ORIGINAL ARTICLE

Heavy Metals in Soil and Vegetables at Agricultural Areas in Kota Bharu and Bachok Districts of Kelantan, Malaysia

Nur Fatin Najihah Ismail[1], Siti Marwanis Anua[1], Nurul Izzah Abdul Samad[1], Nurul Ainun Hamzah[1], Nurzafirah Mazlan[2]

[1] Environmental and Occupational Health Programme, School of Health Sciences, Health Campus, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia

[2] Department of Diagnostic and Allied Health Sciences, Faculty of Health and Life Sciences, Management and Science University, University Drive, Seksyen 13, 40100 Shah Alam, Selangor, Malaysia.

ABSTRACT

Introduction: Soil pollution with heavy metals inadvertent to food contamination resulting from root-soil heavy metal uptake is of great concern. The aim of this study was to determine the concentration of heavy metals such as lead (Pb), iron (Fe) and copper (Cu) and cadmium (Cd), in soil and vegetables. **Methods:** Using systematic grid sampling, 54 soil samples and 18 vegetable samples were collected from Kampung Binjai Manis, Kota Bharu and Kampung Aman, Kandis, Bachok, Kelantan. Soil and vegetables samples were dried, extracted by acid digestion process and analysed using Atomic Absorption Spectroscopy. **Results:** The overall mean concentration of heavy metal in soil measured in descending order in Kampung Binjai Manis was Fe (958.53 mg/kg) > Pb (26.07 mg/kg) > Cu (11.83 mg/kg) > Cd (0.66 mg/kg). Whereas, the overall mean concentration of heavy metal measured in descending order in Kampung Aman was Fe (461.18 mg/kg) > Cu (8.25 mg/kg) > Pb (2.48 mg/kg) > Cd (0.27 mg/kg). There were significant different in the mean concentration of Pb, Fe and Cd between Kampung Binjai Manis and Kampung Aman. In vegetables, only Cu shows significant different between Kampung Binjai Manis and Kampung Aman. Significant correlations were found between soil and vegetables in Kampung Binjai Manis for Cu (r= 0.861, p= 0.003) and Cd (r= 0.933, p= 0.001). **Conclusion:** The mean concentration of heavy metal in soil and vegetables at Kampung Binjai Manis and Kampung Aman were above the permissible limit as set by the Department of Environment and World Health Organisation.

Keywords: Heavy metals, Soils, Vegetables

Corresponding Author:
Siti Marwanis Anua, PhD
Email: smarwanis@usm.my
Tel: +609-767 7827

INTRODUCTION

Studies on the presence of heavy metals, its environmental fate and health effects to human are of recent interest (1). Members of the public are interested in knowing whether it is safe to consume crops (i.e vegetables, fruits and foods) that are grown in polluted soils. There are various routes of heavy metals entry that can cause human health problems via inhalation, dermal absorption and ingestion (involving dietary intake through the soil-food chain) (2). Heavy metals become environmental concern because it can be harmful to both the humans and animals due to its bio-accumulation tendency (3). The cultivated plants accumulating high concentration of heavy metals from the polluted environment can cause serious health risk especially when freshly consumed (4).

Vegetables are grown worldwide in almost 200 countries and make up a major portion of the humans dietary intake in many parts of the world (5). Moreover, vegetables can absorb both essential and toxic elements from the soil hence these toxic heavy metals can contaminate both its surface and tissue (6, 7). Cuticles of many plants are reported to be able to take up a number of heavy metals such as Cadmium (Cd), Copper (Cu) and Zinc (Zn) at high rates, except for Lead (Pb), that is transmitted in lower quantities (8). Soil pollution is caused by natural processes, anthropogenic activities and agrochemicals sources. Natural processes refer to when parent materials of metal-enriched rocks such as serpentine and black shale inherited heavy metals into soils. The anthropogenic sources are intensified agriculture and industrialisation process for example waste disposal, fossil fuel combustion, smelting and mining (9). Whereas, pollutants from agrochemicals sources include fertilisers, manure and pesticides (10). A research conducted in Cameron Highland has reported that fungicides (53%) were the most abundant class of pesticides found in the survey conducted, followed by insecticides (44%) and herbicide (3%) (11).

