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Risk Assessment of Metals in Irrigated Food Crops Grown along the Bank of Tungan Kawo Dam, Kontagora, Nigeria

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Abstract: *This study was aimed at assessing the health risk of metals in vegetables grown along the bank of Tungan Kawo Dam. Different vegetables; Atarugu, Tomatoes, Onion bulb, Onion leaves, Fresh okro, Spinnach, Karkashi and Ayoyo were collected from across the farmland in cool and dry, hot and dry, warm and wet, and warm and dry seasons. The samples were analysed for Cd, Cu, Fe, Ni, Pb and Zn using Atomic Absorption Spectrophotometer (AAS). The levels of metals in all the vegetable samples recorded high concentration of Cd, Cu (with few exceptions), Fe, Ni, Pb and Zn above the standard recommended limits by WHO. Evaluation of health risk index indicated as hazard quotient (HQM) revealed highest for Cd and Ni above 1. This indicates that consumer of these vegetable might be at risk. Hence, it is concluded that vegetables harvested from the bank of Tungan Kawo Dam are dangerous to the consumers.*

Keywords: *Hazard Quotient, Vegetables, heavy metals, Tungan Kawo Dam*

I. Introduction

Vegetable crops as source of minerals, vitamins, carbohydrates, essential amino acids and dietary fibres plays an important role in the customs, traditions and food culture of African households (Sani et al., 2011). It requires access to fertile land, water and other inputs so as to boast the production particularly in poor and developing countries. Leafy vegetables occupy a very important place in the human diet, but unfortunately constitute a group of foods which contributes maximally to nitrate and other anions as well as heavy metals consumption. The excessive application of nitrogen and other inorganic fertilizers and organic manures to these vegetables can accumulate high levels of nitrate and other anions as well as heavy metals. Consequently their consumption by humans and animals can pose serious health hazards. Although some heavy metals such as Cu, Zn, Mn and Fe are essential in plant nutrition, many of them do not play any significant role in the plant physiology. The uptake of these heavy metals by plants especially leafy vegetables is an avenue of their entry into the human food chain with harmful effects on health (Akan et al., 2009).

The primary source of heavy metals in irrigation and drainage canals is the discharge of domestic waste waters which contain fairly high concentrations of metals such as copper, iron, lead and zinc, which are derived from household products such as cleaning materials, toothpaste, cosmetics and human faeces (El-Shaikh et al., 2005). Also, there are additional quantities introduced from household and washings of herbicides and pesticides of the agricultural land. Some heavy metals such as zinc, copper, manganese, and iron are essential for the growth and well being of living organisms including man. However, they are likely to show toxic effects when organisms are exposed to levels higher than normally required. Other elements such as lead and cadmium are not essential for metabolic activities and exhibit toxic properties (El-Shaikh et al., 2005).

In Nigeria, Government has in recent years built additional dams and canals for dry season farming and have increased the provision of fertilizers, herbicides, pesticides and modern farm equipments to boost both dry and rainy seasons farming of food and vegetable crops production (Akan et al., 2009). While efforts are being consolidated by the government towards improving and increasing food and vegetable crops production, the problem of waste effluents into water bodies is undermining these efforts, especially in Tungan Kawo dam where domestic and agricultural waste are discharged into drain and subsequently into the which is used for drinking, fishing and irrigation of vegetable crops during the dry season farming. Mineral elements are known to be essential in our diet and may enter the food crops or vegetables from soil through mineralilzation by crops, food processing or environmental contamination (Miller, 1996; Onianwa, 2001).

In these areas of study, vegetables are used as food include those used in making soups or served as integral parts of the main sources of a meal. Each plants species has its nutritive requirements differing from others. Thus different plants supported by identical solutions will contain varying concentrations of minor and macro elements (Akan et al., 2009). Based on the above fact, the present aimed to assess the health risk of populace consuming vegetables harvested from Tungan Kawo dam farm lands across the four seasons (cool and dry, hot and dry, warm and wet, and warm and dry).

