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REVIEW ARTICLE

Assessment of Heavy Metal Contamination in Irrigated Farmland and Associated Health Risks in Kano State, Nigeria: A Review

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ABSTRACT
The primary causes of soil pollution in Kano state, which leads to heavy metal contamination in crops grown from such soils, are using contaminated water for irrigation and household and industrial sludge as fertilizers. Along waterways where untreated wastewater flows, vegetables are planted. To determine the existing situation and potential preventative and remediation measures, it has become necessary to conduct multiple research projects on the levels of heavy metals in the soil and plants grown in Kano state, Nigeria. In light of this, this study has focused on the present and potential state of heavy metal buildup in soils and farmed crops and the potential health risks that may arise from this, including food insecurity. The main findings of the conducted research were that regular monitoring of the level of heavy metals in soils and crops should be established, and guidelines for the cultivation and consumption of leafy vegetables grown on contaminated soils should be set equally to avoid health risks.

INTRODUCTION

Food security is achieved when everyone has the physical and financial ability to obtain enough safe and nutritious food according to their dietary preferences, fostering an active and healthy lifestyle. This was expressed at the inaugural World Food Summit held in 1996. Food security, human health, and the environment are all at risk from soil pollution, a hidden threat. Agricultural practices, small-scale mining operations, and the ongoing use of plastics and nylon, which release heavy metals into the soil, are potential sources of soil pollution.

Any metallic element that is dangerous or poisonous even at low concentrations and has a relatively high density is referred to as a heavy metal (Lenntech, 2004). According to Hawkes (1997), the phrase refers to a class of metals and metalloids whose atomic densities are at least five times higher than the density of water or more than 4 g/cm3. The platinum (Pt) group, arsenic (As), silver (Ag), chromium (Cr), copper (Cu), iron (Fe), zinc (Zn), cadmium (Cd), lead (Pb), and mercury (Hg) are examples of heavy metals.

As naturally occurring components of the earth's crust, heavy metals are persistent environmental pollutants that enter the body through food, water, and air and bioaccumulate over time. They are not biodegradable (Lenntech, 2004). Both natural and human-caused sources have the potential to discharge them into the ecosystem. Artificial sources of heavy metal pollution include fertilizers made from municipal waste, contaminated irrigation water, pesticides, herbicide applications in agriculture, and even mineral fertilizers with heavy metal traces. A few other human-caused sources of heavy metals are the following: farming practices that involve the direct disposal of trash; mining operations; the use of lead as an antiknock in gasoline; automobile emissions; cigarette smoking; metallurgy and smelting; aerosol cans; sewage discharge; and building materials like paint (Onakpa *et al.*, 2018).

Excessive accumulation of heavy metals in soft tissues, without proper metabolism, can lead to toxicity, as noted by Sobha *et al.* in 2007. Monitoring and addressing such buildup is crucial for health reasons.). The negative consequences arising from exposure to or ingesting excess levels of heavy metals over the daily prescribed limits are referred to as the toxicity of heavy metals. While each metal has unique toxicity indicators, gastrointestinal issues, diarrhea, stomatitis, tremor, hemoglobinuria, ataxia, paralysis, vomiting, convulsions, depression, and pneumonia when inhaled are the common symptoms of

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cadmium, lead, arsenic, mercury, zinc, copper, and aluminium poisoning (Jaishankar, 2014).

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Exposure to lead, whether through ingestion or inhalation, can adversely affect a child's kidneys, bone marrow, brain, and other vital systems. According to Ihedioha (2015), blood lead levels as low as 5 µg/dL in newborns and kids are linked to developmental issues such as poor cognitive function, behavioural issues, hearing impairment, and stunted growth. Levels over 75 µg/dL can cause coma, convulsions, and even death. Research on the effects of prenatal and postnatal cadmium exposure on deficiencies in intelligence quotients suggests that cadmium may be a neurotoxin (Jaishankar, 2014). Research on developmental exposure in lab animals suggests detrimental effects on operant behavior and conditioned avoidance (Hubbs-Tait et al., 2005). According to USDHA (2008), cadmium can cross the placental barrier and accumulate in the fetus, potentially leading to neurological disorders.

According to UDHA (2005), Nickel is a crucial trace element frequently linked to fibrosis, emphysema, chronic bronchitis, and poor pulmonary function in animals. While chromium and copper are vital components, excessive use of any metal can be harmful (McDowell, 2003). While chromium is frequently found in diabetic treatments and aids in blood glucose regulation, copper is a component of iron metabolism enzymes, the lack of which results in anaemia (McDowell, 2003).

