Jatropha Curcas L. for Phytoremediation of Landfill Soil

by

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CERTIFICATION OF APPROVAL

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Approved by,

____

(Dr. Nurlidia binti Mansor)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

May 2013

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work in my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MUHAMMAD FITRI BIN JAMIL

ABSTRACT

Landfills contain various types of wastes which includes heavy metals. Heavy metals can cause serious environmental pollution and become a threat to public health and safety. Migration of leachate will contaminate the soil and also groundwater. Therefore, contaminated soil must be remediated to avoid any unwanted circumstances. A green technology and cost-saving approach known as phytoremediation has been used to treat contaminated soil by extracting heavy metals using plants where the contamination is accumulated in certain parts of the plant. This research will focus on the accumulation of the heavy metals by using *Jatropha Curcas L*. plant. It will be conducted to investigate the ability of *Jatropha Curcas L.* plant in accumulating and extracting heavy metals from the landfill soil, to find the optimum composition of soil where the plant can extract the highest amount of particular heavy metals and to study which parts of the plant have the highest accumulation of particular heavy metals. *Jatropha Curcas L*. plant was planted on six different planting media T0 (100% healthy soil), T1 (80% healthy soil and 20% landfill soil), T2 (60% healthy soil and 40% landfill soil), T3 (40% healthy soil and 60% landfill soil, T4 (20% soil healthy and 80% landfill soil) and T5 (100% landfill soil) for a period of one months. Plant samples were collected prior to planting into the planting media and after harvest the plant while soil samples were collected before and after planting. The Atomic Adsorption Spectrometer (AAS) was used to determine the concentration of heavy metal in different part of the plant (root, stem and leaves) in each planting medium which is expected to be varies. Besides that, the growth development of *Jatropha Curcas L.* also will be different in its height and number of leaves due to the different toxicity of the soil. The results shows that *JatrophaCurcas L.* have ability to extract Pb from the landfill soil. The optimum composition of landfill soil and healthy soil is 60% where the plant can growth healthy and can extract heavy metal.

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INTRODUCTION

1.1. Background Study

Development of the industrial activities and the population growth has contributed to the increment of the waste generation and changes in consumption pattern. In the 9^{th} Malaysia plan reported that the average per capita generation has increase from 0.67kg/person/day in 2001 to 0.8 kg /person/day in 2005 (Chua, K.H. et al, 2011). These factors have not only increased the solid waste volume but also changed the characteristics of the solid waste which have made it more complex for the municipalities to handle (Mohd Nasiran, M.I. et al, 2008). The issue of landfill creating the negative impacts to the environment and health such as greenhouse gas emission, risk of explosion, odour problem, ground water pollution and also soil contamination due to heavy metal in the disposed waste. Soil becomes contaminated when there are uncontrolled and unmonitored leachate generation which picks up soluble heavy metals and acids from the waste (Mohd Nasiran, M.I. et al, 2008). Proper soil management is put in place to sustain the landfill and avoid environmental pollution. Regular contaminated soil remediation is reported as one of the most expensive technology in environmental management. Thus, many research shows phytoremediation is economically effective and also practical in Malaysia. In this research, *Jatropha Curcas L.* is proposed for the phytoremediation because of the ability to uptake the heavy metal from the contaminated soil.

Jatropha Curcas L. will reach the first harvest within 8 months from seedling (Jatropha Curcas Plantation, 2010). It can grow in tropical and sub-tropical region. It grows in the lower altitudes of 10-600m above the sea level. The ideal rainfall for the fruit production is between 1000-1500 mm/year but it can survive with the rainfall only 300mm/year. It can be planted on the sloping terrain which has proper draining and non-water pooling for more than four days. It can survive in dry months between 4 months to 7 months without rain.

With consideration on the ability of the *Jatropha Curcas* characteristic which are non-edible and can be grown abundantly in large scale on wastelands, it might be effective in removing heavy metals in the landfill soil. Therefore, planting *Jatropha Curcas* could have many advantages such as remediation of metal polluted soil, provision of green space and a source of alternative biofuel.

1.2. Problem Statement

In this project, there are two main problems will be focused on as follows:

i. Lack of solid waste management in landfills, producing leachate that contain heavy metals such as Cd, Pb, Hg, As, Cr, Cu and Zn and acid from the waste which can lead to groundwater and pose a threat to human health and other living things.
ii. High cost of soil remediation to manage and recover the contaminated soil in landfill sites. Phytoremediation cost is 4 times cheaper compared to the common soil remediation method.

1.3. Objective

The objective of this research is to investigate the effectiveness of *Jatropha Curcas L.* plant in the removal of Pb and Cd from landfill soil by determining the following:

i. Growth Performance of the *Jatropha Curcas L.* plant.
ii. Accumulation of the Pb and Cd in the root, stem and leave of *Jatropha Curcas L.* plant.
iii. The concentration of Pb and Cd that have been extracted from the landfill soil.

