International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN: 0974-4290
Vol.8, No.3, pp 1053-1059, 2015

The Study of Herbicides Application on Weeds as a Material of Vermicomposting with Anesic Earthworms

Wheny Masruroh*, Budi Prasetya, and Retno Suntari

Department of Agriculture faculty, Brawijaya University, Indonesia

Abstract: Weeds are a potential material for composting. The presence of weeds in crop cultivation is often controlled with herbicides. The objective of this study was to investigate the effect of herbicides to earthworms, vermikompos, and maize. The purposes are: 1. Knowing the effect of herbicides on weeds to the resistance and the development of earthworms, 2. Knowing the nutrient content of vermicompost (N, P, K, and C), 3. Knowing the Pb content in vermicompost and maize. This study used a completely randomized design with three replications and seven treatments. Herbicides were applicated on weeds in maize cultivation. Then weeds used as material for vermicompost. Weeds and soil were mixed with composition 1 kg of each material. The results of vermicompost used as a growing medium for maize. The results showed that the application of herbicides on weeds as vermicompost materials has not significant effect on the resistance and development of earthworms. Vermicompost containing high nutrients (N, P, K, and C) that caused by earthworm functions during decomposition process. Pb metals content of Vermicompost are affected by Pb content of weeds and the number of earthworms. Pb metal content of vermicompost has signicant effect to Pb content in roots, steem and leaves of maize.
Keywords: herbicide, earthworms, lead and vermicompost.

Introduction

The use of herbicides is the advancement of agricultural technology in weed control. The annual rises in the use of herbicides increasingly difficult to control in crops such as corn, soybeans and cotton has grown from 750 tonnes in 1999 to around 45,000 tonnes in 2011[1]. Besides containing active ingredients, herbicides also contain heavy metals. Cationic metals that generally the cause of environmental problems is mercury, cadmium, lead, nickel, copper, zinc and chromium, while the anionic compound is arsenic. The organic pollutants derived from chlorinated solvents, herbicides and pesticides[2].

Weeds are plants that grow on the cultivation of maize whose presence can reduce the production of corn. Weeds that grow in the cultivation of maize derived from the seeds of weeds in the soil. Certain weed species is a competitor of the corn crop in getting water, nutrients, and light. Level of competition between crops and weeds depends on four factors, namely stages of plant growth, weed density, water stress and nutrient levels, as well as weed species. If left unchecked, broadleaf weeds and grasses can significantly suppress the growth and development of corn[3]. Weeds can cause greater damage to the crops because some weeds have allelopati. Allelopati are secondary products of plants that can poison other plants that are nearby[4].The lower percentage of allelopathy puzzle weed germination, inhibit the emergence of seed time, reduce the number and leaf area and leaf chlorophyll content, decreasing the activity of the enzyme nitrate reductase, nitrogen uptake and forage crude protein content, photosynthesis and dry matter production forage maize[5].

Vermicomposting with *Eisenia andrei* from paper sludge mixed with cow manure in the plot scale trial for six months. In a plot experiments, the number of earthworms increased among 22-36-fold and total biomass increased by between 2.2 to 3.9-fold. Vermicompost produced rich in nitrogen and phosphorus and has a good structure, low levels of heavy metals, low conductivity, high humic acid content and good stability and maturity[6].

Earthworms can accumulate heavy metals in their bodies. Heavy metals accumulated in earthworms from the food eaten[7]. Some sources say that earthworms are able to accumulate heavy metals anesic manifold, namely the earthworm *Eisenia Fetida* and *Lumbricus rubellus* can accumulate heavy metals Pb, Cd, and Zn in their body[8,9].The content of heavy metals in the soil will affect the chemical content in the ground water system. Based on these, the research conducted to analyze the influence of the number of eartrworms, the nutrient content of available N, P, and K on vermicompost, lead contained in vermicompost. and heavy metal content in the maize.

