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Research Paper

Analysis of Iron and Zinc in Soil and Spinach Grown in Irrigated Farmland of Kaduna Metropolis Nigeria

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Abstract **-**This study was conducted to determine the level of iron and zinc in soil and spinach grown in irrigated farmland of Kaduna metropolis. Twenty sampling sites were selected with one control site. Concentration of these metals was determined using atomic absorption spectrophotometer. In the soil analysis it was found most of the concentrations were higher that obtained in the control site. In spinach samples, it found that mean concentration for iron was found to be in the range of 1.84±1.60µgg^{-1} to 14.47±3.42µgg^{-1} and zinc ranged from 0.57±0.49µgg^{-1}to 18.49± 1.91µgg^{-1}.This also shows that concentrations of iron and zinc in spinach were within FAO/WHO Allimentarious standard. Pearson correlation shows positive correlation between soil and vegetable. Therefore, consumption of spinach from these study areas may not constitute health hazard to human at the time this research work.

Keywords: Heavy Metals, Soil, Spinach, Atomic Absorption Spectrophotometer, Kaduna Metropolis, Nigeria etc.

Introduction

Heavy metals and persistent organic pollution are concern due to their potential harmful effects on human beings and environment [8]. Studies have shown that heavy metals are potentially toxic to crops, animals and human when contaminated soil are used for crop production [18].

Heavy metals are discharged into the environment, through industrial activities automobile exhausts, heavy duty electric power generators, refuse burning and pesticides used in agriculture etc. Heavy metals play an important role in body metabolism. The deficiency of trace metals also cause diseases. Whereas their excess cause toxicity to human life [5]. Unlike organic waste, heavy metals are non-biodegradable and they can be accumulated in living tissues, causing various diseases and disorders, therefore, they must be removed before discharge [9].

Ahumada et al., (2004) mentioned that high concentration of metals in soil does not necessarily imply their release or their availability to plants. The mobility and bioavailability of heavy metals depend heavily on their physical and chemical form.

Soil is a vital resource for sustaining basic human needs, a quality food, food supply and a liveable environment [17]. Municipal solid waste has been found to contain appreciable quantity of heavy metals such as Cd, Zn, Pb and Cu which may eventually end-up in the soil [2]. Other identifiable sources include atmospheric depositions, manure and fertilizers, pesticides and industrial discharge [6]. The accumulation of trace metals in agriculture and non-agricultural soils poses health hazards [12].

Vegetables are staple part of food and are taken both in cooked and raw forms. In some settlements within Kaduna metropolis, substantial amount of vegetable were produced. These farms were irrigated with waste water from Kaduna River and drainages within Kaduna metropolis. For the past decades, water from these rivers was clean, however, with the increase in urban population and industrialization it now becomes contaminated with various pollutants among which are heavy metals.

Material and Methods

Sample and Sampling

Spinach samples were collected from October 2009 to February 2010 from twenty one (21) different irrigation site of the farmland of the Kaduna metropolis where they were irrigated with water from the river or pond which are sometimes contaminated. Soil samples were also randomly collected from the farm where these vegetables were grown and irrigated with water. These samples were then stored in polythene bags and taken to the laboratory and dried in an oven at 100^0c.

The dried samples were ground with mortar and pestle and sieved with 2mm sieve.

Description of the Sampling Sites

Soil samples for heavy metal determination were collected from twenty one (21) irrigation sites of the Kaduna metropolis. These sites were Kabala (KBL), Danmani (DMN), Rigasa (RGS), Barnawa (BNW), Makera (MKR), Kakuri (KKR), Badiko (BDK) Nasarawa (NAS, Malali (MAL), Kudende (KUD), Kinkinau (KKN), Kawo (KWO), Unguwan Rimi (URM), Unguwan Sanusi (UNS), Tudun Wada (TDW), Doka (DKA), Unguwan Dosa (UDS), Kabala Costain (CTA), Kurmin Mashi (KMS) and Abakpa (ABK). In this research work soil sample from Rigachikun (RCK) irrigation site was taken as control site.

