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FOREWORD

It is with great delight I welcome you to volume 4 issue 2 of Federal Polytechnic – Journal of Pure and Applied Sciences (FEPI-JOPAS). It is a peer-reviewed open-access multi-disciplinary Journal of global recognition which is referenced and indexed in African Journal Online (AJOL). It is a highly commendable Journal that publishes excellent research contributions and exhibiting also special attention to experience papers coming from the many application areas of pure and applied Sciences. FEPI-JOPAS publishes full-length research work, short communications, critical reviews and other review articles.

The aim of FEPI-JOPAS is to provide intellectual bedrock for both indigenous and international scholars with quality research outputs to express and communicate their research findings to a broader populace. It serves as a valuable platform for the dissemination of information to 21st Century researchers, professionals, policymakers, manufacturers, production staff, R & D personnel as well as governmental and non-governmental agencies. It also aimed to provide a platform for academics and industry practitioners to share cases on the application of management concepts to complex real-world situations in pure and applied sciences and related fields.

This volume 4 issue 2 of FEPI-JOPAS is loaded with quantum and well-featured diversity of trending topics in applied and basic research. These hot and trending topics are: Sustainable Art and Design: Activating Sighting as the Phenomenon of Representational Drawing; Assessment of Heavy Metals in Processed Meat (Tinko) Sold within Igbesa Community; The Hypoglycemic Effect of Musa Sapientum in Alloxan Induced Diabetic Albino Wistar Rat; Rainwater Quality Evaluation for Agricultural Use: Case Study of a Portland cement Producing Area; Analytical Approach to Investigating the Influence of Blood Group and Blood Genotype on the Performance of Students of Federal Polytechnic, Ilaro; Dough Mixing Time: Impact on Dough Properties, Bread-Baking Quality and Consumer Acceptability; Chemical Composition of Harvested Rainwater Around a Cement Factory in Ibeshe, Yewa North, Ogun State.

Furthermore, other topics to be encountered in this issue that have added colour and beauty to this edition are: Physicochemical properties and sensory evaluation of milk candy ‘toffee’ (a

NIGERIA candy) enrich with coconut, tigernut and groundnut; Informal Settlements in Developing Countries: Issues, Challenges and Prospects; Comparison of Sensory Properties of Meals Produced from Cowpea and Pigeon Pea; Automated Lecture Timetable Generation Using Genetic Algorithm; Septic Tanks Contamination in Groundwater Quality around Elementary Schools in Ibadan, Oyo State Nigeria; and Waste Disposal Systems in Some Selected Abattoirs Located in Ilaro Metropolis. FEPI-JOPAS has been centered on discerning the changing needs of the academic world and is committed to advancing research around the world by publishing the latest research in various academic fields and ensuring that the resources are accessible in print, digital, and online formats.

In addition, I would like to thank many people who worked so hard to ensure that publishing this issue 2 of volume 4 is a reality. I would like to thank the Editorial Board for their guidance and the publishing team for the continued support and effort in streamlining the publication process. I am grateful to the reviewers who provided timely and constructive reviews for the papers assigned to them. The authors are solely responsible for the information, date and authenticity of data provided in their articles submitted for publication in the Federal Polytechnic Ilaro – Journal of Pure and Applied Sciences (FEPI-JOPAS).

I am looking forward to receiving your manuscripts for the subsequent publications. You can visit our website (https://fepi-jopas.federalpolyilaro.edu.ng) for more information, or contact us via e-mail us at fepi.jopas@federalpolyilaro.edu.ng

Thank you and best regards.

Prof. Olayinka Oyewale AJANI

(Editor-in-Chief)

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Rainwater Quality Evaluation for Agricultural Use: Case Study of a Portland Cement Producing Area

Oyedeji A.O., Adebayo R.O. and Onifade E.

Department of Science Laboratory Technology, The Federal Polytechnic, Ilaro, Nigeria.