The heavy metal properties of high in toxicity, over sufficient sources, non-biodegradable and accumulative is in fact becoming a serious problem around the world (12). Food is the major intake source of toxic heavy metals among human beings. The most vulnerable food with highest exposure to environmental pollution are vegetables because it can take up heavy metals, regardless its concentration. The plants will accumulate these essential or non-essential heavy metals in both edible and nonedible parts at high concentrations, which can cause health problems clinically to human and animals (13). For example, Cu, Manganese (Mn) and Zn are essential heavy metals to plants at low concentrations, however high concentration of Cd, Chromium (Cr), Nickel (Ni) and Pb can cause toxicity effect to living organisms (14). An investigation of heavy metal composition in surface soils of an impacted area with iron ore-mine in Pahang, Malaysia has revealed a very high concentration of Cu which has exceeded the soil guideline value (15). It worth noted that, a phenomenon known as biological concentration would occur where bioaccumulated heavy metals in the living systems will increase in their concentrations as they are passed from organism of lower trophic level to organism of higher trophic level (16). An investigation involving heavy metals accumulation in leaf of vegetables from agricultural soils in South China had found that, Cd had the highest uptake capacity from soil into vegetables than Mercury (Hg), Cr, Pb and Arsenic (As) (17). Therefore, it is important to investigate the concentration of heavy metals such as Cd, Cu, Fe and Pb in both soil and vegetables in this study.

MATERIALS AND METHODS

Study area

In this research, the soil samples and vegetable samples were collected from selected rural agricultural areas located in Kampung Binjai Manis (coordinate: 6^{o}4′10′′ (N) and 102^{o}18′50′′ (E)), Kota Bharu and Kampung Aman (coordinate: 5^{o}55′38′′ (N) 102^{o}26′46′′ (E)), Kandis, Bachok, Kelantan. The residents' main activities at the study location was agricultural, hence chosen as selected study area. The concentration of heavy metals (Pb, Fe, Cu, Cd) were measured for each of the soil samples and vegetable samples.

Soil and vegetable sampling

A total of 54 soil samples and 18 vegetable samples involving three types of vegetable crops namely eggplant (*Solanum melongena*), chili (*Capsicum annuum*) and luffa (*Luffa acutangula*r) were collected. The soil samples were collected during mid- and post-harvest whereas the vegetables samples were collected during post-harvest from the study location. The soil samples were collected for three times during mid (cycle 1 and cycle 2) and post-harvest (cycle 3). The sampling was conducted within two months from February 2019 until March 2019.

Prior to sampling, the tools such as soil corer was cleaned from any dirt to avoid contamination with other materials. All the apparatus used were cleaned as uncleaned apparatus can affect the heavy metal concentration in the sample. At each sampling location, the soil samples were collected at three sampling points. Systematic grid sampling following (18) was conducted except that in this study, three by three points were applied. In which, each point is located at the starting, middle and end of the area of 1 ha (10 m x 10 m) with the same gap distance of 4.5 m of one another (the starting point started at 1 m followed by middle point at 5.5 m and at the end point of 10 m). At each three points selected, another three sub-points were collected at one line with the 7.5 m length. The gap distances of the three sub-points were at 1 m, 4.25 m and 7.5 m. The sub-samples were homogenised into one composite sample per points for further analysis.

Soil samples from the two villages were taken using a soil sampler at the depth of 15 cm and were placed in an individual and clean zipper plastic bag. The sampling depth of 15 cm was chosen for its factor as the most sensitive zone of erosion, atmosphere deposition and active zone of maximum root concentration (19, 20).

In addition, samples of edible parts of vegetable samples were taken during post-harvest from the same location of sampling areas. The edible part of the vegetables were plucked by using gloves to ensure that the sample was not contaminated by other materials. Each of the plastic bags storing the samples were well labelled.

Sample transportation and storage

The soil and freshly harvested vegetables samples that were kept in plastic bags were then placed in a cooler box upon transportation to the laboratory. The soil samples were dried between 50^{o}C-60^{o}C in the drying oven for three days whereas the freshly harvested of edible part of vegetables were washed under running water in removing the soil, followed by three washing with distilled water to avoid contamination. The vegetables samples were sliced into small pieces using stainless steel knife and weighed using analytical balance. After washing and cutting, the vegetables were placed in an oven for 2-3 days at 50^{o}C- 60^{o}C.

