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Determination of some selected heavy metals in spinach and irrigated water from Samaru Area within Gusau Metropolis in Zamfara State, Nigeria

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Due to insufficient clean water resources, wastewater is largely used for irrigation of vegetables and fruits in many developing countries like Nigeria. As a result of this, vegetables in spite of providing nutrients also accumulate toxic metals and causes health risks. In the present study, the levels of heavy metals (lead (Pb), cadnium (Cd), iron (Fe), zinc (Zn), and copper (Cu)), were analyzed using Atomic Absorption Spectrometers (AAS). The water used for irrigation had the following concentrations, 1.639 ± 0.0016, 0.037 ± 0.0021, 10.046 ± 0.0003, 0.295 ± 0.0022 and 4.236 ± 0.0017 for Pb, Cd, Fe, Cu and Zn, respectively, while the spinach has 0.613 ± 0.0009, 0.022 ± 0.0014, 25.666 ± 0.0011, 1.934 ± 0.0007 and 1.842 ± 0.0003 for Pb, Cd, Fe, Cu and Zn. The heavy metal in the waste-water sample is higher than the spinach and when compared with the WHO recommended safe limits, statistically they are still within the range except for the Fe and Zn. The result of this study will bring awareness to consumers and the government agencies on these samples about what people consumed and its health implication, as well as assist them and the farmers in taking necessary precautions.

Key words: Heavy metals, spinach, waste-water, bioaccumulation.

INTRODUCTION

The problem of environmental pollution due to toxic metals has begun to cause concern now in most major metropolitan cities. The toxic heavy metals entering the ecosystem may lead to geoaccumulation and bioaccumulation (Lokeshwari and Chandrappa, 2006). The use of water from non-conventional resources like polluted water of industrial and household discharge is a common practice in most African countries that are facing the problem of water shortage (Al-Ansari et al., 2013). This uncontrolled irrigation of crops with sewage water leads to the accumulation of some potentially toxic metals in agricultural soil and have very adverse effects on the growth of the plants (Muhammad et al., 2013). It is now a common practice in many parts of Nigeria to use municipal sewage water that contain both industrial effluents and domestic liquid waste for irrigation purpose (Alexander and Ubandoma, 2014; Odoh and Kolawole, 2011). This waste water contains few important plants

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growth nutrients like potassium (K), zinc (Zn), phosphorus (P), nitrogen (N), and organic solids (Gibbs et al., 2006). Whereas it is also the prime source of potentially hazardous organic and inorganic toxic materials. Heavy metals like Iron (Fe), Copper (Cu), Ni and other trace elements are important for proper functional of biological systems and their deficiency or excess could lead to a number of disorders. Food chain contamination by heavy metals has become a burning issue in recent years because of their potential accumulation in bio-systems through contaminated water, soil and air (Lokeshwani and Chandrappa, 2006). Therefore, a better understanding of heavy metal sources, their accumulation in the soil and the effect of their presence in water and soil on plants system seem to be particularly important for researches on risk assessment (Rajesh et al., 2004). Many studies have shown that sewage water irrigation has elevated the levels of toxic heavy metals such as nickel (Ni), Zn, cobalt (Co), manganese (Mn), and Fe in receiving soil (Ali et al., 1996; Singh et al., 2004; Mapanda et al., 2005), and after that vegetables take up metals by absorbing them from that contaminated soils, as well as from deposits on different parts of the vegetables exposed to the air from polluted environments (Oluwole et al., 2013).

Spinach is just like other vegetable plant used as food and constitute an important part of human diet because is rich in carbohydrate, protein, as well as vitamins, minerals and trace elements (Oluwole et al., 2013). They are also made up of chiefly cellulose, hemi-cellulose and pectin substances that give them their texture and firmness (Sobukola and Dairo, 2007). Eating vegetables regularly in diet can have many health benefits by reducing diseases and used to convert fats and carbohydrates into energy (Mercola, 2014). Also, eating vegetables is one of the most important pathways for the human body to absorb dietary minerals necessary for healthy development, but unfortunately harmful elements such as heavy metals may lead to intoxication due to prolong accumulation found in these vegetables (Elsevier, 2008). Some of these metals after accumulating in the soil are transferred to food chain which can cause serious health hazards to human beings and animals. Besides, metals induce deficiency of other nutrients like Cu, Fe and Mn by inhibiting plant uptake of Zn, possibly because of competition for the same carrier site in soil-water system (Rashid and Salim, 1988). Metals like Fe, Mn, Co, Cu, and Ni are essential nutrients but their permissible limits are quite low in living organism (Qadir et al., 1999).