Materials and Methods

Herbicides Applications

Herbicides were applied according to the treatment after 25 days of maize cultivation. The herbicides were containing the active materials of Atrazine and Mesotrion. Herbicide dose range included: 0 L ha^{-1}, 0.5 L ha^{-1}, 1 L ha^{-1}, 1.5 L ha^{-1}, 2 L ha^{-1}, 2.5 L ha^{-1} and 3 L ha^{-1}. Weeds was taken about 5 weeks after herbicide application, and then made as material of vermicompost. Anesic type of earthworms are prepare that live in the soil and feed the organic matter. Anesic earthworm was taken from banana's garden in Jombang, east java, Indonesia. Earthworms were taken by hand shorting method with cow dung traps. Cow manure was placed on the soil surface that gets shade. A week later the land under cow dung was opened to get the earthworms.

Vermicomposting process

Media vermicompost made of a mixture from soil and weeds (Table 1). Then the soil and weeds put into the pot as a medium of decomposition by comparison weeds: soil was 1: 1. Weeds were maked small size with 10 meshes to make more quickly disintegrate and make it easier to eat by earthworms. Weeds and soils have 1 kg of weight. Then, soil and weeds was mixed in a pot as medium of vermicompost. Every media of vermicompost take 10 tails of earthworm. The condition of earthworms are same (5-10 cm of long, 1-2 g of wheight), adult (have clitellium), and health. That media always controlled until 2 month (60 days). Soil type that use in this research is inceptysols type.

Table 1. Characteristic of materials that use as vermicompost

Parameters	Object	Value
Heavy Metals	Soil	Pb : 6.87 $\pm$ 0,16 ppm Cu: 1.06 + 0,02 ppm Cd: 0.82 + 0,01 ppm
pH	Soil	6.67
Organic-C	Soil	0.11 %
P-available	Soil	33.52 ppm
Total-N	Soil	0.21%
K-available	Soil	1.05 Cmol kg^{-1}
Soils texture	Soil	Sand : 25 % Silt : 39 % Clay : 61 %
Ratio C/N	Weeds	P1 : 10.16 P2: 8.88 P3: 10.55 P4: 9.76 P5: 13.85 P6: 9.84 P7: 8.07
Heavy metals	Herbicide	Pb: 0.13 $\pm$ 0,01 ppm

Pb uptake Test of vermicompost

Pb uptake test was done by make maize grow in vermicompost media during the vegetative phase. Seeds of maize have vegetative period 0-40 day. Every polybag contained 2 seeds of maize. Then the plants were observed in the laboratory to know how the content of Pb uptake on leaves, stems and roots of maize was analyzed by AAS (Atomic absorption spectrophotometer).

Results and discussions

A. Effect of herbicide application to the number and productivity of earthworms.

The application of herbicides on weeds as food of earthworms has not significant effect to the resistance and development of earthworms (Table 2). Herbicide that uses to control weeds has not Pb content dangerously yet to earthworms. Earthworms will disturb when Pb contents more 100 ppm. Earthworms can produce cocoons 1-2 normally. In good conditions, cocoons being 2-4 juvenile. Environmental factors that influence the development of earthworms include: pH, moisture, organic matter content, and ambient temperature[10, 11, 12]. Table 2 showed that the number of juveniles either the first or second month, on treatment without the application and the highest dose have the same number of averages. That suspected by the influence of heavy metals Pb contamination of herbicides that can reduce earthworm productivity. Pb can affect the embryonic organ development [13]. There was no increase in production of cocoons on the addition of heavy metal concentrations lead to a concentration of 100 ppm [14]. It can be concluded that in addition to interfere with the growth of earthworms, lead also disrupt the reproductive system of an earthworm. Lead can inhibit the production of cocoons earthworms at a concentration of 100 ppm. Earthworms can produce cocoons 0-2 cocoons per week normally[15].

