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WASTEWATER IRRIGATION SAFETY AND HEAVY METAL CONTAMINATION AWARENESS OF FARMERS ALONG JAKARA RIVER KANO, NIGERIA

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ABSTRACT

The water in the Jakara River consists of effluent from Bompai industries, domestic sewage from most parts of Kano city and runoffs from various local scraps and chemical processing. The wastewater in the river is the main and most preferred source of irrigation water for the farmers along the Jakara River. The wastewater in the river is rich in both organic and chemical contaminants that can contaminate soil and thriving crops. The research was designed to understand the perception of farmers about the safety of the irrigation water they use and its resulting consequences on soil quality and food safety. The information on the farmer's awareness were gathered through oral interviews, 60 farmers were selected for data collection. Information collected includes the demography of the farmers, their farming experience, their concern about the safety of wastewater irrigation and awareness of the dangers associated with soil and food heavy metals (HMs) contamination. The majority (95 %) of the farmers ignorantly believe that the wastewater in the Jakara River is safe for irrigation and 90.00 % believe that crops cannot be contaminated when irrigated with contaminated wastewater. Only 5 % of the farmers know HMs and more than 86 % believe that even if the water is contaminated it cannot pass contamination to soil and growing crops. The overall farmers' awareness of the safety of wastewater irrigation and soil and crop HM contamination is generally poor.

Keywords: Contamination, Heavy metals, Irrigation, Jakara river, Wastewater

INTRODUCTION

The use of wastewater for irrigation is an ancient practice dating back to 3,500 BC (Tzanakakis *et al*., 2007). About 15 billion litres of untreated wastewater is used a day for food production globally to complement the freshwater scarcity (Ungureanu *et al*., 2020). The water scarcity triggered by climate change necessitates the use of wastewater in irrigating agricultural soil in most arid and semi-arid parts of the globe (Khanpae *et al*., 2020). Other factors that are instigating water scarcity and the need for increasing global food production are the fast-increasing world population (Macieira *et al*., 2021; Zhang and Shen, 2019) and issues related to social and economic development, particularly in developing and underdeveloped countries (Zhang and Shen, 2019; Ungureanu *et al*., 2020).

Among the disturbing problems that can be derived from using poor quality irrigation water is the accumulation of organic and inorganic (most importantly trace elements) contaminants that can alter plant growth patterns and food standards (Malakar *et al*., 2019). Possible chemical contaminants that can be sourced from wastewater irrigation include HMs, pharmaceuticals, personal care products and pesticide residues (Singh, 2021). Various hazardous pathogens of bacteria, protozoa and viruses origins were also found in wastewater (Rock *et al*., 2019; Singh, 2021). Persistent irrigation using untreated wastewater can cause damage to soil qualities, initiate several environmental problems and subsequently interfere with the well-being of food crops and humans (Chaoua *et al*., 2019; Malakar *et al*., 2019; Zhang and Shen, 2019; Rashid *et al*., 2023). Even treated wastewater can be a source of organic and chemical contaminants as reported by Helmecke *et al*. (2020). Moreover, Hashem and Qi (2021) reported that uncontrolled use of treated wastewater can have adverse effects on both soil and plants. The global volume of wastewater is expected to increase due to industrial growth, which in turn means the escalation of environmental-related diseases and the emergence of strange illnesses (Zhang and Shen, 2019).

Wastewater effects on the soil may include structural degradation, decreased aeration and conductivity, salinization and toxicity due to HM accumulation. Effects on food crops may include HMs accumulation, changes in the microbial load and composition, delayed or uneven growth and maturity (Ungureanu *et al*., 2020). Prolong wastewater irrigation can also contaminate the vicinal groundwater with toxic HMs (Rehman *et al*., 2019; Ungureanu *et al*., 2020).

Jakara River is the main source of water for urban agriculture in Kano (Sanda *et al*., 2016). The river is extremely polluted with heavy metals including Pb, Cd, Cu, Fe, Zn and Cr (Ekevwe and Bartholomew, 2015). The concentration of heavy metals in the soil around the Jakara River exceeds the international recommended permissible limit in agricultural soil (Dike and Oniye, 2016).

