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Assessment of Irrigation Water Quality Sourced from River Galma in Zaria, Nigeria

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Abstract. This study aimed at assessing the quality of irrigation water sourced from River Galma to irrigate farmlands in Zaria, located between latitudes 11^{o} 00' to 11^{o} 12'N and longitude 07 ^{o} 36' to 07 ^{o} 45'E. Irrigation water samples from River Galma used to irrigate the fadama land were collected from five different points for three consecutive times at the very points where the farmers use the water to irrigate their farms and tested for the following selected metals: chromium (Cr), lead (Pb), nickel (Ni), and arsenic (As). X-ray Fluorescence (XRF) spectroscopy which is an analytical technique was used to determine the metal contents of water samples. Analysis of variance was used to compare the result at 0.01 significant level. The results show the concentration of Cr, Pb, Ni and As as; 0.09, 0.04, 0.04 and 0.03mg/l respectively. Although Cr has the highest mean value and is significantly differentiated at the five sampling locations over the basin, the mean value is below the permissible limit for irrigation water by Nigeria's Federal Environmental Protection Agency concentration of the selected metals was found to be tolerable for irrigation purpose. The study thus recommended that the quality of irrigation water should be investigated from time to time to avoid build-up of heavy metal that may be detrimental to health of both human and animal in the long run.

Keywords: Water quality, Irrigation, River Galma, Metal content, Zaria

1. Introduction

Water, a vital element in all aspects of life on earth, plays an extremely important role for human being, socioeconomic development and the existence of ecosystem (An et al, 2014). The quality and quantity of any water supply planning is highly important, especially when considering for irrigation purposes. Effective irrigation influences the entire growth process from seedbed preparation to germination, root growth, nutrition utilization, plant growth and re growth, yield and quality. It is often used to make dry soil fertile in areas that do not benefit from natural flooding or rainfall. There are different categories of irrigation methods (Frenken, 2005) and each method is aimed at supplying crops with the required water for the crops to flourish.

In many parts of Africa, the traditional method of irrigation has been used to lift water from perennial streams, lakes, dams and basins for the purpose of supplying irrigated field. This is because irrigation allows the primary producer to grow more crops, produce higher quality crops, be more flexible in operations especially during water stress, achieve higher yields and meet market demand, have insurance against seasonal variability and drought and to take advantage of market incentive for unseasoned production (The State of Vitoria, 1996-2009). It further enables farmers to cultivate non-traditional high value crops, such as tomato, green pepper and leafy vegetables etc. Under favourable economic conditions, farmers can thus diversify their cropping patterns and earn higher incomes, which would increase overall household consumption and reduce poverty levels.

Zaria is one of the most developed urban center in northern Nigeria. It is a nerve centre for commerce, education and transportation in the country. The area has been a notable hot spot of vegetable gardening in Nigeria which has extended to the floodplains of the major rivers draining the area (Mashi et al, 2007; Yakubu et al, 2007). This is due increase in population and consequent increase in demand for vegetable and some other annual crops (Olusola, 2012). The input of irrigation water represents one of the main requirements in sustaining the fertility status of the soil. This is very important especially in areas of short and or uncertain water supply but daily utilization of this water raises concern about the health and environmental risk of such practices particularly the heavy metal content of the irrigation water. Although surface water in cities may be advantageous for irrigation since it is largely sewage effluents that may contain valuable plant nutrients, Martins and Bello (1997) however warned that water that drains into surface water is likely to increase the quantities of solutes thereby increasing the concentration of certain ions that may ultimately lower the quality of water for irrigation.

The arable land in Zaria consists of upland and fadama land. The latter being texturally finer and nutritionally richer than the former is agriculturally more productive and is cultivated all year for a host of high value crops. The former on the other hand depends on rains in the wet seasons and residual soil moisture in the dry season. To alleviate the problem of moisture stress during the dry season, supplementary irrigation is provided by pumping water from river Galma. Although, irrigation is useful for sustaining agricultural production in any locality, it is imperative that only good quality water is used because contaminated water affects both soil and crop qualities adversely. Vermilion (2004), for instance reported that 40% of world food and 60% of its grains is under irrigation and land under irrigation had increased drastically from 94 million hectares in 1950 to 240 million hectares in 2000. This is expected because of the increase in world population and the need to expand agricultural land under the threat of climate change.