1.4. Scope of Study

In achieving project objectives, a comprehensive study has to be conducted and it covers the following scopes of study:

i. Gather information on *Jatropha Curcas L.*; any matters regarding the ability of uptaking heavy metal for phytoremediation of landfill soil.
ii. Analyse landfill soil contents; justify the concentration of heavy metal contaminated in the soil before and after the phytoremediation treatment.
iii. Observe the *Jatropha Curcas L.* growing development.

CHAPTER 2

LITERATURE REVIEW

2.1. Phytoremediation

The use of plants to remediate sites contaminated with organic and inorganic pollutants is known as phytoremediation which involve in extracting the pollutants from the contaminated soil (Luhach, J., 2012). Phytoremediation is evolving into a cost-effective means of managing wastes, especially excess petroleum hydrocarbons, polycyclic aromatic hydrocarbon, explosives, organic matter and nutrients (McCutcheon, S.C., 2003). This green technology is more favoured because this method is lower in cost and impact to the surrounding and wider public acceptance. The cost of phytoremediation has been estimated as $25 - $100 per ton of soil and $0.60 - $6.00 per 100 gallons of polluted water with remediation of organics being cheaper than remediation of metals. In many cases phytoremediation has been found to be less than half the price of alternative methods (Steve Bentjen, 1998). Table 1 shows the difference in price for the remediation of soil.

Table 1: Price of Remediation Method

Remediation Method	Type of Contaminants	Cost
Dig and dump	Any contaminant type	$100-500/m3
Soil incineration	On or off site - Organic contamination	$200-600/m3
Chemical extraction	Any type of contamination	$250/m3
Electrokinetic separation	Metals/Salts	$200/m3
Soil lushing/fracturing	Any contaminant type	$250/m3
Land farming	Natural attenuation, Small organics	$50/m3
Bioremediation	Organics	$100/m3
Phytoremediation	Any contaminant type	$25-$50/m3

Source: The Benefits of Phytoremediation: Cost Effective On-Site Decontamination of Petroleum and Salt Impacted Sites, University of Waterloo. (Greenberg, B.M. et al, 2006)

Jatropha Curcas L. was chosen in this experiment because it is a multipurpose, drought resistant, perennial plant. By using the *Jatropha Curcas L.* plant as the hyper accumulator plant in phytoremediation which has a lot of benefits, it can generate the income from the contaminated land.

2.2. Ability of *Jatropha Curcas L.* to uptake heavy metal

Some of the common mineral elements such as Al, Fe, Ca, Na, Mn and Si and trace elements like Cd, Pb, Hg, As, Cr, Cu and Zn present in sludge in significant quantities contaminate the ground water are from industrial waste landfill sites (Parida, B.P., 1999). The usage of hyper accumulator plant will remove the heavy metal from the landfill soil. In many research, the result have shown that *Jatropha Curcas L.* is a hyperaccumulator plant which able to absorb and extract the heavy metal in the contaminated soil (Rajakaruna, N. et al, 2006). The current research concerned on *Jatropha Curcas L*. for at least three reasons as follows. The plant is a species of Euphorbiaceae family that might be effective in removing Pb and Cd. The plant is able to grow under various soil conditions and it promote to be a source of alternative fuel (Sarwoko, M. et al, 2008). Hence, the plant will contribute the advantage in term of remediate the soil, provision of green space and source of the alternative biofuel.

Figure 1: Pre-cultivating of Jatropha Curcas L. plant in Polybag

2.3. After remediation

The ability of *Jatropha Curcas L.* to uptake heavy metals such as Zn, Pb, Cr, Cd and Cu efficiently (Ahmadpour, P. et al, 2010) from the contaminated soil is already known in the recent research. The potential of *Jatropha Curcas L.* in accumulating heavy metals will be justified in the end of this experiment. The benefits of the plants have to be clarified to increase the commercial value of this project. Thus, the contaminated plant can remain valuable after the phytoremediation.

The wood and fruit of *Jatropha Curcas L.* contain viscous oil which can be used for manufacture of candles and soap, in cosmetics industry, as a diesel/ paraffin substitute or extender (Kumar, A. et al, 2008). The production of *Jatropha Curcas L.* plant can be benefit in generating income from the contaminated soil. There are many benefits of every part of this plant as the following (Bionas, 2012).

1. **Oil obtained from the *Jatropha* fruits Oil** obtained from the *Jatropha* fruits when heated will produce a poisonous yellow substance. When it is added with sulfur, it can be applied to minor cuts and wounds. It also used to treat athlete foot. The skin of the fruit is commonly used to treat constipation.

