Original Research Article

ASSESSMENT OF QUALITY OF WASTEWATER BEING USED IN IRRIGATING SOILS UNDER URBAN AGRICULTURE IN ZARIA URBAN AREA

ABSTRACT

The cultivation of food crops in open spaces of cities in the developing world is very common but has not attracted the research attention it deserves. In most areas, the practice relies on the use of wastewater derived from urban sources (houses, industries, markets, public institutions etc) to irrigate soils along the floodplains of streams that drain an urban area. Because such wastewater may be containing some pollutants, concerns are increasingly been raised as to whether urban agriculture is not a threat to public health. There are valid reasons to be so concerned because a wastewater typically contains some pollutants like heavy metals, with tendency to cause several health problems. To ascertain this, a study was conducted to evaluate the quality of wastewater being used in irrigating soils under urban agriculture in Kubanni basin of Zaria area. The results obtained indicate that though there is a presence of As, Fe, Cr, As, Cu, Zn, Mn and Pb in wastewater being used in UPA irrigation practices in the area, their concentrations are generally below the maximum permissible limits set by Nigeria's Federal Environmental Protection Agency for irrigation. However because of the tendency of the metals to accumulate in soils, it is expected that the metals could possibly have been accumulating in the irrigated soils and the crops being grown on them. Thus further studies are required to establish the extent to which this is so. Nonetheless, it would be worthwhile for the farmers to start some significant purification of wastewater in the area to make it safe for irrigating the soils since there are valid fears to be concerned about possibility of heavy metals build up in the soil.

Key words: Heavy Metals; Wastewater; Contamination; Kubanni Basin; Zaria; Nigeria

INTRODUCTION

In the past, crop cultivation use to mainly be a business of rural areas. However as urban population expands, demands for food items, especially vegetables, in the urban areas increase and to meet up with this increasing demand some urban dwellers venture into urban agriculture relying mainly on use of waste water or water from shallow wells in urban river systems to cultivate river floodplains. This practice is commonly called urban and peri-urban agriculture (UPA). Urban agriculture is defined as the practice of farming within the boundaries of towns or cities. Farming in this sense involves crop cultivation, animal rearing, fish farming, etc.

Beside employment and in-flow of cash benefits, UPA has other sets of advantages, and a number of people hold the view that it could be an answer to a number of important environmental problems facing many cities [1]. One of these is the problem of waste disposal contamination of water supply sources. Urban centers produce most of the world's waste and between a third and half of this goes uncollected [2], leading to contamination of water supply sources. Urban wastes contribute to urban pollution and health risks, but when applied to soils it has great potential because it can be exceedingly nutrient rich [3][4]. Waste collection, for use in urban agriculture could therefore mean an improvement of environmental sanitation, food security and nutrition, and the provision of employment for thousands of urban unemployed youth [5].

With UPA now becoming an important feature of urban areas in SSA, it is feared that soil, water and plant contamination, degradation and human health deterioration resulting from UPA are now some important management problems that would now be confronting managers of urban areas. In fact, UPA has been facing some challenges from city authorities because of a range of negative health, environmental, economic and cultural aspects [6]. Such problems include contamination of crops with pathogens, chemical residues and heavy metals [7], soil degradation [8], surface and groundwater pollution with agrochemicals [7], conflicting land and water issues [5] and the perception that agriculture is not an appropriate activity for urban areas [9].

By disposing urban waste on city plots, farmers would obtain a cheap supply of nutrients, while tackling the waste disposal problems at the same time. There are many examples of waste utilization in the developing world (for a comprehensive review see [10], including the use of night soil (e.g. in Ghana - Owusu - [11]), untreated and unsorted waste (e.g. in Senegal - [12]), wood and household waste (e.g. in Nigeria - [13]) and waste water (e.g. in Senegal, Burkina Faso and Mauritania - [14]). At any rate, an important possible long term problem of use of untreated waste water for UPA is build-up of toxic material's or salinity, in the soil and this should be an issue if much public health concern.

Zaria urban area is one of the most developed urban centers in northern Nigeria. It is a nerve center for commerce, education and transportation in the country as virtually all the major roads and rail routes that link the major segments of the country pass through this area. Over the last thirty years, several villages that hitherto used to neighbour this area have now been integrated into the Zaria urban system.

