J-PAL, Vol. 10, No. 2, 2019
DOI: 10.21776/ub.jpal.2019.010.02.10

ISSN: 2087-3522
E-ISSN: 2338-1671

The Analysis of the Heavy Metal Iron (Fe), Cadmium (Cd), Copper (Cu) Content In Crystal Guava (*Psidium Guajava* L.) and Soil at Batu

Hidayati Karamina[1,*], Widowati[2], Tri Mudjoko[3]

[1 2] Agrotechnology Program, Faculty of Agriculture, Tribhuwana Tunggadewi University, Malang, Indonesia
[3] Agrotechnology Program, Faculty of Agriculture, UPN Veteran Jatim, Surabaya, Indonesia

Abstract

Bumiaji region is well-known as it becomes the tourist destination area in Batu City. This area is largely covered by its constant (even below) 20^{o}C temperature along the year in which makes it as the best place to plant horticultural plantation such as Crystal Guava. This plantation is done through careful treatment in applying both organic and inorganic fertilizer and the abundant dose of pesticide continually. These efforts, however, yield some drawbacks to the environment, especially for the soil itself. Thus, this study was aimed for discovering the amount of the heavy metal contained in the soil and Crystal Guava. This study used descriptive analytic method along with using *Spectophotometer* for testing the heavy metal. The elements of three heavy metal Fe, Cd, Cu in the soil concentration in 30 - 60 cm soil depth were higher than in 0 – 30 cm soil depth. The third content of heavy metals in the soil is included in the high category so that it is harmful to the environment and plants. The heavy metal content of Fe, Cd, Cu in the crystal varieties of guajava fruit in plants aged 5, 6 and 11 years has the results of heavy metal analysis that has exceeded the normal threshold of pollution guidelines.

Keywords: Heavy Metal, Crystal Guava, Environmental Pollution

INTRODUCTION

Bumiaji Suburb is a good quality area which is suitable for the development of horticultural planting particularly, Crystal Guava. This plant is usually taken care by giving both organic and inorganic fertilizer along with the abundant amount sprays of the pesticide and insecticide with an eye to preventing them to be infected by plant disease. However, these efforts in maximizing the production also bring drawbacks as well, such as a side effect towards the environment. Those fertilizers have become the ajor heavy metal pollutant for Crystal Guava plantation. According to [1] the content of heavy metal Lead (Pb) in a tested compos fertilizer was around 1,3 -2240 ppm. Another heavy metal pollutant that burden Crystal Guava plant are: the soil condition, the motor vehicle smoke waste, and rainfall. Soil contains of micro element such as timbale, cuprum, cadmium, etc. with the average content of Pb in soil is 10 ppm.

The motor vehicle smoke waste can be such a dangerous pollutant towards that plant along with jeopardize of rainfall in which can easily wrench the micro elements from the foreland to the low land.

Crystal Guava is capable of accumulating the heavy metal to its fruit, which its existence can jeopardize the human's health. One of these jeopardizing heavy metal is Pb. According to [2], the normal levels of Pb in an adult's blood is <40 ppm. The light symptoms of Pb poisoning are such us insomnia and other sleeping anxieties, and in some cases can cause death.

Excessive heavy metal can create soil pollution. [3] argued that the lists of heavy metal which can cause soil pollutant are: Fe, As, Cd, Pb, Hg, Mn, Ni, Cr, Zn, dan Cu, which toxicity level is high due to the over-extensive use. While the United State Environment Protection Agency (US EPA) noted the major polluting and jeopardizing heavy metals are Sb, Ag, Be, Cd, Cr, Cu, Pb, Hg, Ni, Se, Sr, Ag dan Zn [4]. However, there are other heavy metals such as Cr, Cu, Fe, Mn, Mo that are part of micro trace element contents which can be useful for the plants. The soil is poisoned as if the heavy metal is accumulated and is over the critical level in the soil.

MATERIAL AND METHOD

This study was done during May until August 2017 in Bumiaji Sejahtera farm, Batu City, East Java, with the height of soil was ±150 meter above the sea level, along with 20º C for the average temperature, and the average of the around 78 % and the rainfall 200 mm/day.

