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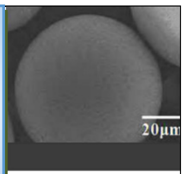

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ZnO nanoparticle

Health Risk Assessment of Heavy Metals from Selected Fruits and Vegetables Sold in Dutse Ultra-Modern Market, Jigawa State

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ABSTRACT

This study was conducted to assess the health risk of heavy metals from some fruits and vegetables sold in the Dutse Ultra-modern market, Jigawa State. Two fruits (watermelon and orange) and two vegetables (okra and spinach) were selected randomly from two vendors for two consecutive periods within one week. The samples were transported to the laboratory for acid digestion. Atomic Absorption Spectrophotometer (AAS) was used for the determination of heavy metal (Cd, Pb, Zn, Fe, Mg, Cr and Ni) concentration in the various samples. Bioaccumulation factor, pollution index, hazard quotient and hazard index were calculated and compared with WHO standard. Results obtained in the present study revealed that Cd levels in the samples were significantly higher as compared with the control value (0.2 mg/mL). Pb, Fe, Cr and Ni evaluated were insignificant as compared with their control (2 mg/mL, 1 mg/mL, 1.3 mg/mL and 10 mg/mL, respectively). The results revealed only Cr (1.5) and Ni (1.7) have significantly high bioaccumulation factors while all other heavy metals show relatively low bioaccumulation. The pollution index of heavy metals in the samples of fruits and vegetables evaluated shows a relatively low pollution index, values obtained vary from 0.11 in Pb to 0.9 in Ni. While hazard quotients and hazard index were insignificant. The study concludes that okra, spinach, orange and watermelon in the Dutse ultra-modern market in Jigawa state despite their proximity to the mechanic village and a lot of activities occurring may not cause a serious health threat to human consumption. The study recommends further studies on other fruits and vegetables not selected for this study.

INTRODUCTION

Heavy metals are inert chemicals that are required for plant development in extremely tiny or trace concentrations. Heavy metals in surface water are caused by anthropogenic activities that alter the natural distribution of heavy metals in surface water, as well as weathering of soils and rocks. Leaded gasoline and paints, mine tailings, fertilizer application on land, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, petrochemical spills, atmospheric deposition, and pesticide residues are just a few of the heavy metal contamination sources that can affect soil [1–5]. Long-term irrigation with sewage effluent contaminates the soil and vegetables to such an extent that it becomes poisonous to plants and causes soil degradation since it includes a significant number of potentially hazardous heavy metals such as Cr, Fe, Cu, Pb, Zn, and Cd [6]. There are hazardous trace levels of heavy metals in nature. Heavy metals are persistent environmental contaminants because they are stable and difficult to break down or remove. They are absorbed by plants from the soil and water used for irrigation, as well as from the air, fertilizers, pesticides, and the deposition of urban and industrial waste. Additionally, modern agricultural practices include using fertilizers, pesticides, and automated farming. Because they contain vitamins and mineral salts, fresh fruits and vegetables are very important in the diet. They also include water, calcium, iron, sulphur, and potash [7–10].

They are highly significant protective foods that are beneficial for health maintenance as well as the prevention and treatment of many ailments [11]. Fruits and vegetables are extensively used for gastronomic purposes. They are used to improve the flavour of soups (leafy vegetables) as well as for nutritional benefits [12]. They are mostly composed of cellulose, hemicellulose, and pectin components, which give them their texture and rigidity [13].

However, these plants have a wide range of essential and harmful metal concentrations. One of the biggest threats to environmental health is heavy metal contamination. Due to bioaccumulation through the food chain, which results from rapid industrial growth, improvements in the use of agricultural pesticides, and human urbanization activities, it is potentially dangerous. Due to the spread of these dangerous substances in the environment and the consumption of food crops tainted by them, the population's health has been negatively impacted. Animal and human health may be at risk from heavy metal uptake by plants through absorption and subsequent buildup along the food chain [14–16]. The aim of this research work, therefore, is to access the health risks associated with the consumption of some fruits and vegetables sold in the Dutse ultra-modern market by accessing the levels of heavy metal concentrations from these samples.

MATERIALS AND METHODS

Study area

The study was conducted at Jigawa State Polytechnic Dutse and samples were collected from Dutse's ultra-modern market. Dutse laid within latitude: 11.0 °N to 13.0 °N and longitude: 8.0 °E to 10.1 °E. (JARDA, 2012) with an average temperature varying from 54°F to 103°F, the wet season in Dutse lasts for about 4.5 months from May to October and rainfall reaches a peak in August and declines afterwards. However, some different species of crops that are usually grown in the area are millet, rice, maize, sesame, cowpea and so on, having an average population of livestock currently estimated at 3.06 million cattle, 5.6 million sheep and 6.6 million goats.