The area has been a notable hot spot of vegetable gardening in Nigeria. Initially, it was confined to the dry season farming on the upland areas and at backyard of homes. In recent times, however, it has extended to the flood plains of the major rivers draining the area. The process of expansion of the dry-season irrigated vegetable production in the area began with Nigeria's soil boom of the 1970s, which was accompanied by an increased demand for vegetable produce by the growing urban and affluent population. Beside the favourable market condition for the product, the cool harmattan season in the region between November and March is another important stimuli. Others include, the region relatively high degree of accessibility by road, rain and air, and pool of prospective labor force. Since the 1990s, expansion has continued markedly along the flood plains of the Kubani-Galma River draining the region. Today, the Zaria area is considered an important vegetable production area and it supplies markets all over Nigeria and beyond.

Besides relying on wastewater that flow freely in the Kubanni-Galma river system, farmers make use of wastes packed in bags from waste dump sites and decomposed sewage wastes in different parts of the town. Such inputs obviously play a very important role in sustaining the fertility status of the soils utilized, but increasing utilization of such materials are raising some concerns about the health and environmental risk of such practices. Of these risks, contamination by heavy metals is considered as very important here because of the enormous health hazards associated with it. Studies are therefore required that evaluate the extent to which to which such practices promote soil contamination in the area and the need for such studies constitutes the problem of research interest to this study.

This study aims at an identification of the presence and concentrations of some heavy metals in wastewater being used by the farmers in irrigating areas under UPA in Zaria area. The heavy metals to which consideration is given here include As, Fe, Cr, As, Cu, Zn, Mn and Pb which are considered as the main ones with much health concerns to human beings [15]).

MATERIALS AND METHOD

Reconnaissance Survey

A reconnaissance of the study area was carried out to select appropriate sites for the study and develop good familiarity with the study area. Information collected during the survey include the different sizes of the cultivated fields, tenure types and history, cropping type and history, sources of irrigation water, input use (fertilisers, wastes, chemicals etc) pattern and history and problems in input use among the farmers. This information was obtained from the elders and farmland owners in the study area.

Field Methods

Selection of Sampling Sites

Following the reconnaissance survey, some farmers were selected at different locations along the Kubanni-Galma river system. The selected farmers are those with adequate, reliable and acceptable history of input use and consistency in use of wastewater in irrigation (Figure 1). On the basis of this, five locations were selected from where wastewater samples were collected. These locations are as follows:

HNE - located at the upstream location, in the Hanwa new extension area of the town. This is where most of the waste water from residential areas of the Hanwa new extension and northern part of the Zaria GRA are discharged into the Kubanni-Galma River.

TJK - This is located in the upstream location, in the Tudun Jukun area of the town and is where most of the waste water from residential areas of the Tudun Jukun and the southern part of the Zaria GRA are discharged into the Kubanni-Galam River.

AGR - This is located at upstream side, the Agoro area of the town and is where most of the waste water from residential areas of the Tudun Wada and the northern part of the Sabon Gari Commercial district of Zaria are discharged into the Kubanni-Galma River.

GYL - This is located within the downstream side, in the Gyallesu area of the town and is where most of the waste water from residential areas of Gyallesu and the southern part of the Sabon Gari Commercial district of Zaria are discharged into the Kubanni-Galma River.

JSH - This is located within the downstream side, in the Jushi area of the town and is where most of the waste water from residential areas of the Jushi, Old Jos Road and Jushi Industrial area of the town are discharged into the Kubanni-Galma River.

These locations were selected in such a way as to ensure effective coverage of all the various areas of active irrigation practices in the Kubanni-Galma River system. This was achieved using information obtained during the reconnaissance survey about the patterns of streams conveying the waste water and distribution of irrigated lands over the study area.

Samples Collection

At every selected farmland, samples of wastewater being used in irrigating the soils were collected. Nitric acid washed plastic bottles were used in collecting the samples. Every collected sample was marked and named after the point of collection. Water samples were collected fortnightly over four months in all the areas.