Sampling method was occupied to gather primary data in analyzing the heavy metal content in both in Crystal Guava and its soil which was

Correspondence address:
Hidayati karamina
Email : hidayatikaramina@yahoo.com
Address : Faculty of Agriculture, Tribhuwana Tunggadewi University Malang, 65144

obtained from the several farms based on the Crystal Guava's crop age. The fruits obtained for the analysis were the edible ones with the ripeness around 90 days after the first flower bloomed. The laboratory analysis of heavy metal content after taking several samples showed that:

A1 : Five-year-old Crystal Guava plants
A2 : Six-year-old Crystal Guava plants
A3 : Eleven-year-old Crystal Guava plants

The soil sampling was done on the surface area 5 x 5 m, and was taken in every 0 - 30 cm dan 30-60 cm treatment under the ground. While for the fruit sampling, the sample was obtained by taking two fruits per tree. The determination on the sampling used simple random sampling and every sample taking process was repeated two times. Then, the sample were analyzed in the laboratory using *Spectophotometer*.

RESULT AND DISCUSSION

Table 1 exhibited the results of the heavy metal analysis in the soil with 0- 30 cm depth with the crop age 11, six, and five years. There were three heavy metals analyzed, that is Fe, Cd and Cu. The highest heavy metal Fe and Cu EPA contamination was found in the eleven-year-old Crystal Guava plants. Moreover, the highest heavy metal Cd contamination was found in the five-year-old Crystal Guava plants.

Table 1. Fe, Cd and Cu concentration on the Crystal Guava farm area with the crop age of eleven, 6, 5 years old (0 – 30 cm)

No	Code	Fe	Cd	Cu
			ppm	
1	A1 /Tree 1	52,20	1,11	5.60
2	A1 /Tree 2	63.40	0,56	11,26
3	A1/ Tree 3	74.12	0,59	15,01
4	A1/Tree 4	73.17	0,76	15.60
5	A1/Tree 5	70.50	0,89	17.26
	Average	70.297	0.782	12.82
6	A2 /Tree 1	62.17	1,04	25.75
7	A2 /Tree 2	63.15	1,20	31.11
8	A2 /Tree 3	70.21	0.19	15.25
9	A2 /Tree 4	62.05	0.77	10.21
10	A2 /Tree 5	63.34	0.76	15.15
	Average	64.184	0.5733	19.494
11	A3 /Tree 1.	65.19	0.58	18.10
12	A3 /Tree 2.	54.16	0.04	20,31
13	A3 /Tree 3	65.30	1.06	19.10
14	A3 /Tree 4	53.24	1.07	17.33
15	A3 /Tree 5	75.50	1.08	57.30
	Average	62.678	0.766	27.957

From the data of the analysis above in 0 depth soil (top soil), we can conclude that all heavy metals were still under control except for Fe. However, several treatments can be applied in order to reduce the existence of Fe in that soil. The excessive content of heavy metal in the soil can cause phytotoxic which deliberately results in functional issues on the other environmental components. This natural phenomenon happens through geogenic and pedogenesis, and even through anthropogenic [5].

In general, the cationic metals which cause such issues (metals element in the soil which own positive ions, for example Pb^{2+}) are cadmium, mercury, tin, copper, nickel, zinc, chromium, iron and manganese. The most frequently encountered anionic compound (a compound which is formed in the soil and is combined with oxygen and holds negative ion such as MoO^{42-}) are arsenic, molybdenum, selenium, and boron [6]

Among the group of metals, Cd, Cu, and Fe are elements having strong competition in the process of plant nutrient absorption and translocation [7]. Thus, they possibly inhibit the absorption of the essential plant nutrient. According to [8], the symptom of toxicity / contamination is similar to the plant suffering of malnutrition and showing the actual symptom of deficiency. Similar symptom was also found in such research as the cultivation of soybean [9], chinese albizia [10], and cucumber [11]. Those findings are in line with the abovementioned data mentioning that the content in 0 cm soil depth (top soil) remains at the threshold, except for Fe. However, there are several treatments to do to depress the content of Fe in such soil depth. The content of heavy metal in the soil may reach a particular level that results in phytotoxicity and functional disturbance towards the other environmental components. This phenomenon may occur naturally through the process of geogenesis and pedogenesis as well as anthropogenesis [5], [6].

