Impacts of Application of the Bamboo Compost on Heavy Metal Polluted Soil Case study on Intensive Farming System in Jember Regency Indonesia

Idah Andriyani*, Elida Novita, Cahyoadi Bowo, and Alisia Ira Mawarni

Department of Agricultural Engineering, University of Jember
Kalimantan Street 37 Tegal Boto Campus, Jember 68121, East Java, Indonesia
idahandriyani@unej.ac.id

Abstract. The excessive use of agrochemicals has led to deteriorated soil physical and chemical properties in alluvial field soils in Jember Regency, which now contains heavy metals. It is imperative to implement bioremediation efforts to ensure soil quality improvement. This study aims to determine the impact of dried bamboo leaves compost dosage as a bioremediation agent on soil physical and chemical properties. The ability of Bamboo compost to reduce heavy metal pollution of Pb, Cd, Cu, Zn in soil and chili product were analyzed. The method used a Completely Randomized Design (CRD). Soil physical properties of aggregate stability, soil chemical properties of pH, C-Organic analysis, and heavy metals Pb, Cd, Cu, and Zn are analyzed, followed by the calculation of heavy metal contamination with Contamination Factor (CF), Geoaccumulation Index (I-Geo), and Pollution Load Index (PLI). The results show that dried bamboo leaves compost has good N, P, K, and C-Organic content according to Indonesian National Standard (INS) compost quality. The conclusion of the research is that dried bamboo leaves compost can be used as a bioremediation agent. The chemical properties and metal contaminants of dried bamboo leaves compost can significantly improve with the best dose at 350g/polybag. However, soil physical properties have not seen significant improvement due to the time limited of research therefore long-term research is required for physical properties to improve.

Keywords: compost, bioremediation, heavy metals.

1 Introduction

Indonesia's lowland rice fields, including in Jember Regency, are almost 55% dominated by aquept and aquent subspecies, which include alluvial soils and glei soils [1]. Alluvial soil fertility largely depends on the source of materials and their production processes. Chili is one of the leading agricultural commodities in the Jember Regency. Chili is a plant with high economic value and is consumptive in Jember Regency [2]. To meet market demand, chili cultivation implements intensive agriculture which triggers excessive use of agrochemicals.

Agrochemicals used such as MOP (Muriate of Potash), kieserite, and RP (Rock Phosphate) which contain heavy metals Zn and Cu and if excessive can be a source of heavy metal pollution [3]. Another heavy metal pollution is Cd which is one of the

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active ingredients of insecticides often used by farmers for pest control, moreover Pb is found in phosphate fertilizers at a dose of 7-225 mg/kg [4]. A lack of knowledge about the negative effects of using agricultural chemicals has caused farmers to overuse fertilizers for decades [3]. Indications of polluted soil are Pb, Cd, Cu, and Zn metal content that exceeds the specified threshold [5].

Compost results from the biological decomposition of organic matter into a humus part [6]. Compost can be used to restore soil fertility and improve the physical and chemical properties of the soil. Dried bamboo leaves are one of the agricultural wastes suitable for composting because they contain 0.74% P and 0.91% K, these contents can help improve soil texture and structure [7]. Organic compost can increase soil organic matter content so that it can improve physical properties, improve biological activity, and nutrient availability by increasing the amount of organic C so that it can improve soil chemical properties [7]. According to [8], microorganisms Saccharomyces cerevisiae, Lactobacillus sp, and Aspergillus sp fungi contained in dried bamboo leaves can decompose organic waste into compost that fertilizes the soil and accelerates microbiological processes to increase nutrient availability.

Compost is one material that can be used for bioremediation, where living organisms, especially microorganisms, reduce environmental pollution. Bioremediation is a process in the decomposition of waste or pollutants both organic and inorganic biologically with the aim of controlling and reducing environmental pollutants using agents of living organisms, especially microorganisms. Bioremediation is the biological process of decontamination of pollutants in polluted environments, where microorganisms are stimulated to degrade harmful pollutants into materials that are safer for the environment. The bioremediation process involves biotransformation and biodegradation by converting contaminants into harmless or less harmful chemicals. Biodegradation is the decomposition of organic matter or bioaccumulation and biotransformation of inorganic compounds into environmentally friendly compounds [9].