Samples Analyses

The collected wastewater samples were preserved with 5 ml of concentrated nitric acid and transported to the laboratory for analyses. While in the laboratory the various heavy metals were extracted from the samples according to USEPA methods [16] and measured using an atomic absorption spectrophotometer. The heavy metals were determined by digesting a known volume of water sample with analytical grade HNO_3. The digested sample was filtered into a 20ml standard flask, made up to the mark with distilled-deionized water and stored in a nitric acid pre-washed polyethylene bottle in the refrigerator prior to the chemical analysis. Each sample was analyzed in duplicate and the average of the results reported. General laboratory quality assurance measures were always observed to prevent sample contamination and instrumental errors. The water used throughout the experiment was doubly distilled in an all glass distiller before it was deionized. Wavelengths setting of the spectrometers used were done daily by the standard instrumental procedure and other equipment used were always calibrated against reference standards

Statistical Analyses

Descriptive statistics (mean, standard deviation and percentage coefficient of variation) were computed for every heavy metal for each of the sampling locations. 2-Way Analysis of variance (ANOVA) statistical test was then used to assess the significance of the difference in the mean values of every heavy metal between the five wastewater sampling locations.

RESULTS AND DISCUSSION

The levels of the heavy metals determined at the sampling points at the five different locations on the Kubanni-Galma river system are presented in Table 1. In Table 2, descriptive statistics (mean, standard deviation and percentage coefficient of variation values) of concentration of every metal over the basin are presented.

There are three main facts that seem to be very clear from the trends shown in the two tables. First, the heavy metals do not indicate consistent pattern of concentrations over the various sampling locations. For instance, none of the sampling locations consistently had highest or lowest concentrations of all the metals considered. This means that the various metals do not have same sources in wastewater of the river, but come from variety of sources within the Zaria town. This implies that no section of the town can be blamed as responsible for addition of heavy metals in wastewater in the area.

Second, the various metals are in general uniformly distributed over the five sampling locations. For instance, of the eight metals, only Fe, Mn and Cr are significantly different among the sampling locations, as revealed by the results of ANOVA statistical test. This again means that addition of the various metals into the wastewater of the Kubanni-Galma River is not restricted to any section of the river basin but are instead distributed all over the basin.

Third, the mean values of the three metals that are significantly differentiated among the five sampling locations, over the basin, are 0.02mgl, 0.02mg/l and 0.01mg/l respectively. Of the three, only that of the Fe is above the permissible limit for irrigation water by Nigeria's federal Environ mental Protection Agency [17]. The highest values of Fe were recorded at NHE and the least at GYL which indicates that the values of the metal decrease with distance towards the downstream location. Mn had highest values at AGR and JSH and least at HNE and GYL while Cr had highest values at TJK and the values for the four other locations are all the same. These again indicate some inconsistencies in the pattern of distribution of the various metals over the various sampling locations.

Fe has the highest concentration in the wastewater, followed by Cr, then Mn and then Pb and Ni while Cu, Zn and As had the least concentrations (Figure 1). The sources of the heavy metals with higher concentrations in the wastewater could probably be from the metal work, construction and engineering and agrochemical industries. A close look at the pattern of distribution of the heavy metals over the various sampling locations, as contained in Table 1, reveals that locations at upstream (HNE, TJK and AGR) contain comparatively higher levels of the heavy metals than those towards the downstream (GYL and JSH). In several other studies, low level of Pb, Mn, Ni, Cd, Cr, and Cu upstream with the corresponding higher level at the downstream in many rivers has also been reported and increasing discharge of contaminants with distance towards the downstream has been blamed for this trend [18][19]. In the area, wastewater in both the upstream and downstream is used for irrigation of many vegetables and other food crops along the bank of the river because no alternative clean water is readily available to 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 [20][21]. Consumption of such food crops could expose man to untold heavy metal hazards.

In general, it should be noted that heavy metals enter rivers and lakes 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 arrived 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 for rivers and lakes [22]. Some of the metals considered in this study are classified biochemically as essential elements as they are present in trace amounts in the bodies of living organisms. For example, copper and zinc play an important role in different physiological processes. On the other hand, lead and cadmium are non-essential elements and considered to be very toxic to the environment [22][23].