The study intended to assess the level of farmers' awareness of the presence of heavy metals (HMs) in wastewater used for irrigation, agricultural soil and food crops produced along the Jakara River. The results of the findings will be used in creating awareness among farmers and concern authorities on the dangers associated with the consumption of contaminated vegetables produced along the Jakara River.

MATERIALS AND METHODS

The Study Site

Jakara River is located at the centre of the Kano metropolis, it lies at the latitude 12° 10 N to 12° 13 N and 8° 31 E to 8° 45 E. Jakara basin belongs to the subtropical zone characterised by long summer and short winter. The region has an annual mean temperature of 25 to 28 °C, and an annual mean rainfall of 800 to 1000 mm (Mustapha, 2012; Mustapha *et al*., 2014). The river flows in a North-East direction and cuts across the Kano metropolitan (Mustapha and Aris, 2011).

Sampling, Data Collection and Data Analysis

Simple random sampling was employed to interview 60 farmers. An oral interview was used to assess the farmers' awareness of wastewater irrigation safety and heavy metal contamination awareness on the agricultural soil and food crops. Information obtained includes the demography of the farmers, their farming experience, their concern about the safety of wastewater irrigation and awareness of the dangers associated with soil and food crop HMs contamination.

The survey was conducted between May and June 2024. Data were collected by face-to-face interviews using Kobo Collect. The survey data were analysed using Microsoft Excel (Version 2021) and were reported as percentages.

RESULTS AND DISCUSSION

Demography of the Farmers

The result for the demography of the vegetable farmers along the Jakara River was presented in Table 1. A total of 60 farmers were interviewed. All the respondents are male, indicating that farming activity along the river is a male-dominated business. The majority (75.01 %) of the farmers aged between 31 and 60 years.

The results for the education status of the farmers showed that 45 % possessed non-formal education, 18.33 % attended primary school, 30 % attended secondary school and 6.67 % attended tertiary institutions. More than 76 % of them are full-time farmers, 21.67 % are doing farming and other businesses, and only 1.67 % are combining farming and civil service. The majority of the farmers (76.67 %) were married. Among the married farmers, 35 %, 30 % and 28.33 % have household sizes of 2-5 persons, 6-10 persons and 11-15 persons respectively. The results also revealed that all the farmers lived in Kano for more than 10 years.

Table 1: Demography of the Farmers along Jakara River (N=60)

DEMOGRAPHY OF THE RESPONDENTS		
		N (%)
Gender	Male	60 (100)
	Female	0 (0.00)
Age	Less than 20	1 (1.67)
	20-30	6 (10.00)
	31-40	10 (16.67)
	41-50	19 (31.67)
	51-60	16 (26.67)
	Above 60	8 (13.33)
Educational level	Non-Formal Education	27 (45.00)
	Primary school	11 (18.33)
	Secondary school	18 (30.00)
	Tertiary Institution	4 (6.67)
Occupation	Farming	46 (76.67)
	Farming and other business	13 (21.67)
	Farming and civil service	1 (1.67)
Marital status	Married	52 (86.67)
	Single	8 (13.33)
	Widowed	0 (0.00)
	Divorce	0 (0.00)
Household Size	2-5	21 (35.00)
	6 to 10	18 (30.00)
	11 to 15	17 (28.33)
	16 to 20	3 (5.00)
	Above 20	1 (1.67)
Length of stay in Kano	5 years or less	0 (0.00)
	6-10 years	0 (0.00)
	Above 10 years	60 (100.00)

Farming Experience of the Farmers along Jakara River

The results of the farming experience of vegetable farmers along the Jakara River were presented in Table 2. The majority (90.00 %) of the respondents have more than 10 years of farming experience and more than 83 % have been practising farming as a business along the Jakara River for

over a decade. Almost all the farmers produce Amaranth, Lettuce, Cabbage and other vegetables such as Onion, Pepper, Carrot, Beetroot, Cauliflower, Parsley, Kale, Cucumber, Green bean and Bitter leaf.

