Risk index assessment of Heavy Metals in some vegetables at Kalay and Kalewa, Sagaing Division

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Abstract

The aim of this paper is to investigate the comparison of health risk assessment of the some heavy metals concentration in vegetables at Kalay and Kalewa (Thitchauk). Vegetables are widely used as food due to their high nutrition values. In this research the vegetable samples (Mustard, Pea–leaf, Calabash–leaf, Centella and Fig–leaf) were collected from Phaungku village at Kalay and Thitchauk village near coal mine area at Kalewa. The heavy metals concentrations in all measured samples which were analyzed in 2019 were assessed with the safe limit of FAO/WHO recommended value. The concentration of some heavy metals such as Aluminum, Titanium, Manganese, Iron, Cobalt, Nickel, Copper, Zinc, and Strontium in vegetable samples were determined by using energy dispersive X–ray fluorescence (EDXRF) method. The metal pollution indexes for ten vegetable samples, daily intake of some heavy elements in all samples were presented. The health risk indexes, hazard quotients were calculated and presented. It was found that risk of iron is observed by consumption of analyzed vegetable because of the fact that the health risk indexes for these heavy metals were greater than one. The health risk indexes in mustard and pea–leaf at Kalewa exceeded those at Kalay. The hazard quotient values exceeding one for iron mean that adverse effect will occur. The hazard quotient of the studied metals Fe at Kalewa exceeded that at the Kalay sites. It may be indicated that there is a relative presence of risks associated with the consumption of some vegetable (mustard, pea–leaf, centella).

Keywords: health risk, heavy metals, pollution indexes, vegetable

Introduction

Vegetables are essential for human nutrition and health. Vegetables are parts of plants that are consumed by humans or other animals as food. The use of vegetables for the purpose of food is a main source of vitamins, minerals and fibers.

The consumption of vegetables contaminated with heavy metals may pose a risk to the health of humans. The human health risk associated with consumption of vegetables depends on the quantity of vegetables consumed and the weight of an individual. Therefore, to evaluate the intake levels of elements in the total diet is relevance for

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assessing the adequacy of the diet with respect to these nutritional elements and for evaluating a possible risk due to low and high consumption.

Aim Of Research

The objectives of this study are to measure specific elements to create awareness among the public about the vegetables having high concentration of these metals, and then to estimate the health risks of some heavy metals such as Al, Ti, Mn, Fe, Co, Ni, Cu, Zn and Sr via the consumption of ten vegetables grown from Phaungku village at Kalay and Thitchauk village near Coal Mine Area at Kalewa by using indexes for vegetable.

Sample Location and Collection

In the present research work; the five vegetable samples were collected from those grown at Thitchauk village near Thitchauk coal mine area, Kalewa. Kalewa is a township in Kalay district in Sagaing division of Myanmar. It is situated at north latitude 23° 09′ 54″ and east longitude 94° 14′ 47″. It is also located to the east of Kalay and far form 23 miles from Kalay. Thitchauk village is located at north latitude 23° 12′ 20″ and east longitude 94° 15′ 21″ and it is four miles away from Kalewa. Other five vegetable samples were also collected from Phaungku village, Kalay. It is situated at north latitude 23° 13′ 20″ and east longitude 94° 07′ 10″. It is also located in Kalay. The vegetable samples collected are mustard, pea–leaf, calabash–leaf, centella and fig–leaf.

Sample Preparation

After collecting the vegetable samples, they were cut into suitable pieces with a stainless knife. The edible part of the samples were washed with tap water and then rinsed with water three times. All wet vegetable samples were dried in natural air at room temperature and the drying process was continued until the constant weight had been obtained. The dry pieces of samples were transferred into a wooden mortar and pound them to turn into homogeneous powder using wooden pestle.