Table 2. Average of total earthworms, juvenile, cocoons on first and second month

Code	Treatments	1st month			2nd month		
		Earthworms (tail)	Juvenile (tail)	Cocoon (grain)	Earthworms (tail)	Juvenile (tail)	Cocoon (grain)
P1	Control	10	5	4	15	5	9
P2	0.5 L ha^{-1} of herbicide	7	4	3	11	4	7
P3	1 L ha^{-1} of herbicide	6	3	3	9	3	6
P4	1.5 L ha^{-1} of herbicide	6	3	2	7	2	5
P5	2 L ha^{-1} of herbicide	6	4	5	10	6	7
P6	2.5 L ha^{-1} of herbicide	11	5	5	15	7	9
P7	3 L ha^{-1} of herbicide	10	4	6	11	7	10

The organic matter is an important factor for development for the number and biomass of earthworms [16]. Organic matter from weeds as food for earthworms in vermicompost containing Pb metals (Table 3). Weeds absorb Pb from the soils that always use herbicide in maize cultivation [17]. After incubated for 2 months in the media vermicompost turns in the earthworm body containing heavy metals Pb. But the Pb content in earthworm body less than 100 ppm. Besides that, earthworm have strategy to hold out at medium that contaminated by herbicide. It was suggested that reduced feeding may have been a strategy to avoid the herbicide [18].

Table 3. Average of Pb content in weeds and earthworms body

Code	Treatments	Pb on weeds	Pb on earthworms
		……………..…………...ppm……...……………	
P1	Control	8.79	0.17
P2	0.5 L ha^{-1} of herbicide	12.05	0.27
P3	1 L ha^{-1} of herbicide	15.73	0.36
P4	1.5 L ha^{-1} of herbicide	18.84	0.23
P5	2 L ha^{-1} of herbicide	26.97	0.25
P6	2.5 L ha^{-1} of herbicide	49.23	0.51
P7	3 L ha^{-1} of herbicide	86.09	0.48

B. Effect of herbicide aplication to Nutrient of Vermicompost

Vermicompost have very high nutrient content. Vermicompost mentioned many have benefits for the plant that nutrients available like: N, P, K and C (Table 4). Vermicompost contained some microorganisms that living in the digestive system of earthworms. Invertebrate animals that decompose organic matter has a digestive system that is not perfect, therefore in digesting organic matter greatly aided by the presence of bacteria that can degrade cellulose in the digestive system. The bacterium is a symbiotic cellulotic bacterium in the digestion of earthworms. Cellulotic bacteria in the digestive system of earthworms can degrade cellulose; the result of bacterial degradation is very useful to improve the compounds necessary for the growth of plants or other microorganisms[19].

Table 4. Average of nutrient in vermicompost

Code	Treatments	N-total (%)	P-available (ppm)	K-available (cmol/kg)	C-organic (%)
P1	Control	0.32	47.91	4.50	1.99
P2	0.5 L ha^{-1} of herbicide	0.34	61.32	5.89	2.29
P3	1 L ha^{-1} of herbicide	0.35	59.35	4.72	2.36
P4	1.5 L ha^{-1} of herbicide	0.33	57.41	4.01	2.10
P5	2 L ha^{-1} of herbicide	0.38	67.72	5.20	2.72
P6	2.5 L ha^{-1} of herbicide	0.38	80.79	4.80	2.67
P7	3 L ha^{-1} of herbicide	0.41	65.73	5.91	2.50

N-total results on vermicompost media showed that the application of herbicides on weeds as food earthworms tend to increase (Table 4). It can be seen that the value of N-highest total achieved at a dose of herbicide 3 L ha^{-1} and the lowest value contained in the treatment without herbicide. It is presumed that the highest dose, weeds can decompose very quickly, thus helping the subsequent destruction by earthworms. Earthworms participate in the N cycle through vermicompost, mucus production and decomposition of dead tissue[8]. Results excretion of earthworms in the form of urine is a material containing urea and ammonia. In addition, a material with high nitrogen content also removed through the body wall as mucus [20].