II. Material and Methods

The Study Area

The Dam is located in Tungan Kawo village, northwest of Kontagora, 7km along Kontagora – Yauri road in Kontagora Local Government Area of Niger State. The Dam has a catchments area of 143km^2. The Dam has a total storage capacity of 17.7M Cubic meters, 20m high and Dam crest length of 1000m. The Dam was commission in May 1991. It is the largest source of water supply in Kontagora Township. The people of Tungan Kawo and its environs are predominantly farmers and have remained so for years. In this area, vegetables are irrigated with dam water and all kinds of available waste and polluted waters. Similarly, to enhance the yield of these vegetables, fertilizers and manures are occasionally added to the soil.

Sampling

The sampling area was divided into five sampling sites 1 – 5. The control site was located further away from the study area. The sample sites are shown in Figure 1.

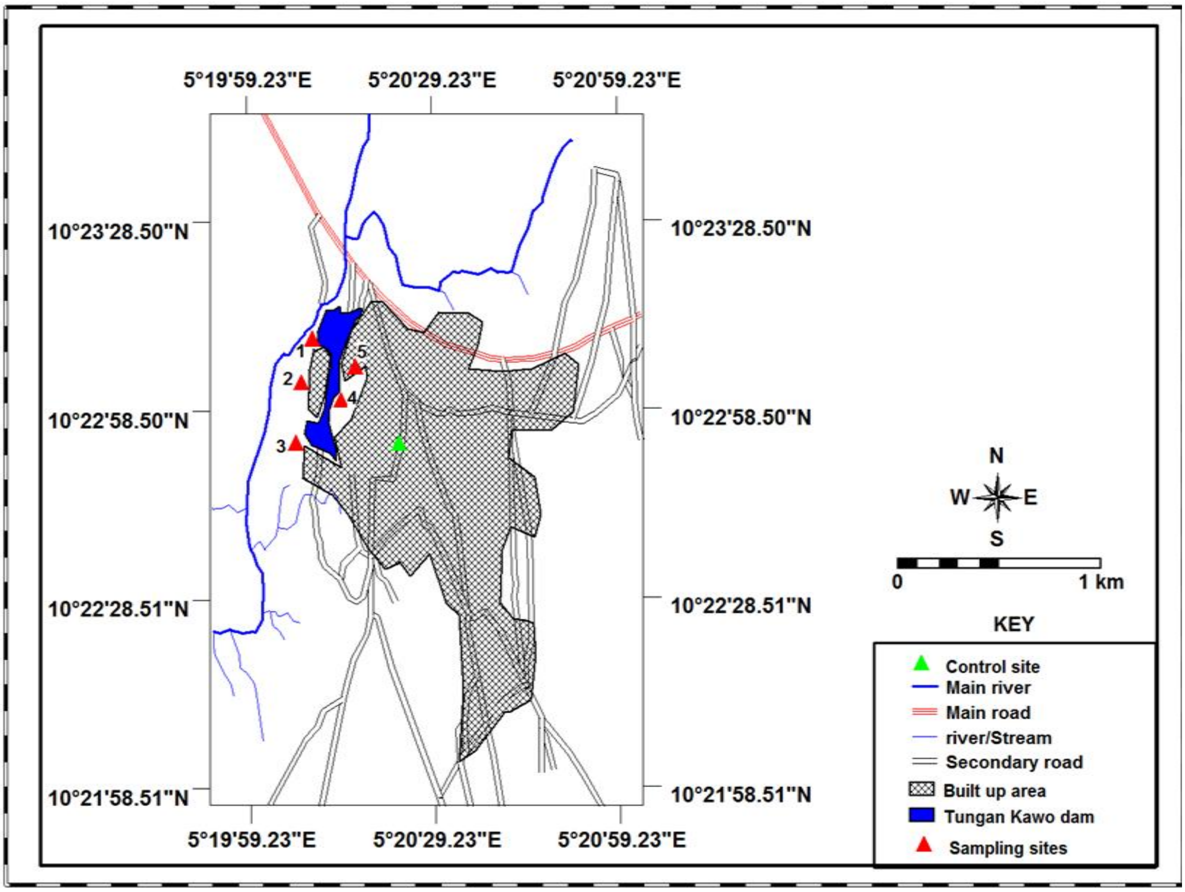

Figure 1: Tungan Kawo Dam showing sampling sites

Source: Adapted and modified from Europa Technologies google earth image, 2010

The vegetable samples – Tattasai (T), Atarugu (A), Tomatoes (To), Onion bulb (OB), Onion leaves (OL), Fresh okro (O), Spinach (S), Karkashi (K) and Ayoyo (AY) were collected at the five sites on a seasonal basis between February 2012 and September 2013 as follows:

Seasons

Cold and dry season	-	December – February
Hot and dry season	–	March – May
Warm and wet season	-	June – August
Warm and dry season	-	September – November

Sample Pre-treatment and Digestion

Vegetable samples were thoroughly washed to remove all adhered soil particles. Samples were cut into small pieces, air dried for 2 days and finally dried at 100 ± 1^{0C} in an hot air oven for 3 h. The samples were ground in warm condition and passed through 1 mm sieve. 0.5g of each of the vegetable samples were weighed with a digital analytical meter AND (GR-200-EC) balance into 100ml beaker. 