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Full Length Research Paper

Determination of some trace metal levels in onion leaves from irrigated farmlands on the bank of River Challawa, Nigeria

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The concentration (mg kg^{-1} dry weight) of Cu, Mn, Ni and Zn were determined in onion leaves samples using atomic absorption spectrometry. A total of 16 samples each of onion leaves freshly harvested were collected from the exposed and control sites for analysis. The trace metal (Cu, Mn, Ni and Zn) levels in the onion leaves of the study site were found to be higher than those of the control site. The trend of abundance of the metals are Ni > Cu > Zn > Mn. For the onion leaves samples of the study site and Ni > Cu > Zn > Mn for the onion leaves of the control site. The trace metals levels in either case were found to be above the FAO/WHO and WHO/EU allowed limits, which could put the consumers of this valuable vegetable at risk health wise. However, Cu and Zn levels are below the MAFF limits.

Key words: Onion leaves, trace metals, irrigated farmlands, Challawa River.

INTRODUCTION

Trace metals may enter food chain from soil through mineralization by crops or environmental contamination as in application of agricultural inputs such as pesticides, fertilizers or use of polluted river for irrigation to water crops (Miller, 1996; Onianwa et al., 2001; Audu and Lawal, 2005). According to World Bank (1995) and Faboya (1997), Kano metropolis (N 1159° 981', E 008° 31.491') is home to about 70% of Nigeria's tanning industries. The Kano tannery industries discharge their effluents in an untreated from directly into a river called Challawa River. Yisa (2004) has shown that the Challawa River is polluted with trace metals, chlorides, sulphate and ammonia. Dry season farming is the major occupation of the people living in the villages along the Challawa River bank. Thus in a bid to struggle for survival, the people living along the bank of this River use the polluted Challawa River to water their vegetable crops. Consequently, pollutants, like trace metals, may enter the food chain putting consumers of vegetable crops from the Challawa River at risk from ingestion of toxic metals at unacceptable concentrations.

Data on the trace metal quality and the health status of irrigated vegetable crops from Challawa River bank are scarce in the literature. Adverse effects are supposed, when the concentration of trace metals exceed their maximum permissible limits in the irrigated vegetable crops. This study was therefore, carried out to determine the levels of Cu, Mn, Ni and Zn in irrigated onion leaves which is commonly used in making vegetable soup in the Northern part of Nigeria due to the health implications to human populations consuming irrigated onion leaves from Challawa River bank.

MATERIALS AND METHODS

Reagents and glasswares

Analytical (AnalaR) grade reagents and distilled water were used throughout the experiment. All glassware and plastic containers used were washed with liquid soap, rinsed with water, soaked in 10% nitric acid for 24 h, cleaned thoroughly with distilled water and dried in such a manner to ensure that any contamination does not occur.

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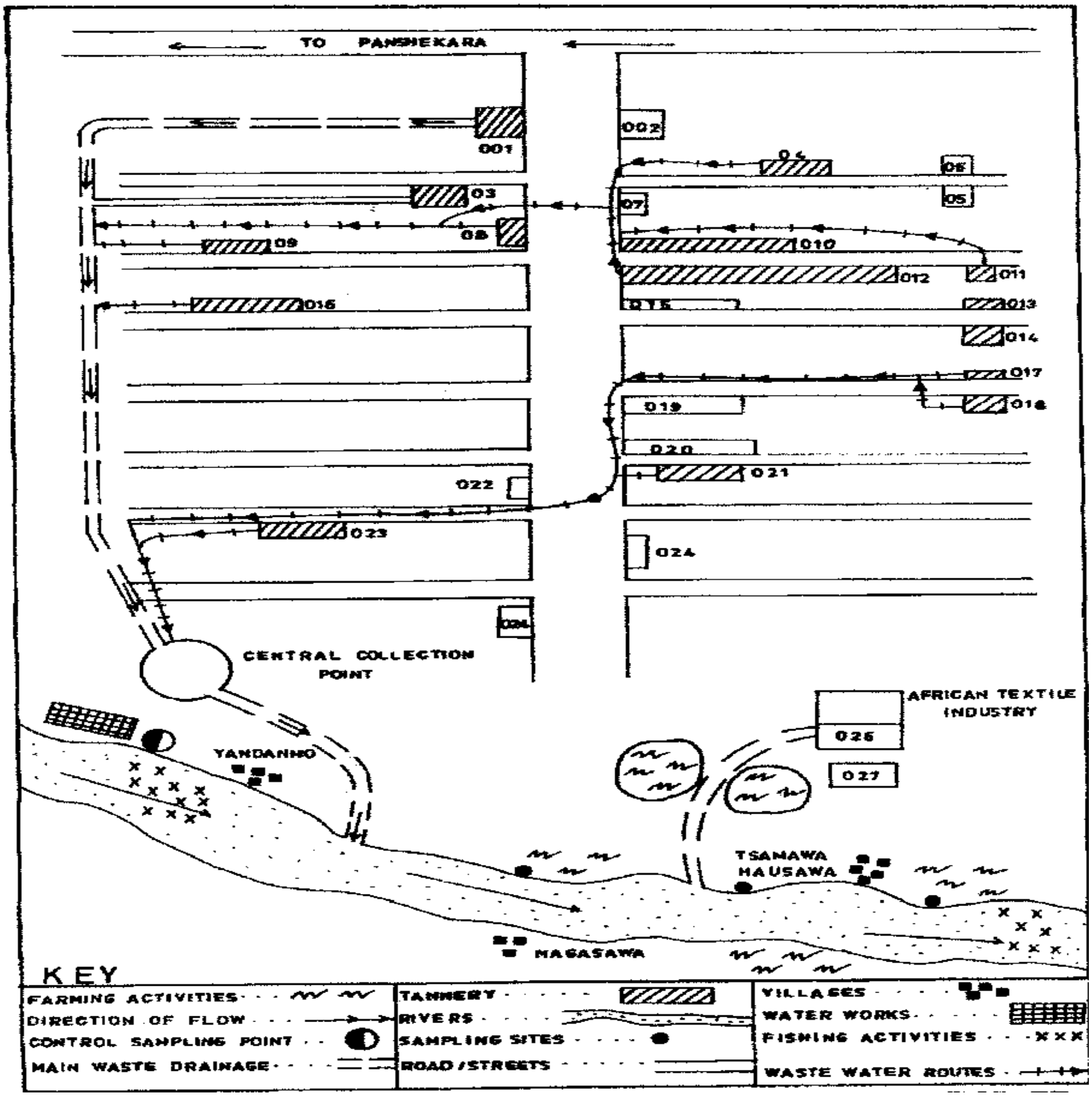

