSSION**

The results of the rainwater samples collected are presented in Table 1. All the samples collected and tested in this study were observed to be colorless. The pH of water governs the solubility and biological accessibility of elemental constituents in the water, such as nutrients and heavy metals. The pH values of the samples collected from the industrial area had an average pH value of $5.26 \pm 0.02$ and a similar case was observed for the non-industrial areas which had an average pH value of $6.398 \pm 0.02$ indicating that the rain is not strongly acidic. The acidic nature of the industrial area may be attributed to the emissions emanating from the industries in the location and the volume of vehicles. The pH of the non-industrial area agrees with the result of Ikhioya, Osu and Obuzor (2015) which reported a pH value of the range 6.0

– 6.5 while the result for the industrial area agreed with the Simmons, Hope, Lewis, Whitmore and Gao (2001). There was a significant difference between the pH values of the collected rainwater samples of the industrial and non-industrial areas ($p<0.05$). The pH values for both industrial and non-industrial areas are both lower than the set limit by WHO (6.5 – 8.5) which means that the water will most likely have a corrosive effect (NHMRC & NRMMC, 2011).

The average temperature of the samples collected from all the locations fall within the

range 25 – 28 $^{o}$C which conforms to the standard set by the World Health Organization (WHO) (20 - 32 $^{0}$C) and pose no human health when used for domestic purposes. The industrial areas had temperatures of $26.25 \pm 1.21$ $^{0}$C while the non-industrial areas have temperatures of $27.87 \pm 0.02$ $^{0}$C. There was a significant difference between these values at $p<0.05$. Biochemical and chemical reactions are affected by temperature. Elevated temperatures allow the toxicity of heavy metals to increase and also alleviate living organisms' sensitivity to toxic substances (SANS, 2005).

The solid content of the rainwater samples which includes Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and Total Solids (TS) all had average values less than 2mg/l which is hardly a sizeable fraction of the WHO standard limit of 1000mg/l. The TSS are particles that are larger than 2 microns found in the water column as anything smaller than 2 microns is considered a dissolved solid and it is known to reduce water transparency. TDS are inorganic matters and small amounts of inorganic matter which are present as a solution in water. Also, pathogens are often clumped or adherent to suspended solids in water (WHO, 2004). This implies that water samples collected may likely not pose health concerns even in households where rain water is consumed directly without any form of purification because of the very low content of TDS in the water samples. The presence of high levels of TDS may become objectionable to consumers owing to excessive scaling in heaters, boilers and other household appliances (WHO, 2004 and 2011). There is no significant difference between the solid content of the rainwater samples from the industrial and non-industrial areas at $p>0.05$.

The average values obtained for the hardness of all the samples collected at all locations had average values of 0.09 ± 0.01mg/l and 0.08 ± 0.01mg/l for the industrial and non-industrial areas respectively and this clearly falls within the set standards of 3mg/l. The industrial areas had a higher average of the hardness content and this can be related to the high number of plastic producing companies in the area. Plastic companies make use of calcium carbonate as filler in plastics since it is abundant in nature and a very cheap mineral (Ilhan, Suleyman, & Eren, 2013). There is no significant difference between the hardness of the rainwater samples from both sampled areas at p>0.05.

Although the chloride content of the industrial area (61.44 ± 2.56) is almost double that of the non – industrial areas (35.86 ± 0.43), these values are well within the WHO permissible limit of 200mg/l. At low concentrations, chloride is usually not harmful but at higher concentrations it can form salts with Calcium, Magnesium and Sodium and this can be harmful to boilers and plantation (Al-Khashman, 2016).

**Heavy Metals Analysis**

Investigation of heavy metals in rainwater samples revealed some degree of similarities. The average values of .Copper can be released through domestic activities like incineration and industrial activities such as mining operations, industrial discharge, sewage treatment plants and antifouling paints (IPCS, 1998). The domestic activities of incineration which is a common practice of getting rid of waste can be related to the presence of Cu in the non-industrial areas while the industrial activities in the industrial areas contribute to the presence of Cu in the industrial areas. Some characteristics of water such as low pH, high temperature and reduced hardness can also lead to the leaching of Cu (EPA, 1994). Contamination of water with a high level of copper may lead to chronic anemia and it is also a fundamental cause of Wilson's disease. There is no significant difference between the Cu content of both areas of the rainwater samples as p>0.05.

