Moroccan Journal of Agricultural Sciences
Vol 2 No 2 (2021): (June 2021)
Nutrition and Food Technology

Heavy metals contamination sources in Kano, Nigeria and their concentrations along Jakara River and its agricultural produce: A review

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Industrialisation, environmental pollution and poor waste management distress food and environmental safety in Kano. Incessant discharge of untreated effluent and sewage, vehicular release, metal and plastic scraps dumping and processing, local dyeing and tanning, atmospheric deposit and excessive use of agrochemicals continue to contaminate the surrounding soil and surface water with toxic heavy metal (HMs). Violation of environmental regulations and failure of environmental regulatory agencies to actively enforce environmental protection laws exacerbate the situation. Soil, water bodies and food produced within the city are under threat due to the HMs contamination. Consumption of contaminated vegetables is the major route for HMs contamination in humans. The concentration of HMs in the irrigation water and soil along the Jakara river exceeds permissible limits and the water is unsafe for drinking and food production. The vegetables produced along the Jakara river were reported to be contaminated with dangerous levels of HMs. The article reviewed relevant literature and provide an overview of the ideal sources of HMs contaminants in Kano and discussed the extensively on HM contaminations in the Jakara river, surrounding soil, fishes and vegetables produced around the river and its tributary. Recommendations were also provided based on the findings of this research.

Keywords: Kano, Jakara River, Heavy Metals, Vegetable Contamination

Introduction

Accelerated population growth, industrialisation and poor waste management and environmental pollution control possess a grave challenge to food and environmental safety in many developing countries including Nigeria (Abdullahi and Mohammed, 2020; Christopher et al., 2017). Breach of environmental regulations and failure of environmental regulatory agencies to actively enforce environmental protection laws contributed immensely to the poor quality of surface water in Nigeria (Ighalo and Adeniyi, 2020). Vigorous industrialisation and the incessant release of effluents account for the continuous accumulation of HMs in the environment (Danjuma and Abdulkadir, 2018). Heavy metals are elements with metallic properties and an atomic number >20, atomic weight between 63.545 and 200.5 g and a specific gravity greater than 4 (Mbong et al., 2014; Tangahu et al., 2011). Heavy metals are ubiquitous environmental contaminants found in soil, water and air, they are persistent, can easily contaminate the food chain and causes serious problems to consumers including humans (Ali et al., 2019). The menace of food HMs contamination is a threat to public health and its increasingly becoming a global problem (Abdullahi et al., 2021).

Soil and water bodies in Kano are under threat due to the HMs contamination commonly sourced from industrial wastes and agrochemicals (Christopher et al., 2017). Rivers in Kano are not fit for human consumption and agricultural activities due to HMs contamination from untreated industrial effluents (Shawai et al., 2019). Excessive and indiscriminate use of agricultural inputs also contributed to soil contamination along Jakara river (Abdulkadir et al., 2013). Consumption of vegetables grown in contaminated soil is the major rout for HMs contamination in humans (Habu et al., 2021). The concentration of Cr, Cu, Cd, Zn, Co, Fe, Pb, and Mn in tomatoes, onions and pepper produce in the Kano exceed FAO limits (Bichi and Bello, 2013b). Mohammed and Inuwa (2017) cautioned the use of medicinal plant grown within Kano metropolis due to high pollution index. Abdullahi and Mohammed (2020) and Habu et al (2021) reported that the food products from the Jakara river can be carcinogenic. Despite the foreseeing danger government is very reluctant to take measures that will prevent people from getting contamination through consumption of the foods produced along the river (Sanda et al., 2016).

HMs Pollution Sources in Kano

The HM concentration in Kano irrigation water exceeds permissible limits (Christopher et al., 2017). The ideal sources of pollution to the Jakara river are sewage, industrial waste and agricultural imputes (Mustapha and Aris, 2011b). Wastewater irrigation, agrochemicals and atmospheric deposit stock up the soil around the river with dangerous levels of HMs (Dawaki et al., 2015a). The practice of using urban wastes as compost by urban farmers in Kano (Lewcock, 1995) can be an additional source of HMs to the agricultural soil. The finding of Adamu (2019b) metal uptake by Taraxacum officinale, Ruby's physiologically based extraction test (PBET confirm that the dumpsites around the Jakara river are highly contaminated with dangerous HMs. In addition to chemical contamination, vegetables irrigated with wastewater are also prone to microbiological contamination (Dahiru and Enabulele, 2013).