The findings revealed that 55 % of the farmers produced amaranth at least 6 times in 12 months, 45 % produced cabbage 3 times in 12 months and 81.67 % produced lettuce 3-5 times in 12 months. A significant proportion (54.55 %) of the farmers can produce between 100-200 bundles (estimated weight; 20-30 kg) of amaranth per harvest, 26.67 % can produce over 100 bags (estimated weight; 80-90 kg) of cabbage and 45 % can produce at most 100 bundles (estimated weight; 40-50 kg) of lettuce per harvest.

Table 2: Farming Experience of Farmers along Jakara River (N=60)

FARMING EXPERIENCE		
		N (%)
Farming experience	5 years or less	2 (3.33)
	6-10 years	4 (6.67)
	Above 10 years	54 (90.00)
Duration of Farming along Jakara River	5 years or less	3 (5.00)
	6-10 years	4 (6.67)
	Above 10 years	53 (88.33)
Vegetable(s) commonly produced*	Amaranth	57 (95.00)
	Cabbage Lettuce	57 (95.00)
	Lettuce	56 (93.33)
Others: (onion, pepper, carrot, beetroot, cauliflower, parsley, kale, cucumber, green bean, bitter leaf)		56 (93.33)
How many cycles of Amaranth harvest do you have in a year?	1-5	27 (45.00)
	6-10	33 (55.00)
How many cycles of Cabbage harvest do you have in a year?	1	11 (18.33)
	2	22 (36.67)
	3	27 (45.00)
How many cycles of Lettuce harvest do you have in a year?	3-5	49 (81.67)
	Above 5	11 (18.33)
Estimate the quantity of Amaranth produced per harvest	100 bundles and below	16 (26.67)
	101-200	33 (55.00)
	above 200	11 (18.33)
	Sell on the farm	12 (20.00)
Estimate the quantity of Cabbage produced per harvest	50 sacks and below	16 (26.67)
	51-100	16 (26.67)
	Above 100	16 (26.67)
Estimate the quantity of Lettuce produced per harvest	100 bundles and below	27 (45.00)
	101-200	11 (18.33)
	above 200	22 (36.67)

*Questions with multiple options

Irrigation Water Safety and Heavy Metals Contamination Awareness among Farmers along Jakara River

Results for Harvey metals contamination awareness among farmers along Jakara River were presented in Table 3**.** All the farmers along the Jakara River are using the wastewater from the stream and 41.67 % are using tube wells as alternative sources of irrigation water. They all prioritised using the wastewater from the Jakara stream over other sources. A similar view was reported by Khanpae *et al*. (2020) in research conducted in Marvdasht County, Iran, the farmers there believe that wastewater irrigation boosts crop yield and cuts production costs.

The majority (95.00 %) of them believe that the wastewater in the Jakara River satisfied the quality requirements for irrigation water and 90.00 % believe that crops cannot be contaminated when irrigated with contaminated wastewater. Khanpae *et al*. (2020) reported that most farmers have no concern about the consequences of wastewater irrigation on soil quality and environmental safety.

Only 5 % of the farmers know HMs and more than 86 % do not believe that contaminated irrigation water can stock soil with HMs and subsequently pass them to the growing vegetable. This agreed with the findings of Sohail *et al*. (2022) who also observed that most of the farmers in Punjab, Pakistan are ignorant of the possible contaminants in the wastewater used for irrigation. A much higher level of awareness (46.60 %) was reported by Zhou *et al*. (2022) among Hubei Province farmers in China. The belief of the farmers on the water-soil-crop HM transfer contradicts the scientifically proven evidence on the negative effects of prolonged wastewater irrigation on the agricultural soil which include accumulation of HMs in the soil, reduction in the

