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Physicochemical Analysis of Surface Water Quality on Seasonal Ponds along Riverine Communities

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Abstract: *Water as a resource is essential to human life beside been the most fundamental resource for his socio-economic development. Within the land-lock Northern Nigeria, the surface water and groundwater resource remain the only source of the region fresh water. With contemporary pronounced effects of climate change as well as various anthropogenic activities, there is consequential rise in demand of fresh water. Consequently, both quantity and quality of fresh water resource is threatened largely due to recent population explosion. However, most developing regions of the world require new methods and innovative approaches for fresh water management, conservation, and judicious uses. Nonetheless, the dependence of arid and semi-arid regions on irrigation holds a special place in the water scarcity and management debates. This study was carried out along the river Anumma in Ngalda area of Yobe State, Nigeria. The study revealed that there is an active pollution largely associated to higher fertilizers and pesticides residues. The study also reaffirmed the calls for immediate action and adoption of sustainable agricultural practices along riverine communities in order to safe-guide the region most precious resource (water).*

Keywords: *Fertilizer Residue, Irrigation, Pollution, Water Resource*

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I. Introduction

Water is commonly regarded as life. The global total water supply is estimated to be about 332 million cubic miles where about 71 percent of the total Earth's surface is covered with water. The oceans constitute about 96.5% of the total water while the remaining 3.5% percent is found in ice and glaciers, rivers, lakes and ponds[1]. In most developing economies, surface water resource is the powerhouse of their agricultural and domestic activities, especially along the riverine communities of West Africa[1]. Water is never static; it exists in the air as water vapour, in rivers and lakes, in icecaps and glaciers, in the ground as soil moisture and in aquifers, and even in plants and humans. Water is necessary to all living organisms' survival. However, not all water is as valid as others; some are cleaner than others. The quality of water is supreme and it is the second attribute after it availabilities[2]. The quality of water determined the roles in almost all aspect water resource management, uses and exploitation[1].

The world surface water is not evenly distributed on the surface of the earth, it's mainly found on various patches spread on the earth surface in various rivers, lakes, wetlands, ponds and streams. These water bodies are significantly sensitive to external elements and processes. Moreover, a body of water can be contaminated by various substances originating from both natural as well as anthropogenic activities[2]. With human limited control over natural processes, experts prioritized the mitigations of numerous unsustainable anthropogenic activities around the world, for instance, the United Nation Sustainable Development Goals[3]. These unsustainable anthropogenic activities resulted to productions of enormous substances that posse's grave danger to the flora and fauna, for example, the use of synthetically made fertilizers, pesticides and insecticides[4-6].

During the last decade, the world clearly realized and understands the adverse consequences of uncontrolled development[6]. Moreover, experts realized that the faster rate of the recent environmental degradations are to some extent a product of human increasing standard of living and demands; largely from industries, transportation, agriculture, and urbanisation[7]. However, these anthropogenic processes have being amplified through various forms of pollution of the air and spreads of pesticides; such as CO2, NOx, SO2 and particulate matter[5], water pollution; such as leachetes, oil spills, etc. by hazardous chemicals[4], soil pollution; such as release of hazardous wastes, sludge, and indiscriminate disposable of non-biodegradable materials [8], and even food poisoning; such as the use of toxic chemicals for grains protection against insects infestations[6].

Being a constant agricultural land, the Northern part of Nigeria is recently experiencing boost in all year agricultural production largely due to increasing participation in irrigation. Despite depending on rain-fed

agricultural activities, this region sees hopes in irrigation with recent decreasing annual rainfall[6]. Amount of annual rainfall in this region is no more sustainable and sufficient for the farmers, therefore, the need for irrigation in most of these riverine communities become a priority[6]. However, based on the physiography of the land, use of agricultural supplements is very much required for profitable agricultural activities within the study area. Most of these synthetically made agricultural supplements have effects in on the environment, food products, human health, animals, soil, etc.[1]. This study analyzed 19 parameters and elements in patches of seasonal ponds along river Anumma, Ngalda area of Fika Local Government, Yobe State, Nigeria.