olalekan.oyedeji@federalpolyilaro.edu.ng *http://orcid.org/0000-0003-1592-3409*

Abstract

The quality and chemical composition of rainwater available for agricultural purposes are influenced by anthropogenic factors that have a significant impact on crops and yields. This study was performed primarily to identify baseline rainwater quality conditions for irrigation and other agricultural purposes. Rainwater from Ibeshe, home to two proximate Portland cement plants, was analysed for anions, and cations and assessed for its agrarian usefulness. The physicochemical characteristics and total dissolved solids (TDS) (34.56 mg/L) measured in situ were suitable for agricultural purposes. Among the cations and macronutrients, Ca^{2+}(434.47±212.67), Na^{+}(1768.9±724.8), K^{+}(594.3±296.0), Mg^{2+}(521.33±62.43), and B^{3+}(10.53±1.75) measured in meq/L exceeded the standards required for irrigation water, while all anions except nitrate, were within acceptable limits. The irrigation quality potentials of the rainwater samples were assessed by determining parameters including sodium adsorption ratio (SAR), sodium hazard (SH), Kelly's index (KI), soluble sodium percentage (SSP), magnesium hazard (MH), potential salinity (PS), and calcium/magnesium ratio (Ca/Mg). Irrigation quality indicators, including SAR (80.91 meq/L), KI (1.85 meq/L), SSP (71.2%), Ca/Mg (0.833) and MH (54.53 meq/L) showed the unsuitability of the rainwater for irrigation purposes, while the PS (0.01 meq/L) and %Na (53.0%) values were within acceptable limits. The rainwater quality will make the soil alkaline, saline, and clayish over time, and unsuitable for specific crops without prior soil amendment. The findings contribute to the understanding of rainfall chemistry in the cement-producing area of Yewaland by providing baseline information for a previously unstudied community.

Keywords: Alkaline soil; Rainwater analysis; Ibeshe; Portland cement plant; agricultural water quality

INTRODUCTION

The quality of rainwater is an indirect indicator of air pollution load created by increased anthropogenic activities from urbanisation, industrialisation, burning of fuel and intensive agriculture (Ghimire & Johnson, 2019). The amount and origin of suspended dust as well as anthropogenic gaseous atmospheric constituents have a great influence on the chemical composition of rainfall water and this has been used to reveal the extent of air pollution (Zeng & Han, 2020). Motor vehicles, industry, mineral extraction and agriculture constantly emit various chemical substances into the atmosphere and are scavenged by rainfall (Kotowski, Motyka, Knap, & Bilewski, 2020). Portland cement production is associated with heavy plants powered with hydrocarbons, increased emissions of air pollutants like SO_2, NOx, volatile organic compounds (VOCs) and various aerosols associated with the combustion of petrol and diesel in truck engines that can be found in precipitation.

Depending on the intensity of these events, rainwater from the affected areas scavenges pollutants from the atmosphere that could pose harmful effects on plants. The suitability of water for agricultural purposes is determined by the type and total amount of salts present, and the individual ions. Various soil and cropping problems develop as the total salt content increases, and special management practices may be required to maintain acceptable crop yields. Water quality or suitability for agricultural use is judged on the potential severity of problems that can be expected to develop during long-term use. Studying the chemical content of rainfall gives an understanding of its agricultural use and yield.

Conceptually, water quality refers to the characteristics of a water supply that will influence its suitability for a specific use, and this is definite by certain physical, chemical and biological characteristics with emphasis on the first two qualities with water for agricultural use since specific uses have different quality needs (FAO, 2019a). Several studies have been performed on harvested rainwater samples Ojo and Oguntimehin, (2017); Olaoye, Afolayan, Adetokun and Akinleye, (2018); Okpoebo, Jayeoye, Abebayo, and Oguntimehin, (2014) and Olowoyo (2011) none of these studies examined the impact of rainfall on agricultural productivity of the areas been studied. Accordingly, to protect plants and crop yields of mining communities, it is necessary to understand the physicochemical characteristics of their rainfall and evolution under anthropogenic conditions since the quality of water is an important factor for sustainable agriculture (Nganje, Hursthouse, Edet, Stirling, & Adamu, 2015).

MATERIALS AND METHODS

Site description

Ibeshe (6º57'33" N, 3º2'15" E) is an agrarian rural community in Ogun state, Nigeria. The community is home to Dangote Portland cement Plc with a power station fired with coal, gas and oil. The plant has in close proximity, Purechem Industries Limited at Onigbedu (6° 58' 0" N, 3° 8' 0" E) that quarries limestone and clay for the production of cement and other building materials. The combined activities of these plants have greatly affected transportation activities in the area by heavy duty trucks resulting dust haze.

Sample collection and analysis

Rain water samples were collected on an event basis between March and August 2022. Samples were collected at an elevation of 50 metres above the ground in funneled polyethylene containers previously rinsed with distilled –deionised water from Ibeshe township centre. The collected rainwater was divided into 3 separate samples for the analysis of cations, anions, and other measurements. Samples collected for chemical analysis were filtered with an acro syringe (0.45-μm) filter into polyethylene bottles while those for cation analysis were further acidified using a few drops of concentrated HNO_3.