Sample Preparation

Spinach samples

5g of the ground spinach samples were ashed in a muffle furnace at a temperature of 550^0c for five hours and digested with 20cm^3 of HNO_3/H_2O_2 (2:1). The digested residues were dissolved with 50cm of distilled water and filtered in 50cm^3 volumetric flask.

Soil sample

20g of the finely ground soil samples was mixed with 60cm^3 (5:5:1) $H_2SO_4/HNO_3/HCl$ acid mixtures and the content were refluxed for 12 hours. The sample was washed with 1M HNO_3 and 100cm^3 of deionized water was also added and centrifuged. The elements (Fe & Zn) were determined using bulk scientific model VPG 210 model atomic absorption spectrophotometer (AAS).

In order to investigate the ratio of the concentration of heavy metal in a plant to the concentration heavy metal in soil, the transfer factor was calculated based on the method described by *Oyedele et al, 1995 and Harrison and Chirgawi, 1989*.

$$TF = Ps\ (\mu gg^{-1} / St\ (\mu gg^{-1})$$

Where Ps is the plant metal content originating from the soil and St is the total content in the soil.

Results and Discussion

The mean concentration of iron and zinc in soil and spinach at various irrigation sites of the Kaduna metropolis are summarized in the below Tables.

KEY: SL = soil

Analysis of iron and zinc Concentrations in Soil

Table 1.0, shows Iron distribution of soil in the irrigation site of the Kaduna metropolis. The result shows that most of the sampling sites had higher concentrations of Iron than the control site (21.70μgg^{-1}). Table 1.0, also shows Zinc distribution of soil in the irrigation site of the Kaduna metropolis. The result shows that all sampling sites had higher concentrations of Zinc than the control site (17.38µ).Zinc concentrations for soil obtained from various sampling sites were higher than 13.56μgg^{-1} and 16.72μgg^{-1} for the Alau dam and Gongulon soil samples respectively as reported by *Uwah et al 2009*.

Sharman et al., (2007) reported a concentration of zinc as 43.56μgg^{-1} in the soil which is higher than the concentration recorded during the present study. Infact high concentration of zinc in the soil may be ascribed to the use of zinc in fertilizers and metal based pesticide.

Oyedele et al., (2008) reported lower concentration of zinc 1.03μgg^{-1} in the soil from Ile-Ife Nigeria which is lower than the concentration of all sample analyzed for zinc in this research work

KEY: SP = Spinach

Iron Concentration in spinach Samples

Table 2, shows mean concentrations for iron in spinach samples from irrigated farmland of Kaduna metropolis.The concentration of all the sampling sites were lower than 8.87 μgg^{-1}obtained from Rigachikun (control site) in contrast with samples from Kabala, Danmani, Makera, Badiko, Kudenda having higher concentration than the control site.

Hussain et al., (1995) reported 13.33μgg^{-1} for cucumber at Shuwaikh which is higher that all the concentration obtained in present study. 65.63μgg^{-1} was reported for iron in spinach by Hashmi et al., (2005), which is also higher than the concentration obtained in this research work.

Zinc Concentration in spinach Samples

Table 2, shows Zinc concentration in spinach, the mean concentration of samples analysed were far below WHO standard of 60.00μgg^{-1}.This implies that, the concentrations for Zinc in spinach are within the tolerable limit in all the sampling sites. However, there are no isolated cases in any site.

Most of the concentrations for Zinc in spinach sample recorded in this research work were lower than 10.38μgg^{-1} as reported by *Hashmi et al., (2005)*.

However, the concentrations of zinc recorded in the present study were also lower that 24.00μgg^{-1} reported by *Sharma et al (2007)* for zinc in vegetable.

Based on the result obtained in the present study iron and zinc does not pose any threat to the consumers of such spinach in the irrigation site of the Kaduna metropolis.