Acid digestion of soils and vegetables

The dried soils and vegetables samples were blended using electrical power grinder to obtain uniform state of samples. One composite sample was formed by mixing the three sub-samples and was sieved (through 2 mm sieve) to remove granulometric fraction and any other unwanted materials such as plastics, leaves and rocks. Approximately 2 g of sieved homogenous soil samples were weighed into 100 ml beaker and the digestion was carried out on a hotplate in a fume hood. Each of the samples was digested with deionised water, 65% of concentrated (HNO_3) and 37% of concentrated hydrochloric acid (HCl).

Firstly, in the fume hood, 5 ml of deionised water was added into the beaker and followed by adding 5 ml of concentrated HNO_3. Under slow heating, the soil was heated on one hotplate until they were refluxing for 10 minutes while being stirred few times to prevent the samples to boil over. The top of the beaker was covered with the watch glass to prevent evaporation of the sample. Then, the sample was removed from the hotplate and allowed to cool for a while. Again, another 5 ml of concentrated HNO_3 was added into each sample and refluxed for another 10 minutes. Once the sample was cool enough to handle, 5 ml of concentrated HCl and then 10 ml of deionised water were added into the sample. The sample was refluxed for 15 minutes while being stirred occasionally. The sample was heated up slowly, the heat was started at level 3 (of the hotplate) and then being reduced to level 1 at the first sign of boiling. A blank sample was also prepared with the equal amount of acids without the soil sample.

Finally, filtration of all digested samples solution through into a 50 ml volumetric flask using Whatman filter paper was performed and then the volume was diluted with 50 ml of deionised water. Each flask at least was inverted 13 times to mix and being transferred into the polyethylene bottles. The polyethylene bottles were kept in 5oC until further analysis using Atomic Absorption Spectroscopy (AAS). Similar procedure was repeated for vegetable samples.

Sample analysis

The determination of Fe, Cu, Cd, Pb concentration were done by using AAS. The procedure of AAS was referred to operating manual provided by AAS Model Perkin Elmer A Analyst 800. For quality control and quality assurance, the standard solution for each heavy metal were prepared by serial dilution from reagent grade chemicals following the manufacturer's instruction. Deionised water was used as blank solution. Calibration standard solutions were prepared in 50 ml volumetric flasks by using molarity standard equation, M1V1=M2V2, where M was the concentration of stock standard solution while V was the volume of stock standard solution. The calibration graph curve was generated for each calibration standard solution of heavy metal, then were followed by each acid digestion extraction of soil samples to obtain the reading.

Data analysis

The value of heavy metal concentration was measured in mg/kg following the standards of heavy metals. The soil and vegetable samples were analysed for heavy metals such as Pb, Fe, Cu and Cd, and compared with the standard permissible limits set by DOE (Department of Environment) in soil and WHO (World Health Organisation) in edible plant. Data analysis was conducted by using Statistical Packages for Social Sciences (SPSS) Version 24.0. Value of non-detected samples was replaced by ½ of limit of detection (20). Descriptive statistics was used to determine the concentration of heavy metals in the soil of vegetables crops as well as for vegetable in Kampung Binjai Manis and Kampung Aman. One-Way ANOVA was used to compare the concentration of heavy metals in soils and vegetables between types of vegetable in Kampung Binjai Manis and Kampung Aman. Independent T-Test was used to compare the concentration of heavy metals in soil and vegetables between Kampung Binjai Manis and Kampung Aman. Correlation was used to relate the heavy metal concentration between soil and vegetable for Kampung Binjai Manis and Kampung Aman.

RESULTS

Heavy metal concentration in soils and vegetable at the sampling sites

Table I shows that Fe has the highest mean concentration in all soil samples for all crops in both villages with the highest total mean of Fe observed in eggplant soil at Kampung Binjai Manis (Mean: 959.39 mg/kg, SD: 0.90 mg/kg). Similarly, Fe was measured to be the highest mean concentration in all types of vegetable in both villages with the highest Fe value reading recorded in luffa at Kampung Binjai Manis (mean: 537.75 mg/kg, SD: 188.31 mg/kg). However, in Kampung Aman, the mean concentration of Fe was the highest in eggplant (mean: 352.78 mg/kg, SD: 285.62 mg/kg).

