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Wastewater Qualities used for urban Agriculture in metropolitan Kano, Kano State, Nigeria

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Abstract

This study was conducted across three metropolitanRivers namely; Salanta (Sharada), KofarRuwa (Federal Secretariat) and Jakara (Kwakwaci) in Kano, Kano state, Nigeria. NineWater samples were collected (SD1, SD2 SD3, FS1, FS2, FS3, KC1, KC2 and KC3, three from each location) at the respective sites, and analysed for cations, anions, micronutrients and heavy metals. Irrigation wastewater indicates that pH were slightly alkaline with Federal Secretariat and Kwakwaci having slightly a higher mean pH values (7.25-7.28), EC mean values were slightly higher at Federal Secretariat and Kwakwaci (1.57-2.13dSm^{-1}), the mean concentrations of Na (10.90 – 11.10 cmol/l) were significantly higher at Federal Secretariat and Kwakwaci than at Sharada (5.33cmol/l). Carbonate, bicarbonate, nitrate and phosphate were all recorded high at Federal Secretariat and Kwakwaci which are domestic and municipal sites than Sharada which is an industrial site. Sulphate and Chloride were higher at Sharada than both Federal Secretariat and Kwakwaci. The mean values of Zn, Mn, Pb and Cd (1.8, 0.87, 2.6, and 5.3) were greater at Federal Secretariat and Kwakwaci than at Sharada (0.67, 0.67, 0.20, and 0.47). Mean values of Cr and Fe were greater at Sharada (0.28, 0.78) than at Federal Secretariat and Kwakwaci (0.22, 0.17).

***Keywords**: wastewater, micro nutrients, heavy metals, Kano metropolis.*

INTRODUCTION

Urban agriculture is a common practice in many cities around the world including Kano, Nigeria, where it is a centuries old practice (Dokaji1978). Although time has modified the system, the principal feature remains the use of stream water to irrigate land at the banks.

Van der Hoek (2004) defines wastewater as domestic effluent which consists of black water (excreta, urine and related sludge) and grey water (kitchen and bathroom). The use of wastewater as an alternative for pure water has equally spread to areas downstream of urban centers (Scott *et al.,* 2004). It has been estimated that over 20 million hecters of land has been under irrigation with wastewater, in over 50 countries (Hussein *et al.,* 2001). Irrigation with wastewater plays a significant role in supplying vegetables to meet the ever increasing population demandsparticularly in urban centers. In any developing areas, the non developed urban lands, especially those lying along the courses of urban drainage systems are sometimes seen as locations for the production of some vegetable that are in high demand by urban dwellers (Mohammed and Abdullahi, 2010).

MATERIALS AND METHODS

Description of the study area: Kano metropolis is situated between latitude 11^0 25' N and 12^0 47' N and longitude 8^0 22' E to 8^0 39' E and lies 472m above sea level. Kano metropolis is the third largest town in Nigeria after Lagos and Ibadan with a population of 2,826307 (NPC, 2006).

Drainage and relief of the study area lies within the Kano plains, which forms a vast gently undulating topography with very long slopes. The relief ranged from lower plains (500m) to highlands of more than 1000m above sea level. The land forms include the Rishi hills, plains with grouped hills, sandy plains, and alluvial channel complexes (Olofin, 1985).

Major land uses are cultivation ofleafy vegetables (cabbage, lettus, spinach, fenugreek etc). Water from streams and rivers that passes through the areas is used to irrigate the crops, also tube wells are used to supplement water from the streams (Tanko 2003; Binns, *et al.,* 2003).

Sampling: Water samples were collected in April, 2014 before the onset of the rain so as to avoid the effect of dilution. Nine water samples were collected (three from each site) inclean polyetheneplastic containers through grab or catch method across the width of the river at each sampling point based on the assumption that the irrigation water was well mixed (Kirda, 1997; AWWA, 1999). Each sampling location was recorded with a hand help GPS device (Garmain etrex1).