Excessive land use around the Jakara River accounts for various pollution in the river. Anthropogenic activities around the Jakara River significantly affect the quality of it is water. Household effluent strongly influences the quality of the water by depositing a large quantity of organic contaminants (Mustapha, 2012). Domestic and industrial wastes are discharging into the river without treatment (Ibrahim and Ibrahim, 2017). Local dyeing in some areas of Kano and untreated wastewater from proximate industries are among the prominent sources of heavy metals contamination (Ekevwe and Bartholomew, 2015). Vehicular releases, solid wastes and agrochemicals also contribute to contamination in addition to wastewater (Dawaki et al., 2013). The heavy metals concentration of the irrigation water exceeds the toxic level set by regulation (Dawaki et al., 2015a). The organic pollutant in Jakara River is also alarming, both domestic and industrial wastewater received by the river can deposit organic contaminants (Dawaki et al., 2015; Ekevwe et al., 2018).

Bichi and Bello (2013a) attributed the higher concentration of HMs in Kano streams to the vigorous tanning activities going on in the city and the failure of the tanneries to respect effluent discharge guidelines. Tannery wastes are toxic and can be lethal to aquatic life (Sivakumar et al., 2016). Untreated effluent from tanneries and textile industries are among the leading sources of environmental HMs (Danjuma and Abdulkadir, 2018). Bichi and Dan'Azumi (2010) also reported that the concentrations of Cr, Cu, Pb, and Zn in the effluents discharged by chemical processing companies in Kano exceed the permissible limits recommended by the Federal Environmental Protection Agency of Nigeria (FEPA) and WHO. The concentrations of Cr, Fe, Zn, Cu, Pb were found to be above the standard limits for effluent discharge approved by WHO (Imam, 2012).

Unauthorised dumping of wastes in Kano accounts for more than 66 % of the total wastes dumping, and these wastes emit dangerous contaminants to the city (Nabegu, 2010). Sharfaddeen et al. (2020) reported higher concentrations of Zn, Fe, Cr, Co, Rb, Lu, Ta and Th in the soil samples collected around waste dumpsites in Kano city. Used medical wastes, which are mostly plastic, are disposed by pit burning, small-scale incineration, burial or open dumping, toxic chemicals from these wastes can leach into soil and contaminate the environment (Oke, 2008) a report on immunization wastes management in Kano State (Nigeria). Untreated wastewater is associated with an unpleasant odour and provides a conducive breeding ground for highly contagious diseases such as malaria and typhoid (Abdullahi et al., 2016). Ahmed (2020) identified nematodes, flukes, and protozoa parasites in cabbage, carrot, lettuce, onion and tomatoes grown along the Jakara river. The situation is getting worse due to inadequate effluent treatment facilitates, noncompliance with standards, lack of active monitoring and enforcement and ignorance (Bichi, 2013). Consumption of HMs through food can be minimised by effective monitoring and enforcement of environmental laws and the establishment of a workable food safety monitoring system (Abdullahi et al., 2021).

The Jakara River

Jakara River took its name from early historic settlements near Dala hill in Kano city (Agbazue et al., 2015). The river started around Jakara pass through the city and drains into Wasai reservoir which owns significant ecological value (Magaji and Rabiu, 2020). The Getsi tributary which joins the Jakara River at Magami is carrying domestic wastewater and industrial effluent from Bombai industrial area. The wastewater in the Getsi stream is characterised by a high level of metal contaminants (Maconachie, 2008). Different vegetables including tomato, pepper, cabbage, amaranth, garden egg, cauliflower, lettuce, okra, etc. are produced along the river in about 5000 hectares of active agricultural land (Ahmed and Sadau, 2015).

The river is seen by some researchers as a mere source of domestic contaminant and many believe that it carries only organic contaminants. This is far from true as many local activities are injecting effluents with higher concentrations of dangerous chemicals including HMs. Examples, the local dying activity vigorously going on around Kurna and Tudun Bojuwa, the traditional tanneries and dying pits within the old city released their wastewater into the river and the scrap-work around Jakara, Kasuwar Kurmi and Kofarruwa, which include various forms of metal and plastic wastes, E-wastes and used batteries among others. Chukwuma et al. (2011) reported HMs contamination in river water close to metal scrap dumpsite. Dangerous levels of Pb and Mn were found in the blood and urine of metalworkers around Jakara (Sani and Abdullahi, 2017) Lead (Pb. DNA damage was also reported by Sani and Abdullahi (2016) in the blood samples of metal workers collected around Jakara.