Comparison of mean concentration of heavy metals in soil and vegetables between eggplants, chili and luffa at the sampling sites

Table II shows the comparison of mean concentration of heavy metals between eggplant, chili and luffa in soils and vegetables at both Kampung Binjai Manis and Kampung Aman. In Kampung Binjai Manis, there was a significant different in the mean concentration of Cu between the types of vegetable soil ($p=0.004$), with the highest mean value measured in luffa soil (mean: 14.17 mg/kg, SD: 3.28 mg/kg) and the lowest mean in soil grown with chili (mean: 9.94 mg/kg, SD: 1.35 mg/kg). Post hoc analysis by Bonferroni shows the mean concentration of Cu in soil was significant between chili and luffa. None of all other heavy metals in soils were found to be statistically different between

Table I : Heavy metal concentration in soils and vegetable at the sampling sites

Sampling site	Heavy Metal	Total Mean Concentration ± SD (mg/kg)					
		Eggplant		Chili		Luffa	
		Soil	Vegetable	Soil	Vegetable	Soil	Vegetable
Kampung Binjai Manis	Pb	25.47±1.70	3.44	26.02±1.97	0.40	26.72±1.74	0.53
	Fe	959.39±0.90	33.72	958.83±2.82	80.72	957.36±2.67	537.75
	Cu	11.38±1.21	9.58	9.94±0.59	9.13	14.17±1.76	17.08
	Cd	0.43±0.24	0.08	0.49±0.05	0.06	1.04±0.18	0.93
Kampung Aman	Pb	2.99±0.49	0.82	1.99±0.41	0.28	2.46±0.08	0.51
	Fe	539.92±20.74	352.78	519.36±23.60	102.30	324.27±10.08	159.59
	Cu	1.32±0.19	114.17	2.35±0.27	14.87	21.08±14.48	61.58
	Cd	0.35±0.05	0.15	0.32±0.05	0.47	0.12±0.20	1.12

SD-Standard Deviation, Pb-Lead, Fe-Iron, Cu-Copper, Cd-Cadmium

Table II : Comparison of mean concentration of heavy metals in soil and vegetables between eggplants, chili and luffa in Kampung Binjai Manis and Kampung Aman

Sampling Sites	Sample types	Heavy Metals	Concentration in Mean±SD (mg/kg)			p-value
			Eggplant	Chili	Luffa	
Kampung Binjai Manis	Soil	Pb	25.47±18.87	26.02±18.75	26.72±20.00	0.990
		Fe	959.39±4.07	958.83±6.11	957.36±7.81	0.775
		Cu	11.38±2.33	9.94±1.35	14.17±3.28	0.004*
		Cd	0.53±0.41	0.45±0.27	1.00±0.73	0.063
	Vegetable	Pb	3.44±0.73	0.40±0.32	0.53±0.42	0.001**
		Fe	33.72±5.74	80.72±6.99	537.75±188.31	0.002*
		Cu	9.58±0.27	9.13±0.55	17.08±1.49	0.001**
		Cd	0.08±0.12	0.06±0.08	0.93±0.40	0.008*
Kampung Aman	Soil	Pb	2.99±2.07	1.99±0.84	2.46±0.79	0.321
		Fe	539.92±259.49	519.36±42.54	324.27±119.75	0.021*
		Cu	1.32±1.04	2.35±0.34	21.08±32.35	0.059
		Cd	0.35±0.42	0.32±0.29	0.12±0.20	0.267
	Vegetable	Pb	0.82±0.55	0.28±0.08	0.51±0.56	0.404
		Fe	352.78±285.62	102.30±8.48	159.59±84.45	0.253
		Cu	114.17±96.28	14.87±3.94	61.58±36.75	0.205
		Cd	0.15±0.15	0.47±0.43	1.12±0.30	0.024*

*p<0.05, **p<0.001, Tested using one-way ANOVA, SD-Standard Deviation, Pb-Lead, Fe-Iron, Cu Copper, Cd-Cadmium

Table III : Comparison of mean concentration of heavy metals in soil and vegetables between Kampung Binjai Manis and Kampung Aman