The main objectives of this research work was to determine the levels of some heavy metals in irrigated waste water in Samaru area in Gusau Local Government Area of Zamfara State, Nigeria and assess the accumulation level in spinach cultivated on the same land in order to ascertain the safety or otherwise of the spinach consumed by the populace of the area.

MATERIALS AND METHODS

Samples collection

The polluted water sample used for irrigation and the spinach from the garden was collected between the months of October and November, 2014 at Samaru irrigation area in Gusau metropolis, Zamfara State, Nigeria. The water samples were collected along the water way in a 100 cm^3 pre acid washed plastic bottle and 1 cm^3 of concentrated HNO_3 was added to the sample to avoid microbial activity. Spinach from the study area was collected at random, and was washed to remove the soil particles and after that dried under the shade for 72 h. The dried samples were then grounded in a mortar, passed through a 2 mm sieve and stored at room temperature before analysis.

Water digestion

One liter of the grey waste water used for irrigating the garden was collected and treated with 1.5 ml of concentrated HNO_3. Fifty milliliters of the water sample was transferred to an evaporating dish and evaporated on a steam bath to about 20 ml. Ten milliliters of 8 M HNO_3 of 98% purity was added and evaporated on a hot plate to near dryness. The residue was quantitatively transferred using two aliquot of 10 and 15 ml of concentrated HNO_3 into a 250 ml flask. Twenty milliliters of $HClO_4$ was added and boiled until the solution became clear and white fumes of $HClO_4$ appeared. It was then cooled and de-ionized distilled water of 50 ml was added and the solution filtered. The filtrate was quantitatively transferred to a 100 ml volumetric flask with two portions of 5 ml of de-ionized distilled water. The solution was diluted to mark and mixed thoroughly by shaking. The heavy metals under study were determined using atomic absorption spectrophotometer (AAS) (Chiroma et al., 2014).

Plant digestion

One gram of prepared spinach sample was weighed into 125 cm^3 conical flasks using the USEPA 3050 method by Miller and McFee (1983) as reported in Odoh and Kolawole (2011). 10 cm^3 of HNO_3 was added and the mixture was heated for 30 min on a water bath at 100°C. The digest was allowed to cool and another 5 cm^3 of HNO_3 was added and continuously heating for 1 h at 100°C. The volume of the digest was reduced by boiling on the water bath and this was allowed to cool. 5 cm^3 of de-ionized water was added when effervescence subsided, 10 cm^3 of H_2O_2 (60%) was added and heating continued for another 30 min. The final digest was allowed to cool and filtered. The final volume of digest was made up to 50 cm^3 with de-ionized distilled water and was analyzed for the required heavy metals by AAS.

Replicates

Each measurement is repeated 3 times, the mean and standard deviation were calculated.

RESULTS

Table 1 shows the concentration of heavy metals in waste water and spinach, while the waste water used for irrigation in this site had the highest content of Fe, followed by Zn, Cu, Lead (Pb) and Cadnium (Cd).

Table 1. Heavy metals concentration (mg kg^{-1}) in irrigation water and spinach from Samaru.

Sample/Elements	Pb	Cd	Fe	Cu	Zn
Waste-water	1.639 ± 0.0016	0.037 ± 0.0021	10.046 ± 0.0003	0.295 ± 0.0022	4.236 ± 0.0017
Spinach	0.613 ± 0.0009	0.022 ± 0.0014	25.666 ± 0.0011	1.934 ± 0.0007	1.842 ± 0.0003

Mean±SD (Standard deviation).

Table 2. Mean concentration (mg kg^{-1}) of heavy metals in irrigated water and WHO limit dose.

Heavy metals	Waste-water	WHO guide line
Pd	1.639	0.05
Cd	0.037	0.003
Fe	10.046	0.30
Zn	4.236	0.03
Cu	1.842	2.00

Table 3. Mean concentration (mg kg^{-1}) of heavy metals in irrigation water, spinach and WHO maximum dose value.

