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AN ASSESSMENT OF THE IMPACT OF TANNERY EFFLUENT ON VEGETABLES PLANTED IN CHALLAWA RIVER BASIN, KANO STATE, NIGERIA

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ABSTRACT

The levels of lead (Pb), cadmium (Cd), chromium (Cr) and zinc (Zn) in cabbage cultivated along Challawa river basin in Kano state, Nigeria have been investigated. Cabbage samples collected were thoroughly washed with distilled water, cut into tiny bits and air dried. The dried samples were pulverized, passed through 1 mm sieve and digested. The heavy metal levels in the digested samples were determined with an atomic absorption spectrophotometer. The levels of heavy metals in samples followed the order: sampling station 1> sampling station 2> sampling station 3. The ranges of the concentrations were 0.46 - 0.76 mg/kg, 0.21- 0.51 mg/kg, 0.24 - 0.47 mg/kg and 1.87-5.32 mg/kg for lead, cadmium, chromium and zinc respectively. The mean of lead, chromium and cadmium levels in samples from the study area were found to be higher than the WHO/FAO safe limits for edible vegetables. The mean level of zinc in edible cabbage tissues from the study area was found to be within the WHO/FAO safe limits for edible vegetables. It was also generally observed that the mean heavy metals levels in samples from the control station were within the WHO/FAO acceptable limits.

1. INTRODUCTION

In his quest to satisfy his needs and aspiration for better living conditions, man generates different kinds of waste which are discharged directly or indirectly into the environment. These wastes frequently accumulate in the environment creating an increasing number of environmental problems with far reaching consequences on land, water and air (Udiba *et al.,* 2015) The major environmental concerns associated with the disposal of industrial, agricultural and urban municipal wastes are the contamination of soil, water and air (Udiba *et al.*, 2015).

The tanning industry is considered to be a major source of pollution and tannery wastewater in particular, is a potential environmental concern (Ros and Ganter, 1998). Among all the industrial wastes, tannery effluents are ranked as the highest pollutants (Shen 1999). Because of the relatively inexpensive cost of labour and materials, over half the world's tanning activity occurs in low and middle-income countries (Azom *et al.,* 2012). Environmental pollution caused by tannery wastewater has become an acute problem as a result of the rapid expansion of the industry, on account of an increased use of chromium sulphate as the mineral tanning material in urban areas (Lawal *et al.*, 1996). Organic matter associated with tannery waste includes biodegradables such as proteins and carbohydrate (Mwinyihija, 2007). Their impacts are primarily the loss of dissolved oxygen, which is detrimental to aquatic organisms. The depletion of dissolved oxygen encourages anaerobic activity, which leads to release of noxious gases (Mwinyihija, 2007).

The indiscriminate discharge of chemical toxins especially Pb, Cd, Cr, Co, etc. into the environment ensure their transfer into plants, animals and man. High concentration of heavy metals in irrigation waters could results in death of crops, interfere with uptake of other essential nutrients or form objectionable deposits on fruits and render the edible portion of plants toxic to human and grazing animals (Bichi,1999). Health risk due to heavy metal contamination of soil has been widely reported (Satarug *et al.*, 2000; Eriyamremu *et al*, 2005; Muchuweti *et al*, 2006; Sharma *et al,* 2007).

The key to healthy vegetable produce is healthy growing medium (soil and water). Heavy metals play an important role in plant physiology since many of them are essential trace elements necessary for the optimal growth of the plants. Their deficiency can result in different diseases. On the other hand, above certain concentrations, these heavy metals can have toxic effects when the plants are consumed (Szabo and Czellérm , 2009). The uncontrolled input of heavy metals in soils is an undesirable one because once in the soil, they are generally very difficult to remove (Smith *et al*.,1996). Vegetable cultivated in soils with elevated metal levels have the potential to significantly uptake such metals to dangerous concentrations in its edible parts. The degree of uptake is largely a function of the soil chemistry, the chemical form of the metals concerned, species and age of the vegetable. It has been reported that vegetables can accumulate some heavy metals to such degree that can have toxic effects on humans (Szabo and Czellérm , 2009).