Consuming excessive amounts of copper and chromium can result in both acute and long-term toxic effects. Acute copper poisoning may lead to anaemia, proximal tubule damage in the kidney, nausea, vomiting, jaundice, and liver necrosis. Chronic copper poisoning, such as Wilson's disease, can exhibit symptoms like dysphagia, ataxia, haemolytic anaemia, renal failure, kidney stones, mental disorders, and hepatic failure. Chromium poisoning typically occurs through physical contact with contaminated dust or soil, resulting in allergic dermatitis characterized by eczema (Barceloux, 1999)

Heavy metal contamination in Kano State, Nigeria, is a pertinent environmental issue necessitating scholarly attention. The region's susceptibility to heavy metal pollution arises from diverse anthropogenic activities, encompassing industrial processes, agricultural practices, and inadequate waste management systems. Common heavy metals implicated include lead, cadmium, mercury, and arsenic, each presenting distinct entry pathways into the environment.

Industrial operations, notably those associated with manufacturing and mining, primarily contribute to heavy metal emissions. Additionally, agricultural practices such as the indiscriminate use of agrochemicals and the application of sewage sludge as fertilizer can introduce heavy metals into the soil and water systems. Furthermore, improper waste disposal practices, including open burning and landfill leachate infiltration, exacerbate contamination.

The ramifications of heavy metal contamination are multifaceted, spanning ecological degradation, public health concerns, and socio-economic repercussions. Soil degradation from heavy metal accumulation impairs agricultural productivity and compromises food security. Concurrently, contaminated water sources pose risks to human health through bioaccumulation in the food chain and direct consumption. Chronic exposure to heavy metals is associated with a spectrum of adverse health effects, encompassing neurological disorders, renal dysfunction, and carcinogenesis.

In light of this, this study has focused on the present and potential state of heavy metal buildup in soils and farmed crops, as well as the potential health risks that may arise from this, including food insecurity. The main findings of the conducted research were that regular monitoring of the level of heavy metals in soils and crops should be established, and guidelines for the cultivation and consumption of leafy vegetables grown on contaminated soils should be set equally to avoid health risks.

METHODOLOGY

This review thoroughly examines existing studies on heavy metals in irrigation soil and crops in Kano state. Academic journals, conference proceedings, and reliable sources were consulted. The collected data (Summarized in Table 1) were analysed to identify recurring themes, trends, and patterns in heavy metals concentrations compared to regulatory standards. The results were interpreted and discussed in relation to the research goals, exploring implications for stakeholders and addressing challenges related to soil pollution. The study concluded by summarizing key findings and offering recommendations for future research and practical application.

TRENDS AND IMPENDING ISSUES ON HEAVY METAL CONTAMINATION OF SOIL AND CROPS IN KANO

Ranked third in Nigeria, after Lagos and Ibadan, Kano City is northern Nigeria's most populated urban centre. The approximate population of the Kano region was 5.945 million in 1963; by 1991, it had grown to 8.686 million. Around 12 million people are thought to live in the region (Olofin et al., 2008), and the urban growth rate is roughly 5.5% annually. In northern Nigeria, Kano State serves as the commercial hub (Mustapha *et al.*, 2014).

The city's significant concentration of industrial and economic activity is the cause of its high population. Kano

City is situated on the primary watershed, dividing the city's two primary river basins. Both the Kano River Basin and the two River Basin were located south of the water divide. The Kano River and Challawa River, two of the basin's main rivers, drain all domestic and industrial wastewater from over 200 industries, including tanneries, plastic and rubber industries, textile and metal smelting industries, and abattoirs. These industries release untreated wastewater into the rivers water sources for agricultural practices.

Soil and plant samples from the Sharada Industrial Area were examined for the presence of specific heavy metals (Babandi *et al.*, 2012). Through their root systems, plants absorb pollutants, which they then store in the biomass of their roots and move to the stem and/or leaves. Industrial wastewater was utilized to irrigate locally consumed plants, such as carrots (*Daucus carota*), okra (*Hibiscus esculentus*), onions (*Alium cepa*), and lettuce (*Lactuca sativa*). The various plant species have different concentrations of heavy metals. Lead (Pb) levels in onions and okra varied from 10.21±0.20–17.14±0.10 µg/g, while 28.00±2.00 µg/g was discovered in the soil. The soil contained more heavy metals than the plants under investigation. The amount of heavy metal accumulated differed among plants.