Table (1) Description of vegetable samples analyzed

Common Name	Botany Name
Mustard	*Brassica nigra*
Pea–leaf	*Pisumsativum*
Calabash	*Lagenaria*
Centella	*Centellaasiatica*
Fig–leaf	*Ficuscarica*

Table (2) Heavy metal concentration for ten vegetable samples in Kalay and Kalewa

Elements	Concentration (mg/kg)										FAO/ WHO
	Mustard		Pea–leaf		Calabash–leaf		Centella		Fig–leaf		
	Kalay	Kalewa	Kalay	Kalewa	Kalay	Kalewa	Kalay	Kalewa	Kalay	Kalewa	safe
	(S_1)	(S_6)	(S_2)	(S_7)	(S_3)	(S_8)	(S_4)	(S_9)	(S_5)	(S_{10})	limit
Al	38.5	75.3	43.2	37.9	103	50.9	196	202	23.9	64.9	NG
Ti	17.2	ND	3.48	ND	22.2	20.9	3.93	1.3	6.14	12.7	NG
Mn	12.7	21	4.64	18.9	7.72	5.76	5.08	39.4	4.52	452	500
Fe	93.1	664	106	814	241	128	602	603	62.8	115	425.5
Co	0.45	ND	0.6	ND	1.07	0.56	ND	ND	ND	0.55	50
Ni	0.36	ND	0.42	ND	0.84	0.46	0.38	0.44	0.43	0.48	4
Cu	0.74	0.56	1.47	ND	1.01	1.13	ND	0.62	1.11	1.05	40
Zn	4.16	10.5	5.62	31.1	3.62	4.13	2.15	16.4	2.31	3.05	60
Sr	11.2	19.4	2.64	3.28	13.5	9.13	0.88	1.68	6.81	6.79	NG

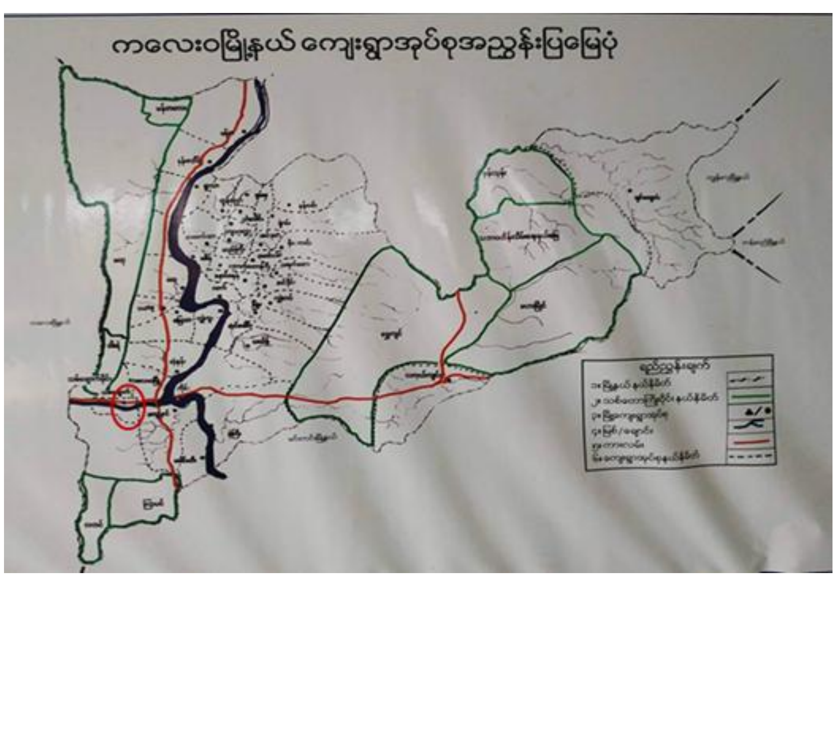

Figure (2) The sample (Mustard) collected site at Kalewa

Figure (3)The sample (Calabash-leaf) collected site at Kalay

Figure (4) The map of Kalay

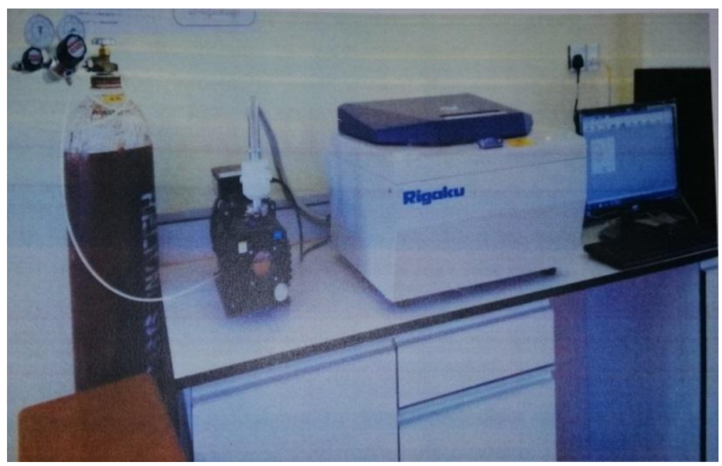

Figure (5) Energy dispersive x-ray fluorescence spectrometer (Rigaku-NEX CG) in university research centre, Taunggyi University.