The high level of heavy metal content in the soil metal is interconnected with acidic pH. Therefore, it causes the heavy metal contained is soluble and actively absorbed by the plant. In addition, the existence of such heavy metal, according to [12] may cause the limited amount of phosphor, potassium, and iron in the plant's root culture, in which they may slow down the root growth and meristem culture development. [13] affirm that by stating that the inhibited growth of aloe vera is also caused by the acidic soil that generally is seriously correlated with soil reaction. Low pH or high acidity may result in the toxic combination of Fe, Cd and Cu. However, the most dominant factor of the poor growth of crystal guava.

Table 2. The concentration of heavy metal Fe, Cd and Cu in Guava Crystal farmland with 11, six, five years old age of crop (30 – 60 cm).

No	Code	Fe	Cd	Cu
			Ppm	
1	A1 /Tree 1	83.27	1.83	26.5
2	A1/Tree 2	83.45	1.65	25.62
3	A1/Tree 3	83.05	1.63	26.18
4	A1/Tree 4	82.04	1.76	25.94
5	A1/Tree 5	83.85	1.68	22.76
	Average	85.152	1.71	25.396
6	A2 /Tree 1	85.91	2.04	31.57
7	A2/Tree 2	84.66	1.83	34.79
8	A2/Tree 3	85.32	1.99	25.22
9	A2/Tree 4	83.55	1.77	15.44
10	A2/Tree 5	85.57	1.66	29.26
	Average	85,002	1.858	27.256
11	A3 /Tree 1	80.54	1.85	28.45
12	A3/Tree 2.	83.60	2.04	30.31
13	A3/Tree 3	84.22	1.96	29.16
14	A3/Tree 4	84.17	1.76	28.41
15	A3/Tree 5	83.50	1.82	78.93
	Average	83,206	1,886	39.052

Table 2. includes the data of heavy metal content in 30- 60 cm soil depth of the various Crystal Guava. The highest heavy metal Fe content was found in five-year-old Crystal Guava plants. While for Cd and Cu was found in eleven-year-old Guava Crystal plants. After comparing to relevant literature studies, it was shown that all those three heavy metal content were above the normal standard. We also can conclude from the data above that soil depth influences the concentrations of the elements inside it. Mostly, the elements' concentration in 30 - 60 cm soil depth were higher than in 0 – 30 cm soil depth.

The existence of heavy metals correlates to the organic content in the soil (Soepardi, 1983). The organic elements will cause the metals' cations to form Kelat ring. Mostly, almost all the processes in the soil are done by clay and *humus.* A colloidal form, both clay or organic, is an essential process in the soil in which the exchange of ions happens.

Heavy metals in the soil can be categorized as follows: ones which are dissolved in the water and in the soil solution, which can be exchanged, which were absorbed in soil complex bonded colloid, organic occluded, which associate to undissolved *humus*, were occluded in iron and manganese oxidase, compounded with sulfide, phosphate, and carbonate, and were structurally occluded with silicate and primer mineral [14]

Heavy metal contained in the soil may be naturally controlled by several minerals contained in the rock composing earth's crust. Human activity may cause the heavy metal absorbed by the atmosphere, soil, and waters and become contaminated. Toxic and hazardous waste is the example of contaminant that potentially damage the environment. [15] contends that metals with specific gravity to the amount of > 5 are considered as heavy metal and may form salt in acidic nature. Moreover, [16] also state that there are 3 categories of nature of heavy metal contamination: high toxicity that consist of metals such as Cadmium, Lead, Zinc, and Copper; medium toxicity such as Chrome, Nickel, Cobalt, and Aluminum; and low toxicity such as Manganese, and Iron.