overall quality of the soil, food contamination and health threat to the farmers and the consumers (Khanpae *et al*., 2020). Surprisingly, Balotin *et al*. (2020) observed that the farmers in Atalanta, U.S.A. are more concerned about the health effects of soil HM contamination than that of food crops HM contamination, this is an indication that a similar perception can be demonstrated by farmers in developed countries. To top it all, numerous researchers reported HM contamination in the irrigation water (Binns *et al*., 2003; Lawal and Audu, 2011; Imam, 2012; Dawaki *et al*., 2015; Ekevwe and Bartholomew, 2015; Tasiu and Sule, 2020), surrounding soil (Haruna *et al*., 2011; Imam, 2012; Dike and Odunze, 2016; Adamu, 2019; Mohammed and Olowolafe, 2020) and various crops produced along the river (Lawal and Audu, 2011; Dawaki and Shu'aibu, 2013; Dike and Odunze, 2016; Ekevwe *et al*., 2017; Danjuma and Abdulkadir, 2018; Abdullahi and Mohammed, 2020; Doka *et al*., 2020; Habu *et al*., 2021). In addition, scientists from other parts of the world also reported HMs contamination in soil and/or crops irrigated with wastewater, this includes Kfle *et al*. (2020) from Eritrea, Rehman *et al*. (2019) from Pakistan, Chaoua *et al*. (2019) and Barakat *et al*. (2020) from Morocco, Islam *et al*. (2020) from Bangladesh.

Only 3.33 % know that consumption of HM-contaminated vegetables can cause health problems. In contrast to this, Zhou *et al*., (2022) reported that 79 % of farmers producing in Hubei Province, China know that HM contamination in food crops can cause health problems. The poor awareness can be attributed to the poor educational background among the farmers in Jakara River. More than 70 % of the farmers are aged above 40 years and this can be an additional reason for the poor awareness. The latter assertion can be supported by the finding of Li *et al*. (2021) who reported a negative correlation between farmer's age and safety behaviour. Hoffmann *et al*. (2019) count the lack of investment in safety along the food supply chain among the leading factors for retarding food safety awareness in low and middle-income countries, he attributed that to the lack of commitment by consumers and policymakers in these countries.

Table 3: Irrigation Water Safety and Heavy Metals Contamination Awareness among Farmers along Jakara River (N=60)

IRRIGATION WATER SAFETY AND HEAVY METAL CONTAMINATION AWARENESS		
		N (%)
What is the source of your irrigation water? *	Wastewater	60 (100.00)
	Tube well	25 (41.67)
	Borehole	0 (28.33)
	Well	0 (0.00)
Do you use water from the Jakara River for Irrigation?	Yes	60 (100.00)
	No	0 (0.00)
Are you satisfied with the quality and safety of the irrigation water?	Yes	57 (95.00)
	No	2 (3.33)
	Not sure	1 (1.67)
Do you know contaminated water can pass contamination to crops?	Yes	2 (3.33)
	No	54 (90.00)
	Not sure	4 (6.67)
Do you know heavy metals?	Yes	3 (5.00)
	No	57 (95.00)
Are you aware that irrigation with contaminated wastewater can stock soil with heavy metals and subsequently pass them to the growing vegetables?	Yes	0 (0.00)
	No	52 (86.67)
	Not sure	8 (13.33)
Are you aware that consumption of heavy metals-contaminated vegetables can cause health problems?	Yes	2 (3.33)
	No	49 (81.67)
	Not sure	9 (15.00)

* Questions with multiple options

CONCLUSION

Farming activities along Jakara River is a male-dominated business with the majority of the farmers aged between 31 and 60 years. Most of the farmers possessed non-formal education, 48 % attended at least primary school, and only 6.67 % attended tertiary institutions. The majority of the respondents have more than 10 years of farming experience. The overall farmers' awareness of the safety of wastewater irrigation and soil and crop HM contamination is generally poor. The majority of the farmers ignorantly believe that the wastewater in the Jakara River is safe for irrigation.

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