5ml of concentrated nitric acid and 2ml of perchloric acid were added and the mixture heated on a low heat hot plate for 15minutes at 70^0C until a light coloured solution was obtained an indication of complete digestion. The sample solution was not allowed to dry during digestion. The sample solution was first filtered into a 50ml standard flask and two 5ml portions of distilled water were used to rinse the beaker and the contents filtered into the 50ml flask. The filtrate was allowed to cool and then diluted to mark and the contents mixed thoroughly by shaking. The digestion was done in triplicates for the vegetable samples. The sample digests were run on Atomic Absorption Spectrophotometer for Cd, Cu, Fe, Ni, Pb and Zn concentration.

Quality Assurance

In order to ascertain the efficiency and reliability and precision of the atomic absorption spectrometry machine and the reliability of the digestion method used for the analysis of Cd, Cu and Fe in the irrigated tomatoes and Onions samples, three sub-samples of one of the tomatoes onion samples were spiked with (0.5 mgL-1 Cd, Cu and Fe, and 3.00 mgL-1 Ni, Pb and Zn) multi-element standard solution.

Health Risk Index

The index hazard quotient (HQM) according to Nabulo et al. (2010) was used to calculate the human health risk resulting from the consumption of the vegetables. The formula below was used for the HQM calculation.

$$HQM = {DI \times MF_{Veg}} \Big/ {WB \times R_f}$$

Where

DI is the daily intake of vegetable, 0.182 and 0.118 kg/d for adults and children, respectively according Nabulo et al. (2010) was use for the calculation.

MF_{veg} is the heavy metal concentration in the vegetable (mg/kg)

R_f is defined as the maximum tolerable daily intake of a specific metals that has no adverse effect (mg/kg/d).

WB is the body weight, the body weight of an adult was assumed to be 55.7 and 14.2 for children (Nabulo et al., 2010).

If the value of HQM calculated should exceed 1 (HQM > 1), then there may be potential risk to consumer.

Data Analysis

Statistical analysis was carried out using SPSS 20.0 for Windows. Differences in the concentrations of heavy metals from the sites were determined using either the Student t-test or the analysis of variance. The post hoc test was used to separate the significant means between the sites.