P-available on vermicompost media showed not significant effect of herbicide application. The increasing the dose of herbicide was increased levels of P-available. This can occur because of the influence of earthworms in the propagation media. In general, when the organic matter through the gastrointestinal worms, most of the phosphorus is converted into a form of P dissolved by digestive enzymes in the worm, most of the phosphorus is converted into a form of P dissolved by digestive enzymes in the worm, the phosphatase and alkaline phosphatase. Further elements of P will be released by microorganisms in dirt worms[21].

K-available on vermicompost showed that the application of herbicides on weeds as food earthworm has a tendency to fluctuate, the lowest K-available is achieved at dose of herbicide 1.5 L ha^{-1} and the highest value achieved at a dose of 3 L ha^{-1}. It is alleged the herbicide dose of 3 L ha-1 are stable clay-humic, which acts as a buffer cations K^+ in the soil[22]. While the treatment of herbicide dose of 1.5 L ha^{-1} potassium existing possibilities are used by microbes as an enzyme activator. Clay content of this soil has high clay content (61 %) that caused K^+ fixation very strong. That can make K^+ concentration decreased in soil colloid [23]. Besides that, the elements of potassium needed microbes in a concentration of about 10^{-3} - 10^{-4} M [24]. At a dose of 1.5 L ha^{-1} is also a condition of treatment with the lowest number of earthworms.

The highest C-organics in vermicompost results are in treatment with a dose of the herbicide 2 L ha^{-1}. While the lowest in the control treatment is not given herbicide, it is normal in the composting process, because in the control treatment that does not use herbicides, microorganisms do not interfere with the herbicide. Carbon of weeds has been used by earthworms and microorganisms as a source of energy. The first composting activities carried out by the earthworms to destroy weeds mechanically litter. Then, litter was digested by microorganisms that living in the digestive systems of earthworms[25]. Earthworms can reduce organic matter of weeds volume up to 40-60%. Every adult worm eats soil organic matter of capable to their weight every day[8].

Increased levels of C-organic vermicompost supported by the application of herbicide before the weeds are used as a medium of vermicompost. Decomposition weeds as organic material can take place due to the influence of the toxicity of herbicides on weed plant tissue. Factors affecting the speed of decomposition of weeds are; pH, climate, humidity and soil organisms[26]. Litters that are in areas that have large numbers of micro-organisms are more likely to be rapidly decomposed than in areas that have a slight amount of micro-organisms. Earthworms destructed organic matter through to the mouth and then into the pharynx and esophagus. After that, proceed to the gizzard which serves as a work mill destroyer foodstuffs mixed with soil. Gizzard is the place of cellulotic bacteria in the digestive system of earthworms [27]. The number of microorganisms which little is closely related to the amount of earthworm, earthworms, through casting called vermicompost able to provide living space for microorganisms in the process of decomposition [19].

C. Effect of herbicide aplication to Pb metal content on Vermicompost and maize.

The increasing doses of herbicides is also increased the content of Pb in the weeds. It is the reason significant to Pb content in the vermicompost results (Table 5). Pb contents were found in the results of vermicompost is also increasing. At doses of herbicide 1.5 L ha^{-1} has the highest content of Pb 16.01 ppm. While the herbicide doses above 1.5 L ha^{-1} had a Pb content of 12.27 – 12.92 ppm. This is presumably due to the number of earthworms that breed at a dose of 1.5 L ha^{-1} very low. Pb absorbed by earthworm body too low, thus remaining Pb on the results of vermicompost is still high (Table 2). In addition, the influence of humic acid secretion results from earthworm body. Humic acid is generated from the vermicompost able to form colloidal adsorption. Humic acid affects the growth and proliferation of beneficial microorganisms. Perhaps the heavy metals Pb degrading microorganisms are also contained in the humus produced in vermicompost. Humus material containing humic substances that contributed to inorganic reactions in the soil [28]. Humus in vermicompost can make strong bonds between the particles increases [29]. Thus Pb bond with humic acid at doses higher the more powerful herbicide.