II. Materials and Methods

The present study is a cross-sectional survey on some temporary surface water quality along river Anumma in Ngalda area of Fika Local Government Area of Yobe State, Nigeria. This is an experimental study and the samples used in the study were collected during the month of December, 2018 (beginning of winter season). During this period, most temporary surface water bodies are utilized for various activities in this region. The people generally resorts to use of these temporary patches of water bodies for their numerous agricultural activities, such as irrigation, crop and vegetable production as well as watering of domestic animals. Standardized materials were used to obtain and store the collected sampled water to ensure that no any other element was admitted into the sampled water other than that in it already. The sampled water was subjected to chemical analysis in accordance with the guideline of United State of America Environmental Protection Agency in 2002[2].

This assessment of surface water quality with regard to the presence of contaminants is done by comparing the existing concentrations in surface water resource to thresholds of regulation that are either threshold values or quality standards. Purposive sampling was used in the selection of sample sites. However, all the sampled sites were adjacent to river Anumma where there are intense ongoing anthropogenic pressures especially from numerous agricultural activities. The present study collected twelve (12) samples from different sites and transported in secured plastic bags to the laboratory of the Department of Water Resources and Environmental Engineering, ABU Zaria, Nigeria for onward screening of some selected analytical parameters, micro-pollutants and macro-pollutants. This study investigates some selected physicochemical parameters and heavy metal content in order to determine the water quality and suitability for agricultural activities. About 19 different physicochemical parameters and elements were examined in this region sampled water. After carefully calculating the samples average, the results of the experiment are compared with the United State of America Environmental Protection Agency in 2002 water quality guidelines to determine their level of toxicity and pollution.

Area of study

This study was conducted along the river Anumma in Ngalda area. This is a riverine area situated in Fika Local Government Area, Yobe state, Nigeria. The region is geographically located at latitude 11°6'10"N and longitude 11°22'56"E. The climate of Ngalda and its environs is referred to as local steppe climate where during the year there is little rainfall (about average 785mm)[6]. The variation in the precipitation between the driest and wettest months is 248 mm. The average annual temperature in Ngalda is 25.7°C. The Ngalda area is used for arable cropping annually. This form of agricultural activities is for long been practiced in this area due to the presence of river Anumma. This arable crop land has been in use continually for rice, maize, sorghum and various forms vegetables cultivation for more than 20 years.

Due to the scarcity of organic fertilizer, synthetic fertilizer was mainly used to maximize production[6]. Moreover, due to riverine nature of the study area, synthetic substances were commonly used for fertilization and weeding since the traditionally hand weeding is very difficult. In view of the above combined effects, the surrounding surface water bodies that were mainly used for domestic and agricultural activities. These surface water bodies were used for watering of various forms of vegetable, by animals for drinking and crops productions. The quantity of this river decreases with season (mostly at its peak during the rainy season and mostly dried up during the drier season)[6].

Developing economies and water demand

In many developing countries, especially those in the arid and semi-arid region of the world, irrigation is viewed as an important input to the agricultural production systems owning to support life of the growing population. Both natural and anthropogenic processes put intense pressure on the earth limited water resource[6]. However, these increases pressures on water resource due to population boom, urbanisation, changes in the living style, and climate change. Though, water tables are now falling in most arid and semi-arid region of the world[1]. Being part of a water-competitive world, where each year about 80 million people lack access to clean and portable drinking water[9]. The UNFPA estimated that most population growth in the world is taking place in the developing economies; the world poorest and least developed countries[10].

Unfortunately, nearly all the projected 3 billion people to be added to this world during the next half century will be born in countries that are already experiencing water shortage[11]. The only 2.5% of total water stock of the world is fresh water sources and the worldwide concern is that the good quality water may become a scarce resource in the near future[12-15]. Because of these reasons, most of these countries have increased their interest in fresh water quality investigation and researches[12,15,16]. Like other arid and semi-arid regions around the world, the Northern part of Nigeria is largely dominated with hot climate and substantial amount of annual rainfall especially those regions that lies within the Sudano-Sahelian zone, where there is minimal amount of annual precipitations. Nevertheless, it is common that farmers in this region uses synthetically made fertilizer since the organic are not available and also very expensive even if found[4]. Since water as per importance, is the most precious resource on earth that life depends on. Modern human activities have resulted to various forms of contamination and consequently pollute the fresh water resources with various forms of compounds. However, these emerging compounds or pollutant can be biological, micro or macro-pollutants[1].