Irrigation water irrespective of its source contains some dissolved salts. It is the concentration and proportion of dissolved elements that determine the suitability of water for irrigation (Ajayi et al, 1990). Evaluation of water quality for irrigation depends on plant, soil and climatic variables all of which can be interdependent. Using poor water quality can create four types of problems, namely toxicity, water infiltration, salinity and miscellaneous (Ayers and Westcot, 1985). Poor quality water may affect irrigated crops by causing accumulation of salts in the root zone, by causing loss of permeability of the soil due to excess sodium or calcium leaching, or by containing pathogens or contaminants which are directly toxic to plants or to those consuming them. Contaminants such as heavy metals, nitrates and salt have affected water quality as a result of disposal of waste from humans and livestock, industrial discharges, inadequate treatment, and over-use of limited water resources (Yakubu et al, 2017). The contaminants in irrigation water may accumulate in the soil and, after a period of years, render the soil unfit for agriculture. Even when the presence of pesticides or pathogenic organisms in irrigation water does not directly affect plant growth, it may potentially affect the acceptability of the agricultural product for sale or consumption.

As River Galma flows through Zaria town before reaching the farming sites, field observation showed tones of refuse with all sorts of household wastes dumped into the river which would probably change the quality of water that is often used to irrigate farmlands along its course. This could in one-way or the other contaminate the soil or crop qualities. Knowledge of irrigation water quality is critical to the understanding for the management require for long-term productivity. The aim of this study is to assess the current quality status of irrigation water of the fadama land along river Galma in Zaria metropolitan area to ascertain its suitability for growing crops with specific reference to some heavy metal concentrations. As crop yield is directly related to quality of water used for irrigation, an assessment of suitability of such irrigation water is essential for the growth of food production (Shahid, 2006).

2. Material and Method

The Study Area

The research was conducted in River Galma, (one of the main tributaries of River Kaduna) (see Fig. 1). Zaria town is located between latitudes 11^{o} 00' and 11^{o} 12' N and longitudes 07^{o} 36' and 07^{o} 45' E. It falls within the tropical savanna climate with distinctive wet and dry seasons. It has a single maxima rainfall regime. The two distinctive seasons in the region (dry and wet seasons) are dictated by the movement of the Inter Tropical Zone of Discontinuity (ITZD), which is in turn dictated, by the movement and dominance of the two contrasting air masses affecting the region like other parts of the country. These two air masses are the Dry Tropical Continental (cT) air mass of Northern origin from the Sahara Desert and the moist Cool Tropical Maritime (mT) air mass of the Southern origin from the Atlantic Ocean.

The tropical continental air mass originates from the Eurasia high pressure belt and it enters the country from the north east. It is a moisture laden wind which brings harmattan into the country and is normally associated with poor visibility and fire outbreak. However, the wind is somewhat of socio-economic importance; hence, it is used in drying crops and other similar functions. The tropical maritime air mass on the other hand because it is a moisture laden wind brings rainfall (Kowal and Kassam, 1973). Zaria has a mean annual rainfall of 970mm, the atmospheric humidity over this area is lowest in the dry season 58% and is highest in the wet season above 90% while evaporation is higher in the dry season and lower in the wet season (Yakubu, 2009). The geology of the study area is part of the Basement complex rocks, the plains attain elevation ranging from about 550m to 740m asl and are underlain by pre-cambriam rocks of variable composition. This area was described as undifferentiated Basement Complex (FDALR, 1990).

The landforms consist of inselbergs, pediment landscape overlying the basement complex nearly level of gently undulating plain (FDALR, 1990), and broad stream valleys. The seasonal vegetation cover in the area and occasional intensive rainfall combined to give rise to wide spread sheet wash. The onset of the raining season in the study area is usually May – June and by July – August its influence covers almost every parts of the country. Zaria has a mean annual rainfall of about 900mm which supports savanna vegetation.

The major soil type of the study area is tropical ferruginous; while along the wide gentle sloping valleys are the dark vertisol and fadama soils. The area falls within the guinea savanna region and therefore most of the vegetation have been degraded due to human interference ranging from agriculture, wood harvesting, overgrazing, urbanization processes etc. The true climatic climax vegetation is almost absent except in the outskirts especially in the southern suburb. The topographical nature of the area is a gentle rolling undulating landscape with residual hills of various sizes and shapes and is drains largely by three channels. These include rivers Galma, Kubani and Saye.