In addition, a lack of organic material in the soil is making soil damage worse. Organic matter is a factor that greatly determines soil fertility because organic matter has a major influence on the soil's physical, chemical, and biological properties. This study aims to determine the effect of using bamboo leaves compost as bioremediation to improve the physical and chemical properties of the soil as well as the effectiveness to reduce contaminated heavy metals in soil.

2 Materials and Methods

2.1 Location

Research intensive farming system was conducted in Ambulu subdistrict, Jember regency.

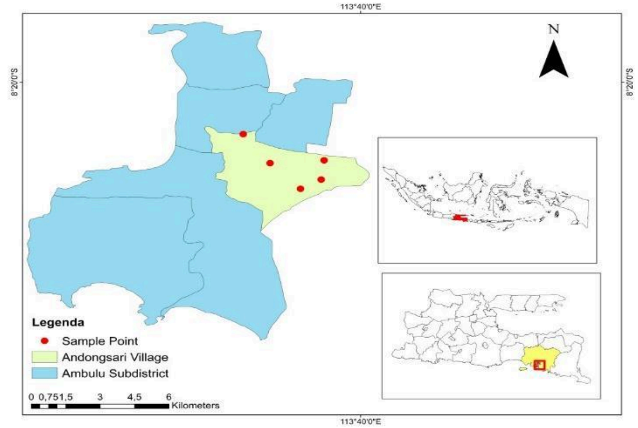

Fig. 1. Research location

2.2 Research Design

The Complete Randomized Design (RAL) with 1 factor of compost dose treatment was used. Determination of dose levels using the formula below.

$$\text{dose}=\frac{A}{land\ area}\ x\ dosage \quad (1)$$

for A is the cross-sectional area of planting in the study. According to research by [10], the use of compost in chili cultivation is an effective dose of 2 kg/m² or 20,000 kg/ha. When this statement is entered into the formula, where A is the area of the polybag with d = 40 cm, a value of 0.25 kg or 250 g is obtained. Therefore, the dosage range of C1 is used: 150 g/polybag, C2: 250 g/polybag, C3: 350 g/polybag to determine the most appropriate dose of dried bamboo leaves compost. The repetition in this study carried out as many as 4 (four) repetitions because, according to [11], in a small treatment, the minimum repetition is 3 (three times).

2.3 Compost

The main components of compost were bamboo leaves and cow dung in a ratio of 1: 1. The activator used is EM4 as much as 60 ml, and as an energy source of microorganisms is added brown sugar solution with a mixture of 1.5 kg of brown sugar and 1.5 L of water. After thorough mixing and closing, the compost is left to ferment for approximately 4 (four) weeks, monitored, and mixed periodically or as needed.

2.4 Analysis of Soil Physical Properties

In this study, the physical properties of the soil were analyzed with 2 (two) parameters, namely soil texture analysis and soil aggregate stability analysis. This analysis was carried out because aggregate stability is one of the physical properties of the soil that can be used as an indicator of soil fertility, because it can determine whether the soil is resistant to erosion [12]. While soil texture analysis is carried out because texture is one of the soil properties that can support plant productivity, this is because texture affects the ability of the soil to hold and conduct water, as well as its ability to store and provide nutrients for plants [13].