Sample types	Heavy Metals	Concentration in Mean±SD (mg/kg)		T-statistic (df)	p-value
		Kampung Binjai Manis	Kampung Aman		
Soil	Pb	26.07±18.47	2.48±1.38	6.619	0.001**
	Fe	958.53±6.01	461.18±188.40	13.710	0.001**
	Cu	11.83±2.96	8.25±20.20	0.912	0.366
	Cd	0.66±0.55	0.27±0.32	3.226	0.002*
Vegetable	Pb	1.46±1.56	0.54±0.46	1.709	0.107
	Fe	217.39±258.90	204.89±187.38	0.117	0.908
	Cu	11.93±3.95	63.54±67.16	-2.301	0.035*
	Cd	0.42±0.47	0.58±0.50	-0.707	0.490

*p<0.05, **p<0.001, Tested using Independent Sample Test, SD-Standard Deviation, Pb-Lead, Fe-Iron, Cu-Copper, Cd-Cadmium the types of vegetable (p>0.05). Whereas in Kampung Aman, the highest mean value of Fe was measured in eggplant soil (mean: 539.92 mg/kg, SD: 259.49 mg/kg) and the lowest mean was measured in soil grown with luffa (mean: 324.27 mg/kg, SD: 119.75 mg/kg). Post hoc analysis by Bonferroni shows the mean concentration of Fe in soil was significant between eggplant and luffa. None of all other heavy metals in soils were found to be statistically different between the types of vegetable (p>0.05).

In the case of comparison in mean concentration of heavy metals between types of vegetables in Kampung Binjai Manis, all heavy metals showed significant different such as Pb (p=0.001), Fe (p=0.002), Cu (p=0.001) and Cd (p=0.008). The highest mean Pb level was measured in eggplant (mean: 3.44 mg/kg, SD: 0.73 mg/kg), the highest mean Fe, Cu and Cd level were measured in luffa (mean: 537.75 mg/kg, SD: 188.31 mg/kg versus mean: 17.08 mg/kg, SD: 1.49 mg/kg versus mean: 0.93 mg/kg, SD: 0.40 mg/kg, respectively). Whereas in Kampung Aman, there was a significant different in the mean concentration of Cd between eggplant, chili and luffa (p=0.024). The highest mean concentration of Cd was measured in luffa (mean: 1.12 mg/kg, SD: 0.30 mg/kg). None of all other heavy metals were found to be statistically different between the types of vegetable (p>0.05).

Comparison of mean concentration of heavy metals in soil and vegetables between locations

Table III describes the mean comparison of heavy metals in soils and vegetables between Kampung Binjai Manis and Kampung Aman. For soil samples, there were significant differences in the mean concentration of Pb (p=0.001), Fe (p=0.001) and Cd (p=0.002), with higher level of heavy metals found in soils samples collected from Kampung Binjai Manis compared to Kampung Aman. However, the mean concentration of Cu was not significantly different between Kampung Binjai Manis and Kampung Aman (p>0.05). Similarly, the mean concentration of Cu in vegetable samples for Kampung Aman was significantly higher (mean: 63.54 mg/kg, SD: 67.16 mg/kg) than Kampung Binjai Manis (mean: 11.93 mg/kg, SD: 3.95 mg/kg) (p=0.035). None of all other heavy metals were found to be statistically different in vegetables between both villages (p>0.05).

Correlation of heavy metals concentration between soil and vegetables

Table IV shows the results for correlation of heavy metals between soil and vegetable types in Kampung Binjai Manis and Kampung Aman. A significant correlation was established for Cu between soil and vegetables (r=0.861, p=0.003) in Kampung Binjai Manis. Cd concentration level also showed a very strong positive significant correlation between soil and vegetables (r= 0.933, p= 0.001). This would indicate, as the value of Cu and Cd in the soil increases, the value of these heavy metals in vegetables also increased. However, none of the heavy metals in Kampung Aman were found to be statistically correlated between soil and vegetable (p>0.05).