Figure 1. Sketch map of Challawa industrial estate showing the sampling sites.

Sampling

As shown in Figure 1, farms used for irrigation on the Challawa River bank were divided into study area (after tannery effluents discharge point into the River) and control area (before tannery effluents discharge point into the River). Sixteen (16) irrigated onion leaves samples were freshly collected from both the study and control areas in the month of May, 2006. These were packaged into paper bags, labeled and transported immediately to the laboratory for processing.

Sample preparation

In the laboratory, each of the irrigated onion leaves sample was washed with tap water and thereafter with distilled water. The samples were then cut into nearly uniform size. This was done to facilitate drying of the pieces at the same rate. The cut pieces were placed in clean acid-washed porcelain crucible according to label and oven-dried at 105°C for 24 h in Mommert oven (Schutzart DIN 400-50-IP20) until they were brittle and crisp. At this stage no microorganism can grow and care was taken to avoid any source of contamination. All crucibles were labeled according to sample numbers. The dried onion leaves samples were grinded using acid-washed mortar and pestle and sieved to obtain fine powder. These were finally stored in screw capped plastic containers and labeled appropriately for analysis.

Recovery experiment: Validation of experimental protocol

In order to ascertain the efficiency and reliability and precision of

Table 1. Percentage recoveries of onions leaves samples.

Trace metal	Cu	Mn	Ni	Zn
Mean recovery (%)	86.10	91.60	95.00	96.60

Table 2. Mean (± SD) and range (mg kg^{-1}) d.w of trace metal contents in onion leaves samples of study and control area.

Site	Trace metal			
Study area	**Cu**	**Mn**	**Ni**	**Zn**
Mean (± SD)	7.834±0.746	6.592±0.796	8.760±1.262	8.333±0.710
Range	6.917 – 9.833	5.417 – 7.917	8.567 – 11.223	7.333 – 9.000
Control area	**Cu**	**Mn**	**Ni**	**Zn**
Mean (± SD)	5.578± 0.447	2.026±0.449	7.015±1.694	5.125±0.513
Range	4.917 – 6.333	1.083 – 3.000	6.567 – 8.933	4.000 – 5.667
FAO/WHO Limit	5.0	-	-	0.3
MAFF Limit	50	-	-	20
WHO/EU Limit	0.2	0.2	0.2	0.2

the atomic absorption spectrometry machine and the reliability of the digestion method used for the analysis of Cu, Mn, Ni and Zn in the irrigated onion leaves samples, three sub-samples of one of the onion leaves samples were spiked with (0.5 mgL^{-1} Mn and Ni, and 3.00 mgL^{-1} Cu and Zn) multielement standard solution.

Digestion and analysis of samples

Samples and blanks were digested as described by (Awofolu, 2005): 0.5 g of powdered onion leaves samples were weighed into a 100 ml beaker. 5 ml concentrated nitric acid and 2 ml of Perchloric acid, together with few boiling chips were added. The mixture was heated at 70°C for 15 min until a light coloured solution was obtained (digestion complete). The samples solution was not allowed to dry during digestion. The sample was then filtered into a 50 ml standard flask and two 5 ml portions of distilled water were used to rinse the beaker and the contents filtered into the 50 ml flask. The filtrate was allowed to cool to room temperature before dilution was made to the mark and the content mixed thoroughly by shaking. The digestion was carried out in triplicate for both samples and blank. The digests were run on the atomic absorption spectrometry machine. Similarly, spiked and unspiked samples were digested and analysed as above.

