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Research Article

Mercury Content of Soil, Water and Proximate Composition of *Spinacia oleracea* Irrigated with River Tudun Wada, Kaduna State, Nigeria

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Abstract

The study was conducted to determine the mercury content of soil, water and proximate composition of *Spinacea oleracea* irrigated with river Tudun Wada, Kaduna State, Nigeria. The average percentage proximate composition was estimated using standard methods and the concentrations of mercury by cold vapour atomic absorption spectrophotometer (CV-AAS). The results of the proximate composition revealed Ash (3.86 ± 0.13 %), Crude fibre (4.76 ± 0.15 %), Crude fat (0.0997 ± 0.07 %), Protein (3.93 ± 0.18) and Moisture (73.4 ± 2.7 %). The concentrations of mercury in the soil ranged from 2.10 - 2.90 µg/kg, in *Spinacea oleracea* it ranged from 0.500 – 1.30 µg/kg and below detection limit in water which indicates that *Spinacea oleracea* could be an excellent bio-indicator. The transfer factor ratio is < 1 which shows that mercury concentration is greater in the soil than plant part, the transfer coefficient at some points indicate high probability of contamination by anthropogenic activities.

Keywords: Mercury; *Spinacea oleracea*; Tudun Wada; Soil; Water.

Introduction

The contamination of food by heavy metals from agricultural, industrial and anthropogenic activities which adversely cause some health effects is a global concern [1]. Vegetables being rich sources of vitamins, minerals, fibres, and also have beneficial anti-oxidative effects. However, intake of heavy metals like mercury in contaminated vegetables may pose risk to the human health [2].

Industrialization and urbanization in many parts of the world have increased the presence of heavy metals into the terrestrial environment which have potential health impacts from consuming contaminated products such as vegetables [3]. The determination of foods contaminated with heavy metals is one of the most important aspects of food quality assurance [4]. The possible sources of vegetables contamination with heavy metals may include; application of fertilizers, pesticides, sewage sludge, irrigation with wastewater, mining and other agricultural activities [5]. Vegetables are important to human diet; particularly they provide trace elements and heavy metals. Trace elements are essential to health if they come from organic sources however, from an inorganic source, become toxic due to the accumulation of heavy metals [6].

Heavy metal accumulation in plants depends upon plant species, and the efficiency of different plants in absorbing metals is evaluated by either plant uptake or soil to plant transfer factors of the metals [7]. The consumption of heavy metal-contaminated food can seriously deplete some essential nutrients in the body that are further responsible for decreasing immunological defenses, such as intrauterine growth retardation, impaired psycho-social facilities, disabilities associated with malnutrition and high prevalence of upper gastrointestinal cancer rates [8].

Industrials produce large amount of wastewater which is discharged into drains and then eventually into the rivers. There is no proper method for treatment of industrial effluents in many urban centers and they are used for irrigating vegetable fields especially during the dry season farming [9]. The accumulation of heavy metals in plants, sediments, sewage, and sludge is a potential risk to human health due to their translocation and uptake by plants and their

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introduction in food chain [10]. This research is aimed at determining the level of mercury (Hg) in River Tudun Wada, soil and *Spinacia oleracea* cultivated and irrigated with water from River Tudun Wada, Kaduna State, Nigeria also, to determine the transfer factor of mercury to the edible parts of the vegetable.

Materials and methods

Study area

The study was carried out in Tudun Wada, Kaduna State, Nigeria. Tudun Wada has a River which its water content empties into River Kaduna. The sampling points were identified as A, B, C, D and E. The geographical coordinates are: Latitude $10^0$30'36s N and Longitude $7^0$25'9s E, latitude $10^0$30'4s N and longitude $7^0$25,9s E, latitude $10^0$30'3s N and longitude $7^0$25'8s E, latitude $10^0$30'1s N and longitude $7^0$25'6s E and latitude $10^0$30'2s N and longitude $7^0$25'7s E. Tannery wastewaters from tannery activities are discharged into this river. Vegetables which are cultivated and irrigated with the river water are not only consumed locally but are supply to other parts of the state. Fig. 1 show the picture of the tannery activities in Tudun Wada and point of discharge into river Tudun Wada. The fig. 2 shows the picture of vegetable irrigated with river Tudun Wada and the point of discharge into river Kaduna.

Fig. 1. The picture of the tannery activities and point of discharge into river Tudun Wada

Fig. 2. The picture of vegetable irrigated with river Tudun Wada and the point of discharge into river Kaduna

Sample collection and analysis

Collection of water samples

Water samples were collected from River Tudun Wada in five (5) places marked A, B, C, D and E using sterile large clean plastic bottles and rinsing it three times with the river water to be collected. When collected, the water was swirl gently in the large container before been decanted into the sample bottles. A total of six (6) water samples were collected including point of discharge into the river by the tannery factory to serve as control at the depth of 0-10 cm. The samples were treated with 3 ml HNO_3 and transported to the laboratory for storage in the refrigerator for subsequent analysis.