The Zinc content of rainwater samples of the industrial areas (0.93 ± 0.01) and the non-industrial areas (0.82 ± 0.01) was lesser when compared with the WHO standard of 2.0mg/l. There is no significant difference between the values obtained for both areas at p>0.05. There is a relationship between Zn, lead and roof material as the rainwater samples were collected from rooftop run-offs with most being galvanized roofing. Zn and lead found in rainwater could be linked to a combined corrosive action by solar radiation, wind, weathering and pollution on rooftop structure materials. Numerous studies have indicated that exposure to solar ultraviolet radiation can rapidly fade coatings on structure materials, scale off tiny metallic micro-particles and paints on coated surfaces and trigger corrosion (Kogler, 2015; England, 2011).

The concentration of Lead in rainwater samples was higher than 0.01mg/l limit of WHO in both areas. The industrial area revealed a value of 0.20 ± 0.01mg/l while the non-industrial area has 0.19 ± 0.01mg/l. the higher values may be attributed to the rooftop flashing in both areas and lead emissions originating from petrol (Lars, 2003). There is no significant difference between the two areas at p>0.05. This implies that the consumption of such water can put the consumers at risk if consumed directly or through the consumption of irrigated agricultural products from the sites or locations. Lead interferes with functions performed by essential mineral elements such as calcium, zinc, iron and copper. It inhibits red blood cell-enzyme systems (Vasudevan & Streekumari, 2000). Lead can also displace calcium in the bone to form softer denser spots and also inactivates cysteine containing enzymes, allowing more internal toxicity from free radicals, chemicals and other heavy metals (Underwood, 2002).

The values obtained for Nickel for the industrial areas (0.11 ± 0.01) and the non-industrial areas (0.09 ± 0.01) were very high in comparison with the WHO standard value of 0.02mg/l and this can be attributed to sources of Ni which include both industrial and domestic activities. The industrial activities that could be responsible for the high content in the industrial areas include pollution from power plants, nickel plating, battery manufacturing and others. The use of generator sets and incineration in the non-industrial areas are possible sources of Nickel. It has been reported that excessive intake of Ni may be linked with various health hazards, some of which include higher chances of lung, nose, larynx and prostate cancer development. Worsening eczema, hair loss and derma toxicity in hypertensive humans

Table 1: Physicochemical Properties of Rainwater for Industrial and Non-industrial Areas

| Parameter/site | Industrial | Non-Industrial | P value | WHO Standards |
|---|---|---|---|---|
| pH | 5.26 ± 0.02 | 6.39 ± 0.02 | 0.002 | 6.5 – 8.5 |
| Temp. ($^0$c) | 26.25 ± 1.21 | 27.87 ± 0.01 | 0.021 | 20 - 32$^0$C |
| TSS (mg/l) | 1.26 ± 3.48 | 0.69 ± 0.10 | 0.432 | 1000mg/l |
| TDS (mg/l) | 0.69 ± 0.13 | 0.46 ± 0.01 | 0.492 | 1000mg/l |
| TS (mg/l) | 1.58 ± 3.48 | 0.98 ± 0.02 | 0.393 | 1000mg/l |
| Hardness (CaCO3/50ml) | 0.09 ± 0.01 | 0.08 ± 0.01 | 0.778 | 3mg/l |
| Chloride (mg/100ml) | 61.44 ± 2.56 | 35.86 ± 0.43 | 0.250 | 200mg/l |
| Cu (mg/l) | 0.15 ± 0.01 | 0.17 ± 0.01 | 0.536 | 2.0mg/l |
| Zn (mg/l) | 0.93 ± 0.01 | 0.82 ± 0.01 | 0.411 | 2.0mg/l |
| Ni (mg/l) | 0.11 ± 0.01 | 0.09 ± 0.01 | 0.324 | 0.02mg/l |
| Pb (mg/l) | 0.20 ± 0.01 | 0.19 ± 0.01 | 0.977 | 0.01mg/l |
| Fe (mg/l) | 3.80 ± 1.20 | 3.72 ± 3.10 | 0.929 | 0.3mg/l |

*Data are average of triplicates ± standard deviations (SD). Water standards (maximum acceptable concentration) of the WHO— World Health Organization (2011).

have also been related to Ni (Jennings, Sneed, & Clair, 1996; Kaaber, Veien, & Tjell, 1978).