Table 3, shows the correlation coefficient for iron with $p = 0.002 < 0.05$ for spinach, there is significant correlation between Iron concentrations in soil and Iron concentrations in the vegetables. The correlations is strongly positive with the value of $r = 0.630$. This implies that both Iron concentrations in soil and Iron concentrations in the vegetables increase and decrease together in the same direction. As Iron concentrations in soil increases, Iron concentrations in the vegetables also increases and vice versa.

Table 4, shows correlation coefficient for zinc with $p = 0.000 < 0.05$ for spinach, this shows that there is significant correlation between Zinc concentrations in soil and Zinc concentrations in the vegetables. The correlation is strong positive with the value of $r = 0.787$. This implies that both Zinc concentrations in soil and Zinc concentrations in the vegetables increase and decrease together in the same direction. As Zinc concentrations in soil increases, Zinc concentrations in the vegetables also increases and vice versa.

Table 5, shows transfer factor for heavy metal from soil to spinach. All transfer factor are below 1 with the exception of sample from Kawo , Tudunwada, Unguwan dosa, Abakpa and Rigachikun (control).
The value of Fe were low when compared with 0.50 as observed by *Hannatu et al., (2001)* and also lower than 0.50 reported by *Uwa et al.*
Hannatu et al (2001) reported 0.30 lower than the obtained transfer factor for Zn but there are few exception from Kabala and Tudunwada.

Table 6, shows percentage ash in spinach sample from irrigated farm land of Kaduna metropolis. The value obtained in this study was lower than 10.83% for spinach as reported by Umar et al 2007. Most percentage ash obtained in the study areas were higher than 17.33% obtained from Rigachikun (control site) .

Conclusion

In the present study, the concentration of iron and zinc were determined in the soil and spinach obtained from irrigation site of the Kaduna Metropolis, Nigeria. The result revealed that the concentration of these metals were within the recommended limit stipulated by FAO/WHO (2007) alimentarius. Therefore consumption of spinach from the study areas may not posed health hazards to human at the time of study.

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Table 1: Concentrations of Iron and Zinc in soil samples from different irrigation sites of the Kaduna metropolis.

Sampling Sites	Mean concentration	
	Fe (μgg^{-1})	Zn (μgg^{-1})
SL (KBL)	44.88 ± 1.08	32.38 ± 6.18
SL (DMN)	44.83 ± 0.94	31.17 ± 9.03
SL (RGS)	102.23 ± 1.91	66.93 ± 26.29
SL (BNW)	101.83 ± 2.49	34.36 ± 25.49
SL (MKR)	43.38 ± 2.96	41.4 ± 0.74
SL (KKR)	96.14 ± 10.68	51.72 ± 9.90
SL (BDK)	45.71 ± 1.97	24.27 ± 6.71
SL (NAS)	43.37 ± 9.35	31.25 ± 6.38
SL (MAL)	12.53 ± 0.75	27.25 ± 0.42
SL (KUD)	47.42 ± 0.93	40.37 ± 4.48
SL (KKN)	35.60 ± 12.34	29.37 ± 2.29
SL (KWO)	102.48 ± 3.63	46.99 ± 5.27
SL (URM)	104.61 ± 1.44	62.91 ± 30.13
SL (UNS)	101.86 ± 2.00	49.39 ± 1.63
SL (TDW)	100.01 ± 3.09	40.84 ± 6.18
SL (DKA)	74.22 ± 60.75	29.79 ± 24.67
SL (UDS)	16.00 ± 0.20	25.32 ± 1.61
SL (CTA)	29.25 ± 0.65	27.87 ± 0.63
SL (KMS)	39.52 ± 0.97	22.43 ± 0.70
SL (ABK)	19.50 ± 1.54	25.6 ± 0.58
SL (RCK)	21.70 ± 16.15	17.38 ± 3.70

Table 2: Concentrations of Iron and Zinc in Spinach from different irrigation sites of the Kaduna metropolis.