Sample collection

Two fruits and two vegetables were selected randomly from two vendors for two consecutive periods within one week. This makes a total of sixteen samples. The samples were transported to the laboratory for acid digestion.

Pretreatment

The edible parts of the samples were baked in the oven at 80 degrees Celsius for two to three days, and they were weighed periodically until they reached a consistent weight. The dried samples were first kept in polythene bags before being pounded into a fine powder using a mortar and pestle and then passed through a 2 mm screen. The powder was then subjected to acid digestion.

Digestion Experiment

The equipment was instructed to prepare the samples following the predetermined protocols; briefly: A total of two hundred milligrams (200 mg) of samples were weighed before being moved into microwave digestion tubes containing ninety millilitres. Each jar received an additional ten millilitres of a combination consisting of 15.9N trace metal grade nitric acid, hydrogen peroxide, and perchloric acid in a ratio of 7:2:1. Following a waiting period of one hour (1h), the samples were put through a microwave digestion device and processed as follows: ramp temperature from room temperature to 200 degrees Celsius over twenty minutes, then maintain the temperature at 200 degrees Celsius for twenty minutes; following digestion, they were allowed to cool to roughly fifty degrees Celsius or lower before being handled. After transferring the digestion into a volumetric flask containing 50 millilitres, the volume of the solution was brought up to 50 millilitres with deionized water, and it was filtered in preparation for instrumental analysis.

Statistical analysis

ANOVA was performed to examine whether there is a statistical difference in heavy metal concentrations between the four distinct samples (orange, watermelon, okra and spinach). The link between heavy metals in different samples was determined using correlation analysis.

RESULT AND DISCUSSION

Figs. 1 and **2** show various levels of heavy metal concentrations in the samples of fruits(orange and watermelon) and vegetables (okra and spinach) analyzed. Results obtained in the present study revealed that Cd levels in the samples were significantly higher as compared with the control value (0.2 mg/mL). Cd ranges from 0.34±0.01 mg/mL in spinach to 0.6±0.02 mg/mL. Pb content in the samples evaluated was insignificant as compared with the control (2mg/mL), values obtained vary from 0.4±0.005 mg/mL in spinach to 0.8 ±0.01 mg/mL in Okra. In terms of Zn, values range from 0.45±0.02 mg/mL in watermelon to 0.8±0.01 mg/mL in both spinach and orange. Except for spinach and orange samples, Zn content in the other samples was insignificant.

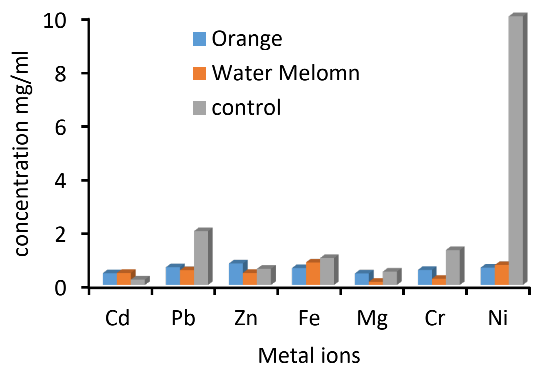

Fig. 1. Estimated heavy metals concentrations in different concentrations of orange and watermelon obtained from the Dutse market.

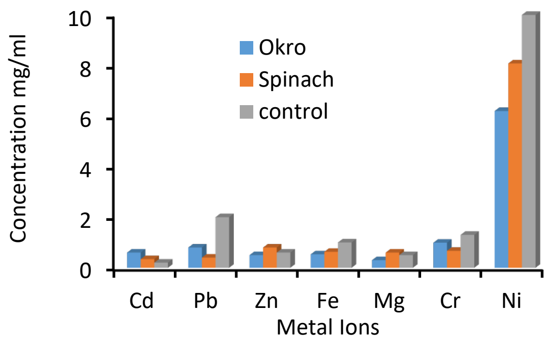

Fig. 2. Estimated heavy metals concentrations in different concentrations of Okro and spinach obtained from the Dutse market.

Fe content in the samples was also insignificant as all values obtained ranged from 0.53±0.01 mg/mL in Okra to 0.63±0.01 mg/mL in both spinach and orange. These values were less than the control (1mg/mL). In Mg figures obtained vary from 0.12±0.04 mg/mL in watermelon to 0.6±0.06 mg/mL in spinach. All values were insignificant except for the spinach sample. Results from samples were insignificant they vary from 0.23±0.03 mg/mL as obtained in watermelon and 0.99±0.01 mg/mL in Okra in terms of Cr, while the control value was 1.3 mg/mL. Finally, Ni shows similar values as in Cr, values vary from 0.75±0.01 mg/mL in watermelon to 8.08±0.01 mg/mL in spinach, control value was 10 mg/mL.