III. Results and Discussion

Heavy Metal Concentrations in Vegetable Samples

The results of Cd, Cu, Fe, Ni, Pb and Zn concentrations in Tattasai (T), Atarugu (A), Tomatoes (To), Onion bulb (OB), Onion leaves (OL), Fresh okro (O), Spinnach (S), Karkashi (K) and Ayoyo (AY) in the four seasons are shown in Tables 1 - 4. Generally, the level of Cd, Cu, Fe, Ni, Pb and Zn in all the vegetable samples indicate significantly ($p < 0.05$) different across the season. Also, a common trend could not be established for the concentration of all the studied metals across the four seasons. For Cd, the concentration range between 5.77 (S) – 12.43 (T), 5.37 (OB) – 13.23 (To), 0.93 (S) – 11.40 (O), and 4.98 (OB) – 8.93 (S) mg/kg in cool and dry, hot and dry, warm and wet, and warm and dry seasons, respectively. The trend in the concentration of Cd for the vegetable samples showed significant variation ($p < 0.05$) across the seasons. The highest concentration of Cd was recorded for tomatoes (13.23mg/kg) in hot and dry season. This is due to the fact that the dam have received run-off from the farmland due to the early rain (March – May). In the present study, all the concentrations recorded for Cd in the vegetable samples were above the accepted limit of 0.21mg/kg (WHO, 2001). The application of Superphosphate fertilizer on farmlands could be the reason for the high level of Cd in the vegetables. Accumulation of Cd above the recommended limits causes acute and chronic poisoning of the liver and may also replace calcium in the bone of the young children (Heyes, 1997).

The concentration of Cu varied between 7.87 (OB) – 25.74 (A), 4.87 (S) – 28.74 (To), 4.87 (OB) – 21.33 (OL), and 5.58 (OB) – 21.95 (O) mg/kg in cool and dry, hot and dry, warm and wet, and warm and dry seasons, respectively. Similar to Cd, it is observed that the highest level of Cu was recorded for tomatoes (28.74mg/kg) in hot and dry season. The results showed that the level of Cu in tomatoes was exceptionally above the recommended limits of 15mg/kg (WHO, 2001) in all the seasons. Similarly, Atarugu (with exception of warm and dry season), onion bulb (in hot and dry season), onion leaves (in cool and dry, and warm and wet seasons), okro (with exception of cool and dry season), spinach (in cool and dry, and warm and dry seasons), Karkashi (in cool and dry season), and Ayoyo (in hot and dry, and warm and dry seasons) are above the recommended limit. In sufficient amounts that do not exceed 15mg/kg, Cu plays an important role in the maintenance of immunity, fertility, formation of melanin, and promotion of consistent pigmentation (Lion and Olowoyo, 2013). Also, it predicted to play a role in preventing high blood pressure by keeping cholesterol levels low. However, in high levels it may cause enzyme malfunctioning (Singh and Taneja, 2010) and may pose risk in reduction of total homocysteine and folate which are essential to body metabolism (Tamura and Turnland, 2014).

Fe concentrations ranged between 488.87 (OB) – 1826 (A), 426.37 (OB) – 1335.71 (OL), 538.33 (OB) – 1971.67 (S), 469.25 (K) – 3280.90 (To) mg/kg in cool and dry, hot and dry, warm and wet, and warm and dry seasons, respectively. For Fe, the levels of Fe in all the vegetable samples were significantly higher than all the other metals. The highest concentration of Fe was recorded for tomatoes (3280.90mg/kg) in warm and dry season. However, the concentrations of Fe in all the samples exceeded the 425mg/kg set by the WHO (2001). Fe is an important element in human body metabolism which acts as a catalyst and it contains haemoglobin (Hashmi et al., 2007). It is important for diabetic patient, since it helps in the oxidation of carbohydrates, protein and fat thereby controlling weight (Khan et al., 2007). In humans, excess amounts of Fe in the circulation may damage cells in the liver (Xing et al., 2010). Several lesions in the gastrointestinal tract, followed by metabolic acidosis, shock and toxic hepatitis (Elinder, 1986).