Laboratory analysis: pH of water was determined at point of collection while EC of the water samples was determined directly in the sampling containers using an automated digital conductivity meter (Jenway Digital Conductivity Meter Model 4520; Jenway Scientific Equipment, Staffordshire, UK). Total metals inwater were extracted with HNO_3 as described byBackstrom et al. (2003).Carbonate and bicarbonate were determined through acidimetric method, sulphate was determined turbidimetrically, Nitrate was determined by devardad's alloy reduction method. Chloride was determined in water by Mohr's titration method; Phosphate was determined by the HNO_3-H_2SO_4 digestion and calorimetric method of Adepetu (2000). Sodium and potassium were read on flame photometer while Calcium and Magnesium was determined using Atomic Absorption spectrophotometer after digestion with nitric acid.

RESULTS AND DISCUSSION

The quality of the irrigation water was determined with respect to salinity and cations as indicated in Table 1.The meanpH values (7.22-7.28) obtained in the three study sites showed that the quality of the water used at the various sites might be rated as suitable for irrigating crops according to FAO,(1992) which is reported 8.4.

The mean EC values across the three sites (Sharada, Federaral secretariat and Kwakwaci) ranged from 0.48-2.13dSm^{-1}. The higher EC values at Federal secretariat and Kwakwaci (1.58 - 2.13 dSm^{-1}) might be linked to presence of dissolved salts from domestic and municipal effluent discharged into the respective rivers. Generally, the range considered for irrigation water suitability are 0 - 2.99 dSm^{-1} with respect to salinity hazards (FAO, 1992). From this perspective, sites two and three (Federal sectariat and Kwakwaci) could be described as being slightly unsafe for irrigation.

The mean values of Na recorded across the three sites ranged from 5.33 - 11.10 cmolkg^{-1}. Mean sodium values at Federal Secretariat and Kwakwaci varied significantly from Sharada. The highest Na ion concentration was obtained at Federal Secretariat (11.10cmolkg^{-1}), followed by Kwakwaci (10.90cmolkg^{-1}) and the least Na mean value was at Sharada (5.33cmolkg^{-1}). The mean Na value recorded at Federal secretariat and Kwakwaci (11.10 and 10.90 cmolkg^{-1}) may therefore be interpreted as posing severe risk factor (9cmol/l) of sodium toxicity to the soil with the exception of the Sharada site (5.33 cmolkg^{-1}) based on ranking of FAO (1992) recommended threshold. Excess sodium in irrigation water when applied to the soil can be detrimental to soil structure and can significantly reduce the soils ability to transmit water (Mace and Amrhein, 2001). The higher mean Na values at Federal Secretariat and Kwakwaci might be due to effect of domestic effluent.

The SAR mean values across the three sites are not significant. The mean values of SAR across the three sites ranged from 0.04, 0.09 and 0.22cmol/l for Sharada, Federal Secretariat and Kwakwaci in that order.The SAR values at Federal Secretariat and Kwakwaci were slightly higher; this may not be surprising as the Na values were relatively higher. Increasing sodicity hazards may be associated with SAR values exceeding 6 and SAR values above 13 is considered high therefore, the three sites are considered low in SAR falling within safe limit based on FAO, (1992) ranking.

Mean Mg values across the three sites were 1.80, 1.13 and 2.67 cmol/l respectively. Mg values across the three sites varied significantly ($p > 0.05$) with Kwakwaci having the highest mean value of 2.67cmol/l followed by Sharada (1.80cmol/l) and Federal Secretariat (1.13cmol/l) as the lowest. The normal range of Mg^{2+} is between 0 – 5cmol/l (FAO, 1992), by this criterion the magnesium content across the three sites could be described as within safe limit. The relatively lower amounts of magnesium compared to the calcium may be good because Mg deteriorates soil structure particularly where waters are sodium dominated. The reason for this structural degradation is that high level of Mg usually promotes a higher development of exchangeable Na in irrigated soils (Maurya, 1982). The Magnesium content of water is also considered as an important qualitative criterion in determining the quality of water for irrigation because more magnesium in water will adversely affect crop yields, as the soils become more alkaline.

The mean Ca values across the three sites were 4.73, 6.73 and 4.00 cmol/l. statistically mean Ca values did not vary significantly. However, Federal secretariat had the highest mean value of 6.73cmol/l, followed by Sharada (4.73cmol/l) and Kwakwaci had 4.00cmol/l. By this criterion Ca content within the three sites could be described as being within safe limits of 0 – 20cmol/l (FAO, 1992).