Experimental Procedure

All the pellet samples were analyzed 600 sec for four secondary targets with Rigaku-NEX CG system and measurement atmosphere is helium purge. 50kV bias voltage was used and tube current was automatically adjusted by hardware. The analyzed energy range is 0-50 keV. The electron beams are incident on the palladium (Pd) anode target of X-ray tube. The X-ray from the Pd target excited the atoms of the sample to emit radiation. Secondary targets used in this spectrometer were copper (Cu), Molybdenum (Mo) and Aluminum (Al). The X-ray spectrum was analyzed with the help of computer to obtain the concentration of each element in the sample. This research was done in University Research Centre, Taunggyi University.

Index for Vegetables

There are many indexes for food and foodstuff according to the field of the study area.

Metal Pollution Index MPI

Metal Pollution Index MPI (mg/kg) = $(Cf_1 \times Cf_2 \times .... \times Cf_n)^{1/n}$

Daily Intake of Metal (DIM)

The daily intake of metal (DIM) was determined by the use of following equation:

Daily Intake of Metal $=(C_{metal} \times C_{factor} \times D_{food\ intake})/(B_{average\ weight})$.

For this present work, the average daily vegetable intake for adult was set to 0.345kg person^{-1} day^{-1} (expressed as fresh weight). The average body weight was taken as 70kg for adults according to the World Health Organization (WHO 1993).

Health Risk Index (HRI)

Health risk index HRI is the ratio of daily intake of metal DIM to the reference dose RD, and it was calculated by using the following equation:

Health risk index HRI $=\frac{Daily\ intake\ of metal\ DIM}{reference\ dose\ RD}$

Hazard quotient

Hazard quotient HQ is a unit less number that is expressed as the probability of an individual suffering an adverse effect.

$$HazardquotientHQ = \frac{AveragedailyintakeofmetalADI}{Referencedose\ RD}$$

Integrated health risk (or) hazard index, HI = $\sum$ HQ

Table (3) Metal pollution indexes for ten vegetable samples in Kalay and Kalewa

Samples		MPI values (mg/kg)
Mustard	Kalay (S_1)	0.0547
	Kalewa (S_6)	0.3259
Pea–leaf	Kalay (S_2)	0.0420
	Kalewa (S_7)	0.5687
Calabash–leaf	Kalay (S_3)	0.0831
	Kalewa (S_8)	0.0590
Centella	Kalay (S_4)	0.1078
	Kalewa (S_9)	0.1213
Fig–leaf	Kalay (S_5)	0.0484
	Kalewa (S_{10})	0.0513

Table (4) Health risk index (HRI) values for ten vegetable samples in Kalay and Kalaywa

Elements	HRI									
	Mustard		Pea–leaf		Calabash–leaf		Centella		Fig–leaf	
	Kalay	Kalewa	Kalay	Kalewa	Kalay	Kalewa	Kalay	Kalewa	Kalay	Kalewa
	(S_1)	(S_6)	(S_2)	(S_7)	(S_3)	(S_8)	(S_4)	(S_9)	(S_5)	(S_{10})
Al	0.0161	0.0315	0.018	0.0158	0.0431	0.0213	0.0821	0.0846	0.01	0.0271
Ti	0.0018	ND	0.0003	ND	0.0023	0.0021	0.0004	0.0001	0.0006	0.0013
Mn	0.0378	0.0621	0.0135	0.0564	0.0228	0.0171	0.015	0.1178	0.0128	0.0128
Fe	0.0557	3.9737	0.0634	4.8714	0.1441	0.0765	3.6027	3.6087	0.0375	0.0687
Co	0.005	ND	0.01	ND	0.02	0.01	ND	ND	ND	0.01
Ni	0.005	ND	0.005	ND	0.015	0.005	0.005	0.005	0.005	0.01
Cu	0.0075	0.005	0.015	ND	0.01	0.01	ND	0.005	0.01	0.01
Zn	0.0056	0.0143	0.0076	0.0433	0.005	0.0056	0.003	0.0226	0.003	0.004
Sr	0.0076	0.0135	0.0018	0.0021	0.0093	0.0063	0.0005	0.0011	0.0046	0.0046