Analysis of anions and cations

The temperature, pH and conductivity of the samples were measured in situ with the P713 laboratory multiparameter pH/conductivity meter (Shanghai Yoke Instr. Co. Ltd., China). The anions were analysed with 930 Compact IC Flex from Metrohm (Metrohm AG, Herisau, Switzerland). The column was a Metrosep A Supp 5 - 100/4.0 with a flow of 07 mL/min at a pressure and temperature of 7.84 MPa and 35.0ºC, respectively with 3.2 mmol/L $NaCO_3$ and 1.0 mmol/L $NaHCO_3$ as eluents. Cation's analysis was performed on an inductively coupled plasma optical emissions spectrophotometer (Agilent 720-ES ICP-OES from Agilent Technologies, Mumbai, India). The machine was calibrated with appropriate standards for the different metals, and calibration curves with good regression equations and values were obtained before the analysis of real samples.

Suitability of the rainwater samples for irrigations purposes

The suitability of the rainwater samples was assessed with irrigation water quality indices that include sodium adsorption ratio (SAR), exchangeable sodium percentage (%Na), Kelly's index, permeability index, potential salinity (PS), magnesium hazard, total dissolved solids and total hardness. The details of the different determinations using anion and cation concentrations of the samples are shown in Table 1 (Rawat, Singh, & Gautam, 2018; Al-Saffawi, Ibn Abubakar, Abbass & Monguno, 2020).

RESULTS AND DISCUSSION

Some of the anions in the rainwater samples of Ibeshe are shown in the chromatogram in Figure 1.

Table 1: Summary of water quality indices for irrigation

Sodium adsorption ratio (SAR)	$\frac{Na^+}{\sqrt{\frac{(Ca^{2+} + Mg^{2+}}{2}}}$
Soluble sodium percentage (SSP)	$\frac{Na^+ + K^+}{Mg^{2+} + Ca^{2+} + K^+ + Na^+} x\ 100$
Sodium hazard or percent sodium (%Na)	$\frac{Na^+}{Ca^{2+} + Mg^{2+} + Na^+ + K^+}$ x 100
Kelly's ratio (KR) or Kelly's index (KI)	$\frac{Na^+}{Mg^{2+} + Ca^{2+}}$
Magnesium hazard (MH) or magnesium adsorption ratio (MAR).	$\frac{Mg^{2+}}{Mg^{2+} + Ca^{2+}}$
Potential salinity (PS)	$Cl^- + 0.5\ x\ SO_4^{2+}$
Total hardness	2.5 x Ca^{2+}+ 4.1 x Mg^{2+}

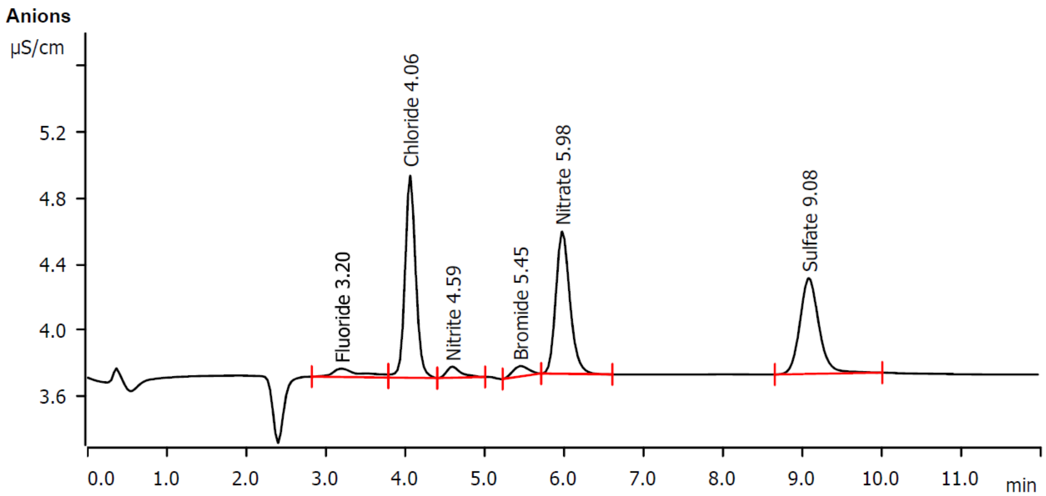

Figure 1: The chromatographic profile of some anions in the rainwater samples of Ibeshe