The presence of potassium ions in excessive amounts does not constitute any risk and may even supplement crops' needs as only values exceeding 50cmol/l may be considered as posing any serious risk factor with irrigation water.

Anion concentration in water: Values of anions across the three sites are presented in Table 2. The mean values of nitrate across the three sites varied from 0.23, 0.68 to 0.61mgl^{-1}, and statistically the mean values of nitrate across the three sites varied insignificantly.

Table 1. Chemical properties of irrigation water.

Treatment	pH	EC	Ca	Mg	K	Na	SAR
		dSm^{-1}	----	-------	cmol/l---	----	
Site(S)							
Sharada	7.25	0.48b	4.73	1.80b	16.40a	5.33b	0.04
Fed Sec	7.28	2.13a	6.73	1.13c	28.27a	11.10a	0.09
Kwakci	7.22	1.58a	4.00	2.67a	8.40b	10.90a	0.22
Significance	NS	**	NS	*	*	*	NS
LSD	0.23	0.83	2.48	0.60	12.96	5.86	0.27
FAO 1992	6.5-8.4	3.0	20	5	2.00	9	13

LSD= least significant difference, * = significant at 0.05, ** = significant at 0.01. FAO = Food and agricultural org.

However, Federal Secretariat and Kwakwaci recorded slightly higher mean values (0.68 and 0.61 mgl^{-1}) than Sharada (0.23mgl^{-1}).Nitrate (NO_3^-) is an important anion assessed for irrigation water.The slightly higher mean nitrate values at Federal Secretariat and Kwakwaci

might be attributed to domestic sewage disposal as reported by Akan *et al.,* (2008). The normal ranking for nitrate is a maximum of 10mgl^{-1} (FAO, 1992). By this standard all the sites could be described as being within safe limit.
The mean of PO_4^{3-} values (14.41, 26.47 and 17.71) mgl^{-1} recorded in this study was higher than the value of 10mgl^{-1} as approved by FAO (1992).Phosphate is another important anion assessed for irrigation water. The high phosphate values recorded at Federal Secretariat and Kwakwaci may be due to wastes emanating from homes, abattoir and car washing activities (Akan *et al* 2008). Dike *et al.,* (2010) reported the mean annual values of phosphate around Jakara River to be 7.0mgl^{-1} which was lower than the value of 10.0mgl^{-1} approved by FAO (1992) for irrigation with wastewater, and lower than the values obtained in this study (14.41 to 26.47 mgl^{-1}).
The mean Sulphate values across the three sites were 15.18, 8.03 and 8.83 mgl^{-1} for Sharada, Federal secretariat and Kwakwaci. Statistically the mean values of sulphate at Sharada (15.18 mgl^{-1}) vary significantly ($P > 0.05$) from Federal Secretariat and Kwakwaci (8.03 and 8.33 mgl^{-1}). The higher mean value of sulphaterecorded at Sharadasite compared to Federal secretariat and Kwakwaci might be linked to the use of SO_4^{2-} salt of Cr in tanning industries. Wakawa*et al.,* (2008) reported the mean values of sulphate (640.00 - 644.67 mgl^{-1}) around ChallawaRiver to be far above the values of sulphate obtained in this study (8.03 - 15.18 mgl^{-1}). The mean values across the three sites (Sharada, Federal secretariat and Kwakwaci) were within safe limits of 100mgl^{-1} limit as recommended by FAO (1992).
The mean values for carbonate in irrigation water across the three sites were 20.0, 35.0 and 25.0 cmol/l respectively. The values of carbornate across the three sites varied insignificantly although Federal Secretariat had the highest mean value (35.0cmol/l) followed by Kwakwaci (25.0cmol/l) and the least was recorded at Sharada (20.0cmol/l).The effect of high carbonates in irrigation water is on the alkalinity status of the soil. High alkalinity indicates that the water will tend to increase the pH of the soil, possibly to a point that is detrimental to plant growth. However low alkalinity could also be a problem in some situations. This is because many fertilizers are acid-forming and could, over time, make the soil too acidic for some plant. Another aspect of alkalinity is its potential effect on sodium. Soil irrigated with alkaline water may, upon drying, cause an excess of available sodium. Several potential sodium problems as highlighted above could therefore result.
The mean values of bicarbonate across the three sites were 162.67, 721.83 and 589.67 mgl^{-1} for Sharada, Federal Secretariat and Kwakwaci. Statistically the values of bicarbonate across the three sites varied significantly with the highest mean (721.83cmol/l) recorded at Federal Secretariat, followed by Kwakaci (589.67cmol/l) and the least mean value at Sharada (162.67cmol/l). Bicarbonate levels above 3.3cmol/l will cause lime (calcium and magnesium carbonate) to be deposited on soils. High HCO_3^- tends to precipitate calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$), when the soil moisture dries. If the concentrations of calcium and magnesium in soil solution are reduced relative to sodium, the SAR of the soil solution tends to increase (Maurya, 1982).
Heavy metal concentration in water: Heavy metal status in irrigation water is presented in Table 3. The mean concentrations of Pb across the three sites were 0.27, 0.20 and 0.20mgl^{-1} for Sharada, Federal secretariat and Kwakwacirespectively. Statistically the Pb mean values across the three sitesvaried insignificantly, although the mean valueof Pb atSharada site was higher.