The dissolved with water ones were only 1-5 %, even though these forms were the least of all, but they become so essential in the environment as the absorbent and food delivery were done by these heavy metals. In the soil, the heavy metals were detained through bonding, precipitation, and complexity were going out from the soil through the plants' absorbent and abstersion. Some heavy metals such arsenic, mercury, and selenium could evaporate due to their capability in changing into a gas compound. The dynamics of heavy metals in the environment or soil are determined by the soil and environment themselves. The major parameter in heavy metals study is bioavailaibility in the soil. This becomes so essential in the effort of heavy metals contaminated soil bioremedial [17]

Table 3. The analytical results of the fruits (HNO_3 + $HClO_4$)

No	Code	Fe	Cd	Cu
			Ppm	
1	A1	106.80	4.13	22.18
2	A2	103.37	4.59	22.18
3	A3	78.44	5.21	22.38

Table 3 showed that the content of heavy metal Fe, Cd and Cu in the fruits was quite high. For Fe, the highest was in the fruits which trees were five years old. While for heavy metals Cd and Cu was in the fruits which trees were 11 years old. From the data above, we can acknowledge that they are corresponding to the normal standard guidelines stated by [18], where the tolerable level of heavy metals Fe is around 2- 20 ppm, Cd is 0.2- 0.8 ppm, Cu is 4- 15 ppm, Pb is 0.1-10 ppm, and Al is 5-100 ppm. The data analysis above showed that all those fruits contained excessive Fe, Pb, Cu, Cd dan Al heavy metals.

The fact shows that the entrance process of heavy metals into the soil mostly is because of humans' activities. The existence of heavy metals in the environment will not poison living creatures unless if it enters their metabolism system and surpass the normal standard [19]. However, the normal standard can be different in every living creature. The entrance of heavy metals into human's and animal's metabolism system can be divided into direct and indirect. The direct entrance can happen through the drunk water, the inhaled air, or physical contact. While indirect entrance can happen through the food that we eat. To be concise, the heavy metals which come from the soil, water and air are absorbed to the plants that will be eaten by humans and animals [20].

Several principles of both free and non free heavy metals are bound to some soil elements. In its non free form, heavy metal may be bound to the soil nutrient, organic materials, or even inorganic materials. Meanwhile, in their free form, heavy metals may be toxic and be quickly absorbed by plant [17]. With the abovementioned principles, heavy metals may affect the soil's nutrient availability for plant and contaminate it so that it may have inhibited growth and be died [21]. Furthermore, Table 4 showed the guidance of safe threshold for heavy metals in the soil, water, and plant.

Moreover, Table 3 showed that Lead (Pb) contained in the 11 year old plant exceeded the normal threshold. If related fruit is continuously consumed in a long period of time, it will result in health issues [1]. In addition, if the heavy metals continuously contaminate soil, sooner or later, their amount will exceed the normal threshold and the plant will easily absorb them. Furthermore, if the root defense system gets worse, it will distribute the heavy metals to the other plant's parts such as trunk, leaves, and fruit [22].

CONCLUSION

The elements of three heavy metal Fe, Cd, Cu in the soil concentration in 30 - 60 cm soil depth were higher than in 0 – 30 cm soil depth. The third content of heavy metals in the soil is included in the high category so that it is harmful to the environment and plants.

The heavy metal content of Fe, Cd, Cu in the crystal varieties of guava fruit in plants aged 5, 6 and 11 years has the results of heavy metal analysis that has exceeded the normal threshold of pollution guidelines.

ACKNOWLEDGMENT

The project was financially supported by the Ministry of Research, Technology and Higher Education of the Republic of Indonesia through applied beginner lecturer research. The authors wish to thank Dean of the Faculty of Agriculture, Tribhuwana Tunggadewi University for allowing the implementation of this research. Thanks are extended to the member of agroecotechnology for their participation in this study.

REFERENCES

[1]. Charlena. 2004. Pencemaran logam berat Timbal (Pb) dan Cadmium (Cd) pada sayur - sayuran. http://www.rudyct.com/PPS702 ipb/09145/charlena.pdf. Diakses tanggal 22 Februari 2019

[2]. Palar H. 2008. Pencemaran dan Toksikologi Logam Berat. Jakarta: Rineka Cipta.