[17] observed that excessive metal concentrations in the plant could limit the plant's ability to synthesise chlorophyll, increase oxidative stress, and decrease stomata resistance. Whether the pollution originates from the soil or the air, heavy metals like chromium (Cr) and cadmium (Cd), which are naturally occurring heavy metals, can hinder the development of plants. This is true regardless of the source of the pollution [18].To survive, plants have developed several strategies that are both efficient and accurate for coping with the effects of exposure to high levels of heavy metals. Some of the adaptive mechanisms that plants have developed to deal with higher metal stress include chelation, immobilization, and the exclusion of plasma membranes. Other mechanisms include the production of specialized heavy metal transporters, the activation of stress proteins, and the limitation of absorption and transport [19–21]. However, as a result of these activities, plants have accumulated harmful substances, which may then be passed to a human being. Despite all of this, the plant may still have a healthy appearance, but it may have accumulated greater quantities of harmful heavy metals, particularly heavy metals that are metal-based.

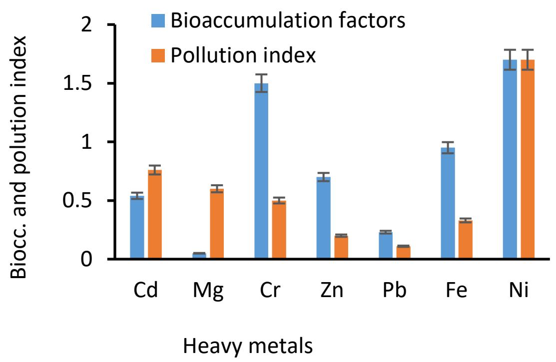

Fig. 3. Bioaccumulation Factors and population index of heavy metals from selected fruits and vegetables.

Bioaccumulation > 1 has high uptake of heavy metals,
Bioaccumulation <1 have low uptake of heavy metal and hyper accumulate in those certain metals.
Pollution index > 1 indicates high contamination of heavy metals
Pollution index < 1 indicates low contaminations of heavy metals

Fig. 3 above described the bioaccumulation and pollution index of heavy metals from selected fruits in the environment they are found. The bioaccumulation factor (BAF) is a measure of the metal enrichment at each trophic level. BAF was calculated by dividing the metal concentration at the second or third trophic level by the metal concentration at the trophic level immediately. In earlier studies, the bioaccumulation factor (BAF) was strongly applied to quantify the bioaccumulation of environmental pollutants [22]. Heavy metal concentrations in fruits and vegetables and the impact they had on the soil were illustrated by the BSF in this study. the ratio of heavy metal concentrations in plants to those in their primary living environment is known as BAF [23–27]. Higher BAF values of greater than one for chromium and nickel indicate high heavy metal uptake in fruits and vegetables. on the other hand, the pollution index is a quantitative measure that describes the ambient quality of an environment where vegetables and crops can be cultivated [28]. the index is obtained by combining figures for various environmental pollutants into a single measurement. a pollution index greater than one indicates high contamination of heavy metals by plants [29,30]. Nickel has the highest pollution index, which shows that vegetables and fruits accumulate nickel more than all the analysed metals.

Table 1. Estimated Hazard Quotient and Hazard index of heavy metals from selected fruits and vegetables from Dutse ultra-modern market.

Heavy metal	Hazard quotients	Hazard index
Cd	0.303	0.233
Mg	0.0003	0.233
Cr	0.0098	0.233
Zn	0.0556	0.233
Pb	0.134	0.233
Fe	0.0033	0.233
Ni	0.284	0.233

Table 1 shows the Estimated Hazard Quotient and Hazard index of heavy metals from selected fruits and vegetables from the Dutse ultra-modern market. The hazard quotient *HQ* (the risk factor applied to noncarcinogens) relates the dose delivered at the exposure point (the Average Daily Dose *ADD*) to a toxicological end-point: the reference dose *RfD* (10.10) [31]. The data show that the HQ and HI levels did not surpass the threshold of HQ and HI. This indicated that the investigated heavy metals and hazardous metals had daily intake levels that were below the level of concern (HQ greater than 1); as a result, the non-carcinogenic risk from heavy metals through fruits and vegetable ingestion was acceptable [32]. Our study's findings are consistent with those of research conducted in China, India and Malaysia. However, the HQ level of Pb is above the threshold level of greater than one in both fruits and vegetables obtained from the market. The increased level, poses a health threat to consumers, especially cancer. This may be due to a lot of anthropogenic activities occurring in the market as well as the proximity of the market to the mechanic village.

CONCLUSION

The result obtained for health risk assessment of heavy metals from fruits and vegetables shows that despite a lot of anthropogenic activities happening in the market, the concentration of the heavy metals is within the WHO levels. The result of the Bioaccumulation index shows that the plants accumulate Cr and Ni while Pb may pose a health threat by having a hazard quotient of more than one.

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