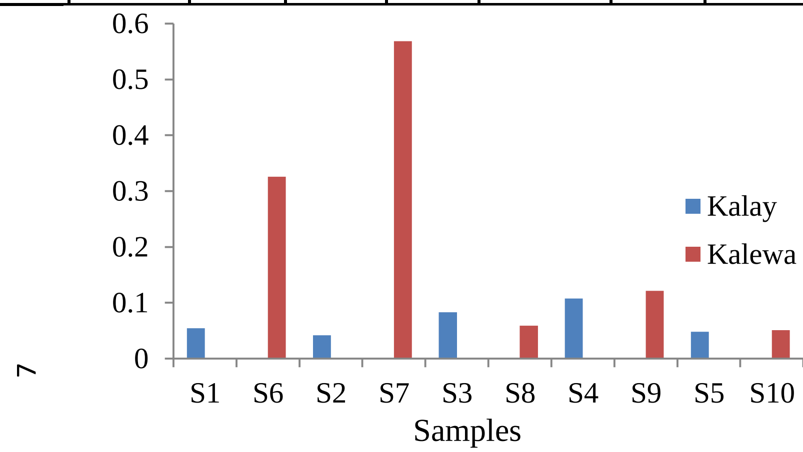

Figure (6) Metal pollution indexes in ten vegetable samples

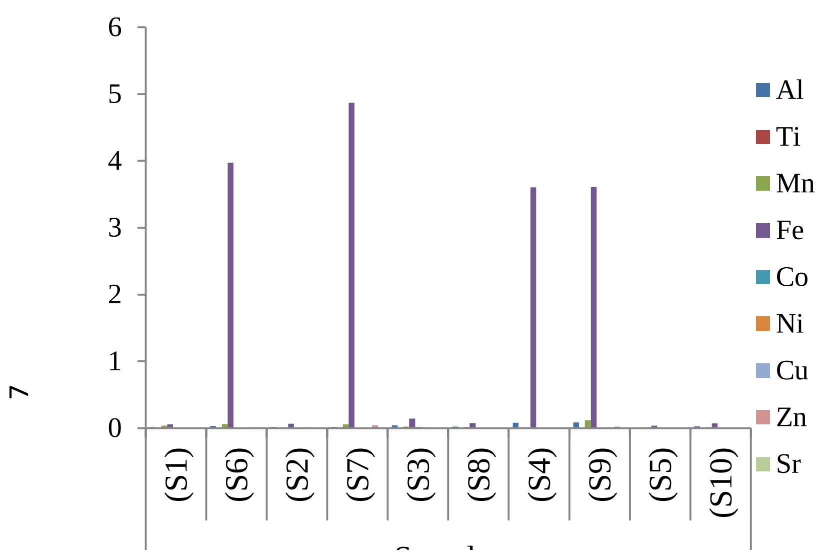

Figure (7) Health risk index values in ten vegetable samples

Table (5) Hazard quotient (HQ) values for ten vegetable samples in Kalay and Kalewa

Elements	Kalay	Kalewa
Al	0.0338	0.0360
Ti	0.0011	0.0012
Mn	0.02	0.0528
Fe	0.1321	2.5197
Co	0.01	0.01
Ni	0.005	0.005
Cu	0.01	0.0075
Zn	0.0046	0.018
Sr	0.0046	0.0055