Sampling Sites	Mean concentration					
	Fe (μgg^{-1})			Zn (μgg^{-1})		
SP (KBL)	13.61	±	16.13	6.26	±	5.51
SP(DMN)	9.39	±	3.60	5.48	±	3.14
SP (RGS)	5.32	±	0.29	18.49	±	1.91
SP(BNW)	1.84	±	1.61	1.97	±	1.73
SP (MKR)	9.33	±	8.21	7.06	±	3.78
SP (KKR)	4.13	±	1.50	15.39	±	7.64
SP (BDK)	10.19	±	4.22	0.57	±	0.49
SP (NAS)	5.2	±	0.72	5.27	±	0.76
SP (MAL)	8.2	±	3.98	7.07	±	0.47
SP (KUD)	10.33	±	1.14	9.97	±	2.24
SP (KKN)	8.07	±	3.41	6.77	±	1.31
SP(KWO)	6.13	±	1.10	9.37	±	1.79
SP(URM)	6.00	±	2.00	6.53	±	2.40
SP (UNS)	8.07	±	5.78	5.00	±	0.80
SP(TDW)	8.12	±	5.47	12.48	±	14.34
SP (DKA)	8.16	±	2.63	6.28	±	1.64
SP (UDS)	8.93	±	4.92	6.63	±	1.52
SP (CTA)	9.87	±	2.27	7.27	±	6.19
SP (KMS)	14.47	±	3.42	6.20	±	4.36
SP (ABK)	8.93	±	2.27	5.10	±	2.59
SP (RCK)	8.87	±	2.73	3.07	±	1.42

Table 3: Correlation coefficients for Iron

Vegetable type			Iron concentration in spinach sample (ug/g)
Spinach	Iron concentration in soil sample (ug/g)	Pearson Correlation	0.630
		Sig. (2-tailed)	0.002

Table 4: Correlation coefficients for Zinc

Vegetable Type			Zinc concentration in spinach sample (ug/g)
Spinach	Zinc concentration in soil sample (ug/g)	Pearson Correlation	0.787
		Sig. (2-tailed)	0.000

Table 5: Transfer factor (TF) for each metal from soil to Spinach

Sampling Sites	Fe (μgg^{-1})	Zn (μgg^{-1})
Kabala	0.30	0.41
Danmani	0.21	0.18
Rigasa	0.05	0.27
Barnawa	0.11	0.06
Makera	0.22	0.18
Kakuri	0.05	0.30
Badiko	0.22	0.02
Nasarawa	0.12	0.16
Malali	0.65	0.26
Kudenda	0.22	0.25
Kinkinau	0.23	0.23
Kawo	0.06	0.19
Unguwan Rimi	0.06	0.10
Unguwan Sanusi	0.08	0.10
Tudunwada	0.08	0.31
Doka	0.11	0.21
Unguwan Dosa	0.56	0.26
Costain	0.34	0.26
Kurmi mashi	0.37	0.28
Abakpa	0.46	0.19
Rigachikun	0.41	0.18

Table 6: Percentage Ash in Spinach Sample

Samples	Mean Percentage ash (%)	Std Deviation (%)
Kabala	14.0	2.00
Danmani	17.66	2.08
Barnawa	20.00	8.72
Makera	15.00	3.00
Badiko	20.67	2.08
Nasarawa	18.00	2.00
Malali	18.67	3.06
Kudende	20.00	3.61
Kinkinau	23.67	3.51
Kawo	17.33	3.06
Unguwan Rimi	24.67	4.50
Unguwan Sanusi	22.00	3.00
Tudun Wada	26.00	4.00
Doka	19.67	3.51
Unguwan Dosa	27.33	1.53
Costain	16.00	2.00
Kurmin Mashi	17.33	4.16
Abakpa	17.33	3.06
Kakuri	17.67	2.51
Rigasa	18.33	3.51
Rigachikun Control	17.33	3.06