Mukhtar (2016) reported higher concentrations of Zn, Mn, Pb and Cd in water samples collected from Kwakwaci and Kofarruwa tributaries. Similar values for Cu, Ni, Pb and Cd were reported by Dawaki et al. (2014) in soil samples collected from Jakara and Challawa irrigation sites. Concerning vegetable consumption risk, Dawaki et al. (2013) ranked Jakara irrigation site as the most riskier source of vegetables in Kano city. Yusuf (2010) reported higher concentrations of Zn, Fe, Mn, Cu, Cd, Cr and Ni in the soil around Jakara than in the soil around streams carrying industrial effluents in the other parts of Kano, he associated that to population density, sewage disposal, traffic and automobile activities. In an ideal situation, there is no way these sources can contribute HMs contamination more than untreated industrial effluents from tanneries, plastic and other chemical processing industries. The findings of Yusuf (2010) support this argument and revealed how dangerous these local chemical processing are. Bichi and Halliru (2010) associated higher concentrations of HMs in the river with the domestic use of synthetic chemicals, human and land use activities, population growth and agrochemicals.

Irrigation Water along Jakara River

Jakara river is used for irrigation, domestic use and fishing (Bichi and Halliru, 2010; Bichi, 2013)2007 and FEPA, 1999 respectively. However, the research findings show that almost all samples reveal lead pollution. The highest value is recorded as 0.86 mg/l at the Industrial discharge point (X4 July. The quality of the water is influenced by many anthropogenic activities (Mustapha, 2013) including urbanisation, industrial activities (Andleeb and Hashmi, 2017), population growth and climate change (Shawai et al., 2019). Pollution sources in the Jakara river are usually anthropogenic during the dry season and natural during the wet season (Mustapha et al., 2012a). Direct dumping of wastewater into the river and its tributaries continue to ruin the quality of the water (Ibrahim and Said, 2010; Mustapha et al, 2013). The pH of the water is slightly acid to slightly alkaline depending on the season (Agbazue et al., 2015; Badamasi, 2014). Mukhtar (2016) reported alkaline pH in water samples collected from the Kofarruwa tributary.

Results of the Water Quality Index study conducted by Mustapha and Aris (2011) placed the river water under very bad category and the results of their findings also indicated that the water is unsafe and is not physically, chemically or biologically acceptable for use as raw water for drinking, animal herding, recreational activities and irrigation. Using wastewater for vegetable production along the Jakara River posed a serious risk to the environment and humans (Dawaki et al., 2013). The quality of the water varies along the river. Construction activities including land clearing and some natural processes such as erosion and runoff account for the quality variation of the irrigation water used along the river (Mustapha et al., 2013a). The metal contents of the water and soil around the Jakara River are getting higher due to the discharge of various contaminants into the water body (Sanda et al., 2016).

Irrigation using wastewater elevated the concentration of heavy metals in the soil (Dawaki et al., 2015b). These domestic and industrial toxins are reaching dangerous levels in the irrigation areas (Maconachie, 2008). A positive correlation between water and soil metal concentration along the river was reported by Dawaki and Shu’aibu (2013). These contaminants are passed to the growing vegetables through the soil (Dawaki et al., 2013). Agricultural activities around the river reduce the contamination pressure in the water (Mustapha, 2012). Because it serves as a channel for passing metal contaminants to humans through consumption of the food irrigated with the water. The heavy metals content of vegetables produce along the Jakara River is higher than that produced in other irrigation areas of Kano (Lawal and Audu, 2011).

Odour and colour of the irrigation water change sporadically, this commonly happens during dry season (Binns et al., 2003). Mustapha et al. (2012b) and Agbazue et al. (2015) reported seasonal variation on the properties and qualities of the irrigation water along the river. The variation in the overall water quality resulted from HMs contamination (Mustapha and Aris, 2012). The concentrations of Cr, Fe, Zn, Cu, Pb in the irrigation water are significantly affected by year season (Imam, 2012). Binns et al. (2003) also reported variation in the HMs content in irrigation water samples collected at different times of a day. Badamasi (2014) reported a trivial seasonal variation on Pb and Zn content in water samples collected from the Wasai dam. Mustapha et al. (2013b) opined that the variation in the irrigation water quality is due to irrigation agriculture, construction, clearing of land, domestic waste disposal and natural processes such as erosion and runoff. This can be supported by the findings of Razali et al. (2020) who also reported that these activities can cause seasonal variation and increase the risk of HMs health implications.