The concentration of Ni varied between 13.73 (OB) – 25.33 (K), 11.67 (OL) – 21.73 (T), 11.00 (T) – 25.99 (To), and 15.23 (OL) – 77.00 (A) mg/kg in cool and dry, hot and dry, warm and wet, and warm and dry seasons, respectively. Similar to Fe, Ni is far above the 1.63mg/kg recommended limits (WHO, 2001). Highest concentration of Fe was recorded for Atarugu (77.00mg/kg) in warm and dry season. Although, Ni had concentrations far exceeded the recommended limit of 1.63mg/kg, these values may not be of great concern because Ni toxicity in humans is not a very common occurrence due to the fact that its absorption in the body is very low (Oninwa et al., 2000). Hence, Ni intake via foodstuff does not cause hazards for the majority of consumer (Codex, 1995).

Also, Pb varied between 0.73 (OB, OL, K) – 6.40 (S), 0.43 (OB) – 6.40 (To), 0.74 (OL) – 4.23 (AY), and 0.47 (OL) – 6.95 (A) mg/kg in cool and dry, hot and dry, warm and wet, and warm and dry seasons, respectively. From the present study, the concentration of Pb exceeded the recommended limits of 0.43mg/kg (WHO, 2001) with exception of concentration for onion bulb in hot and dry season. The high level of Pb in this study could be attributed to acid-Pb batteries as waste dumped in the dam from run off during the seasons. The severe accumulation of Pb in the human body may induce both acute and chronic poisoning and it may also affects the functioning of the kidney and the liver adversely (Heyes, 1997).

Zn concentrations across dry seasons ranged between 39.06 (AY) – 156.00 (A), 32.30 (OB) – 204.53 (AY), 30.18 (K) – 237.33 (A), and 33.97 (K) – 155.12 (A) mg/kg in cool and dry, hot and dry, warm and wet, and warm and dry seasons, respectively. The highest concentration of Zn was recorded for Atarugu (237.33mg/kg) in the warm and wet season. The concentrations of Zn in all the samples in the four seasons were generally above the recommended limit for Zn concentration in human diet 10mg/kg (WHO, 2001). The values recorded in this study is were similar to 70 – 320 mg/kg reported by Lion and Olowoyo (2013), though higher than 0.01 – 2.63mg/kg reported in Nigeria (Ekeanyanwu et al., 2010). This disparity between the results of the present study and those reported from other locations could be explained by the indiscriminate use of excess Zn as micronutrients in Agriculture practices in Nigeria during the last two decades. It has been reported that the utilization of inorganic fertilizers in agriculture vegetables has increased more than 50 times in Nigeria and world over (Singh and Teneja, 2010). Zn is one of the most ubiquitous of the essential metals (Florence and Batley, 1980). The absorption of ingested Zn is highly variable (10 – 90%) (Elinder, 1986). Zn acts to diminish the toxicity of Cd and Cu (Florence and Batley, 1980). The presence of Zn in the human body promotes growth and development but in excess may lead to metal poisoning and growth retardation (Singh and Teneja, 2010).

In general, the extent and seriousness of Cd, Fe, Ni, Pb, Zn and Cu (with few exception) contamination in all the vegetable samples were high, above recommended limits. This is similar to other studies that the high concentrations of metals observed in the vegetables and food crops samples might be related to the concentrations of the metals in the soil.

Table 1 Concentration (mg/kg) of metals in vegetable crops grown during the cool and dry season

Vegetable	Metal					
	Cd	Cu	Fe	Ni	Pb	Zn
Tattasai	12.43±0.06	12.24±0.01	709.67±0.58	19.07±1.17	0.98±0.02	85.30±0.91
Atarugu	6.24±0.01	25.74±0.01	1826.13±0.58	22.26±0.04	2.40±0.10	156.00±1.00
Tomatoes	6.80±0.20	21.73±0.02	885.73±0.02	14.74±0.01	5.90±0.10	70.67±0.58
Onion Bulb	7.77±0.20	7.87±0.12	488.87±0.99	13.73±0.02	0.73±0.02	60.00±1.00
Onion Leaves	5.83±0.15	20.37±0.12	1068.73±0.02	15.83±0.15	0.73±0.02	53.33±0.15
Fresh Okro	7.68±0.10	14.90±0.10	871.00±1.00	22.27±0.21	1.74±0.01	76.37±0.15
Spinach	5.77±0.07	16.33±0.15	716.20±0.10	20.33±0.15	6.40±0.10	44.74±0.01
Karkashi	6.15±0.15	18.23±0.02	895.40±0.59	25.33±0.15	0.73±0.02	46.45±0.49
Ayoyo	7.90±0.10	14.40±0.10	687.73±0.02	23.84±0.14	1.24±0.01	39.06±0.60
WHO (2001)	0.21	15	425	1.63	0.43	10