In comparison to other plants, onions had the greatest value of copper (Cu) in the soil, at 9.00±2.00 µg/g (8.00±0.10 µg/g). The different plant species have different rates of cobalt (Co) uptake. The maximum cobalt content was found in *Moringa oleifera* (14.00±8.00µg/g), whereas the lowest cobalt concentration was found in onions (5.00±2.00µg/g). The fact that farmers are watering these plants with untreated industrial effluents may cause the high metal values. Due to the high values of these metals in the plant samples, eating these vegetables may put consumers at risk for health issues because the levels in soil and plant samples are all greater than the WHO-permitted limits.

Heavy metals from farmland soils for irrigation agriculture along the Tatsawarki River in Kano, Nigeria, are examined by Bichi & Bello (2013). Samples of soil were collected from three farms (a, b, and c) situated along the riverbanks, utilizing surface water for irrigation. Additionally, control samples were obtained from farms (d) far from the riverbank. These samples, collected at 0 to 15 cm depths, were carefully placed in polyethylene bags and transported to a laboratory for thorough examination. In each zone, two samples were taken – one from farms relying solely on surface water and another from those dependent solely on groundwater. Analysis was done on the samples' pH, texture, and levels of heavy metals (Cr, Cu, Co, Cd, Fe, Zn, Mn, and Pb). It was found that irrigation using tainted water greatly affected the amount of heavy metals in the soil. Because of the soil's acidic nature and low clay content, this enhanced porosity and decreased retention capacity, which made groundwater more vulnerable to increased metal mobility. Notably, cadmium (Cd) levels exceeded set limits compared to EU standards. It was determined that heavy metals build up in soils and that if the source of pollution is not addressed, the pollution will eventually approach and surpass the established regulatory limit. It is advised that immediate action be taken to control this progressive accumulation.

Dawaki *et al.* (2013) investigated soils' heavy metal content and physicochemical properties in urban agricultural lands in Kano, Kano State, Nigeria, specifically along the banks of three rivers: Challawa, Jakara, and Watari. The soils exhibited a mean pH range of 7.42 to 7.77, indicating alkalinity, medium to high levels of organic carbon (7.16 to 11.27g/kg), and a moderate CEC (12.63 to 23.11cmol/kg). Total concentrations of Cu, Cr, Ni, Zn, Pb, and Cd ranged from 4.95 to 5.99, 5.85 to 165.66, 54.03 to 57.77, 55.07 to 255.52, 42.84 to 68.12, and 0.59 to 11.81 mg/kg, respectively. All readings, except for Cd at Jakara and Challawa, were below the maximum permitted concentrations in soil. Soluble concentrations for Cu, Cr, Ni, Zn, Pb, and Cd ranged from 0.27 to 0.48, 0.61 to 15.91, 5.60 to 7.15, 4.90 to 17.42, 2.78 to 9.36, and 0.00 to 0.60 mg/kg, respectively. A significant relationship ($p \leq 0.05$) was identified between exchangeable and total metal forms and soil properties such as organic carbon, available P, total N, and basic cations. Although appreciable amounts of metals were detected in various forms, concentrations were significantly higher ($p \leq 0.05$) in areas irrigated with waters receiving industrial and domestic sewages, namely Challawa and Jakara, compared to Watari, the control.

In their 2013 study, Dawaki et al. assessed the impact of urban agriculture pollution on food security in Kano, Nigeria. Soil, water, and lettuce (Lactuca sativa L.) were examined from two locations irrigated with industrial and domestic wastewaters—Challawa and Jakara, respectively. Harmful metals (Pb, Cd, Cr, and Cu) potentially affecting human health were analyzed in the samples, compared to a control site unrelated to Watari's effluent. Each site was divided into upstream, midstream, and downstream sectors. Results indicated Cu contamination at both sites and the control group (pollution indexes [PI] = 0.14, 0.16, and 0.14, respectively). Lead contamination was higher at the industrial wastewater site and control (PI = 0.8 and 0.54, respectively) compared to the domestic wastewater site (PI = 1.09). Both sites showed significant Cd and minimal Cr pollution, while the control group had both (PI = 0.74 and 0.06 for Cd and Cr, respectively). Water from both the control and sites exceeded the recommended levels for irrigation water. Positive correlations were found between Pb, Cr, and Cd in soil and water, while negative correlations were observed between Cu in soil and water. At the domestic wastewater site, a significant metal transfer from soil to plants occurred (metal transfer factor Pb = 1.602, Cr = 1.126, and Cu = 1.834). The residential wastewater site exhibited high plant accumulated concentrations (Pb = 26.21 mg/kg, Cd = 1.03 mg/kg, Cr = 28.63, and Cu = 2.66 mg/kg), surpassing permissible vegetable limits. The risk of human consumption ranked as follows: Watari > Challawa > Jakara.