In this study, the levels of heavy metals in cabbage planted along the Challawa river basin in Kano state, Nigeria was investigated. This investigation was carried out because the effluents from the tanning industry in Challawa are discharged into this river.

2. MATERIALS AND METHODS

2.1. Study Area

Kano (Lat. 11° 59 m 18.3s N, Long 08° 32 m 05.8s E) is 418 m above sea level and is the head quarter of Kano State. Kano, Nigeria. Kano state has three main industrial estates namely Bompai, Challawa and Sharada.

2.2. Sample Collection

Procedure for sample collection preservation and preparation was adopted from APHA (2005). Four sampling stations were established along Challawa river basin where the crop samples were obtained. The first station was around the point source and the second point was 400 meters downstream of the first sampling station and the third point was 400 meters downstream of the second station. The fourth sampling station was 1000 meters before the first sampling station. This served as the control. A total of sixteen samples were collected monthly from February to April 2016 in black polythene bags and sent for analysis. The vegetable collected was cabbage (*Brassica oleracea*).

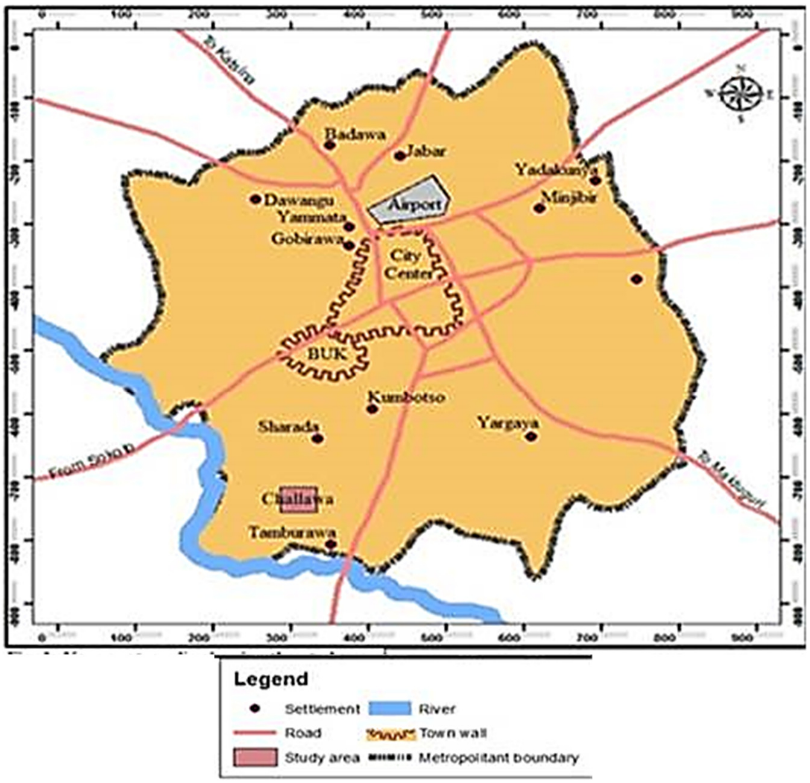

Figure 1: Map of Kano metropolis showing the study area (Challawa)

2.3. Sample Preparation and Analysis

Cabbage samples collected were thoroughly washed with distilled water so as to remove all adhering soil, and then cut into tiny bits and air dried at ambient conditions for 5 days. The dried samples were pulverized manually using a porcelain mortar and pestle, passed through 1 mm sieve and digested. The digestion of 1 g was carried out using 5 ml of concentrated nitric acid. A mixture of Nitric acid (Conc. HNO_3) and Perchloric acid (Conc. $HClO_4$) was first prepared in ratio 10:1. 10 ml of the prepared mixture was taken and added to 1 g of the ground sample in a 250 ml Kjeidahl flask. The sample was heated in a fume cupboard using an electric hotplate. The digestion process was allowed to continue for not less than 2 hours until the brown fume disappeared and white fumes emerge leaving a clear solution in the flask with all the samples being digested.