The physicochemical characteristics, anion and cation concentrations of the harvested rainwater samples are as indicated in Table 1. The TDS, pH, and conductivity of the samples are within the limits of irrigation standards for water and are not limiting factors in the water for the agricultural lands in the study area. Sodium, chloride, and boron from water known to concentrate in certain crops to cause damage and reduce yields were found at concentrations beyond the stipulated standards (FAO, 2019b). The total sum of K^+ and Na^+ in this study is a major limiting factor for the agricultural usefulness of the samples since the two ions combine with Cl^- to give salty water. Excessive Cl^- in the leaves of plants after transpiration causes drying of leaf tissues and leaf burn (Hussain, Alquwaizany & Al-Zanah, 2010). The unusual high K^+ and Na^+ concentrations in the rainwater samples is an indication of natural and industrial brines in the atmosphere of the sampling area, and greater amounts of evaporite minerals, like gypsum and anhydrides available for dissolution (Driscoll, Carter, Williamson & Putnam, 2002). Magnesium, greatly adsorbed than Na^+in soils and at the same proportion with $Ca^{2+}$is above the specified limits for irrigation water in this study. Magnesium content of irrigation water is an important qualitative criterion, particularly its equilibrium with calcium (Joshi, Kumar & Agrawal, 2009; Berhe, 2020). The Ca/Mg ratio for the rainwater samples was 0.833. This ratio of macronutrients is essential since it affects plant physiological processes and forage quality (Rishi, 2010). A lower than unity Ca/Mg ratio in irrigation water, as observed in this study, is harmful to plants, poses an impending problem connected to plant nutrition and compromises soil conditions (Hussain et al., 2002; Hussain et al. 2010). Low Ca/Mg ratio affects the solubility and availability of other plant nutrients, specifically phosphorus, and some other microelements. Iron, though not specifically toxic to plants, leads to reduced soil pH resulting in acidification and loss of molybdenum and phosphorus essential to plants from soils (Głowacka, Szostak & Klebaniuk, 2020). The presence of Fe^{2+} in overheard sprinklers may result in unsightly deposits on plants that could hinder photosynthesis and other metabolic processes (FAO, 2019c). While all cations exceeded the established limits for irrigation water as shown in Table 2, some of these metals (molybdenum) may not be toxic to the soil at the reported concentrations, but livestock if forage is grown on it. Specifically, the concentration of As^{5+} and Co^{2+} makes the water samples unsuitable for cultivating rice and tomato, respectively. Alongside F^-, the presence of As^{5+} and Co^{2+}in soils will require neutral and alkaline treatments to be suited for rice and tomato cultivation (FAO, 2019c). Copper, Pb^{2+}, Ni^{2+}, Al^{3+} and V^{3+} are also toxic to plants at relatively low concentrations by inhibiting plant cell growth. A previous study by Adetunji, Eludoyin and Martins (2018) on rainwater samples from a cement plant in close proximity to this study area with lower sensitive analytical equipment reported a few anions and cations in lower concentrations compared to what is obtained in the current study. However, higher concentrations of Mg^{2+}, Ca^{2+}, Na^+ , K^+, and Cl^- were reported relative to other ions and this is consistent with our findings.

Table 2: Physical and chemical characteristics of harvested rainwater

Parameters		Mean±SD	Irrigation Standard*
Temperature (ºC)		29.7±0.5	
pH		6.5±0.2	6.0 – 8.5
Conductivity (dS/m)		0.05±0.01	0 – 3
TDS (Calc.) (mg/L)		34.56	< 450
F^-	meq/L	0.02±0.0	0.11
Cl^-		1.19±0.68	0 – 4
NO_3^-		23.31±23.37	0 – 5
NO_2^-		0.12±0.08	0 – 5
PO_4^{3-}		0.11±0.10	NA
SO_4^{2-}		0.02±0.0	0 – 20
Br^-		0.10±0.0	NA
Ca^{2+}		434.47±212.67	0 – 20
Na^+		1768.9±724.8	0 – 40
K^+		594.3±296.0	0 – 2
V^{3+}		1.02±0.02	NA
Mo^{2+}		0.73±0.03	0.001
Mg^{2+}		521.33±62.43	0 – 5
Fe^{2+}		5.81±0.0	0.18
Co^{2+}		0.59±0.0	0.002
Ni^{2+}		0.29±0.0	0.007
Cu^{2+}		0.31±0.0	0.006
Al^{3+}		15.57±1.8	0.56
B^{3+}		10.53±1.75	0 –2
Pb^{2+}		8.29±1.7	0.05
Si^{4+}		725.3±16.2	NA
As^{5+}		7.68±1.90	0.06

Key – NA – Not available: *FAO, 2019b; *Hussain, Alquwaizany & Al-Zanah, 2010.