Due to increased vegetable consumption in the surrounding urban community, (Chiroma et al., 2014) Examine the presence of heavy metals in the soil and produce irrigated in Fagge, Kano, Nigeria, using urban grey wastewater. They point out that there may be a health risk associated with this contamination. As a result, an investigation was conducted into the possible contamination issue caused by the presence of certain The irrigation of soils and vegetables with urban grey wastewater resulted in heavy metal concentrations (Fe, Zn, Mn, Cu, and Cr) that were, respectively, 2.8, 2.1, 19.5, 2.3, and 143.1 times higher than recommended values (5.0 µg/ml, 2.0 µg/ml, 0.2 µg/ml, 0.2 µg/ml, and 0.1 µg/ml). Heavy metals in soils ranged from 24% to 84%. Despite washing, most vegetable parts exceeded critical Fe, Mg, Zn, Cu, and Cr concentrations, indicating potential toxicity. Effective water quality management and adopting appropriate cultivation practices are crucial to mitigate health risks associated with elevated heavy metal levels.

To compare the levels of heavy metals in the soil from irrigated land using tube-well water and industrial effluent at Gidan Maza and Yarimawa of Kano Municipal and Tofa Local Government over 12 months, from March 2011 to February 2012 (Lambu *et al*., 2017) conducted a comparison study. Twenty samples were chosen randomly, and after standard protocols were followed, the samples were tested for pH, heavy metals, Ni, Cu, Pb, Cr, Fe, and Cd. The values of Pb (1.24±0.93 mg/kg), Cu (1.35±0.43 mg/kg), Ni (1.27±0.32 mg/kg), Cr (1.61±0.35 mg/kg), Fe (6.12±0.25 mg/kg), and Cd (0.96±0.78 mg/kg) were the heavy metals found in Yarimawa. There were 4.34±0.54 mg/kg of Pb, 4.12±0.87 mg/kg of Cu, 2.90±0.45 mg/kg of i, 7.37±0.65 mg/kg of Cr, 8.88±0.66 mg/kg of Fe, and 1.79±0.17 mg/kg of Cd. The heavy metal contents in the soil samples from Yarimawa and Gidan Maza differed significantly (p=0.05). The results from the two sites are within the FAO and WHO's maximum allowable levels for agricultural reasons; nevertheless, the issue with heavy metals in the environment is that they build up through the food chain and have long-term effects. Therefore, to slow down the deterioration of agricultural produce over time, it is advised that uncontrolled discharge of untreated effluents near the sample sites be restricted, particularly notably through irrigation and other human activities.

Imam *et al.* (2019) explored the physicochemical characteristics and heavy metal concentrations in River Getsi irrigation water, along with the accumulation of heavy metals in various parts of irrigated vegetables. The evaluation of irrigation water's physicochemical features revealed an average temperature of 30.1 °C, pH of 7.3, and mean biochemical oxygen demand of 80.3 mg/l. Chromium was the most abundant heavy metal at 7.8 mg/l, while mercury was the least available at 0.0 mg/l.Analysis of heavy metal concentrations in irrigation soil indicated chromium as the most abundant (t = 5.5 mg/kg, r = 0.4 mg/kg, SD = 0.1 mg/kg) and mercury as the least abundant (t = 0.0 mg/kg, r = 0.0 mg/kg, SD = 0.0 mg/kg), both within recommended dietary intake levels. The study concluded a notable level of heavy metal contamination in the water, soil, and vegetables in the River Getsi irrigation basin. It was recommended to emphasize proper washing and processing techniques for irrigated vegetables during health awareness campaigns in Kano, and to educate farmers near the River Getsi irrigation area about environmentally friendly irrigation practices.