Table 2 Concentration (mg/kg) of metals in vegetable crops grown during the hot and dry season

Vegetable	Metal					
	Cd	Cu	Fe	Ni	Pb	Zn
Tattasai	8.77±0.21	9.80±0.17	855.20±0.44	21.73±0.02	1.40±0.10	55.07±28.87
Atarugu	7.40±0.10	20.40±0.10	818.53±1.00	16.24±0.01	0.47±0.06	60.23±0.02
Tomatoes	13.23±0.02	28.74±0.01	1882.87±4.62	21.40±0.10	6.40±0.10	120.00±0.44
Onion Bulb	5.37±0.12	17.23±3.09	426.37±0.12	15.17±0.35	0.43±0.06	32.30±0.20
Onion Leaves	5.60±0.53	10.70±0.26	1335.71±0.05	11.67±0.11	NA	50.23±0.02
Fresh Okro	6.73±0.02	19.07±0.28	521.83±0.15	11.83±0.15	0.74±0.01	75.78±0.41
Spinach	7.19±0.07	4.87±0.23	779.97±0.42	13.84±0.14	0.73±0.02	57.08±0.29
Karkashi	7.93±0.12	8.90±0.17	588.82±0.39	20.23±0.02	1.23±0.02	33.90±0.17
Ayoyo	6.71±0.05	20.23±0.02	839.00±1.00	16.40±0.10	NA	204.53±0.85
WHO (2001)	0.21	15	425	1.63	0.43	10

NA: Not Available

Table 3 Concentration (mg/kg) of metals in vegetable crops grown during the warm and wet season

Vegetable	Metal					
	Cd	Cu	Fe	Ni	Pb	Zn
Tattasai	2.40±0.10	7.92±0.14	629.83±0.29	11.00±7.46	2.33±0.15	30.67±0.58
Atarugu	7.87±0.13	19.40±0.41	1157.72±2.68	23.68±0.10	3.23±0.02	237.33±0.52
Tomatoes	9.02±0.21	18.15±0.30	1446.48±3.41	25.99±0.44	3.40±0.10	74.70±0.26
Onion Bulb	5.05±0.26	4.87±0.13	538.33±2.89	16.20±0.26	1.23±0.02	34.92±0.52
Onion Leaves	5.21±0.05	21.33±0.52	1344.25±1.09	12.63±0.13	0.74±0.01	45.18±0.39
Fresh Okro	11.40±0.10	16.23±0.02	880.00±2.00	22.11±0.56	1.23±0.02	121.33±0.52
Spinach	0.93±0.08	8.91±0.29	1971.67±4.27	21.50±0.50	0.94±0.07	57.97±0.46
Karkashi	8.02±0.41	8.30±0.18	459.75±0.90	18.47±0.30	1.40±0.10	30.18±0.49
Ayoyo	8.23±0.02	12.87±0.13	617.67±2.52	21.92±0.52	4.23±0.02	174.12±0.55
WHO (2001)	0.21	15	425	1.63	0.43	10

Table 4 Concentration (mg/kg) of metals in vegetable crops grown during the warm and dry season