The water in the Jakara river is unsafe for food production due to the higher levels of HMs (Dawaki and Shu’aibu, 2013). The average concentrations of Cd, Cu, Cr, Pb, Fe and Zn in the water exceeded the allowable limits set by WHO (Ekevwe and Bartholomew, 2015). The concentrations of Fe, Cr and Pb also exceeded WHO and SON threshold (Agbazue et al., 2015). Getsi tributary possesses higher concentrations of Cd, Cr, Ni, and Pb (Jamila and Sule, 2020). Tributaries with different chemical compositions are draining into the Jakara river. The effects of confluence on the river water HM concentrations was reported by Binns et al. (2003) and Bichi and Halliru (2010).

Continuous wastewater irrigation stock-up soil with dangerous HMs, this is a threat to the safety of underground water since the metal can infiltrate and contaminate groundwater (Rehman et al., 2019). Sa’eed and Mahmoud (2014) reported a dangerous level of Pb in a borehole water sample collected around Kwarin Gogau. Shawai et al. (2017) associated the higher concentration of HMs in the groundwater samples collected from Gezewa Local Government to its closeness to Wasai dam which receives wastewater from the Jakara river.

The soil around Jakara River

Contamination of soil, water and produce from urban farms by domestic and industrial toxins is attaining hazardously high levels in Kano city (Binns et al., 2003). Pollution index between 5.2 and 9.3 was reported by Inuwa and Mohammed (2018). The soil along the river was characterised by low fertility (with organic matter content of 3.22 % around Hajj Camp) due to massive agricultural activities taking place year-round (Adamu and Dawaki, 2008). A slight increase in the organic matter content was reported twelve years later by Abubakar et al. (2020). In contrast, Abdulkadir et al. (2013) reported positive nutrients balances in Kano urban and peri-urban agricultural systems. Farming activities around the river involve the use of both inorganic (NPK and urea) and organic fertilizer (Abdullahi et al., 2020). The excessive use of both fertilizer and manure influences soil HMs content (Massoud et al., 2019). Sawut et al. (2018) reported livestock keeping among the major anthropogenic activities causes vegetable HMs contamination.

Bioavailability of HMs depends on soil pH (Zhou et al., 2019), low soil pH and higher organic matter content favoured HMs uptake by crops (Eid et al., 2020; Hou et al., 2019; Hu et al., 2017; Liu et al., 2020; Ouyang et al., 2020). Alkaline pH lowers HMs solubility (Świątek et al., 2019), therefore, alkaline soil retains HMs and prevents their uptake by plants (Hamid et al., 2019; Martínez-Cortijo and Ruiz-Canales, 2018). The pH of the soil around the river is slightly acidic to slightly alkaline (Adamu, 2019b). The soils around Akija, Airport Road and Magami are slightly alkaline with medium to high organic carbon (Dawaki et al., 2014). This can justify the lower contaminations reported by Mansur and Garba (2010) in these areas. The soil around the Kofarruwa tributary it’s also slightly alkaline with low organic matter (Mukhtar and Samndi, 2016). The soil condition around the river will depress HMs uptake by the crops.

The soil HMs concentration along the river is a function of year season (Mohammed and Olowolafe, 2020). Imam (2012)B, C, D, E, and F. Acid-washed (1L reported effects of seasons on the accumulation pattern of HMs, a higher concentration of Zn was reported during the dry season and a higher concentration of Fe was found during the wet season. Data reported by Dawaki et al. (2015) showed a downstream decrease in Pb, Cd, Cu, Ni and Zn concentrations in soil samples collected during dry season. The concentration of HMs in lettuce, spinach (Dike and Odunze, 2016), okra, tomato and onion (Lawal and Audu, 2011) produced along the river is determined by the growing season. Mohammed and Olowolafe (2020) attributed seasonal variation in the soil HMs content to the leaching, run-off and dissolution that commonly occur during rainy season. The uptake of HMs by plants depends on the plant physiology and the concentration of HMs in the growing soil (Mohammed and Inuwa, 2017). Different plants have different HM accumulation capacities, leafy foods accumulate more metals than tuber crops (Babandi et al., 2012).

The HM contents of the soil along the river exceed international permissible limits (Dike and Odunze, 2016). The findings of Haruna et al. (2011) confirmed that continuous irrigation with wastewater increases the soil HMs content. The Pb and Cd in the soil around the river are highly mobile and readily available for plant uptake (Y. A. Adamu, 2019b). The soil along the river is severely polluted with Pb, Cd and Cr (Dawaki and Shu’aibu, 2013). Samples of soil and spinach recently collected around Kwakwachi found to contain metals in the following order Ni>Cd>Pb>Zn>Cu>Cr (Abdullahi and Mohammed, 2020).