2.5 Analysis of Soil Chemical Properties

In this study, soil chemical properties were analyzed with 3 (three) parameters, which are soil pH, soil C-Organic, and soil heavy metal parameters, including Pb, Cd, Cu, and Zn. Soil chemical analysis is represented by these 3 (three) parameters, because the pH value greatly affects the harvest's success [14]. The C-Organic parameter itself is a fundamental indicator of soil fertility, availability of soil nutrients, improvement of physical properties and survival of soil microorganisms [15].
The third parameter is soil heavy metals which become a serious problem for Indonesian agriculture if too much accumulates in the soil. States that agricultural land pollution in Indonesia, especially Pb, Cd, Cu, and Zn on intensively managed land, has exceeded the threshold value [5]. In heavy metal analysis continued with the calculation of metal pollution in the environment, with the Contamination Factor (CF) method, which assesses environmental quality based on the concentration of heavy metals in sediments with the formula

$$CF = \frac{C_x}{C_{background}} \tag{2}$$

C_x is the concentration of metal x in the sample and C background is the normal average of metal x, then calculate the Pollution Load Index (PLI) which can be used to assess the exposure status of heavy metals, with the formula

$$\sqrt[n]{CF1 \times CF2 \times CF3 \times \ldots \times CFn} \tag{3}$$

where n is the amount of metal to be analyzed, the last method Geoaccumulation Index (I-Geo), which is an estimate of heavy metals in sediments due to human activities with the formula [11].

$$\log log\ 2\ \frac{(C_x)}{(1{,}5 \times CBackground)} \tag{4}$$

3 Results and Discussion

3.1 Quality Test of Compost

After fermenting for 4 (four) weeks, compost quality analysis was carried out with parameters N, P, K, and C-Organic. The results of the analysis are presented in Table 1.

Table 1. Compost analysis results

Parameter	(INS 19-7030-2004)		Analysis Results (%)
	Minimum (%)	Maximum (%)	
C-Organic	9,8	32	16,5
N	0,4		0,9
P	0,1		0,53
K	0,2		0,75

The calculation of the C/N ratio of dried bamboo leaves compost yields a value of 18.33 which is obtained from C-Organic/N. The ideal C/N ratio range is between 14 and 20. The C/N ratio is the ratio of carbon (C) to nitrogen (N) in organic matter.

Microbiological activity decreases when the C/N ratio is high. The results of the bamboo leaf litter compost analysis in Table 1 meet INS 19-7030-2004 standards. The analysis results of dried bamboo leaves compost are influenced by raw materials, microorganisms, and activators.

Dried bamboo leaves containing 0.91% P and 0.74% K are the main raw material [7]. Additional ingredients in the form of cow dung contain 0.5% N, 0.25% P, and 0.5% K [16]. The statement of raw material content is following the results of compost analysis in Table 1, with concentrations of N, P, K, and C exceeding the minimum limit determined by Indonesian National Standard (INS). Microorganisms have a key role in the composting process. For example, in dry bamboo leaves, there are microorganisms such as Saccharomyces Cerrevisiae, Lactobacillus sp, and the fungus Aspergillus sp which play an important role [8]. Along with that, cow dung used as raw material for compost also contains microbes such as Bacillus sp., Corynebacterium sp., Lactobacillus sp., Aspergillus sp. fungi, and Candida sp. who contributed to this process. Therefore, in an effort to manage the composting process effectively, it is important to understand and measure the population of these microorganisms in compost, including Saccharomyces Cerevisiae, Lactobacillus sp, Aspergillus sp, Bacillus sp., Corynebacterium sp., and Candida sp. This will help you better optimize the composting process.

In an effort to maintain environmental sustainability and support sustainable agriculture, much research has been conducted to explore the potential of natural organic materials, such as compost, in improving soil quality and overcoming environmental pollution problems. One organic material that attracts attention in this context is compost produced from dry bamboo leaves. The latest research conducted by Widowati and colleagues in 2022 brings new insights into the use of dry bamboo leaf compost as an effective bioremediation tool. The results of this research not only validate that dry bamboo leaf compost meets the criteria of INS 19-7030-2004, but also reveal the great potential of this compost in improving the chemical and physical properties of soil, as well as making a significant contribution as a nutrient needed for plant growth. This shows that dry bamboo leaf compost is not just organic waste, but is also a sustainable solution in an effort to support more environmentally friendly and productive agriculture.