CONCLUSION

The wastewater in Kubanni-Galma river basin being used for urban irrigation agricultural practices have heavy metal contents that are all below the maximum permissible limits for irrigation set by Nigeria's Federal Environmental Protection Agency [17]. The only two metals that are above the limits are Zn and Cu which fortunately are among the least hazardous for public health. Infact the metals are among the so-called essential trace metals for crop nutrition. However, since the wastewater contains some unwanted heavy metals such as Cr and Pb, there is the need for monitoring to be conducted of the extent to which the metals are accumulating in the soils being irrigated with the wastewater and in the crops being grown on the soils.

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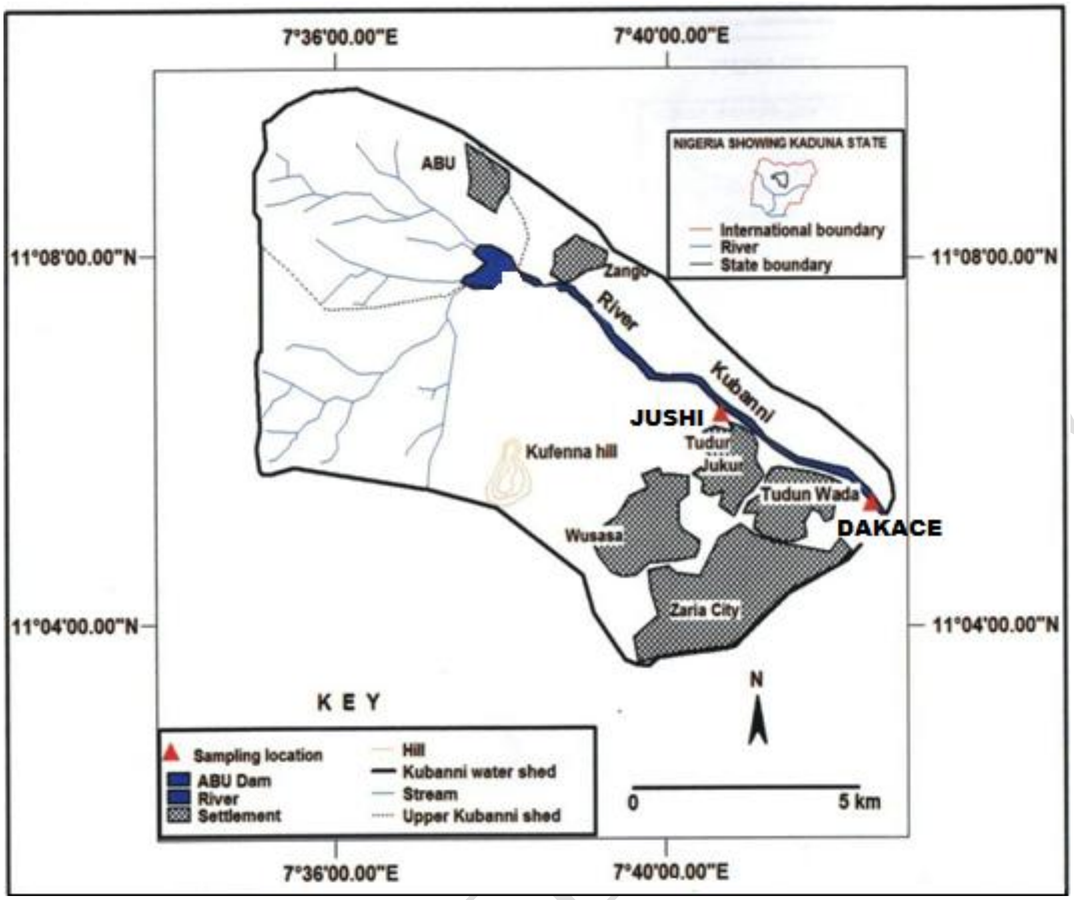