According to Alhassan *et al.* (2019), correlational research and pollution index assessment of toxic metal distribution in soil and crops are crucial for understanding the risk of chronic diseases associated with these metals. The study conducted correlational analysis in the sampling zones of Bunkure (BKR), Danbatta (DBT), Gwarzo (GRZ), Ungogo (UGG), and Wudil (WDL) in Kano State, Nigeria, to determine the distribution of lead (Pb), cadmium (Cd), chromium (Cr), and mercury (Hg) in soil (S), beans (B), and maize (M). Samples were collected from farm harvests in each sampling zone, and atomic absorption spectroscopy (AAS) was used to measure metal content. The results revealed the following respective ranges for Hg, Pb, Cd, and Cr across local governments: 0.33 - 3.13, 0.14 - 0.84, 0.02 - 0.05, and 0.01 - 0.49 in soil; 0.04 - 4.23, 0.06 - 0.23, 0.02 - 0.04, and 0.00 - 0.10 in maize; and 0.20 - 4.23, 0.16 - 0.19, 0.03 - 0.04, and 0.00 - 0.03 in beans. All of the hazardous metals, except for mercury, fall below the acceptable range specified by both European regulatory standards and international acceptable levels. The fact that the observed amounts are within higher acceptable bounds raises the possibility of a potential threat. Nearly all of the samples had greater mercury levels, suggesting that there may be risks related to human activity in those places. A notable positive correlation in soil samples regarding hazardous elements may indicate a shared characteristic of the soil, while a negative correlation could result from variations in applied agrochemicals. According to the pollution load index, Wudil exhibited the highest soil pollution load index for Hg (3.13 ± 0.16), Cd (1.6×10-2 ± 0.01), and Cr (4.9×10-3 ± 0.01), whereas Ungogo had the highest pollution load for Pb. All grains in the research locations also displayed a favorable transfer factor, except for Bunkure, Danbatta, and Gwarzo's Cr. It is conceivable that some of these hazardous metals may bioaccumulate in crops grown in such areas, entering the food chain and posing a risk to human health.

Edogbo et al. (2020) evaluated the Transfer factor (TF) and risk analysis of four heavy metals (cadmium (Cd), chromium (Cr), lead (Pb), and zinc (Zn)) in five different vegetables: potato, onion, tomato, lettuce, and spinach and fish and water samples around the industrial area of Challawa in Kano State, Nigeria. A total of 80, 56, and 130 fish, water, and vegetables with their soils were sampled, respectively, between February and April 2017. Cadmium accumulated the most with the transfer factor (TF) of 6.52E–5–2.88, while Pb had the lowest accumulation with a TF of 0.23–0.34. Irish potato had the highest TF (2.88 for Cd). This shows a higher level of metals in the soil. Target Hazard Quotient (THQ) was used to determine the potential risk of human exposure as the THQ values in the two species ranged between 1.211.92, 1.883.84, 0.19, and 0.26 and 0.0001 and 0.01 for Cd, Cr, Pb, and Zn, respectively. Daily intake of Cd in Challawa water ranged from 0.04 to 0.08; Cr – 0.08–0.10, Pb – 0.03–0.05, and Zn – 0.02–0.03. The average daily intake of metals followed this order Cr > Cd > Pb > Zn. In conclusion, the concentrations of Cd and Cr in water, fish, and vegetables were above the permissible limits, as consuming vegetables and fish from this river may pose a potential human risk, especially to people living around this area.

(Hussaini *et al.*, 2021) examined the influence of industrial effluent irrigation on soil and crop heavy metal levels in Kano Metropolis. Soil and crop samples (cucumber, maize, onion, and spinach) were randomly collected from three sites and analyzed for Cd, Cr, Ni, and Pb using an atomic absorption spectrophotometer (AAS). Results were compared to World Health Organization (WHO) standards to assess potential health hazards associated with consuming these heavy metals through crop consumption. The observed amounts of heavy metals in the soil (4.76–52.38 mg/kg for Cr, 2.45–3.43 mg/kg for Ni, and 7.65–14.21 mg/kg for Pb) did not exceed the permissible thresholds of 100, 50, and 100 (mg/kg) for Cr, Ni, and Pb, respectively. However, the Cd concentrations in all soil samples (3.67–4.28 mg/kg) surpassed the permissible limit of 3.00 mg/kg. While all electrical conductivity (EC) readings were above the normal range, pH values were below it in plant samples, except for Ni, the mean concentrations of the heavy metals exceeded the highest allowable thresholds recommended by WHO/FAO. The estimated daily intake (EDI) contents in all plant samples exceeded the acceptable tolerated daily intake (PTDI) level for Cd and Cr set by the European Food and Safety Agency (EFSA). Hazard index (HI) values for all samples and hazard quotient (HQ) values for Cd and Pb indicated a high potential health risk associated with consuming the contaminated crops. The study suggests that irrigation with untreated wastewater is likely the primary cause of heavy metal pollution in the investigated soils and plants. Therefore, it is recommended to discourage the use of wastewater for farmland irrigation to mitigate potential health risks.