Table 2: Anion status in water of the study sites.

Treatments	PO_4	SO_4	NO_3	HCO_3	CO_3	Cl^-
	------------------	----------------	----------------	mgl^{-1}	----------------	-------------
Site(S)						
Sharada	14.41	15.18a	0.23	162.67b	20.00	171.58a
Fed Sec	26.47	8.03b	0.68	721.83a	35.00	47.3c
Kwakwaci	17.71	8.83b	0.61	589.67a	25.00	112.42b
Significance	NS	*	NS	**	NS	*
LSD	33.8	8.74	0.48	216.87	17.3	96.68
FAO, 1992	10.0	100	10	8.5	1.0	10

.PO_4= Phosphate, SO_4= Sulphate, NO_3= Nitrate, HCO_3= Bicarbonate, CO_3= Carbonate, Cl-= chloride, LSD= Least Significant Difference. FAO= Food and Agricultural Organization

The high Pb value at Sharada in addition to contamination by vehicular discharges and atmospheric deposition, industrial effluents might have contributed very much to the slightly higher concentration at the Sharada site compared to Federal secretariat and Kwakwaci. Mohsen (2008) highlighted the effect of industrial effluents as the main cause of the high levels of lead in the waters they analyzed. The standard for irrigation water approved by FAO (1992) for Pb is 5mgl^{-1}. These results show that Pb content across the three sites is safe and can be used for irrigation without any hazards.

The mean concentrations of Cd across the three sites were 0.40, 0.43 and 0.53mgl^{-1}. Mean Cd values across the three sites varied insignificantly, however Cd mean concentration at the Kwakwaci and Federal secretariat (0.43 and 0.53 mgl^{-1}) were slightly higher than Sharada (0.40 mgl^{-1}). The slightly higher mean Cd values at Federal Secretariat and Kwakwaci might be ascribed to dissolution from its content in products such as batteries and alloys which are discarded as municipal solid wastes and are subsequently washed into river bodies as alleged by Wild (1996). The standard for irrigation water approved by FAO (1992) for Cd is 0.01mgl^{-1}. These results shows that Cd content in the entire three sites were found above the range, implying that the water is not safe for irrigation with respect to Cd.

The mean concentrations of chromium across the three sites were 0.28, 0.25 and 0.17mgl^{-1} respectively. Statistically chromium varied insignificantly across sites. However, Sharada recorded slightly higher mean value than Federal Secretariat and Kwakwaci. Cr is an element that is associated with industrial waste waters especially the tanning industries (Maldonado, 2008). This fact explains the slightly higher concentrations at the Sharada site where the largest tanning factory is located in the city. The standard for irrigation water approved by FAO (1992) for Cr is 0.1mgl^{-1} for neutral to alkaline soil, meaning the water is not safe for irrigation with respect to Cr content.

Table 3: Heavy metal status in irrigation water.