Heavy metals	Waste-water	Spinach	WHO/FAO Guide line
Pd	1.639	0.613	5.00
Cd	0.037	0.022	0.01
Fe	10.046	25.666	5.00
Zn	4.236	1.842	2.00
Cu	1.842	1.934	0.20

The irrigated water sample from this site shows high concentration in almost all the estimated metals when compared with the WHO limit dose as shown in Table 2 and Figure 1, except for Cu which was a little less than the 2.0 mg/L.

Table 3 and Figure 2 show the comparison in mean concentration of heavy metals in irrigation water, spinach and WHO maximum dose value.

DISCUSSION

Samaru area in Gusau, Zamfara State, is an urban area and most of the small scale industries like Ginneries, Water Board, Zamfara Testile and some Fuel Filling Stations located in the area discharge their effluents and dust particle to this area. Some household waste products are also discharged into the water channel, which may be the cause of the detectable heavy metals in the water sample. The concentration of heavy metals in waste water used for irrigation in this site had the highest content of Fe, followed by Zn, Cu, Pb and Cd as shown in Table 1.

The results of heavy metal concentration in the spinach cultivated with this polluted water are as shown in Table 1. The sample from the site reveal a little lower level of these metals (Pb, Cd, Zn, and Cu) when compared with the WHO/FAO dosage level as shown in Table 3 and Figure 2. The mean concentration of Fe in the spinach is very high when compared with the WHO limit, while Zn, Cd and Cu are moderately elevated. This result reflects a contamination of soils from this irrigated farmland by heavy metals, but the soil has a good retention power which might be due to different pH and organic level in the soil which leads to reduction in the level of metals in the spinach when compared with the water as shown in Table 3. Cadmium is relatively mobile in soil under the range of pH, organic carbon and cation exchange capacity condition (Odoh and Kolawole, 2011). Sharma et al. (2007) also reported that plant grown on waste water-irrigated soils are contaminated with heavy metals and pose health concern. Absorption and accumulation of heavy metals in plants tissues depend upon many factors. These factors include temperature, moisture, organic matter, pH and nutrient availability. City dwellers have long contended that any form of water with proper composition and processing can make good manures that farmer will gladly pay for. Municipal refuse may

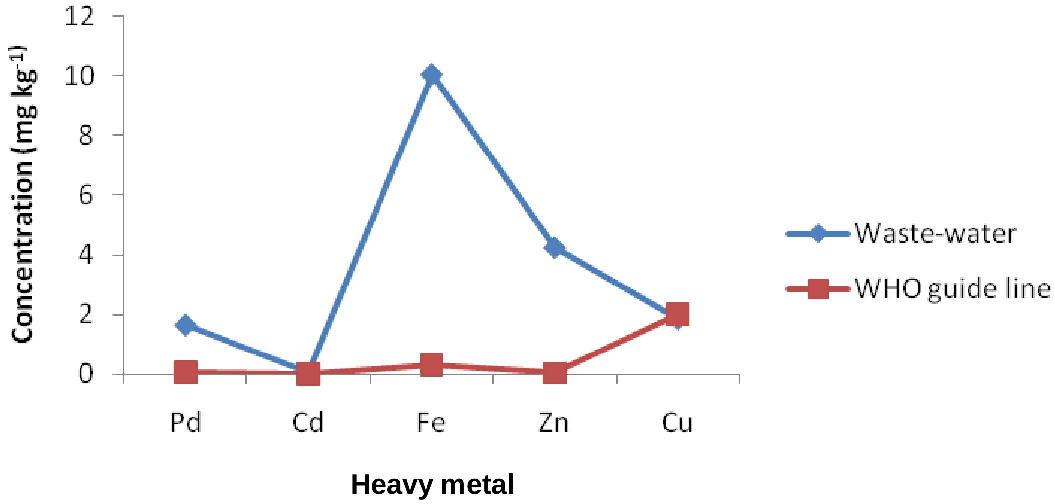

Figure 1. Mean concentration (mg kg^{-1}) of heavy metal in irrigated water and WHO limit dose.