Vegetable	Metal					
	Cd	Cu	Fe	Ni	Pb	Zn
Tattasai	7.92±0.14	14.63±0.55	1384.23±0.02	23.00±0.67	2.40±0.10	115.67±0.58
Atarugu	6.87±0.13	12.83±0.29	959.75±0.66	77.00±1.00	6.95±0.09	155.12±0.55
Tomatoes	5.57±0.16	18.87±0.13	3280.90±2.12	17.40±0.10	NA	90.95±0.26
Onion Bulb	4.98±0.03	5.58±0.15	945.78±1.00	17.98±0.03	2.23±0.02	42.38±0.47
Onion Leaves	5.33±0.14	14.52±0.49	1244.45±0.61	15.23±0.28	0.47±0.06	50.20±0.33
Fresh Okro	6.98±0.25	21.95±0.26	1025.73±0.49	27.87±0.13	1.70±0.05	54.03±0.41
Spinach	8.93±0.08	16.25±0.25	853.00±1.00	21.92±0.14	1.23±0.02	133.92±0.14
Karkashi	7.87±0.13	7.98±0.03	469.25±0.66	22.38±0.47	1.23±0.02	33.97±0.46
Ayoyo	8.62±0.15	15.38±0.13	3912.00±1.00	21.75±0.44	1.23±0.02	94.03±0.41
WHO (2001)	0.21	15	425	1.63	0.43	10

NA: Not Available

Health Risk Index

The hazard quotient (HQM) of metals in vegetable samples as consumed by adult and children are presented in Tables 5 – 8. The HQM for Cd is generally far above Cu, Fe, Ni, Pb and Zn in this study, this is due to high concentration of Cd above the recommended limits. Value of HQM > 1 were also generally recorded for Ni across the seasons which indicates a potential risk for the consumer. The harvested vegetables posed the highest risk potential of Cd and Ni to the consumer. The values of HQM reported in this study are generally higher than compared to those of Lion and Olowoyo (2013). Contrary to Lion and Olowoyo (2013), the HQM value was generally higher for adult than for the children in this study.

IV. Conclusion

The results of the study showed that the vegetables harvested from Tungan Kawo Dam Bank Farmlands are contaminated with Cd, Cu (with few exceptions), Ni, Fe, Pb and Zn with values above the recommended limits by WHO. The highest concentration of all metals was recorded during the dry season, and indication that irrigation is the major contribution of these metals. Health risk index using the HQM indicates that there is health risk of Cd and Ni to consumers of these harvested vegetables. Hence, this study is significant due to general perception that vegetables harvested from irrigated sources as dam are safe. Hence, the study has clearly showed that vegetable harvested from Tungan Kawo Dam posed health risk to the immediate consumer.

Table 5 Hazard Quotient of metals in vegetable crops grown during the cool and dry season

Vegetable	Cd		Cu		Ni		Pb		Zn	
	Adult	Children	Adult	Children	Adult	Children	Adult	Children	Adult	Children
Tattasai	40.62	26.33	1.00	0.65	3.12	2.02	0.80	0.52	0.93	0.60
Atarugu	20.39	13.22	2.10	1.36	3.64	2.36	1.96	1.27	1.70	1.10
Tomatoes	22.22	14.41	1.78	1.15	2.41	1.56	4.82	3.12	0.77	0.50
Onion Bulb	25.39	16.46	0.64	0.42	2.24	1.45	0.60	0.39	0.65	0.42
Onion Leaves	19.05	12.35	1.66	1.08	2.59	1.68	0.60	0.39	0.58	0.38
Fresh Okro	25.09	16.27	1.22	0.79	3.64	2.36	1.42	0.92	0.83	0.54
Spinach	18.85	12.22	1.33	0.86	3.32	2.15	5.23	3.39	0.49	0.32
Karkashi	20.10	13.03	1.49	0.97	4.14	2.68	0.60	0.39	0.51	0.33
Ayoyo	25.81	16.74	1.18	0.76	3.89	2.53	1.01	0.66	0.43	0.28

The body weight of adult and children are 55.7 and 14.2kg (Nabulo et al. 2010)

Table 6 Hazard Quotient of metals in vegetable crops grown during hot and dry season