Analysis of variance of Pb in maize showed that herbicide application significantly different to the uptake of Pb in roots, stems and leaves of maize plants (Table 5). Pb in roots, stems, and leaves of maize plants showed the highest content contained in the herbicide dose 0 L ha^{-1} (Table 5). This is thought to treatment without herbicide has a low nutrient content, so it is absorbed by the roots of plants is a heavy metal that is the result vermicompost (Table 4). Chelate bond Pb in soil will be very strong if soil nutrient in high condition. Pb absorbed by plants during fertility conditions and low soil organic matter content [30, 31]. In the state of heavy metals Pb will loose from the ground and form free-moving ions in the soil solution. If other metals are not able to inhibit its existence, then it was occured Pb uptake by plant roots [30]. The Pb content on roots tends to decrease with increasing doses of herbicides. This can occur due to increasing doses of herbicide weed death process can take place quickly. Furthermore, when earthworms entered will destroy the input as the decomposition process. The decomposition produces humic acid is capable of binding heavy metals Pb in vermicompost. Casting exist in vermicompost produce N, P, K is high enough, so that plant roots can absorb nutrients better than heavy metal Pb [32].

Table 5. Average of Pb metal content in vermicompost and maize

Code	Treatments	Pb on vermicompost	Roots	Stems	Leaves
		……………………………g/polybag……………………………			
P1	Control	60.63	20.53	4.90	1.87
P2	0.5 L ha^{-1} of herbicide	92.42	16.91	4.19	2.92
P3	1 L ha^{-1} of herbicide	157.09	18.20	3.61	2.35
P4	1.5 L ha^{-1} of herbicide	160.08	7.46	5.74	2.84
P5	2 L ha^{-1} of herbicide	129.17	17.37	3.05	1.32
P6	2.5 L ha^{-1} of herbicide	122.67	7.64	2.29	0.29
P7	3 L ha^{-1} of herbicide	125.50	9.16	1.36	1.23

Factors that control the accumulation of Pb in plants are the concentration and type of metal in the soil solution, the metal movement of the soil to the root surface, metal transport from the roots to the root surface, and its translocation from the roots into the plant canopy. Pb is more passive in the ground because it is difficult degraded in soil[33]. Lead (Pb) tends to accumulate and sedimented in the soil due to their low solubility and relatively free of degradation microorganisms [34]. So that the Pb content of vermicompost are increasing with increasing doses of herbicides on weed given. Plants can absorb Pb on condition of low organic matter content of the soil and CEC[31]. In this state of heavy metals Pb will loose from the ground and form free-moving ions in the soil solution. If other metals are not able to inhibit its existence, then it happen Pb uptake by plant roots. This is supported by the pH value of the vermicompost results in this study in the range of 5.0-6.0 (Acid). High soil pH values can change into a compound of lead metal precipitates [35].

Conclusions

Herbicide application on weeds with increasing doses that used as materials of vermicomposting has not significant effect on the resistance and development of earthworms. Vermicompost containing high N, P, K and C that caused by earthworm functions during decomposition precess. The highest C-organics, Total-N, available P, K-available, and was achieved by treatment with herbicide application dose of 3 L ha^{-1}. Pb metals content of Vermicompost are affected by Pb content of weeds and the number of earthworms. Pb metal content of vermicompost has signicant effect to Pb content in roots, steem and leaves of maize in average 7.48-20.53, 1.36-5.74, and 0.29 -2.92 ppm respectively.