[3]. Saeni, M. S. 2002. Bahan Kuliah Kimia Logam Berat. Program Pascasarjana IPB. Bogor

[4]. Sukhendrayatna, 2001. Bioremoval logam berat dengan menggunakan mikroorganisme: suatu kajian kepustakaan. Japan: ISTECS. hal. 1-9.

[5]. Alloway, B.J. 1995. Heavy metal in soils. Second edition. New York: Blackie Academic and Professional- Chapman and Hall

[6]. Lacatusu, R. 2000. Appraising Levels of Soil Contamination and Pollution with Heavy Metals. In: Heineke, H.J., Eckelmann, W., Thomasson, A.J., Jones, R.J.A., Montanarella, L. and Buckley, B., Eds., European Soil Bureau—Research Report No. 4, 393-403.

[7]. Marschener, H. 2002. Mineral nutrition of higher plant. San diego, Ca. Academic Press London. p.902

[8]. Rahma, H., S. Sabreen., S. Alam and S. Kawa. 2010. Effects of aluminium ongrowth and composition of metal micronutrients in barley plants grown in nutrient solution. *Journal of Plant Nutrition*. 28 (2): 393-40

[9]. Netty. 2013. Potensi remediasi beberapa tanaman akumulator pada tanah pasca penambangan. Program Doktor Ilmu Pertanian Fakultas Pertanian Universitas Brawijaya. Disertasi : 75-8

[10]. Setiadi, Y. 2001. Status Penelitian dan Pemanfaatan Cendawan Mikoriza Arbuskula dan Rhizobium untuk Merehabilitasi Lahan Terdegradasi. Seminar Nasional Mikoriza. 15-16 November 1999. Bogor

[11]. Azis, E. E., N. Gad. and N. M. Badren. 2007. Effect of plumbum and aluminium on plant growth system of quercus ilex trees and effects of selected ligands present in the xylem sap. *Journal of Plant physiology*. 166 (2) : 270-277.

[12]. Connell, D.W and G.J Miller. 2005. Kimia dan Ekotoksikologi Pencemaran. Diterjemahkan

oleh Yanti Koestoer. Universitas Indonesia Press. Jakarta.
[13]. Fitter, A. H. dan R. K. M. Hay. 2001. *Fisiologi lingkungan tanaman*. Gadjah Mada University Press. Yogyakarta
[14]. Pathan, S. M. and T. D. Colmer. 2002. Reduced leaching of nitrate, ammonium and phosphorus in a sandy soil by Fly Ash Amendment. *Journal of Soil Research*. 40 (3): 1201-1211
[15]. Kidd, P., J. Barcelo., M. P. Bernal., F. Navari Izzo., C. Poschenrieder., S. Shilev., R. Clemente. and C. Monterrose. 2009. Trace element behavior at the root soil interface. Implication in phytoremediation. *Journal Enviromental and Experimentl Botany*. 67(1) : 243-259
[16]. Liu, A. and A. A. Bomke. 2004. Effect of cover crops on soil aggregate stability, total organic carbon and polysacharides. *Journal Soil Science*. 69 (1): 2041-2048.
[17]. Li, Y. M. and A. J. M. Baker. 2000. Phytoremediation of heavy metal contaminated soils. *Journal Bioremediation of Contaminated Soils*. 12 (1): 837- 857.
[18]. Barchia, M.F. 2009. Agroekosistem Tanah Mineral Masam. Gadjah Mada University Press. Yogyakarta
[19]. Brown, K. H. and J.S. Stern. 2005. Effects of dietary energy density and feeding frequency on total daily energy intakes of recovering mainourished children. *Journal of Agriculture*. 62 (3) : 13-18.
[20]. Notohadiprawiro, T. 1993. *Logam Berat dalam Pertanian* (http://www.chem-is-try.org) Diakses tanggal 11 Mei 2010
[21]. Kolar, J. S., H. S. Greival and B. Singh. 2003. Nitrogen substituion and higher productivity of a rice wheat cropping system through Green Manuring. *Journal Tropical Agriculture*. 70 (4) : 301-304.
[22]. Fonte, S. J. and E. Y. Quansah. 2009. Fertilizer and residue quality effects on organic matter stabilization in soil aggregates. *Journal of Soil Science*. 73 (1): 961-965