Collection of soil samples

Soil samples were collected at the bank of River Tudun Wada from five (5) places marked A, B, C, D and E. A total of six (6) soil samples including the tannery site were collected at the depth of 0 - 20 cm. The samples were taken and transferred into polythene bags and transported to the laboratory. The soil samples were placed on a plastic tray and spread to air-dry. The soil samples were redistributed twice daily for two weeks for effective drying. When dried, the soil samples were crushed in a mortar and sieved through 2 mm pore sieve into plastic containers and stored for subsequent analysis.

Collection of vegetable samples

Vegetable Samples irrigated with river Tudun Wada were collected at the bank of River Tudun Wada from five farms marked A, B, C, D and E. The leaves and stalk were acquired; all samples appeared suitable for human consumption and had no signs of rotting. The samples were washed with distilled water to remove dust, sand and any other deposits on it. The samples were transported to the laboratory for analysis.

Digestion of soil samples

One gram (1.0 g) of the soil samples were placed in a 250 mL digestion tube and 10 mL of concentrated HNO_3 was added. The mixture was boiled gently for 30 min to oxidize all easily oxidizable matter. After cooling, 5 ml of 70 % $HClO_4$ was added and the mixture was boiled gently until dense white fumes appeared. The solution was cooled, filtered and transferred quantitatively to a 100 ml volumetric flask by adding distilled water [11].

Digestion of water sample

Exactly 100 ml aliquot of thoroughly mixed water samples were transferred to a beaker followed by addition of 2 ml of concentrated HNO_3 and 5 ml of concentrated HCl. The sample was covered with a watch glass and heated on a hot plate until the volume reduced to 20 ml. The beaker was removed and allowed to cool, then filtered into a 100 ml volumetric flask and made up to mark with distilled water [12].

Digestion of vegetable samples

Exactly one gram (1.0 g) of ground dried plant sample was placed in a small beaker. Exactly 5.0 ml of an acid mixture composed of HNO_3 and $HClO_4$ (4:1) was added to each sample and heated on a hot plate in a fume chamber. Then the digests were allowed to cool, filtered and transferred to a 100 ml volumetric flask and made up to mark with distilled water for analysis [13].

Transfer factor

The transfer factor (TF) is calculated by the formula below:

$$TF = \frac{concentration\ of\ metal\ in\ edible\ part}{concentration\ of\ metal\ in\ soil} \quad (1)$$

Result and discussion

Concentration of mercury (Hg) in the Soil, water and Spinacia oleracea

The concentration of Hg in the soil investigated is in the range of 2.10 - 2.90 µg/kg as shown in table 1. These concentration was lower compared to the concentration of Hg in soil irrigated with wastewater in Kubanni River was reported to be 2030 µg/kg [14]. The concentration of Hg in soils cultivated with edible vegetables in Tehran Province was reported to be 85 ± 6 µg/kg [15]. The concentration of Hg in *Spinacia oleracea* investigated in this research ranged from 0.500 – 1.30 µg/kg which is lower compared to the concentration of Hg in the leaves of *Spinacea oleracea* irrigated with wastewater from river Kubaanni was reported to be 1060 µg/kg [14]. The concentration of Hg in Spinach irrigated with wastewater was reported to be 38 ± 3 µg/kg [15]. The value of Hg in the irrigated soil and the species of Spinach studied is less than the values reported by other researchers cited. The low values recorded explain the fact that the Mercury (Hg) may not be from the tannery activities. The transfer factor ratio is < 1 which shows that there is more Mercury concentration in the soil than the plant parts [16]. Samples point A (0.524) and E (0.522), the transfer coefficient of Mercury is slightly greater than 0.50 which is an indication that the plant has a high probability of Hg contamination by anthropogenic activities [17].

Proximate composition of Spinacia oleracea

The result of the proximate composition of the *Spinacia oleracea* harvested from the banks of river Tudun Wada in Kaduna State is presented in table 2.

Table 1. Concentration of Hg in Water, Soil and *Spinacia oleracea* Irrigated with River Tundun Wada

Sample Code	Water (µg/l)	Soil (µg/kg)	*Spinacia oleracea* (µg/kg)	Transfer Factor (TF)
A	ND	2.10	1.10	0.524
B	ND	2.90	1.30	0.448
C	ND	2.10	0.50	0.238
D	ND	2.70	0.70	0.260
E	ND	2.30	1.20	0.522
Mean ± SD		2.42 ± 0.40	0.960 ± 0.30	0.398 ± 0.14

Table 2. Proximate Composition of *Spinacia oleracea* Irrigated with River Tudun Wada