References

1. Jamalzen. 2012. OECD and transgenic maize. Agroindonesia Bulletin. October 16^{th} 2012 edition. www.agroindonesia.co.id
2. Olaniran, A. O., A. Balgobind, and B. Pillay. 2013. Bioavailability of Heavy Metals in Soil: Impact on Microbial Biodegradation of Organic Compounds and Possible Improvement Strategies. International Journal of Molecular Sciences. p: 10197-10228
3. Fadhly, A.F. and F. Tabri. 2004. Weed control in maze cultivation. Balai Penelitian Tanaman Serealia, Maros. p: 238-254
4. Bertholdsson, N.O. 2012. Allelopathy—A Tool to Improve the Weed Competitive Ability of Wheat with Herbicide-Resistant Black-Grass (*Alopecurus myosuroides* Huds.). *Agronomy* : 284-294
5. Kristanto, B. A. 2006. The Change of Maize Charakteristic (*Zea mays* L.) caused by Allelopatyi and the Rivalry of *Cyperus rotundus* L. *J.Indon.Trop.Anim.Agric*. 31. (3): 189-194
6. Yadav, A., dan V.K. Garg. 2011. Recycling of organic wastes by employing *Eisenia fetida*. *Bioresource Technology* 102: 2874–2880
7. Zhang, Z.S. dan D.M. Zheng. 2009. Bioaccumulation Of Total And Methyl Mercury In Three Earthworm Species (*Drawida* sp., *Allolobophora* sp., and *Limnodrilus* sp.). Bull. Environ. Contam. Toxicol. 83: 937-942
8. Nakashima, T., T. Okada, J. Asahi, A. Yamashita, K. Kawai, H. Kasai, K. Matsuno, S. Gamou, and T . Hirano. 2008. 8-Hydroxydeoxyguanosine generated in the earthworm *Eisenia fetida* grown in metal-containing soil. Mutat. Res. 654: 138-144
9. Andre, J., J. Charnock, S.R.Sturzenbaum, P. Kille, A.J. Morgan, and M.E. Hodoson. 2009. Accumulated Metal Speciation In Earthworm Populations With Multigenerasional Exposure To Metalliferous Soils: Cell Fractionation And High-Energy Synchrotron Analyses. *Environ*. *Sci*. *Technol*. *43*: 6822-6829.
10. Haukka, J.K. 1987. Growth and Survival of *Eisenia fetida* (sav) (Oligochaeta: Lumbricidae) In Relation To Temperature, Moisture, And Presence Of *Enchytreus albides* (Henle) (Enchytraeidea). Biology And Fertility Of Soils: 99-102
11. Brown, G.G. 1995. How Do Earthworm's Effect Microfloral and Faunal Community Diversity. Kluwer Academic Publishers: 247-269
12. Lavelle, P. and A.V. Spain. 2001. Soil Ecology. Kluwer Academic Publ., Dordrecht. p: 273-279
13. Smeester, L., A. E. Yosim, M.D. Nye, C. Hoyo, S.K. Murphy, and R.C. Fry. 2014. Imprinted Genes and the Environment: Links to the Toxic Metals Arsenic, Cadmium and Lead. *Genes*. 477-496
14. Spurgeon, D.J., S.P. Hopkin, and D.T. Jones.1994. Effects Of Cadmium, Copper, Lead And Zinc On Growth, Reproduction And Survival Of The Earthworm *Eisenia Fetida* (Savigny): Assessing The Environmental Impact Of Point-Source Metal Contamination In Terrestrial Ecosystems. J. Environmental Pollution 84: 123-130
15. Gestel, C.A.M. Van, D. Breemen, E.M. and R. Baerselman. 1992. Influence of environmental conditions on the growth and reproduction of the earthworm *Eisenia andrei* in an artificial soil substrate. *Pedobiologia* 36: 109-120
16. Hernández, D.L. 2012. Earthworm Populations in Savannas of the Orinoco Basin. A Review of Studies in Long-Term Agricultural-Managed and Protected Ecosystems. *Agriculture*. 87-108
17. Yoon, J., X. Cao, Q. Zhou, and Q.L. Ma. 2006, Accumulation of Pb, Cu, and Zn in Native Plants Growing on a Contaminated Florida site. Science of the Environment. 368, 456-464.
18. Ribeiro, S., Souza, J.P., Nogueira, A.J.A., Soares, A.M.V.M., 2001. Effect of endosulfan and parathion on energy reserves and physiological parameters of the terrestrial isopod Porcellio dilatatus. Ecotoxicol. Environ. Safety: 131– 138.