2.4. Heavy Metal Analysis

The concentrations of lead, cadmium, chromium and zinc in the digests were determined using Atomic Absorption Spectrophotometer (model AA-6800, Japan). Average values of three replicates were taken for each determination. Data obtained were subjected to statistical analysis.

2.5. Analytical Quality Assurance

In order to check the reliability of the analytical method employed for metal determination, one blank and combined standard were run with every batch of samples to detect background contamination and monitor consistency between batches. The result of the analysis was validated by digesting and analysing standard reference material, Lichens coded IAEA-336 following the same procedure. The analysed values and the certified reference values of the elements determined were compared to ascertain the reliability of the analytical method employed. All the reagents that were used- HNO_3 (Riedel-deHaen, Germany), HCl, (Sigma-Aldrich, Germany) and, HF and $HClO_4$ (British Drug House Chemicals Limited, England) were of analytical grade.

2.6. Statistical Analysis

Data collected was subjected to the statistical test of significance using the analysis of variance test to assess significant variation in concentrations of the physicochemical parameters and metal levels across the sampling locations. Probabilities less than 0.05 ($p < 0.05$) was considered to be statistically significant. Duncan multiple test or Donnette T was adopted for multiple comparison of parameters between sampling stations depending on whether the homogeneity test was greater than or less than 0.05. Pearson product moment correlation coefficient was used to determine the association between metal levels in soil, and crop samples at $\alpha = 0.05$. SPSS software 17.00 for windows was used for all statistical analysis.

3. RESULTS AND DISCUSSION

3.1. Analytical Quality Assurance

To evaluate the accuracy and precision of the analytical procedure employed standard reference materials of lichen coded IAEA - 336 was analysed in like manner to the samples. The results are shown in Table 1.

Table 1: Results of analysis of reference material (Lichen IAEA -336) compared to the certified reference value

Element (mg/kg)	Pb	Cr	Cd	Zn
A value	5.25	0.140	4.00	55.78
R value	4.2-5.5	0.1-2.34	3.1-4.1	56-70

A Value = Analyzed value R Value = Reference value.

The analyzed values for each heavy metal were found to be within the range of the certified reference values for the metals determined which implies that the method employed is reliable.

3.2. Metal Content of Edible Cabbage Tissues

Results obtained from the determination of metal contents of edible cabbage (*Brassica oleracea*) tissues from the sampling stations are presented in Table 2. Table 2 shows that lead, cadmium, chromium and zinc contents of edible cabbage tissues from Challawa river basin, Kano followed the order: Sampling Station 1>Sampling Station 2>Sampling Station 3. The ranges of the concentrations were 0.46 - 0.76 mg/kg, 0.21- 0.51 mg/kg, 0.24 - 0.47 mg/kg and 1.87-5.32 mg/kg for lead, cadmium, chromium and zinc respectively. The lowest concentrations of all the metals were recorded at sampling station 3 in the month of February and the highest concentration at sampling station 1 in the month of April. The first rainfall of the year in February may have led to low concentrations of heavy metals in the soil due to dilution. The concentration of heavy metals in the soil subsequently kept increasing, as the amount of water in the soil was reducing. Since sampling station 1 was closest to the point source of tannery effluent discharge, it may have had the highest deposit of heavy metals from the effluent; hence the cabbage sample collected from this sampling station had the highest level of heavy metals present. The heavy metals in sampling stations decreased as their distance increased from the point source of effluent discharge; hence the heavy metals level in the cabbage from sampling 2 was higher than that from sampling stations 3. Statistical analysis shows that the differences in lead, cadmium and chromium content of edible cabbage tissues across the established sampling stations from the point source downstream were statistically significant at 95% confidence level ($P < 0.05$). Also, the differences in lead, cadmium and chromium content of edible cabbage tissues sampled from station 1 and those sampled from station 3 were significant at 95% confidence level ($P < 0.05$). However, the differences in heavy metal content of samples from sampling station 1 and those from sampling station 2 were significant only for Lead and chromium at 95% confidence level ($P < 0.05$); also, differences in metal content of samples between sampling station 2 and sampling station 3 for lead, cadmium and chromium were not significant at 95 % confidence level. Zinc content of edible cabbage did not show any significant differences across the sampling stations. The differences in metal concentration between the study area and the control were found to be statistically significant at 95% confidence level ($P < 0.05$) for the four heavy metals.