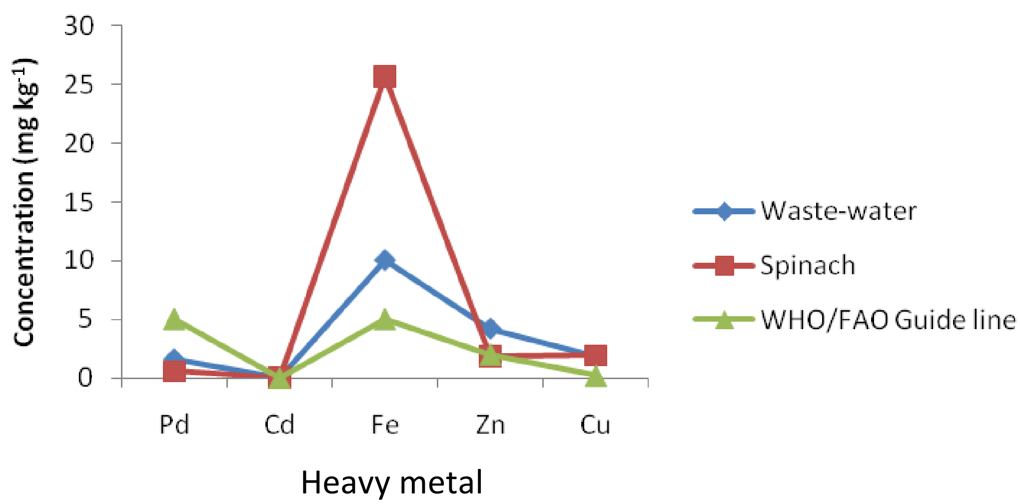

Figure 2. Mean concentration (mg kg^{-1}) of heavy metal in irrigated water, spinach and WHO maximum dose value.

contain paper, food wastes, metals, glass, ceramics and ashes. Studies have shown that these wastes can accumulate heavy metals which can persist in soil at environmentally hazardous level (Odoh and Kolawole, 2011). Mohammed et al. (2014) also reported that the accumulation of heavy metals such as Fe, Mn, Cu, Zn and Pb in plant significantly increased by sewage water irrigation. Similar work reported by Ademoroti (1996) in Akan et al. (2009), observed that vegetables accumulate considerable amount of heavy metals especially Pb, Cr, Cu, and Zn in roots and leaves.

Statistical test of significance using the student t-test and ANOVA, showed no significant difference ($p > 0.05$) between the levels of heavy metals in waste-water, spinach and the WHO/FAO recommended guide limits. The elevated level of Fe in both spinach and the waste water could be attributed to excessive usage of fertilizers and other agro-chemicals (Uwah et al., 2011).

Pb pollution has been shown to be commensurate with population/vehicle density (Afolani, 2010). Pb poisoning is a global reality and fortunately is not a very common clinical diagnosis yet in Nigeria except for few occupational exposures (Anetor et al., 2008). Oluwole et al. (2013) reported the work of Qui et al. (2000) in which they observed that Pb accumulate in the body and it enters into the body system through air, water and food and it cannot be removed by washing fruits and vegetable alone. Cd is a heavy metal with high poisonous ability and it is a non-essential element in foods and natural waters and it accumulates principally in the kidney and liver (Oluwole et al., 2013). Cu is essential for plant growth, and is a component of other proteins associated with the processing of oxygen. In cytochrome oxidase, which is required for aerobic respiration, Cu and iron cooperate in the reduction of oxygen. Cu is also found in many superoxide dismutases, proteins that detoxify superoxides, by converting it to oxygen and hydrogen peroxides (Oluwole et al., 2013).

Conclusion

The results indicated that the waste water sample analyzed in this study had high level of heavy metals. The heavy metals were higher than those recommended by WHO. The results also reveals that sewage is the main source of pollution of this water used for irrigation and which also relatively leads to increase of some of these heavy metals in the spinach. With time, the high levels of these heavy metals in the water used for irrigation and the levels in the spinach might place the consumers of these vegetables grown in this area at health risk, unless an urgent step is taken by relevant agencies in addressing this issue by enlighten the farmers on the implications of using the waste water for cultivation and the government in their part should provide fund for the farmers as a kind of soft loan to make boreholes, so that the water from them can serve as a source of irrigation.

Conflict of interest

Authors have none to declare

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