19. Reanida, P., Supriyanto, dan Salamun.2012. Exploration of cellulotics bacteria from mangrove soils. Jurnal Untan. Sumber jurnal.untan.ac.id diakses 18 Nopember 2014
20. Edward C.A. and J.R. Lofty, 1977. Biology Of Earthworms. Bookworm Publishing Company. New York. p: 56-112
21. Suthar, S. 2009. Impact of Vermicompost and Composted Farmyard Manure on Growth and Yield of Garlic (*Allium sativa L*) Field Crop. *International Journal of Plant Production*. 3(1) : 595-605
22. Suthar, S. 2007. Nutrient changes and biodynamics of epigeic earthworm Perionyx excavatus (Perrier) during recycling of some agriculture wastes. Bioresource Technology: 1608–1614
23. Puslittanak
24. Pramanik, P., G.K. Ghosh, P.K. Ghosal, and P. Banik. 2007. Changes in organic – C, N, P and K and enzyme activities in vermicompost of biodegradable organic wastes under liming and microbial inoculants. Bioresource Technology: 2485–2494
25. Subowo. 2008. Earthworms potentioals for biological technology to resorption process in dry land. Jurnal Litbang Pertanian, 27(4), 2008 : 35-36
26. Sulistiyanto, Y., J.O. Rieley, dan S.H. Limin. 2005. Decomposition rate and nutrient availability of liiter at two levels type in swamp forest. Jurnal Managemento of Tropical forest. 9 (2): 1-14
27. Suhartanti, D., E.D. Anggara, dan Susanti. 2014. Detection of cellulotic bacteria from digestive system and casting of *Lumbricus terestris*. http://www.archieve-eprints.uad.ac.id/-71010170202007-skripsi/pdf. Diakses pada 18 Nopember 2014
28. Stevenson, F.J. 1994. Humus Chemistry: Genesis, Composition, Reactions. John Wiley and Sons, p:238 - 240
29. Fahriani, Y. 2007. The effect of Leaves Sludge Vermicompost to Soil Physical Characteristic and Maize (*Zea Mays* L.) Growth in Alfisols at Jatikerto. Minor thesis of Agriculture faculty, Brawijaya University, Indonesia.
30. Miller, G., G. Begonia, M. Begonia and J. Ntoni. 2008. Bioavailability and Uptake of Lead by Coffeeweed (*Sesbania exaltata* Raf.). Int. J. Environ. Res. Public Health 5(5): 436-440
31. Charlena. 2004. Pb and Cd heavy metals contamination on vegetables. http://www.rudyct.com/PPS702ipb/09145/charlena.pdf.
32. Nagavallemma, K.P., S.P. Wani, S. Lacroix, V.V. Padmaja, C. Vineela, R.M.Babu, and Sahrawat K.L. 2004. Vermicomposting: Recycling wastes into valuable organic fertilizer. International Crops Research Institute for the Semi-Arid Tropics. An Open Access Journal published by ICRISAT. p: 20
33. Alloway, B.J. (editor), (1995). Heavy Metals in Soils, Blackie Academic & Professional. Glasgow. p: 39-57, 206-223
34. Jung, M.C. 2008. Heavy Metal Concentrations in Soils and Factors Affecting Metal Uptake by Plants in the Vicinity of a Korean Cu-W Mine. Sensor : 2413-2423
35. Novandi R., R. Hayati, and T.A. Zahara. 2012. Remediation of soils that was contaminated by lead with amaranth (*Amaranthus tricolor* L.). http://www.jurnal.untan.ac.id/index.php/jmtluntan/article/5734.

*****