Table 2: Heavy metal levels in edible cabbage tissues from Challawa river basin, Zaria

Heavy metal	Month	Sampling Station 1	Sampling Station 2	Sampling Station 3	Control
		Heavy metal concentration (mg/kg).			
Lead	February	0.68	0.54	0.46	0.11
	March	0.75	0.67	0.54	0.13
	April	0.76	0.64	0.57	0.15
	Mean ± SD	0.73±0.04	0.62±0.07	0.52±0.06	0.13±0.02
Cadmium	February	0.32	0.28	0.21	0.11
	March	0.48	0.32	0.28	0.14
	April	0.51	0.38	0.28	0.16
	Mean ± SD	0.44±0.10	0.33±0.05	0.26±0.14	0.14±0.03
Chromium	February	0.38	0.26	0.24	0.1
	March	0.43	0.34	0.27	0.11
	April	0.47	0.36	0.25	0.12
	Mean ± SD	0.43±0.05	0.32±0.05	0.25±0.02	0.11±0.01
Zinc	February	2.45	2.43	1.87	0.21
	March	4.98	3.98	3.64	0.26
	April	5.32	4.11	3.21	0.23
	Mean ± SD	4.25±1.57	3.51±0.93	2.91±0.92	0.23±0.03

Metal content of edible cabbage tissues from sampling stations were generally found to be higher than those of the control. The uptake of heavy metals from the soil at the sampling stations may be responsible for the higher levels of the heavy metals in the cabbage. The mean lead, chromium and cadmium levels in edible cabbage tissues from the study area were found to be higher than the WHO/FAO maximum permissible limits of 0.3 mg/kg, 0.5 mg/kg and 0.2 mg/kg respectively for lead, chromium and cadmium in edible vegetables (WHO/FAO, 2007). The mean levels of zinc in edible cabbage tissues from the study area were found to be within the WHO/FAO safe limit of 5.00 mg /kg for zinc in edible vegetables (WHO/FAO, 2007). The mean levels of chromium and lead in cabbage from the sampling stations were generally higher than their mean levels in carrots root from Galma basin as studied by Udofia *et al.* (2016). It was also generally observed that the mean heavy metals levels in edible cabbage from the control station were within the WHO/FAO (2007) acceptable limits. This may have been due to the fact that the tannery effluent at this point did not have much impact on the soil as against what was observed at the sampling stations.

4. CONCLUSION

In this study, the effects of tannery effluent on cabbage planted at Challawa river basin have been investigated. The following conclusions can be drawn from this study:

- The concentrations of heavy metals in sample decreased as the sampling stations were farther from point source.
- Heavy metal levels in samples from sampling stations were generally found to be higher than those from the control.
- The differences in metal concentration between the study area and the control were found to be statistically significant at 95% confidence level ($P < 0.05$) for the four heavy metals.
- The lowest concentrations of all the heavy metals were recorded at sampling station 3 in the month of February and the highest concentrations at sampling station 1 in the month of April.
- The mean lead, chromium and cadmium levels in samples from the study area were found to be higher than the WHO/FAO safe limits in edible vegetables. However, the mean levels of zinc in samples from the study area were found to be within the WHO/FAO safe limit in edible vegetables.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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