Table IV : Correlation of heavy metals concentration between soil and vegetable in Kampung Binjai Manis and Kampung Aman

Sampling site	Heavy metals	r	p-value
Kampung Binjai Manis	**Pb**	-0.297	0.438
	Fe	-0.156	0.689
	Cu	0.861	0.003*
	Cd	0.933	0.001**
Kampung Aman	**Pb**	0.555	0.121
	Fe	0.288	0.452
	Cu	-0.072	0.853
	Cd	-0.447	0.227

*p<0.05, Tested using Pearson Correlation, r-correlation coefficient, Pb-Lead, Fe-Iron, Cu-Copper, Cd-Cadmium

DISCUSSION

The overall mean soil heavy metal concentration measured in descending order in Kampung Binjai Manis was Fe (958.53 mg/kg) > Pb (26.07 mg/kg) > Cu (11.83 mg/kg) > Cd (0.66 mg/kg) wheras in Kampung Aman was Fe (461.18 mg/kg) > Cu (8.25 mg/kg) > Pb (2.48 mg/kg) > Cd (0.27 mg/kg). There was significantly different of Pb concentration in soils between Kampung Binjai Manis and Kampung Aman. The mean Pb level in soils in Kampung Binjai Manis was detected above the permissible limit set by the Department of Environment (DOE) however in Kampung Aman, the mean Pb level in soils was still below the permissible limit. This result resembled those presented in a previous study (22) that found Pb concentration in the cultivated soils increased significantly (p<0.05) due to fertiliser. From the results, Fe was found to be the most predominant heavy metals at the soil sampling sites than other heavy metals such as, Pb, Cu and Cd. The reason for this extreme value of Fe in soil might be due to the sampling procedure as the soils were collected from the depth of 15 cm. This was supported by another study (23), explained that the highest concentration of Fe is found at 2-15 cm level despites the Fe content varies with the type and depth of the soil, ranging from 20,000 to 550, 000 mg/kg. The higher value of Fe in this study are also consistent with our recent study in Pasir Puteh, Kelantan (18).

Cu concentration level in soil of vegetable crops between eggplant, chili and luffa was significantly different in Kampung Binjai Manis (*p*=0.004). It was found that the mean concentration of luffa soil was above permissible limit set by the DOE (the DOE's permissible limit of

Cu in soils is 13.80 mg/kg). In contrast to this study findings, higher level of Cu was found in soil and vegetable samples in Pakistan with the highest level (71.89 mg/kg) in the soil of *Peganum harmala* (24). Similarly, the Cd concentration in soils between Kampung Binjai Manis and Kampung Aman was significantly difference (p=0.002) with the level of Cd in Kampung Binjai Manis was higher than Kampung Aman but both still under normal range of standard heavy metal in soil as set by the DOE (14.40 mg/kg).

It can be summarised that Pb concentration level in vegetable crops between eggplant, chili and luffa was significantly different in Kampung Binjai Manis (p= 0.001). However, the mean concentration of eggplant was observed to be above the World Health Organisation (WHO) permissible limit in plants. WHO's permissible limit of Pb in plants is 2 mg/kg. The availability of Pb in soil is also can be affected by the soil type since Pb prefers to absorb on clay and oxides as well as form complex with organic matter (25). This finding might be the factor that cause Pb concentration was high in Kampung Binjai Manis because the soil type in this village is clay soil compared to Kampung Aman that has sand-texture soil.

The Fe concentration level in vegetable crops between eggplant, chili and luffa was significantly different in Kampung Binjai Manis (p= 0.002). It was observed that the mean concentration of Fe in eggplant, chili and luffa were above the permissible limit set by WHO (20 mg/kg). This result was compared with reference (26) that found in some of edible portion of vegetable samples, their Fe concentration level was found to be above the critical toxic level prescribed by WHO. Whereas, the Cu concentration in vegetable between Kampung Binjai Manis and Kampung Aman was significantly difference (p=0.035) with the level of Cu in Kampung Aman higher than Kampung Binjai Manis and exceed the permissible limit set by WHO.

It can be stipulated that eggplant absorbed a much higher quantity of Cu than chili and luffa in both Kampung Binjai Manis and Kampung Aman. The mean concentration of Cd level in vegetable crops between eggplant, chili and luffa were significantly different both in Kampung Binjai Manis (p= 0.008) and in Kampung Aman (p= 0.024). Based from the results, the mean concentration of Cd in eggplant, chili and luffa were above the permissible limit set by WHO (0.02 mg/kg). This result can be compared with a study in the lower north of Thailand that reported Cd and Pb contamination (above the maximum allowable concentration) in more than 80% of vegetables from their fresh market (27).