(Doka et al., 2021) explored the accumulation of potentially harmful components in various vegetables at the Dogon Dawa irrigation sites in Bichi, Kano. Using an atomic absorption spectrophotometer, the study measured the levels of hazardous elements (Cd, Cr, Pb, Mn, Co, and Ni) and their accumulation in five different vegetables. Results indicated no detectable Cd and the concentration of Cr in the vegetables ranged from 0.067 to 0.083 mg/kg. Lettuce exhibited the highest Mn concentration (5.889±0.301 mg/kg), while cabbage absorbed lead effectively (2.113±0.022 mg/kg). Pepper had the highest Ni concentration (1.747±0.21 mg/kg), and lettuce had the highest Co concentration (0.541±0.017 mg/kg). All metals Except lead (Pb) were within WHO/FAO acceptable levels. None of the vegetables were identified as hyperaccumulators based on the range of values for transfer factors: Cr (0.35–0.95), Co (0.21–0.49), Pb (0.16–0.34), Mn (0.02–0.56), and Ni (0.20–0.73). However, the discovered Pb contents make the vegetables unsafe for consumption, emphasizing the need for strict standards in producing and consuming green vegetables cultivated on polluted soils to prevent health concerns.

She-she *et al.* (2022) Determine the levels of heavy metals in commonly produced vegetables from different farming districts in Kano State. In many regions of the world, particularly African nations, metal toxicity in food ingredients has been identified as a primary contributor to illnesses and ailments. Vegetables are an essential component of many Nigerian meals and specialties; however, eating them could have detrimental effects on one's health due to heavy metal toxicity. The study aimed to evaluate the levels of various heavy metals in vegetables sourced from significant farming regions in Kano, Northern Nigeria. Samples from four distinct farming areas in Kano, including commonly consumed vegetables and irrigation fluids, were subjected to oven-drying and acid digestion. Spectrophotometry was utilized to determine Pb, As, Cd, Ni, Zn, and Cu concentrations in the obtained solution. Results indicated higher levels of Pb and Cd in water and vegetables from two farming sites compared to others, surpassing WHO/FAO-accepted limits. These findings highlight elevated concentrations of certain hazardous heavy metals in vegetables from these regions, raising concerns for food safety officials.

SUMMARY OF CITED STUDIES

Table 1: Summary of the synthesized literature.

RESEARCHER	SAMPLE ANALYZED	HEAVY METALS ANALYZED	SUMMARY OF FINDINGS
Babandi *et al*., (2012)	Soil and plants: carrots (*Daucus carota*), okra (*Hibiscus esculentus*), onions (*Allium cepa*), and lettuce (*Lactuca sativa)*	Pb, Cu, and Co	Soil and plant samples have heavy metals value greater than the WHO-permitted limits
Bichi and Bello (2013)	Soil	Cr, Cu, Co, Cd, Fe, Zn, Mn, and Pb	cadmium (Cd) levels exceeded set limits
Dawaki *et al.* (2013)	Soil	Cu, Cr, Ni, Zn, Pb, and Cd	Water from both the control and sites exceeded the recommended levels for irrigation water.
Dawaki *et al.* (2013)	Soil, water, and lettuce (Lactuca sativa L.)	Pb, Cd, Cr, and Cu	The residential wastewater site exhibited high plant accumulated concentrations (Pb = 26.21 mg/kg, Cd = 1.03 mg/kg, Cr = 28.63, and Cu = 2.66 mg/kg), surpassing permissible vegetable limits. The risk of human consumption ranked as follows: Watari > Challawa > Jakara.
Chiroma *et al*., (2014)	soils and vegetables	Fe, Zn, Mn, Cu, and Cr	soil and plant samples have heavy metals value greater than the WHO-permitted limits
Lambu *et al*.,(2017)	soil	Ni, Cu, Pb, Cr, Fe, and Cd.	Samples have heavy metal values within the higher acceptable bound limit for WHO-permissible limits.
Imam *et al.* (2019)	vegetables.	Cr and Hg	Chromium was the most abundant heavy metal, while mercury was the least abundant.
Alhassan *et al.* (2019)	Soil, beans and maize	Hg, Pb, Cd, and Cr	samples have heavy metal values within the higher acceptable bound limit for WHO-permissible limits
Edogbo et al (2020)	potato, onion, tomato, lettuce, and spinach, and in fish and water	Pb, Cd, Cr, and Zn	the concentrations of Cd and Cr in water, fish, and vegetables were above the permissible limits as consuming vegetables, and fish from this river may pose potential human risk, especially to people living around this area.
Hussaini *et al*., (2021)	Soil and crop samples (cucumber, maize, onion, and spinach)	Cd, Cr, Ni, and Pb	The estimated daily intake (EDI) contents in all plant samples exceeded the acceptable tolerated daily intake (PTDI) level for Cd and Cr set by the European Food and Safety Agency (EFSA). Hazard index (HI) values for all samples and hazard quotient (HQ) values for Cd and Pb indicated a high potential health risk associated with consuming the contaminated crops.
Doka et al. (2021)	Vegetables	Cd, Cr, Pb, Mn, Co, and Ni	All metals Except lead (Pb) were within WHO/FAO acceptable levels. However, the discovered Pb contents make the vegetables unsafe for consumption,
She-she *et al.* (2022)	Vegetables	Pb, As, Cd, Ni, Zn, and Cu	Results indicated higher levels of Pb and Cd in water and vegetables from two farming sites compared to others, surpassing WHO/FAO-accepted limits.