3.2 The Effect of Compost on the Physical Properties of the Soil

The first parameter of soil physical properties is aggregate stability. This parameter is analyzed by a double sieving method, with results in Table 2.

Table 2. Aggregate Stability Analysis Results

Classification		Stability Index Results			
Class	Stability Index	C0	C1	C2	C3
Stablest	>200				
Very stable	80 – 200	116	90	100	93
Stable	66 – 80				
Rather stable	50 – 66				
Less stable	40 – 50				

Classification		Stability Index Results			
Class	Stability Index	C0	C1	C2	C3
Unstable	<40				

Table 2 shows that all samples of the aggregate stability index are in the very stable class. These results are influenced by soil stability factors such as soil parent material, microorganism activity, tillage activity, and soil surface canopy cover [17]. On another hand, there is no improvement in the stability index category between pre-bioremediation (C0) and post-bioremediation (C1, C2, C3).

According to [18], applying compost in dose different affects soil aggregates but does not affect the beginning of generative growth. This statement corresponds to the results in Table 2, since aggregate stability analysis was performed at the beginning of chili growth. From the above statement, compost can increase aggregate stability, but it is recommended for long-term use, because the changes in soil physical properties take a long time [18].

The second parameter of soil physical properties is soil texture. The texture compares the fraction of sand, dust, clay, and clay [13]. Soil texture data was obtained secondarily from data on rooting media and soil nutrient retention of Jember Regency and presented in Table 3.

Table 3. Soil texture data

Texture	Content (Soil Research Institute, 2004)		
	Sand (%)	Dust (%)	Clay (%)
Clay	0 – 45	0 – 40	40 – 100
Clay loam	20 – 45	15 – 33	27 – 40

Andongsari Village, Ambulu subdistrict, Jember Regency has 2 (two) types of soil texture, namely clay and clay loam. Clay texture has the ability to hold water and provide high nutrients [15]. Texture is not only related to water absorption, but also to metal absorption. Heavy metals absorbed in soil depend on the clay content, where 96% of heavy metals are contained in clay fractions, it is because clay is a source of negative exchange and contributes greatly to cation exchange [19]. Soils with clay loam texture have lower porosity than sandy loam because clay has higher pores [20]. In this case, the application of compost is needed, because on the other hand clay texture soil has rich nutrition that is suitable for agriculture but has a high ability to absorb heavy metals as well. Compost can absorb metals and form complex compounds so that metals are difficult to remove [21]. Compost can also increase the porosity of clay soil [20].

3.3 The Effect of Compost on the Chemical Properties of the Soil

Soil chemical properties are measured using 3 (three) parameters with the first parameter is soil pH measured by a pH meter, shown in Table 4 below.

Table 4. Soil pH analysis results

pH Standard	Analysis results pH			
	C0	C1	C2	C3

<7 (acid)				
7 (neutral)		7	7	7
>7 (alkaline)	7,5			

Soil pH shows a value of 7.5 in pre-bioremediation soil (C0), these normal values lead to alkaline. All pH of soil samples are 7, meaning the soil is in a normal pH state. The pH of alluvial fields is influenced by the parent material and the process of alluvial soil formation itself. The ideal pH is usually acidic for chili plants, ranging from 5.5 to 6.6 [22]. Based on this statement, the pH analysis results in Table 4 are still above the ideal range for chili, but in post-bioremediation (C1, C2, and (C3), there has been a stability in the ph value compared to pre-bioremediation (C0) which has a ph level of 7.5 tends to be alkaline. Lowering soil pH can be done by applying compost and manure, because both materials have acidic properties.

The second parameter of soil chemical properties is C-Organic tested using the Walkley and Black method, as shown in Table 5 below.