CONCLUSION

In conclusion, the mean concentration of Pb in soil were detected to be exceeding the permissible level in Kampung Binjai Manis, whereas the mean concentration of Cu exceeded the permissible limit in luffa soil only. The descending order of overall mean soil heavy metal concentration measured in Kampung Binjai Manis was Fe (958.53 mg/kg) > Pb (26.07 mg/kg) > Cu (11.83 mg/kg) > Cd (0.66 mg/kg). On the other hand, for Kampung Aman was Fe (461.18 mg/kg) > Cu (8.25 mg/kg) > Pb (2.48 mg/kg) > Cd (0.27 mg/kg).

The results of heavy metals concentration in vegetables samples at Kampung Binjai Manis exceeded the permissible limit set by the WHO for Pb (eggplant), Fe (eggplant, chili and luffa), Cu (luffa) and Cd (eggplant, chili and luffa). However, in Kampung Aman the level of Cu and Cd was much higher than Kampung Binjai Manis and had exceeded the permissible limit for eggplant, chili and luffa. There was a significant correlation between Cu in soils and vegetables in Kampung Binjai Manis. Cd concentration level also shows a very strong positive correlation and has significant value in soils and vegetables. This indicates, as the value of Cu and Cd increases, the value of these heavy metals in soils and vegetables also increases.

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REFERENCES

1. Ibraheen LH, Abed SA. Accumulation detection of some heavy metals Al-Diwaniyah City, Iraq. RASĀYAN J Chem. 2017; 10(2), 339–343.
2. Komárek M, Ettler V, Chrastný V, Mihaljevič M. Lead isotopes in environmental sciences: A review. Environ Int. 2008. 34(4); 562–577. doi:10.1016/j.envint.2007.10.005
3. Abdalla AMS, Bashir NHH, Abdelbagi AO, Assad YOH. Heavy metals concentrations in drinking water in Dongola and Merowe, Northern State, Sudan. EC Pharm Toxic. 2018. 6.9 (September); 829–837.
4. Naser HM, Sultana S, Mahmud NU, Gomez R, Noor S. Heavy metal levels in vegetables with growth stage and plant species variations. Bangladesh Journal of Agricultural Research. 2011.