The data in most published papers are deficient in some vital information that will assist readers in understanding the trends of metal accumulation along the river, for an instant, sampling time and date were not reported by many researchers, even sampling locations were not fully defined in some publications. These account for un-unanimous data with many irregularities and without any specific pattern. Data reported in the same year from samples collected from nearby locations reported with very wide variations, examples, the wide variations reported by Mansur and Garba (2010) and Yusuf (2010) on the concentrations of Cd and Cu in soil samples.

Adamu (2019a) recommended a phytoremediation technique for the removal of Pb, Cd and Cr from the agricultural soil around the Jakara river using Lantana camara and Nerium oleander. Suleiman et al., (2020) reported that untreated rice husk can effectively absorb Cr from tannery effluent when its pH adjusted to 4.

Foods Contamination along the River

Irrigation with wastewater contaminates growing crops and humans through the consumption of the contaminated crops (Danjuma and Abdulkadir, 2018). The vegetables produced along the river were found to be contaminated with HMs, severe contamination was found in cabbage, lettuce, okra, spinach and pepper (Doka et al., 2020). Onion irrigated with river water contains number of organic contaminants (Ekevwe et al., 2017). The lettuce produces along the river contains Pb, Cd and Cr above FAO/WHO permissible limits (Dawaki and Shu'aibu, 2013). Spinach produced along the river is severely contaminated with Pb and Ni (Abdullahi and Mohammed, 2020). Spinach, okra, onions and tomatoes grown along the Jakara river possess higher concentrations of Co, Cu, Zn and Cr (Lawal and Audu, 2011). The onion produced along the river is characterised by higher bioaccumulation capacity and pollution index above 1 (Habu et al., 2021).

The fluctuation of the physicochemical parameters along the river affects zooplankton abundance and richness (Imam and Balarabe, 2012). Zooplanktons are essential food for fishes and their presence in water control algae and bacterial abundances (Mustapha, 2008). Contaminated industrial effluent from Bompai destroys the zooplanktons and lower the species richness and organism's density (Imam et al., 2011). This affects the life of aquatic organisms including fishes (Imam et al., 2010). Tannery effluent with high Cr content can affect oxygen consumption and bioaccumulation in fishes and can deposit large amounts of Cr at the gills (Sivakumar et al., 2016). Higher concentrations of Zn, Cu, Fe, Cr and Pb were found in fish samples collected from Wasai Dam (Agbazue et al., 2015). Tilapia obtained from the Jakara river has Pb content above the permissible limit (Ibrahim and Said, 2010). Sani et al. (2020) also reported that Kano abattoir effluent alters the river water pH and dissolved oxygen content and these changes are toxic to the blood, gills and liver tissue of Clarias gariepinus.

Recommendations

• Genuine and sincere enforcement of environmental protection laws is necessary to protect human lives and ensure the safety of food produced by urban agriculture. The existing environmental laws need to be reviewed, and more should be enacted to effectively protect soil and surface water meant for irrigation in Kano.

• There is a need for massive collaborative research between agricultural scientists, health specialists and urban planners to tackle the foreseeing challenge on safety and sustainability of urban and peri-urban food production in Kano.

• Public enlightenment and adequate treatment of wastewater before use for irrigation purposes will reduce HMs food crops contamination

• There is a need for Kano State Government to establish a wastewater management agency.

• Provision of alternative farmlands for vegetable production in the city, use of soil management practices that hinders HMs uptake and production of HMs-tolerant vegetable species will certainly minimise HMs consumption through foods.

Conclusion

The menace of food HMs contamination is a threat to public health and its increasingly becoming a global problem. Contaminated soil in cities can pose a health risk to urban dwellers. People living in urban areas are at risk of been contaminated by heavy metals through the ingestion of contaminated food and water. Consumption of contaminated vegetables is the major route for HMs contamination in humans. The article reviewed relevant literature and provide an overview of the ideal sources of HMs contaminants in Kano and discussed extensively on HM contaminations in the Jakara river, surrounding soil, fishes and vegetables produced along the river and its tributaries. Most of the processing industries in Kano do not have adequate effluent treatment facilities, hence, compliance with regulations becomes a problem to them. The activity of enforcement agencies is also surrounded by many questionable attitudes. Vigorous industrialisation and the incessant release of effluents account for the continuous accumulation of HMs along the Jakara river. The HM contents of the water and the soil along the river exceeds international permissible limits and continues irrigation with the wastewater increases the soil HMs content. The water in the Jakara river is unsafe for drinking and food production. The vegetables produced along the Jakara river were reported to be contaminated with dangerous levels of HMs.

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