Figure 1: Kubanni-Galma River Basin showing the sampling locations

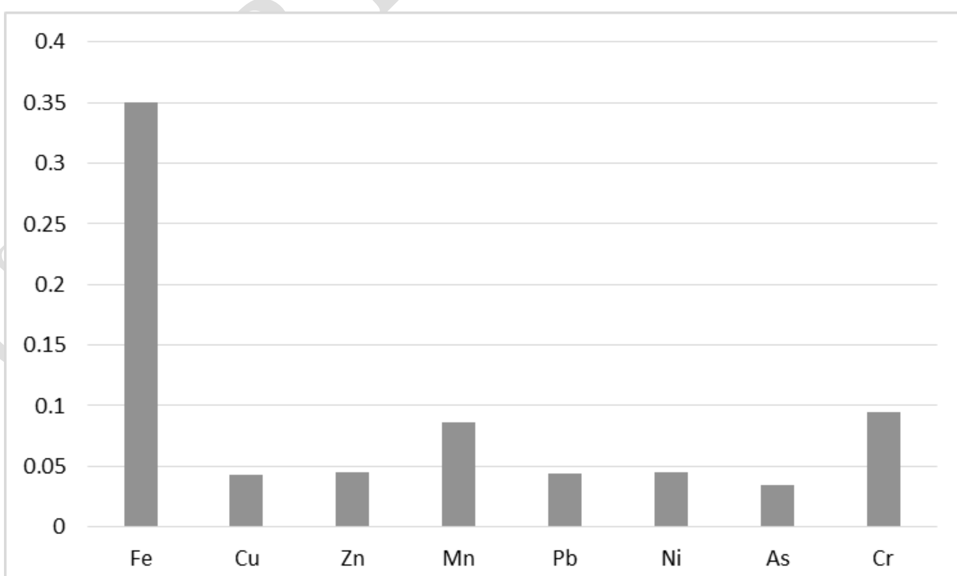

Figure 2: Mean concetrnations of various heavy metals (mg/l) in wastewater samples of Kubanni-Galma river basin

Table 1: Mean Concentrations of the various metals (mg/l) across different Sampling Locations in Kubanni-Galma River Basin

Heavy Metal	Maximum Allowable in Irrigation Water	Mean value for the various wastewater sampling locations (mg/l)					Summary of ANOVA Results		
		HNE	TJK	AGR	GYL	JSH	Calculated F-value	Critical F-value	Significance of the Difference
Fe	**0.01**	0.6	0.05	0.4	0.2	0.5	2.15	1.78	S
Cu	**0.2**	0.03	0.02	0.05	0.04	0.03	1.02	1.78	N S
Zn	**Up to 5.0**	0.02	0.02	0.03	0.04	0.03	1.32	1.78	NS
Mn	**0.2**	0.1	0.04	0.08	0.1	0.08	2.32	1.78	S
Pb	**-**	0.03	0.02	0.05	0.04	0.06	1.17	1.78	NS
Ni	**0.2**	0.03	0.03	0.05	0.04	0.04	0.96	1.78	NS
As	**0.1**	0.02	0.02	0.03	0.03	0.05	0.54	1.78	NS
Cr	**0.1**	0.01	0.07	0.1	0.1	0.1	2.42	1.78	S

Note:

Index to the Sampling Locations**:** HNE (Hanwa Extension); TJK (Tudun Jukun); AGR (Agoro); GYL (Gyallesu); JSH (Jushi)

'S' Mean difference between the mean values are statistically significant, at 0.01 probability level
'NS' Mean difference between the mean values are statistically not significant, at 0.01 probability level

Table 2: Descriptive statistics of the heavy metals determined in Kubanni-Galma River Basin

Heavy Metal	Maximum Allowable in Irrigation Water (mg/l)	Descriptive Statistical Parameters			
		Range (mg/l)	Mean (mg/l)	Standard. Deviation	Coefficient of Variation (%)
Fe	**0.01**	0.05-0.6	0 35	0.0224	5.7
Cu	**0.2**	0.02-0.05	0.03	0.01	33.3
Zn	**Up to 5.0**	0.02-0.04	0.03	0.007	23.3
Mn	**0.2**	0.04-0.1	0.08	0.02	25.0
Pb	**-**	0.02-0.06	0.04	0.007	17.5
Ni	**0.2**	0.03-0.05	0.04	0.007	17.5
As	**0.1**	0.02-0.05	0.03	0.01	33.3
Cr	**0.1**	0.07-0.1	0.09	0.01	11.1