Sample Code	Sample Name	% Ash	% Crude Fibre	% Crude Fat	% Protein	% Moisture
A	*Spinacia oleracea*	3.49 ± 0.0	5.47 ± 0.1	0.200 ± 0.1	3.90 ± 0.2	73.5 ± 0.3
B	*Spinacia oleracea*	3.34 ± 0.2	5.42 ± 0.1	0.0498 ± 0.1	3.87 ± 0.3	73.7 ± 3
C	*Spinacia oleracea*	4.55 ± 0.1	5.52 ± 0.2	0.149 ± 0.0	4.00 ± 0.1	73.8 ± 3
D	*Spinacia oleracea*	4.56 ± 0.1	5.39 ± 0.2	0.0498 ± 0.01	3.87 ± 0.1	72.5 ± 3
E	*Spinacia oleracea*	3.38 ± 0.1	1.99 ± 0.0	0.0498 ± 0.0	4.03 ± 0.2	73.7 ± 4
Mean ± SD		3.86 ± 0.13	4.76 ± 0.15	0.0997 ± 0.07	3.93 ± 0.18	73.4 ± 2.7

Ash

The ash content of the vegetable analyzed was 3.86 ± 0.13 %. The ash content of some vegetables investigated from Benue State are in the range of 1.06 - 2.37 % [18]. which is lower than the values recorded in this work probably it could be due to varietal differnces. The proximate parameters of Indigo (*Indigofera astragalina*) from Sokoto were reported; the ash content is 8.17 % [19]. The proximate composition of vegetables irrigated with polluted water report the ash content in the range of 8.65 - 8.97 % [20]. The proximate composition of *Vernonia amygdalina* harvested from Eleme and reported the ash content to be 10.4 % [21]. The ash content values reported by [19], [20] and [21] are higher than the values recorded in this research.

Crude fibre

The fibre content of the vegetable analyzed has a mean value of 4.76 ± 0.15 %. The crude fibre content of some vegetables investigated from Benue State are in the range of 1.30 - 20.2 % [18]. The proximate parameters of Indigo (*Indigofera astragalina*) from Sokoto were reported; the crude fibre content is 2.67 % [19]. The proximate composition of vegetables irrigated with polluted water and reports the crude fibre content in the range of 10.8 - 11.3 % [20]. The proximate composition of *Vernonia amygdalina* harvested from Eleme and reported the crude fibre content to be 10.2 %. [21]. The fibre content values reported by [20], [18] and [21] are higher than the values recorded in this work, this could be due to the nature of the soil, plant species and the anthropogenic activities in those places.

Crude fat

The fat content of the vegetables analyzed has a mean value of 0.10 ± 0.07 % similar to some vegetables investigated from Benue State are in the range of 0.05 - 0.71 % [18] which is in the range of the value recorded in this work. The proximate parameters of Indigo (*Indigofera astragalina*) from Sokoto were reported; the crude fat content is 5.00 % [19]. studied the proximate composition of vegetables irrigated with polluted water and report the crude fat content in the range of 3.05-3.29 % [20]. studied the proximate composition of *Vernonia amygdalina* harvested from Eleme and reported the crude fat content to be 2.25 % [21]. The fat content values reported by [19], [20] and [21] are higher than the values recorded in this research.

Protein

The protein content of the vegetables recorded a mean value of 3.93 ± 0.18 %. The crude protein content of some vegetables investigated from Benue State are in the range of 0.03 - 0.33 % [18], lower than the values reported in this work. The proximate parameters of Indigo (*Indigofera astragalina*) from Sokoto were reported; the crude protein content is 8.23 % [19]. The proximate composition of vegetables irrigated with polluted water reports the crude protein content in the range of 4.96 - 5.08 % [20]. The proximate composition of *Vernonia amygdalina* harvested from Eleme was analyzed and reported the crude protein content to be 10.7 % [21]. The protein content values reported by [19], [20] and [21] are higher than the values recorded in this research.

Moisture

The moisture content of the vegetables recorded a mean value of 73.4 ± 2.7 %. The moisture content of some vegetables investigated from Benue State are in the range of 62.3 - 93.4 % [18] which is far higher than the values reported in this work. The proximate parameters of Indigo (*Indigofera astragalina*) from Sokoto were reported; the moisture content is 50.1 % [19]. The proximate composition of *Vernonia amygdalina* harvested from Eleme determined and reported the moisture content to be 4.12 % [21]. The moisture content values reported by [19,21] are lower than the values recorded in this research.

Conclusions

In this study, the levels of Hg recorded in the soil, water and *Spinacea oleracea* are lower than the values in the literature cited; this could be due to low level of pollution in the area and is an indication that the tannery wastewater discharged into river Tudun Wada may or may not contain mercury salt. The transfer factor ratio shows more mercury concentration in the soil than plant parts which also explain that the contamination of the vegetable parts with mercury is not from the tannery activities and we recommend that further work be carried out on the soil and the vegetables parts in order to trace other sources of metal contamination by the vegetables.

Conflict of interest

Authors declared no conflict of interests.

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