Surface water resource contamination by heavy metals is increasingly becoming very common environmental problem that are affecting ponds, lakes and rivers around the world[1,4,5,10]. The ever increasing presence of physical and chemical parameters in surface waters consequently led to deterioration of the environmental balance in aquatic environments, posses danger to human health and affects the quality of product produced[2,13]. Consequently, these changes categorically cause declines in water quality in the region. For these reasons, it is very important to regularly analyze physicochemical properties and heavy metal contents of surface water in order to monitor any sudden changes[1,11]. The existence of heavy metal pollutes the aquatic environment and leads to serious concerns about their influences whether directly or indirectly.

Heavy metals concentration in surface water resources are the most common environmental pollutants recently[9]. Therefore, their presence in higher concentrations in surface water indicates the presence of diverse external element from either natural or anthropogenic sources[17,18]. Though, heavy metals can occur naturally in the water, but rarely at toxic level and higher concentrations[19]. The most common natural sources of the heavy metals in fresh waters are weathering of rocks, soil leaching and dissolution of aerosol particles from the atmosphere[17]. Heavy metal contamination refers to the excessive deposition of toxic heavy metals in the environment caused by human activities and the anthropogenic sources are associated mainly with industrial and domestic wastes and the increased use of metal based pesticides and fertilizer in agriculture[19,20,21].

The concentrations of some heavy metals are beneficial and essentially required for normal and normal body growth and functions of living organisms such as metal nutritional requirements (Co, Cu, Fe, Mn, Ni and Zn)[21]. But, some heavy metals can cause biological toxicity, such as arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb) and mercury (Hg)[21]. Also the heavy metals and other physical and chemical compounds are easily affected by environmental factors such as surface runoff, deposition from the atmosphere and anthropogenic pollutants. Hence, it is important to quantify the concentrations of these heavy metal content and monitor any eminent changes as early as possible[1,20,21].

III. Results and Discussions

Analysis of water quality parameters

The present study has collected samples along river Anumma around Ngalda region in Yobe State, Nigeria. Various elements mainly from anthropogenic sources have greater potentials of altering some of the compound concentrations and can pollutes the water (both surface and groundwater)[8]. Since the origin of most of these emerging elements are from diverse anthropogenic activities sources, their effects are mainly severe around human populated region and the pollutants are spread all over[11]. These pollutants may be mobile and persistent in air, water, soil, sediments and ecological receptors even at low concentrations[22]. However, within the land-lock Northern Nigeria, surface water and groundwater resource remain the only source of the region fresh water resource for both domestic and agricultural activities[22]. With contemporary effects of climate changes and consequential rising demand of water, most of the developing regions of the world require new methods for judicious use as well as innovative approaches for water resource management and conservation[23,24]. Fresh and clean drinkable water is rapidly becoming a scarce in most developing countries of the World[22].

Several studies on emerging contaminants have focused on surface waters because they are expected to contain significant concentrations from sources[16]. Most of these relevant studies have reported that toxicity data from wastewater treatment plants, seepage from septic tanks, land-fills areas, and surface water run-off are mostly not available for most of these micro-compounds[2,15,16,18]. Although studies and reviews can be found in the literature on sources, occurrence, environmental behaviour and fate of emerging contaminants[15], but there is no single study on surface water resource around Ngalda region despite it irrigational importance in terms of various agricultural productions of numerous crops and vegetables for the surrounding communities.

Physicochemical analysis of surface water

For the purpose of this study, the samples were grouped into three different categories; Category-A, Category-B, and Category-C respectively. On category-A; a diagnostic analysis of some selected analytical parameters was conducted, on category-B; the concentration of selected macro-elements was analyzed, and lastly on category-C; the concentration of selected micro-elements was analyzed. The data obtained was examined and compared in order to determine the concentration of these compounded parameters and elements in the water samples. These analyses are vital in ensuring the physicochemical concentration in water is safe for various human activities[25]. However, higher concentration of various any elements in water body will consequently degrade it quality and results to production of several toxic and carcinogenic by products[22]. The present study categories the water analysis into three basic forms of analysis; the analysis of some selected parameter, the analysis of micro-pollutants, and the analysis of macro-pollutants respectively.