The concentrations of the anions are within acceptable limits except nitrate (23.31±23.37 meq/L) that could be injurious to susceptible plants (Adeyemi, Muhammed & Oludare, 2019). Previous studies from semiarid and arid regions have shown that rainwater ionic composition can be severely influenced by alkaline particles from mining and other anthropogenic activities and mineral soil dust (Deusdara et al., 2016). The pattern of ionic distribution in this study is similar to the results of rainwater chemistry in the Caatinga region of Brazil, the chemical composition of rain, snow and sleet in Krakow, Poland (Deusdara et al. 2016; Kotowski et al., 2020). Contrary to our result, SO_4^{2-} reported to be within acceptable limit was the most inorganic ion in the precipitation of semi-arid rural and industrial areas of South Africa, this suggests that rainwater chemical composition of is highly dependent on the anthropogenic activity in the study area (Mphepya, Pienaar, Galy-Lacaux, Held & Turner, 2004). The micro and non-nutrient elements in this study (Pb, As, Ba, Al and V) have higher concentration values than those in rainwater samples from Southeastern Nigeria with particular reference to Nkalagu, an age-long Portland cement producing town (Nganje et al., 2015).

Quality indices of the rainwater samples for irrigation purpose

The sodium adsorption ratio in this study as shown in Table 3 is 80.91, and it is greater than the recommended value of 10. High SAR reduces soil permeability, aeration and water infiltration, thereby making the soil compressed and impermeable (Joshi et al., 2009; Berhe, 2020). The SAR for the rainwater will be more damaging since the samples also have lower Ca/Mg ratio (FAO, 2019c). Sodium adsorption ratio influences the percolation time of water into the soil, and is used to assess the potential of Na^+ to accumulate in the soil, primarily at the expense of Ca^{2+}, Mg^{2+} and K^+ (Rawat et al., 2018).

Table 3: Classification of rainwater (meq/L) within the study area for irrigation purposes

Index	SAR	SSR (%)	%Na	KR	MH	PS	TH	TDS
Value	80.91	71.2	53	1.85	54.53	0.01	41944.3	34.56
Class	Unsuitable		Permissible	Excess Na^+	Not Recom.	Suitable	Very hard	Preferred

The percentage sodium (%Na) in this study, as shown in Table 3 is within the acceptable limit for irrigation. High %Na values restrict the free movement of water in soils in wet conditions due to the formation of clay particles through a base-exchange reaction by the removal Ca^{2+} and Mg^{2+} ions. This exchange process in soil restricts the water and air movement capacity, thus, making the soils become hard when dry. Sodium also reacts with CO_3^{2-} and Cl^- to form alkaline and saline soils, respectively, leading to retarded crops and agricultural losses. The rainwater has excess sodium as shown by the Kelly's index (KI), making it unsuitable for plant growth because of alkali hazards as previously enunciated. An ideal KI value for irrigation water should be ≤ 1 have been recommended for adequate plant growth, while those with KI ≥ 1 are not recommended because of their alkali hazards (Al-Saffawi et al., 2020; Rawat et al., 2018). The magnesium hazard (MH) or magnesium adsorption ratio (MAR) as obtained in this is above the MH≤50 recommended for irrigation water. A high MH value can increase soil pH resulting in lower phosphorous for plants and decreased crop yield. The potential salinity (PS), another irrigation water quality parameter-based index however showed that the rainwater is suitable for irrigation purposes since the 0.01 meq/L obtained in the study is lower than the 3 meq/L indicated as been suitable for use in irrigation water. The total hardness (TH) of the samples computed from the Ca^{2+} and Mg^{2+} concentrations in meq/L indicated that rainwater is very hard and unsuitable for agricultural purposes. This shows the extent of mineralisation of the rainfall in the area since the cement production is associated with Ca^{2+}.. Excessive mineralisation leads to accumulation of salts at the crop's root zone after evapotranspiration due to increased soil osmotic potential, thereby preventing its access to water from the soil that results in water stress over a time-period, slowed growth and yield reduction (Joshi et al., 2009). Contrary to our findings, the agricultural index of all rainwater samples from the southeastern region of Nigeria, where cement is mined, suggested the suitability of the water for agricultural purposes (Nganje et al., 2015).

CONCLUSION

The mineral contents of the rainwater samples exceeded standards established for irrigation and is evident of the mining activity occurring in the study area since water from mining areas is highly mineralised. The alkaline nature of the rainwater showed a dominance of neutralising compounds, such as calcium and magnesium. This will lead to a gradual mineralisation and hardening of soil in the affected areas leading to soil erosion and a decline in agricultural productivity. It is recommended that the cultivation of plant species resistant to salts should be encouraged among farmers. Dangote Cement Plc, and other mining companies in the area should monitor rain chemistry on a continuous basis in and around their operational areas, and support any effort in the same direction by the Nigerian government.

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