Treatments	Cr	Ni	Pb	Cd
	---------	$-mgl^{-1}$------------	---------	---------
Sites(S)				
Sharada	0.28	0.18	0.20	0.40
Fed Seccretariat	0.25	0.18	0.26	0.43
Kwakwaci	0.17	0.13	0.26	0.53
Significance	NS	NS	NS	NS
LSD	0.20	0.13	0.19	0.27
FAO(1992)	0.1	0.2	5.0	0.01

LSD= Least Significant Difference, * = significant at 0.05, ** = significant at 0.01, FAO= Food and Agricultural Oraganization.

Micronutrient status in irrigation water: Micronutrients status in irrigation water is presented in Table 4. The mean values of Cu content in irrigation water in the three sites (Sharada, Federal secretariat and Kwakwaci) ranged from 0.39 to $0.52mgl^{-1}$. Statistically the mean values of Cu across the three sites showed no significant difference. However, Kwakwaci had the highest mean value ($0.52mgl^{-1}$) while Sharada recorded the lowest. The results showed that Cu content in all the three sites were found not to be within the safe limit of ($0.2mgl^{-1}$) as reported by (Pescod, 1992; FAO, 1992 and FAO, 2000). The higher Cu values in domestic and industrial wastewaters have also been highlighted by Binns*et al.* (2003) and Mohsen (2008). These therefore explain the higher concentrations in all the three sites (Sharada, Federal secretariat and Kwakwaci).

The mean values of Zn across the three study sites were 0.67, 1.08 and $0.75mgl^{-1}$ for Sharada, Federal secretariat and Kwakwaci respectively. The mean values of Zn cross the three sites varied insignificantly. The highest mean value ($1.08mgl^{-1}$) was detected at Federal Secretariat followed by Kwakwaci ($0.75mgl^{-1}$). The highest mean recorded at Federal Secretariat and Kwakwaci might probably be due to the fact that Zn is associated with domestic effluent and waste. The standard for irrigation water approved by FAO (1992) for Zn is $2.0mgl^{-1}$. These results showed that Zn content of all the three sites were found in deficient concentrations below the standards.

MeanMn content across all the three sites were 0.67, 0.73 and 0.87 mgl^{-1} for Sharada, Federal secretariats and Kwakwaci respectively. The mean values of Mn across sites varied insignificantly. Kwakwaci and Federal Secretariat recorded the highest mean concentration of Mn than Sharada which could also be associated with domestic effluents and waste. Acording to FAO, (1992) the maximum level of Mn in irrigation water is $0.2mgl^{-1}$. These results showed that Mn content was found above safe range.

Table 4: Micronutrient status in irrigation water.

Treatments	Zn	Cu	Fe	Mn
	-------	mgl^{-1}-------	--------	-------
Sites(S)				
Sharada	0.67	0.39	0.78	0.67
Fed Sec	1.08	0.39	0.28	0.73
Kwakwaci	0.75	0.52	0.22	0.87
Significance	NS	NS	NS	NS
LSD	0.69	0.23	0.64	0.52
FAO(1992)	2.0	0.2	5.0	0.2

LSD= Least Significant Difference, * = significant at 0.05, ** = significant at 0.01, FAO= Food and Agricultural Oraganization.

The mean concentrations of Fe ranged from 0.78, 0.28 and 0.22 mgl^{-1} for Sharada, Federal secretariat and Kwakwaci respectively. The mean values of Fe across the sites varied insignificantly. However Sharada had the highest mean (0.78) mgl^{-1} followed by Federal Secretariat (0.28 mgl^{-1}) and Kwakwaci (0.22 mgl^{-1}). The standard for irrigation water approved by FAO (1992) for Fe is 5.0mgl^{-1}. These results shows that Fe content of all the three sites were in safe range.

Conclusion: Going by the data obtained from this study, it is obvious that wastewater plays a significant role in urban agriculture by providing the soil with nutrients needed by plants (N, P and K). The wastewater also contains some level of toxic metals, but some are still within the recommended limit.

Recommendation: For successfulapplication of wastewater for irrigation there is need for proper management practices which include selection of tolerantcrops, treatment of wastewater prior to its re-use for irrigation, and the increase in the frequency of irrigation to leach excess salts.

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