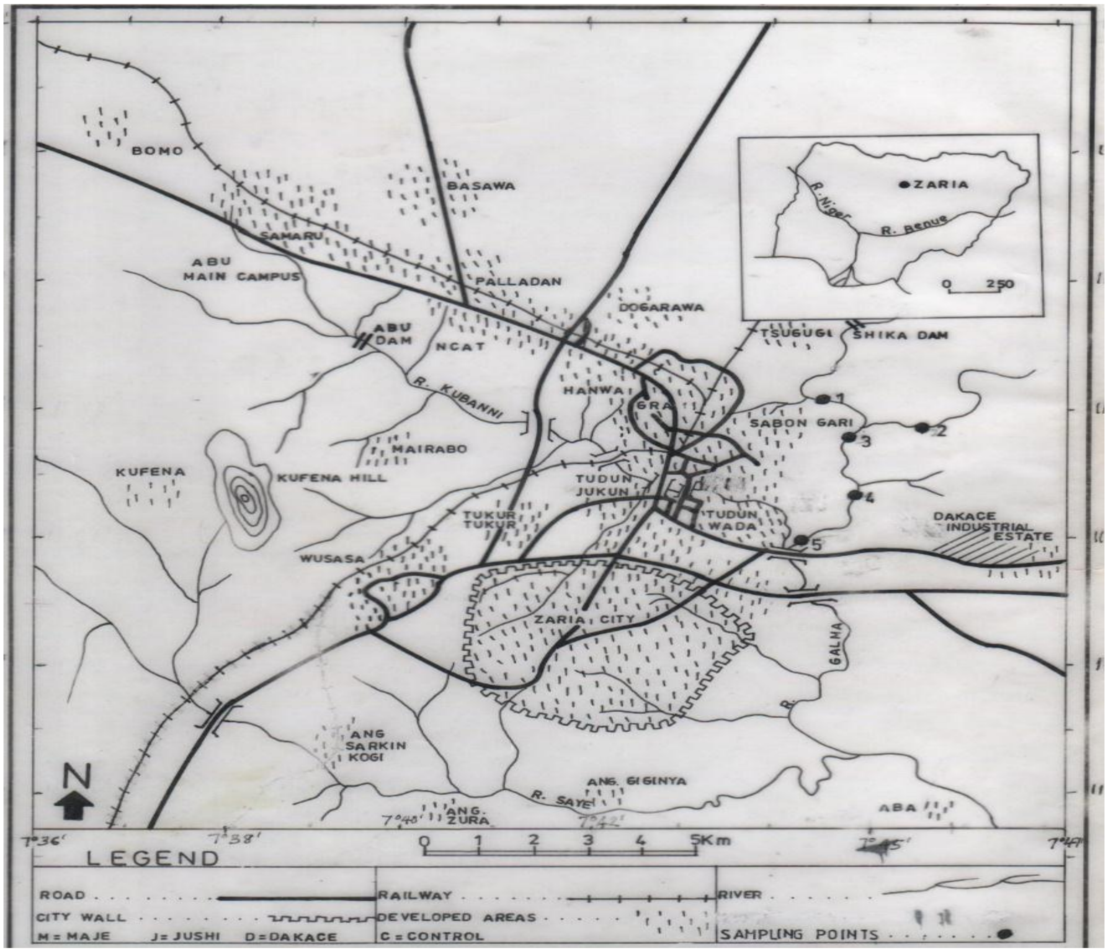

Fig. 1: The sampling points

Sample Collection

Irrigation water samples were collected four times from five different points along River Galma. That is, at the points where the farmers use the water to irrigate their farms. Clean plastic bottles rinsed with distil water were used for the collection of water samples at 10cm depth. The water samples collected were then taken straight to the laboratory for determination of the following heavy metals; chronium (Cr), lead (Pb), nickel (Ni) and asenic (As).

Sampling Techniques and Data Analysis

X-ray fluorescence (XRF) spectroscopy which is an analytical technique widely used for the qualitative and quantitative elemental analyses of environmental, geological, biological, industrial and other samples was used to determine the samples at Center for Energy and Research Training, Ahmadu Bello University, Zaria. XRF has the advantage of being non-destructive, multi-elemental, fast and cost effective compared to other competitive techniques such as Atomic Absorption Spectroscopy (AAS), and Neutron Activation Analysis (NAA). Analysis of variance was used to compare the results among the various sampling points at 0.01 levels of significance.