Vegetable	Cd		Cu		Ni		Pb		Zn	
	Adult	Children	Adult	Children	Adult	Children	Adult	Children	Adult	Children
Tattasai	28.66	18.58	0.80	0.52	3.55	2.30	1.14	0.74	0.60	0.39
Atarugu	24.18	15.68	1.67	1.08	2.65	1.72	0.38	0.25	0.66	0.43
Tomatoes	43.23	28.03	2.35	1.52	3.50	2.27	5.23	3.39	1.31	0.85
Onion Bulb	17.55	11.38	1.41	0.91	2.48	1.61	0.35	0.23	0.35	0.23
Onion Leaves	18.30	11.86	0.87	0.57	1.91	1.24	NA	NA	0.55	0.35
Fresh Okro	21.99	14.26	1.56	1.01	1.93	1.25	0.60	0.39	0.83	0.54
Spinach	23.49	15.23	0.40	0.26	2.26	1.47	0.60	0.39	0.62	0.40
Karkashi	25.91	16.80	0.73	0.47	3.31	2.14	1.00	0.65	0.37	0.24
Ayoyo	21.92	14.22	1.65	1.07	2.68	1.74	NA	NA	2.23	1.44

The body weight of adult and children are 55.7 and 14.2kg (Nabulo et al. 2010)

Table 3 Hazard Quotient of metals in vegetable crops grown during warm and wet season

Vegetable	Cd		Cu		Ni		Pb		Zn	
	Adult	Children	Adult	Children	Adult	Children	Adult	Children	Adult	Children
Tattasai	7.84	5.08	0.65	0.42	1.80	1.17	1.90	1.23	0.33	0.22
Atarugu	25.72	16.67	1.58	1.03	3.87	2.51	2.64	1.71	2.58	1.68
Tomatoes	29.47	19.11	1.48	0.96	4.25	2.75	2.78	1.80	0.81	0.53
Onion Bulb	16.50	10.70	0.40	0.26	2.65	1.72	1.00	0.65	0.38	0.25
Onion Leaves	17.02	11.04	1.74	1.13	2.06	1.34	0.60	0.39	0.49	0.32
Fresh Okro	37.25	24.15	1.33	0.86	3.61	2.34	1.00	0.65	1.32	0.86
Spinach	3.04	1.97	0.73	0.47	3.51	2.28	0.77	0.50	0.63	0.41
Karkashi	26.21	16.99	0.68	0.44	3.02	1.96	1.14	0.74	0.33	0.21
Ayoyo	26.89	17.44	1.05	0.68	3.58	2.32	3.46	2.24	1.90	1.23

The body weight of adult and children are 55.7 and 14.2kg (Nabulo et al. 2010)

Table 4 Hazard Quotient of metals in vegetable crops grown during warm and dry season

Vegetable	Cd		Cu		Ni		Pb		Zn	
	Adult	Children	Adult	Children	Adult	Children	Adult	Children	Adult	Children
Tattasai	25.88	16.78	1.20	0.77	3.76	2.44	1.96	1.27	1.26	0.82
Atarugu	22.45	14.55	1.05	0.68	12.58	8.16	5.68	3.68	1.69	1.10
Tomatoes	18.20	11.80	1.54	1.00	2.84	1.84	NA	NA	0.99	0.64
Onion Bulb	16.27	10.55	0.46	0.30	2.94	1.90	1.82	1.18	0.46	0.30
Onion Leaves	17.42	11.29	1.19	0.77	2.49	1.61	0.38	0.25	0.55	0.35
Fresh Okro	22.81	14.79	1.79	1.16	4.55	2.95	1.39	0.90	0.59	0.38
Spinach	29.18	18.92	1.33	0.86	3.58	2.32	1.00	0.65	1.46	0.95
Karkashi	25.72	16.67	0.65	0.42	3.66	2.37	1.00	0.65	0.37	0.24
Ayoyo	28.17	18.26	1.26	0.81	3.55	2.30	1.00	0.65	1.02	0.66

The body weight of adult and children are 55.7 and 14.2kg (Nabulo et al. 2010)

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