HEALTH IMPLICATION OF FINDINGS

Cr, Cu, Co, Cd, Fe, Hg, Mn, Ni, Pb, and Zn are the heavy metals investigated in the reviewed studies. Cr, Cd, and Pb are above the WHO/FAO-accepted limits, while others are of higher values within the upper bound limit of WHO/FAO-accepted limits. Accumulating heavy metals in agricultural soil can affect food quality and safety and cause serious health concerns.

Cd may damage the metabolism of calcium, which will cause calcium deficiency and result in cartilage disease and bone fractures. Pb can affect and damage many body organs and systems, such as the kidney, liver, reproductive system, nervous system, urinary system, immune system, and the basic physiological processes of cells and gene expression. High levels of Cr can irritate the nose lining, nose ulcers, runny nose; and breathing problems, such as asthma, cough, shortness of breath, or wheezing.

Cu, Zn, and Ni are essential trace metals in the human body, but if the body takes excessive Cu, Zn, and Ni from the outside environment, they will damage human health. Ni and Cu are tumor promoting factors, whose carcinogenesis effect has attracted global concerns. Workers who are in close contact with the nickel powder are more likely to suffer from respiratory cancer, and the content of Ni in the environment is positively correlated with nasopharyngeal carcinoma.

CONCLUSION

Heavy metal contamination of soil is a threat to food security. The reviewed works show Cr, Cu, Co, Cd, Fe, Hg, Mn, Ni, Pb, and Zn concentrations in the soil, plants, and irrigation water within the upper bound limit of WHO/FAO-accepted limits while Cr, Cd, and Pb are above the WHO/FAO-accepted limits in the soil, plants, and irrigation water. Therefore, it is essential to monitor the concentrations of these metals in both food and the human body.

RECOMMENDATIONS

1. Strict adherence to guidelines for cultivating and consuming green vegetables grown on polluted soils is crucial to prevent health concerns.

2. Soil leaching should be adopted to wash the heavy metal contaminated soil with specific reagents and thus remove the heavy metal complex and soluble irons adsorbed on the solid phase particles. This method separates heavy metals from the soil and recycles them from the extraction solution.

3. Farmers should equally be educated on Phytoremediation. It involves growing specific plants in the soil contaminated by heavy metals. These plants have a certain hyper-accumulation ability for the contaminants in the soil (accumulated mainly in the root or above the root).

4. Microbial remediation should be practiced in such irrigation sites. It refers to using some microorganisms to perform the absorption, precipitation, oxidation, and reduction of heavy metals in the soil.

5. Farmers should be informed about the content of heavy metals in fertilizers: phosphoric fertilizer> compound fertilizer> potash fertilizer> nitrogen fertilizer, and should be encouraged to use the least-risk fertilizer.

6. There is a need for regular heavy metal monitoring in soil, farm products and irrigation water quality.

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