Table 5. Results of C-organic analysis

C-Organic Standard (%)	Analysis results (%)			
	C0	C1	C2	C3
<1 (very low)				
1 – 2 (low)	1,62			
2 – 3 (medium)				
3 – 5 (high)		4,26		
>5 (very high)			6,29	6,83

Table 5 presents the results of post-bioremediation analysis at C1, C2, and C3 showing an increase in C-organic values compared to pre-bioremediation soil in C0. The highest C-organic content in the C3 sample (6.830%), which is getting the highest compost dose in this study, is 350 g/polybag. That suggests that the use of compost can increase soil C-organic levels, especially at high doses. Because, the more compost and manure are applied, the soil's organic C content [15]. C-Organic content is very important for sustainable agriculture, because C-Organic is the basis of soil fertility. In cultivation, the content of organic matter is an important success factor because it can support plant nutrition and microorganism nutrition, produce substances that stabilize soil aggregates, increase water binding, and help control surface runoff and erosion [15].

The last parameter of soil chemistry tested is heavy metal testing on the soil using the Atomic Absorption Spectrophotometer (SSA) method. Table 6 presents the analysis results.

Table 6. Heavy metal analysis results

Quality standard (mg/L)			Analysis results (mg/L)			
Metal	Category	Grade	C0	C1	C2	C3
Pb	TCLP-A	3	6,1			

	TCLP-B	0,5				
	TCLP-C	0,2		0	0	0
Cd	TCLP-A	0,9				
	TCLP-B	0,15	0,2			
	TCLP-C	0,06		0	0	0
Cu	TCLP-A	60	67,4			
	TCLP-B	10		29,3	21,4	14,4
	TCLP-C	4				
Zn	TCLP-A	300				
	TCLP-B	50	138	37,5		24,6
	TCLP-C	20			14,4	

Hazardous & Toxic Material Category 1 : Content > TCLP-A (P.55/Menlhk-Setjen/2015).
Hazardous & Toxic Material Category 2 : TCLP-B ≥ Content ≤ TCLP-A (P.55/Menlhk-Setjen/2015).
TCLP (Toxicity characteristic leaching procedure) is a laboratory procedure to predict the leaching potential of B3 from a 1. Post-bioremediation heavy metals (C1, C2, C3) in Table 6 show reduced metal exposure compared to pre-bioremediation (C0). The heavy metals that are still present in the soil after bioremediation are Cu and Zn. Cu metal, with the highest value of 29.32 mg/L at C1. The concentration of Cu on the soil scale is still allowable because it naturally contains concentrations of 5-30 mg/l in the soil. On the other hand, Cu is an important essential metal in the soil which is important for plant micronutrients [5]. Therefore, based on this study, the concentration of Cu after bioremediation is still classified as safe for soil and plants. The situation for Zn is like Cu. Zn metal is still classified as safe for soil and plants because after bioremediation, Zn in C2 is below the TCLP-C value.
Compost treatment containing microorganisms with bioremediation technology causes a decrease in heavy metal content in the soil to comply with the limits regulated in PP RI No.22 of 2021. The metal adsorption mechanism is related to cation exchange reactions due to the high sorbent cation exchange capacity [23]. The mechanism of bioremediation by microorganisms is mostly an ion exchange process, where the process is based in several ways, namely based on cell metabolism, based on heavy metal position (extracellular accumulation or precipitation, intracellular accumulation, and metal absorption by the cell surface). In the metabolic process, heavy metals accumulate on the cell membrane (extracellular) and in the cytoplasm (intracellular) [24]. When the bioremediation mechanism occurs, microorganisms enzymes modify toxic pollutants where they are degraded, and their structure becomes non-complex and then becomes harmless and non-toxic metabolites [24].

3.4 Level of Pollution and Metal Contamination

Heavy metals are toxic substances when toxicity exceeds the maximum standard limit. Toxicity due to heavy metals can be a threat to the ecosystem for a long time and have great effects. The following are the results of the calculation of

Contamination Factor (CF), PLI (Pollution Load Index), and I-Geo (Geoaccumulation Index).