36(4); 563–574. doi:https://doi.org/10.3329/bjar.v36i4.11743
5. Varadaraju R, Patel P. Health benefits of vegetables. International Journal of Chemical Studies, 20197(2), 82–87.
6. Hajeb P, Sloth JJ, Shakibazadeh S, Mahyudin NA, Afsah-Hejri L. Toxic elements in food: occurrence, binding, and reduction approaches. Compr Rev Food Sci. 2014; 13(4), 457–472. doi:10.1111/1541-4337.12068
7. Seilsepour M, Bigdeli M. Investigation of metals accumulation in some vegetables irrigated with waste water in Shahre Rey-Iran and toxicological implications. American- Eurasian Journal of Agricultural & Environmental Sciences. 2008. 4(1), 86–92.
8. Hogan CM. (2011). Heavy metal. Retrieved April 13, 2019, from https://editors.eol.org/eoearth/index.php?title=Heavy_metal&oldid=135134
9. He Z, Shentu J, Yang X, Baligar V, Zhang T, Stoffella P. Heavy metal contamination of soils: sources, indicators, and assessment. J Environ Indicators, 2015; 9, 17–18. Retrieved from http://www.eea.europa.eu/data-and-maps/indicators
10. Kayastha SP. Heavy metal pollution of agricultural soils and vegetables of Bhaktapur District, Nepal. Scientific World. 2015. 12(12); 48–55. doi:10.3126/sw.v12i12.13597
11. Mispan R, Haron SH, Abd Rahman NF, Khalid K. The use of pesticide in agriculture area, Cameron Highlands. Int J Sci Prog Res 2015. 15(1); 19-22.
12. Hu B, Jia X, Hu J, Xu D, Xia F, Li, Y. Assessment of heavy metal pollution and health risks in the soil-plant-human system in the Yangtze River Delta, China Bifeng. Int J Environ Res Public Health, 2017; 14(9), 1042. doi:10.3390/ijerph14091042
13. Jolly YN, Islam A, Akbar S. Transfer of metals from soil to vegetables and possible health risk assessment. SpringerPlus. 2013. 2(1); 385. doi:10.1186/2193-1801-2-385
14. Eid EM, Alrumman SA, Farahat EA, El-bebany AF. Prediction models for evaluating the uptake of heavy metals by cucumbers (Cucumis sativus L.) grown in agricultural soils amended with sewage sludge. Environ Monit Assess. 2018. 190; 501. doi:10.1007/s10661-018-6885-y
15. Diami SM, Kusin FM, Madzin Z. Potential ecological and human health risks of heavy metals in surface soils associated with iron ore mining in Pahang, Malaysia. Environ Sc Pollut Res. 2016. 23(20); 21086–21097. doi:10.1007/s11356-016-7314-9
16. Singh Sidhu, G P. Heavy metal toxicity in soils: sources, remediation technologies and challenges. Advances in Plants & Agriculture Research. 2016. 5(1);445–446. doi:10.15406/apar.2016.05.00166
17. Chang CY, Yu HY, Chen JJ, Li FB, Zhang HH, Liu, CP. Accumulation of heavy metals in leaf vegetables from agricultural soils and associated potential health risks in the Pearl River Delta, South China. Environ Monit Assess. 2014. 186(3);1547–1560. doi:10.1007/s10661-013-3472-0
18. Anua SM, Muhammad Salleh NF, Abdul Samad NI, Mohd Shukri N, Mamat MN, Hamzah NA, et al. Heavy metal concentration in soil of vegetable crops in Pasir Puteh, Kelantan. Asia Pacific Environmental and Occupational Health Journal. 2019; 5(1); 12-18
19. Malan M, Müller F, Cyster L, Raitt L, Aalbers J. Heavy metals in the irrigation water, soils and vegetables in the Philippi horticultural area in the Western Cape Province of South Africa. Environ Monit Assess. 2015. 187(1);1–8. doi:10.1007/s10661-014-4085-y
20. Neagoe A, Ebenå G, Carlsson E. The effect of soil amendments on plant performance in an area affected by acid mine drainage. Chemie Der Erde. 2005. 65(SUPPL. 1);115–129. doi:10.1016/j.chemer.2005.06.009
21. Helsel D. Much ado about next to nothing: Incorporating nondetects in science. Ann Occup Hyg. 2010. 54(3): 257-262. doi:10.1093/annhyg/mep092
22. Atafar Z, Mesdaghinia A, Nouri J, Homaee M, Yunesian M, Ahmadimoghaddam M et al. Effect of fertilizer application on soil heavy metal concentration. Environ Monit Assess. 2010. 160:83–89. doi:10.1007/s10661-008-0659-x
23. Mahender A, Swamy B, Anandan A, Ali J. Tolerance of iron-deficient and toxic soil conditions in rice. Plants, 2019. 8(2); 31. doi:10.3390/plants8020031
24. Shah A, Niaz A, Ullah N, Rehman A, Akhlaq M, Zakir M, et al. Comparative study of heavy metals in soil and selected medicinal plants. J Chem. 2013; 1-5. Retrieved from http://dx.doi.org/10.1155/2013/621265%0A
25. Epstein AL, Gussman CD, Blaylock MJ, Yermiyahu U, Huang JW, Kapulnik Y et al. EDTA and Pb-EDTA accumulation in Brassica juncea grown in Pb-amended soil. Plant and Soil. 1999. 208; 87-94. doi:10.1023/A:1004539027990
26. Charan PD, Jakhar AK., Singh, M, Bithoo, KS, & Meena, MK. Analysis of some heavy metals in waste water irrigated vegetables grown in Bikaner City, Rajasthan. J. App. Phytotechnology in Environ. Sanitation. 2014. 3(1); 29–34.
27. Wachirawongsakorn P. Health risk assessment via consumption of Pb and Cd contaminated vegetables collected from fresh markets in the lower north of Thailand. Hum Ecol Risk Assess. 2016. 22(3);611-622. doi:10.1080/10807039.2015.1095631