4 There is also no significant difference between the values obtained from both areas (p>0.05).

5 Critical levels of Iron (Fe) were observed both in the industrial (3.80 ± 1.20) and non-6 industrial (3.72 ± 0.01) areas. The minimum daily requirement for iron depends on various 7 factors, with the range being between 10 and 50 mg per day. The lethal dose of iron is 200– 8 250 mg/kg of body weight, but death has occurred after ingestion of doses as low as 40 mg/kg 9 of body weight. Studies have shown that excess iron can result in hemorrhagic necrosis and sloughing of mucosa areas in the stomach. The possible sources of Fe are its natural existence in rivers, lakes and underground water and it may be released from natural deposits, industrial wastes, refining of iron ores and corrosion of iron containing metals. This explains the high concentrationof Fe in industrial areas. The consumers of the water in the areas with high iron concentrations are most likely to be affected. (Bo, 2017). There is no significant difference for the Fe content between the two areas as p>0.05. The fluctuations in the levels of the pollutants recorded in this study may be attributed to variations in the source of the samples, anthropogenic activities at the different sites and the fact that rainwater chemistry can also be influenced by long distance transport (Al-Khashman, 2009; Bidisha & Abhik, 2018).

## CONCLUSION

From the results presented, it is observed that though the collected rainwater from sampling areas is within the WHO limit for potable water, the concentrations of Ni, Fe and Pb were considerably higher than the limit. This could be a result of anthropogenic inputs.. The quality of rainwater is always dependent on the location and environmental factors as is the case in this present study. From the values obtained, it can be concluded that both areas that were tested are not contaminant free. Industrialization is a huge contributor to pollution of the environment. However, considering that the other sources of pollution which include domestic, vehicular and agricultural activities have lesser prominence in the industrial areas 30when compared with the non-industrial areas, it can be concluded that rainwater contamination is not limited to industrial activities alone but the other factors such as incineration of wastes, vehicular movement can also be responsible for the contamination as seen in the results of the non-industrial areas. This shows that these other sources when integrated into an environment, be it industrial or non-industrial can work together to increase the level of contamination to a level almost as high as that of industrialization. Public education on the effects of untreated rainwater samples and its treatment is highly recommended. A repeat of this work is also recommended to be carried out at intervals of five (5) to ten (10) years with focus on these other sources of pollution, how they measure up to industrialization and the effect of roofing materials on the quality of the rainwater.

## REFERENCES

Adeniyi, I. F., Olabanji, I. O., & State, O. (2005). The physico-chemical and bacteriological quality of rainwater collected over different roofing materials in Ile-Ife south western Nigeria. Chemistry and Ecology, 21(3), 149–166.

Al-Khashman, O.A. (2016). Study of chemical composition in wet atmosphericprecipitation in Eshidiya area, Jordan. Atmospheric Environment, 39, 6175-6183.

Bidisha, C., & Abhik, G. (2018). Study and Interpretation of Chemical Composition of

Rainwater in Selected Urban and Rural Locations in India Using Multivariate Analysis.American Institute of Physics, 020034, 1-7.

Bisht, D. S., Srivastava, A. K., Joshi, H., Ram, K., Singh, N., Naja, M…Tiwari, S.(2016). Chemical characterization of rainwater at a high-altitude site "Nainital" in the central Himalayas, India. Journal of Environmental Science and Pollution Research, 24,3959–3969.

Cobbina, S. J., Duwiejuah, A. B., Quansah, R., Obiri, S., & Bakobie, N. (2015). Comparative Assessment of Heavy Metals in Drinking Water Sources in Two Small-Scale Mining Communities in Northern Ghana. International Journal of Environmental Research and Public Health, 12, 10620-10634.

Central Pollution Central Board (CPCB). (2003). Parivesh, Polycyclic Aromati Hydrocarbons (PAHs) in air and their effects of human health, November, CentralPollution Central Board, Ministry of Environment and Forest, Delhi, pp. 20.

Dinrifo, R. R., Babatunde, S. O. E., Bankole, Y. O., & Demu, Q. A. (2010). Physico- Chemical properties of Rain Water Collected from Some Industrial Areas of Lagos State Nigeria. European Journal of Scientific Research, 41(3), 383-390.

Evans, C. A., Coombes, P. J., & Dunstan, R. H. (2006). Wind, rain and bacteria: The Effect of weather on the microbial composition of roof-harvested rainwater. Water Research, 40(1), 37-44.