Table 7. Contamination Factor

CF																Contamination Factor (CF)
Pb				Cd				Cu				Zn				
C0	C1	C2	C3	C0	C1	C2	C3	C0	C1	C2	C3	C0	C1	C2	C3	
	0	0	0		0	0	0						0,8	0,4	0,5	CF<1 (Low Contamination)
				1,4					2,9	2,1	1,4	2,8				1<CF<3 (Moderate Contamination
																3<CF<6 (High Contamination)
12,1								6,7								CF>6 (Very High Contamination)

The first method in calculating metal contamination is CF (Contamination Factor). In post-bioremediation soils, only Cu metal was in the medium contamination class, with the highest number of 2.93 in the C1 sample. Cu metal or copper, is an essential metal, but at excessive levels, it will be toxic. Cu is one of the metals with a high accumulation potential in the soil due to the long-term use of inorganic fertilizers [5]. Conclusion The results of the calculation of contamination factor (CF) bioremediation using compost are proven to reduce metal contamination in sediments. When done long-term it is very possible to have low contamination levels of heavy metals.

The second method in calculating metal contaminants is PLI (Pollution Load Index), with the following calculation results.

Table 8. Pollution Load Index

PLI				Pollution Load Index (PLI)
C0	C1	C2	C3	
				< 0 (Unpolluted)
	1,5	1	0,8	0 - 2 (Unpolluted to slightly polluted)
				2 - 4 (Moderate polluted)
4,2				4 - 6 (Badly polluted)

6 - 8 (Very badly polluted)
8 - 10 (Extremely polluted)

Table 8 shows a decrease in heavy metal pollution, and this is influenced by the use of organic compost dried bamboo leaves. Agriculture and industry significantly affect heavy metal pollution in the soil [5]. However, considering that soil sampling locations are carried out in areas far from industrial sites, this means that agricultural activities are a major factor in pollution. Fertilizers, pesticides, and sewage sludge are the most common causes of heavy metal pollution [5]. Urea, MOP, Kieserit, RP (Rock Phosphate) fertilizers include Zn and Cu [3]. Cd heavy metal is one of the active ingredients of insecticides and Pb is contained in phosphate fertilizer of 7 – 225 mg/kg [4].
These statements reinforce the results of Table 8 that agricultural activities can make soils classified as severely polluted in pre-bioremediation soils. In post-bioremediation soils classified as unpolluted to lightly polluted, this proves that compost in bioremediation can reduce soil pollution significantly. The lowest value was obtained from soil sample C3 with the highest dose, which is 350g / polybag. This value proves that in polluted soil, the dose of 350g/polybag is the most appropriate dose. Compost uses humus contained in it and the cation exchange ability is able to form complex compounds and react with metal ions, so that metal ions are difficult to free [25].

Table 9. Geoaccumulation Index (I-Geo)

CF																
Pb				Cd				Cu				Zn				Geoaccumulation Index (I-Geo)
C0	C1	C2	C3	C0	C1	C2	C3	C0	C1	C2	C3	C0	C1	C2	C3	
	0	0	0	-5,6	0	0	0				-0,1		-1	-1,8	-1,6	I-Geo<0 (Unpolluted)
									0,97	0,5		0,9				0<I-Geo<1 (Slightly polluted)
1																1<I-Geo<2 (Moderate polluted)
								2,2								2<I-Geo<3 (Badly Polluted)
																3<I-Geo<4 (Very badly polluted)
																4<I-Geo<5 (Extremely polluted)
																I-Geo>5 (Very Extremely polluted)

The last method in calculating metal contaminants is the Geoaccumulation Index (I-Geo), which calculates the enrichment of heavy metal concentrations above the threshold due to human activities. Table 9 shows a decrease in pollution levels between pre-bioremediation (C0) and post-bioremediation (C1, C2, and C3). Cu metal with C1 and C2 samples is still classified as lightly polluted.