Analysis of analytical parameters

A total of 7 analytical parameters were analyzed; the temperature, alkalinity, acidity, pH, dissolve oxygen, chemical oxygen demand, and biochemical oxygen demand in the sampled water from the study area. The table 1 below shows the average results from the 12 sampled sites.

Table no 1: Average analytical parameters concentrations

S/N	Parameter	Average Value (mg/L)	Standard Tolerance Limit (mg/L)
1	Dissolve Oxygen (DO)	20.25	2.5 – 30
2	Chemical Oxygen Demand (COD)	272	Not more than 80 – 90
3	Biochemical Oxygen Demand (BOD)	206.5	80 – 90
4	pH	6.7	6.5 – 8.5
5	Acidity	0.15	No Guideline
6	Alkalinity	258.7	30 – 100
7	Temperature (^oC)	30.7^o	$18.29.4^o$

Source: *Primary survey, 2018; APHA[2]*

The dissolved oxygen (DO) is the level of oxygen found in a giving sample of water, it is an indicator for maintaining necessary favourable conditions for growth and reproduction of normal population of fish and other aquatic life[15]. However, this study discovered an average dissolved oxygen value of 20.25mg/L. This result of dissolved oxygen in fresh water indicates that the water is suitable and sustainable for aquatic life[15]. Chemical oxygen demand (COD) is used in defining the pollution level of water[26]. When the COD level of the water is higher than 25 mg/L, it shows that there is higher concentration of pollutants. Also, if the COD levels more than 50 mg/L, it is indicate that there is an intense pollution which can be toxic for aquatic life[13]. The average COD value in this study is 272mg/L. The COD is more than the standard tolerance limit and will be classified as toxic for aquatic life.

Biological oxygen demand (BOD) indicates the oxygen amount required by the microorganisms[15]. It is used for identifying the pollution potential and assimilation capacity of any receiver environment[13]. The present study has an average BOD value of 206.5mg/L. The pH level of water stands as the "potential of hydrogen" in water. The hydrogen ion concentration of pH is a parameter that shows the chemical and biological characteristics and it is used in classifying alkalinity or acidity of waters. In addition, drinking water normal pH level varies between 6.5 and 8.5. The average pH value of this study sampled water is 6.7. These results indicate that the study area has basic character and is in Class-I (6.5-8.5) in terms of pH value[15]. On pH scale, a value 7 is refers to as neutral water, below 7 is acidic water while any value above 7 is basic water[13]. The temperature is one of the most important factors that affect the biological activity of aquatic organisms. The average value of temperature is 30.7^oC at the time of conducting of this study. Discern that there is high temperature variation in this region.

Analysis of macro-elements concentration

A total of 6 Macro-elements were analyzed; phosphate, potassium, calcium, nitrate, sulphate, and magnesium in the sampled water from the study area. Macro-elements are chemical elements that are required in relatively large quantities for normal physiological processes. The table 2 below shows the average results from the 12 sampled sites.

Table no 2: Average Macro-pollutant concentrations

S/N	Parameter	Average Value (mg/L)	Standard Tolerance Limit (mg/L)
1	Phosphate (PO_4^{-3})	42.2	30
2	Potassium (K)	238	88-99 (Min.-Max.)
3	Calcium (Ca)	533	---
4	Nitrate (NO_3-)	3.9	1.0
5	Sulphate 4 (SO_3^{-2})	13.17	250
6	Magnesium (Mg)	0.65	0.05

Source: *Primary survey, 2018; APHA*[2]

The phosphate exists in three forms: orthophosphate, meta-phosphate, and organically bound phosphate, each compound contains phosphorus in different chemical arrangements[1]. Phosphate support heavy aquatic plant growth that usually leads to algal blooms. The present study average phosphate value stand at 32.2 mg/L. The phosphate value found in water is slightly above the standard tolerance limit, and can easily leads to eutrophication[19]. Potassium is also an essential element found in water for aquatic life sustainability[16]. It is one of the nutrient minerals that affect the productivity of aquatic organisms. The average value of potassium in sampled water as observed by this study is 238mg/L. This phosphate concentration indicates that the samples potassium content exceeds the standard tolerance limit. Hence, among natural anions in the water, the presence of the sulphate (SO4) is one of the key anion for improving biological productivity and supporting heavy aquatic plant growth, and consequently leads to algal blooms[19]. Nitrogen is derivatives of nitrite (NO2), nitrate (NO3) and ammonium nitrogen (NH4+). Recently, one of key sources of nitrite (NO2) in waters are fertilizers, organic matters, and some of minerals[1,19,26]. The nitrite concentration in waters higher than 1 mg/L indicates pollution[19]. This study discovered average nitrate (NO_3-) value of 3.9mg/L which indicates high concentrations.