Ferner, D. J. (2001). Toxicity, heavy metals. Journal of Emergency Medicine, 2, pp.1.

Fujita, S., Takahashi, A., Weng, J. H., Huang, L. F., Kim, H. K., Li, C. K., …Jeng, F. T.(2000). Precipitation chemistry in East Asia. Atmospheric Environment, 34:525–537.

Haque, M., Rahman, A., & Samali, B. (2016). Evaluation of climate change impacts on Rainwater harvesting.JournalofCleanerProduction,137, 60–69 . https://doi.org/10.1016/j.jclepro.2016.07.038

Hou, T., Takamatsu, M., Koshikawaand, M., & Hosomi, P. (2005). Trace metals in bulk precipitation and throughfall in a suburban area of Japan. Atmospheric Environment, 39, 3583 – 3595.

Ilhan, O., Suleyman, S., & Eren, F. (2013). Production and Characterization of Polyethylene/Calcium Carbonate Composite Materials by Using Calcium Carbonate Dry and Wet Coated With Different Fatty Acids. Polymer & Polymer Composites, 21(3),183-187.

National Health and Medical Research Council (NHMRC), NaturalResource Management Ministerial Council (NRMMC). (2011). Australian Drinking Water Guidelines: 6, 2011. National Water Quality Management Strategy, Canberra. NHMRC and NRMMC.

Olowoiya, O., & Omotayo, A. (2010). Assessing the Potential for Rainwater Harvesting. Water Resource Management, 24, 2129–2137.

Pu, W., Quan, W., Ma, Z., Shi, X., Zhao, X., Zhang, L., …Wang, W. (2017). Long-term trend of chemical composition of atmospheric precipitation at a regional background station in Northern China. Science of the Total Environment 580, 1340–1350.

Rao, P. S. P., Tiwari, S., Matwale. J. L., Pervez, S., Tunved, P., Safai, P. D., …Hopke, P. K. (2016). Sources of chemical species in rainwater during monsoon and non-monsoonal periods over two mega cities in India and dominant source region of secondary aerosols. Atmospheric Environment 146, 90–99.

Roy, A., Chatterjee, A., Tiwari, S., Sarkar, C., Das, S. K., Ghosh, S. K., & Raha, S. (2016). Precipitation chemistry over urban, rural and high altitude Himalayan stations in eastern India. Atmospheric Research. 181, 44–53.

Singh, A. K., Mondal, G. C., Kumar, S., Singh, K. K., Kamal, K. P., & Sinha, A. (2007). Precipitation chemistry and occurrence of acid rain over Dhanbad, coal city of India.

Environ Monit Assess 125, 99–110. South African National Standards (SANS) 241, Drinking Water Quality Management Guide for Water Services Authorities, Annexure 1, 2005.

Underwood, L.S. (2002). Long – term effects of childhood exposure to lead at low dose; an eleven years follow – up report. New England Journal of Medicine, 322, 83 – 88.

Vasudevan, D. M., & Streekumari, S. (2000). Biochemical aspect of environmental pollution. Textbook of Biochemistry for Medical Students. 2nd ed. Jaypee Brothers Medical Publishers, Ltd, New Delhi, India. Pp. 485 – 467.

Vet, R., Artz, R. S,, Carou, S., Shaw, M., Ro, C-U., Aas, W., …Reid, N. W (2014). A global assessment of precipitation chemistry and deposition of sulfur, nitrogen, seasalt, base cations, organic acids, acidity and pH, and phosphorus. Atmospheric Environment.93, 3–10.

Vikaskuma,r G.S., Hugh D.R., Phillip M.G., Peter, C., Timothy, K.R., & Tony, R. (2007). Comparison of Water Quality Parameters from Diverse Catchments during Dry Periods and Following Rain Events. Water Research, 41, 3655-3666.

World Health Organization (WHO). Guidelines for Drinking-Water Quality: Recommendations; World Health Organization: Geneva, Switzerland, 2011.

Wu, Y., Xu, Z., Liu, W., Zhao, T., Zhang, X., Jiang, H., …Zhou, X. (2016). Chemical compositions of precipitation at three non-urban sites of Hebei Province, North China: influence of terrestrial sources on ionic composition. Atmospheric Research. 181, 115–123.

Xiao, J. (2016). Chemical composition and source identification of rainwater constituents at an urban site in Xi'an. Environmental Earth Science. 75, 209.