RESULTS AND DISCUSSION

Validation protocol

The mean percentage recoveries shown in Table 1 revealed the following trends: Zn > Ni > Mn > Cu, respectively. Also, the results showed that Zn has the highest recovery of 96.60. Generally, acceptable recoveries were obtained in all cases, which validate the experimental procedure and the efficiency of the Atomic Absorption Spectrophotometer.

Table 3. Correlation matrices between trace metals in onion leaves samples of study area.

Factor	Cu	Mn	Ni	Zn
Cu	1.000			
Mn	0.441	1.000		
Ni	0.967	0.2000	1.000	
Zn	0.996	0.518	0.942	1.000

Trace metals content in onion leaves

Average metal concentrations and ranges (mg kg^{-1} dry weight) found in onion leaves from study area and control areas are shown on Table 2. Cu, Mn, Ni and Zn concentration levels also ranged from 6.750 – 9.833, 5.417 – 7.917, 7.233 – 11.233 and 7.333 – 9.000 mg kg^{-1}, respectively. The profile of the metal content of onion leaves in the study area were found to be in the order Ni > Zn > Cu > Mn. As Table 3 shows, positive correlation was found between all the metal in the samples from the study area. This indicates the appearance of local high concentration of other metals, which suggests that the metals might have originated from the same anthropogenic source.

Generally, trace metals in onion leaves samples were monitored in order to provide tools for estimating the level of contamination, the source and habitat. Compare to the control areas, Cu, Mn, Ni and Zn mean total contents were slightly higher at the study area than at the control ones, would suggest that the investigated onion leaves of control areas were noticeably contaminated by these metals.

Zinc is present in appreciable amount in the samples analysed. The observed high values could be connected with the continuous discharge of effluents in the area. The concentrations of Zn were low when compared to literature reports from different areas. For example Sardans et al. (2005) reported the concentration of Zn as high as 22.70 mg kg^{-1} d.w., Anthony and Balwant (2004) reported 738 mg kg^{-1} and Singh and Abdulkasheem (1999) reported concentration range of Zn as high as 98 –244 mg kg^{-1} d.w. which was far above the maximum concentration determined in the present study. However, Zn concentrations in samples analysed are all above the guideline limits of FAO/WHO and WHO/EU. However, the concentrations were below the MAFF guideline values.

In case of Mn, maximum concentration in onion leaves of the study area was found higher compared to others studies. This value is much higher than 5.39 mg kg^{-1} d.w. in onions reported by Audu and Lawal (2005). Also, these concentrations were much higher than 0.2 mg kg^{-1} d.w. limits set by Pennington et al. (1995). Different vegetable species accumulate metals depending on available form of trace metals. Higher value of Mn was obtained in samples analysed compare to standard limit (WHO/EU, 1989). Soil type of the area and sources such as application of agricultural pesticides and fertilizer could be responsible the high value (Audu and Lawal, 2005).

Concentrations of Ni obtained in this study were higher than 0.99 and 1.20 mg kg^{-1} in onions and tomatoes samples reported by Audu and Lawal (2005) and 1.20 mg kg^{-1} reported by John and Stephen (1982). Although, values obtained in this study were low compare to world average of 40 mg kg^{-1} (Forstner and Wittmann, 1984). The average total concentration of Ni vegetable samples was higher than permissible limits 0.2 mg kg^{-1} given by WHO/EU (1999). However, high level of Ni in this study could be due to chronic discharge of industrial waste into the river, which would result to accumulation of the metal in the environment.

Cu concentration found in this study was higher than 1.11 and 7.50 mg kg^{-1} in tomatoes and onions samples reported by Audu and Lawal (2005) but lower than 44.00 mg kg^{-1} (Sandans et al., 2005) and limits given by MAFF (1992). Compared with the world average concentration of 20 mg kg^{-1} (Forstner and Wittmann, 1984), Cu levels in this study showed lower concentrations. However, possible contribution of water metallic burden from environmental sources such as household waste and heavy duty vehicles use to convey sand from the river is quite evident when concentrations from control area are considered.

Conclusion

Vegetables are very important part of a diet. With increasing health consciousness and the growing number of vegetarians nowadays, vegetable safety is a very important issue. The results of this study indicate the pollution tendencies of tomatoes and onions and perhaps other vegetable crops grown within the same vicinity. The trace metals concentrations were found to be above the allowed limits of FAO/WHO and WHO/EU of all the metals analysed. However, the concentration levels of Cu and Zn are below the MAFF allowed limits of 50 and 20 mg kg^{-1}, respectively. Although, the essential elements Cu, Zn, Ni and Mn are beneficial to man and plants, but found in excessive amounts above the WHO limits in food, which could prove detrimental to health. The results further showed that with continuous discharge of Industrial effluents from industries into the Challawa River, pollution within the study area is likely to have severe but localized effect, except where and when water courses and levels may tend to spread the pollutants to other areas.

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