Metal contamination is due to human activities in agriculture, which directly affects metal pollution, including excessive use of chemical fertilizers and pesticides in the long term [21]. Bioremediation treatment using compost is proven to minimize metal pollution based on the calculation of the Geoaccumulation Index (I-Geo) in Table 9 the highest dose of compost, which is 350g/polybag, is proven to produce the lowest pollution value with a value of < 0 or unpolluted.

3.5 Heavy Metal Content in Chili

The heavy metal content of chili for pre-bioremediation (C0) and post-bioremediation (C1, C2, and C3) soils were tested by the Atomic Absorption Spectrophotometer (SSA) method in Table 10 below.

Table 10. Chili analysis

KEPDIRJEN No 03725/B/SK/VII/1989		Analysis Results (mg/kg)			
Heavy Metal	Range (mg/kg)	C0	C1	C2	C3
Cu	0,1 – 150	0,03	0,14	0	0,20
Zn	2,0 – 100	7,29	57,4	6,27	6,38

The results in Table 10 show heavy metals Cu and Zn levels below the maximum value determined by KEPDIRJEN No. 03725/B/SK/VII/1989. Mechanism of transmission of heavy metals to plants by phytoextraction mechanisms (plants remove harmful components from contaminated soil), phytostabilization (immobilization and reduction of heavy metal mobility in the soil), rhizofiltration (using plant roots to absorb toxic substances) [5]. The uptake of Cu metal by plants is influenced by plants' soil physicochemical properties and other physiological parameters, while Zn metal is transmitted by roots [5]. Cu and Zn metals with the lowest content are found in C2 samples. Cu and Zn metals themselves are essential metals that, in small amounts, are needed by soil, plants, and humans. Cu metal in small quantities can be plant nutrition and seed production, while Zn metal plays an important role in photosynthetic redox in plants [5].

The results of Table 10 cannot be separated from the influence of applying organic material such as dried bamboo leaves compost. The organic fertilizer and pesticide are effective for chili production with low heavy metal contamination according to the Food and Drug Control KEPDIRJEN No.03725/B/SK/VII/1989. Plants can absorb heavy metals if they have poor fertility with organic matter and low cation exchange capacity as well. Therefore, it further strengthens that compost can be used as a deterrent to the content of heavy metals in crop yields.

4 Conclusion

The best content of dried bamboo leaves compost at a dose of 350g/polybag. The study concluded that dry bamboo leaf compost can improve soil physical properties but has not shown significant results because it takes a long time to improve soil physical properties. However, it is improving the chemical properties of soil which the pH level reduces and C-Organic increases.

Compost of dried bamboo leaves can reduce heavy metal levels, as evidenced by the results of the analysis in Table 6. Pb which is a non-essential metal in pre-bioremediation contained 6.1 mg/L classified as category 1 waste while for post-bioremediation Pb was no longer detected for all dose samples. Cd, which is also an essential metal in pre-bioremediation, contains 0.2 mg/L and is classified as category 2 waste, while post-bioremediation is no longer detected in all samples. In addition, the pre-bioremediation Cu essential metal contained 67.4 mg/L or classified as category 1 waste while in post-bioremediation classified as category 2 waste for all samples with a C1 value of 29.3 mg/L; C2 21.4 mg/L; C3 14.4 mg/L. Zn which is also an essential metal in pre-bioremediation 138 mg/L is classified as category 2, for post-bioremediation samples C1 and C3 are classified as category 2 waste with successive values of 37.5 mg/L and 24.6 mg/L while the lowest value in C2 which is not classified as waste 1 or 2 with a value of 14.4 mg/L.

According to the Pollution Load Index (PLI), post-bioremediation soils are classified as non-polluted to lightly polluted, with the lowest value obtained from C3 sample soil with a value of 0.8. Reviewing pre-bioremediation classified as severely polluted with a value of 4.2. Compost from dried bamboo leaves applied to the soil can produce chilies with low metal content when adjusted to the standards of fruit and vegetable content in KEPDIRJEN No. 03725/B/SK/VII/1989.

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