Analysis of micro-elements concentration

A total of 6 micro-elements were analyzed; zinc, chloride, sodium, iron, lead, cadmium, and chromium in the sampled water from the study area. Though, studies on the ecotoxicological importance of these micro-elements are in early stages due to the lack of satisfactory data. The table 3 below shows the average results from the 12 sampled sites.

Table no 3: Average micro-elements concentrations

S/N	Parameter	Average Value (mg/L)	Standard Tolerance Limit (mg/L)
1	Zinc (Zn)	1.9	4.0
2	Chloride (CL^{-1})	123.1	4
3	Sodium (Na)	7.31	1.25
4	Iron (*Fe*)	1.7	0.1 - 0.3 (Min.-Max.)
5	Lead (Pb)	2	0.015
6	Cadmium (Cd)	0.03	0.005

Source: *Primary survey, 2018; APHA*[2]

The origins and conduit of micro-pollutant can be associated directly to synthetic fertilizers, pesticides, insecticides, municipal solid wastes and industrial wastewaters[1,19,26]. Based on their unique characteristics, micro-pollutants require changes in the conventional approach to pollution prevention, management and control[13,17]. Recently, various studies reported that changes in agricultural practices, changes in demographic behaviour and intensive use of synthetic supplements in developing countries have greatly increased the appearances of biological pollutants in both surface and groundwater resources[1,15,17,19,27]. Consequently, these micro-pollutants have contributed to scores of modern health problems[14,25]. The presence of four essential micronutrients (Cu, Fe, Ni and Zn) in significant quantities was detected in the samples collected. Though, Cu, Fe, Ni and Zn are essential metals in human body, but it excessive quantity can significantly damages human health. Besides the essential micronutrients, this study observed an increasing content of three toxic heavy metals, explicitly, Pb, Cd and Hg values have exceeded the standard tolerance limit. Most these pollutants denote endocrine disruptors which are poorly inventoried and regulated with only small marginal information existing regarding their occurrence, fate and their impact on the environment[27].

IV. Conclusion

The present study collected samples of surface water and analysed about 19 parameters (7 analytical parameters, 6 macro-element, and 6 micro-elements) from seasonal ponds around river Anumma in Ngalda, Yobe State, Nigeria. Though, the study agreed with the relevant of the concentration of these parameters in water, however, it discovered increasing accumulation of various elements. This poses a great danger to the environment, fauna and flora. Higher concentration these elements can consequently results to significant toxicity due to their carcinogenic effects on human healths[1,17,26]. This study concludes that there are slightly higher concentrations of some physicochemical elements in the seasonal ponds around river Anumma in Ngalda

area, Yobe State, Nigeria. Most of the physicochemical elements concentrations were found to be higher than the standard tolerance limit (mg/L) by the American Public Health Association water quality guidelines. It is also evident that the production of new chemicals extends and often goes beyond the power of current safety monitoring and risk assessment methods, as well as of existing preventative and remediation technologies. This study understands that these higher concentrations of emerging elements have potentials of posing serious challenges to the ecosystems and human health.

Considering the current situation of agricultural activities in this study area, this study affirmed the axiom that "use of synthetic agricultural supplements around reverine communities has great potentials of polluting the environment, surface and groundwater resource, and endangering human health with severe possibilities of carcinogenic effects." This study emphasizes on the need for frequent monitoring of surface water quality to ensure that humans, aquatic organisms as well as the environment are protected. This study is a useful resource for future baseline studies on surface water quality in this region as well as adding to the existing literatures on various water estimations, impacts and pollution. The study also advocates more measures like the identification and reparation of comprehensive lists of emerging contaminants and presume proper monitoring and the need for establishing sustainable management action plans.

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