3. Results and Discussion

From the study, the results show that the concentration level of Cr in irrigated water ranged from 0.01 to 0.1mg/l with a mean of 0.09mg/l and a standard deviation of 0.01. This is followed by Pb and Ni with mean values of 0.04mg/l and standard deviation of 0.07 respectively. The value for As ranged between 0.02 - 0.05mg/l with a mean of 0.03mg/l and a standard deviation of 0.01. this confirm the study of Komosa (1999), Gonzalez et al (2000) and Wajahat et al (2006) reported a high concentration of such metal contents in irrigation water and river sediments. The sources of these heavy metals in irrigated water could probably be from the urban wastes generated from metal work, construction, agrochemical industries and other household disposal. A close look at the pattern of distribution of the heavy metals over the various sampling locations, as contained in Table 1, revealed that the selected heavy metals do not follow consistent pattern of concentrations over the various sampling locations. This means that the various metals do not have same sources but come from variety of sources within Zaria town.

Table 1: Metal concentration in irrigated water and permissible level by FEPA
S = Significant, NS = Not Significant at 0.01, NA = Not Available

Element (mg/l)	Point 1	Point 2	Point 3	Point 4	Point 5	Mean	Standard Deviation	Max Allowable (FEPA,1991)	ANOVA
Cr	0.01	0.07	0.01	0.1	0.1	0.09	0.01	0.1	S
Pb	0.03	0.02	0.05	0.04	0.06	0.04	0.07	NA	NS
Ni	0.03	0.03	0.05	0.04	0.04	0.04	0.07	0.2	NS
As	0.02	0.02	0.03	0.03	0.05	0.03	0.01	0.1	NS

Cr has the highest concentration and is significantly differentiated among the five sampling locations over the basin, but the mean value is below the permissible limits for irrigation water by Federal Environmental Protection Agency (FEPA, 1991). The highest value of Cr (0.1mg/l) was recorded at points 4 and 5. Low level of Cr, Pb, Ni and As upstream with the corresponding higher level at the downstream in many rivers has been reported while increasing discharge of contaminants with distance towards the downstream was blamed for this trend (Gasparon and Burgess, 2000).

Furthermore, River Galma at both upstream and downstream is used for irrigation of many vegetables and other food crops along its bank with no readily available clean water for the farmers. Accumulation of heavy metals by crops receiving such contaminated water for irrigation is common and metals could be biomagnified along food chain to a higher tropic level (Wang, 2003). Consumption of such food crops could expose man to untold heavy metal hazards.

From the result, the heavy metals did not show consistent pattern of concentration over the various sampling points. That is, the various elements do not have the same sources in the irrigation water, rather, they come from varieties of sources within Zaria metropolis. More so, the ANOVA results show that only Cr is significantly different among the sampling points. None of the metals is above the permissive limit for irrigation by Nigerian's Federal Environmental Protection Agency (FEPA, 1991).

In general, it should be noted that heavy metals enter rivers from a variety of sources. The rocks and soils directly exposed to surface water are the largest natural sources. Dead and decomposed vegetation and animal matter contribute small amounts of metals to adjacent waters. Wet and dry fallout of atmosphere particulate matter from natural sources as well as man's activities can introduce large quantities of metals. In addition to the natural sources, the discharge of various treated and untreated liquid wastes to the water body can introduce large amounts of trace metals to rivers and lakes (Pires and Mattiazzo, 2003).

4. Conclusion and Recommendation

Assessment of the use of River Galma as irrigation water source in Zaria metropolis indicated that the water is suitable for irrigation. The heavy metals investigated (Cr, Pb, Ni and As) fall within the tolerable limits for irrigation purposes but the long-time implication is uncertain. It is important to know that irrigation water quality can influence crop productivity more than soil fertility, hybrid, weed control and other factors. With the current potential of the fadama land in Zaria, if fully harnessed and properly managed, will increase crop production and consequently alleviate food scarcity in the area.

It is therefore recommended that the quality of irrigation water should be investigated from time to time, since the type, extent and rate of irrigated water contamination varies from time to time and season to season. In addition, indiscriminate waste disposal along the river course should be restricted.

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