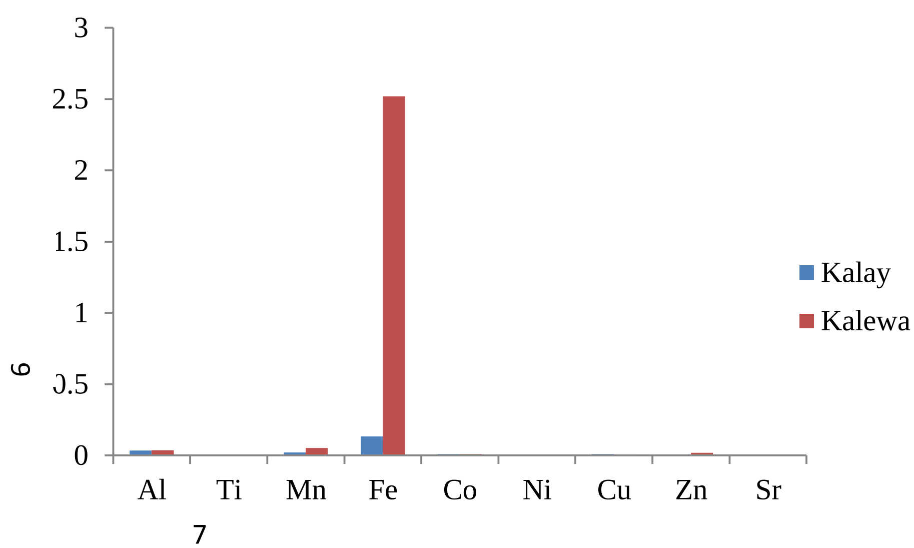

Figure (8) Hazard quotient (HQ) values for ten vegetable samples in Kalay and Kalewa

Discussion

The concentrations of some heavy metals were presented with the comparison of safe limit (FAO/WHO). The iron (Fe) concentration was the highest among the other elements in all samples. The concentration of metal in samples decrease as following order: Fe>Mn>Zn>Cu>Co>Ni respectively. The concentration values of Fe in mustard, pea–leaf, centella and fig–leaf samples at Kalewa and Fe in centella at Kalay were greater than the safe limit of 425.5 mg/kg. Other concentration values were less than the safe limit.

The daily intake of metals (Al, Ti, Mn, Fe, Co, Ni, Cu, Zn, and Sr) for human with an average body weight 70 kg was calculated. According to WHO, the required amount of vegetables in our daily diet is must be 300 to 350 g per person guideline (WHO 1998). DIM values of Fe in mustard, pea–leaf, and centella at Kalewa and centella at Kalay were more than the required amount indicating no safe for the consumer. Other DIM values were less than the required amount indicating safe for the consumer.

The health risk assessment is associated with some heavy metals (Al, Ti, Mn, Fe, Co, Ni, Cu, Zn, Sr) in vegetable samples estimated and risk index has been calculated. The health risk index results showed that Fe in mustard, pea–leaf and centella at Kalewa and centella at Kalay will cause health problems because health risk index was more than one. HRI values of Fe in calabash–leaf and fig–leaf at Kalay and Kalewa do not cause health problems because health risk index was less than one. But all tested metals except Fe were not found to cause any risk to the consumers. For iron, the comparison of HRI values in mustard, pea–leaf and centella samples at Kalewa were more than those in the samples at Kalay.

The hazard quotients (HQ) have been calculated for some heavy metals in vegetable samples at Kalay and Kalewa. In Kalay, HQ values of all analyzed metals were less than one for all samples. In Kalewa, HQ values of all analyzed metals except Fe were less than one for all samples. Therefore, HQ values of iron in some vegetable samples at Kalewa exceeds those at the Kalay sites.

Conclusion

Consuming the vegetable samples contaminated with heavy metals have different detrimental effects on human health; therefore aluminum, titanium, manganese, iron, cobalt, nickel, copper, zinc and strontium was analyzed in all vegetable samples. The concentration of heavy metals were determined in sequence Fe>Mn>Zn>Cu>Co>Ni. Among six heavy metals studied in the samples, concentration of Fe was the highest. Moreover, the daily intake of Fe was greater than other elements.

The health risk index for all heavy metals was less than one in calabash–leaf and fig–leaf at Kalay and Kalewa and this indicated that there was not any risk. Moreover, HRI values for all heavy metals were less than one in mustard and pea–leaf at Kalay and this indicated no risk. But HRI values for Fe in mustard, pea–leaf and centella at Kalewa and centella at Kalay would cause health problems because health risk index was more than one. Therefore, it can be calculated that consumption of vegetables with elevated levels of heavy metals may lead to high level of accumulation in the body causing related health problem.

Hazard quotient of some heavy metals also suggested that Fe in tested vegetables would be potential risk for health of people who consume vegetables grown near the coal mine area because these indexes for some vegetable samples in Kalewa were highter than those in Kalay and this may be due to the higher amount of some heavy metals.

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