2. **Brewed leaves** of these *jatropha* plants are known to have antipyretic and anti-malarial properties. The leaves are also food for the silkworms. Shed leaves that fall to the ground will decompose hence promoting soil fertility.

3. **Barks are used** to treat snakebites and sprains. They are also effective in removing the white off a baby’s tongue and relieving extreme body heat. They may also be used to produce dark blue fabric dye.

4. **The roots** are used as laxatives as well as to treat rheumatism.

5. **The seeds** serve as active ingredients in potent traditional remedies for treating knee pains, cough, scalds, gonorrhoea, paralysis, swellings, jaundice, pneumonia, itches, ulcers and growths.

6. **The sap** is used for alleviating toothache and mouth ulcers but should not be consumed due to its poisonous nature. It is also used in treating post-circumcision wounds to expedite recovery.

7. **Deposits produced** from *jatropha* oil processing may be reused as natural fertilizers for they are rich in nitrogen, phosphorus and potassium. They may also serve as fodder for livestock cattle.

2.4. Landfill Soils

Landfill soil is taken from Sungai Wangi disposal site located at Sitiawan, Perak. The size of this landfill is 25 acres which is the largest in Perak and it receive about 120 – 140 metric tonnes per day (Majlis Perbandaran Manjung, 2012). Due to the lack of waste management, leachates are formed that contain a wide range of heavy metal such as As, Ba, Cr, Cu, Hg, Ag, Ni, Zn, Se, Cd and Pb (Aucott M., 2006).

Figure 2: Scenery of rubbish hill at Sri Wangi Disposal Site, Manjung

Figure 3: Soil sampling at Sri Wangi Disposal Site, Manjung

Figure 4: Scenery of Sri Wangi Disposal site that will turn into green space.

This landfill will turn into green space such as recreational park. The management of this landfill will design this place into park by covering the entire rubbish hill with the cover soil and planting trees there to turn this place into a park (Majlis Perbandaran Manjung, 2012)

CHAPTER 3

METHODOLOGY

3.1. Project Flow

This section explains the activities involve starting from *Jatropha Curcas L.* cultivation, soil sampling until fruit sampling and analysing.

3.1.1. Pre-cultivating *Jatropha Curcas L.* plants

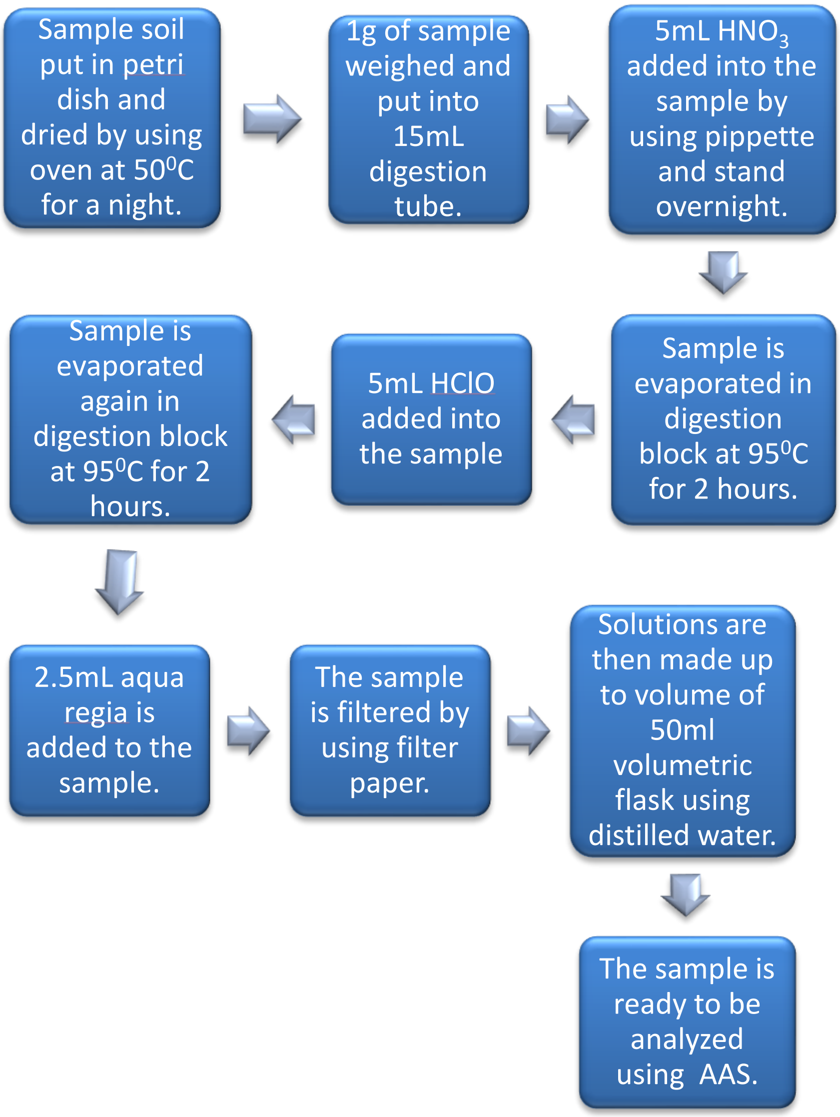
Jatropha Curcas L. aged about 2 - 3 month was planted on the different ratio of landfill soil and healthy soil. The total weight of the soil in each container is 21 kg. Planting media differs in their weight composition between healthy soil and landfill soil as the following:

- T0 (100% healthy soil);
- T1 (80% healthy soil and 20% landfill soil);
- T2 (60% healthy soil and 40% landfill soil);
- T3 (40% healthy soil and 60% landfill soil);
- T4 (20% healthy soil and 80% landfill soil);
- T5 (100% landfill soil)

The heights and diameters of the plants were measured every two weeks during the study period with measuring tape while the basal diameter was measured using a vernier calliper every two weeks. Soil sampling and plant sampling will be done after 1 month of planting into the respective planting media.

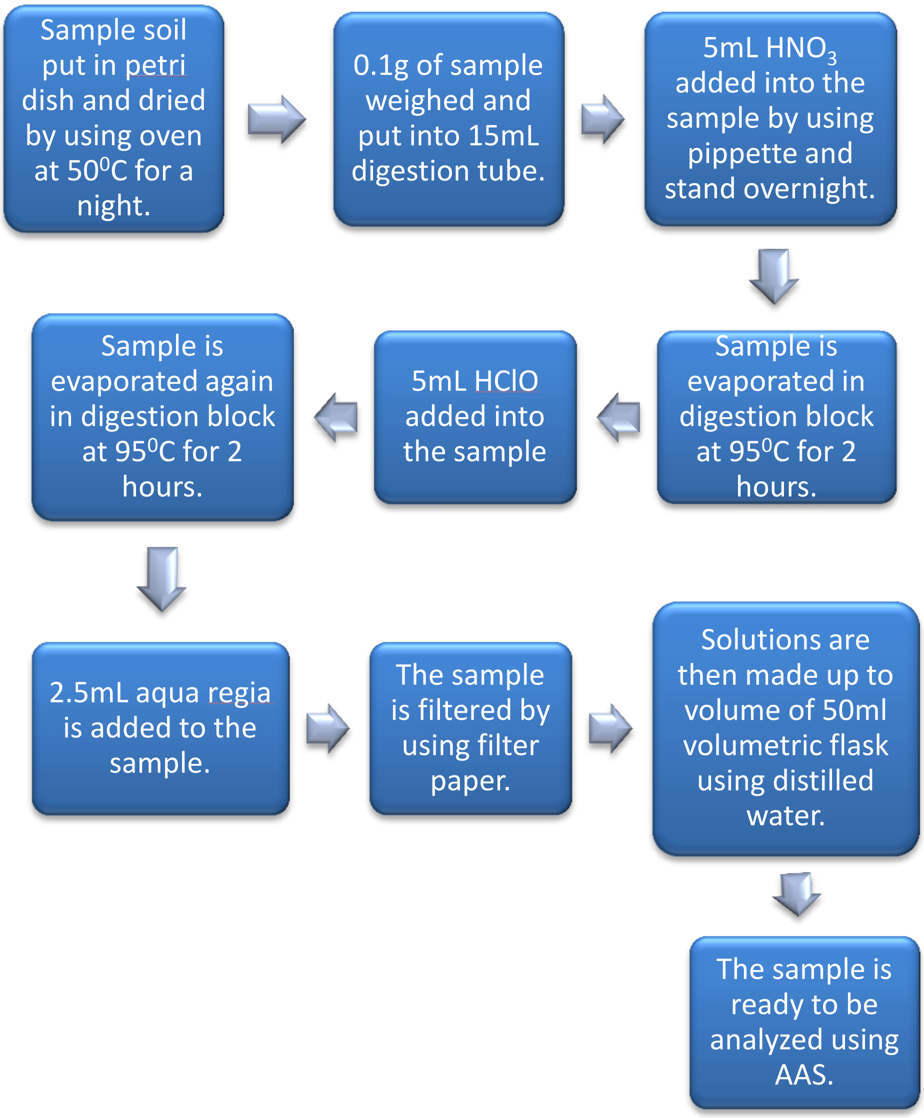
3.1.2. Soil Sampling

The soil and harvested plant were analysed for heavy metals by Atomic Absorption Spectrophotometry, which is an ideal, sensitive and accurate method for quantification of heavy metals. The sample of soil is prepared as shown below and the concentration of heavy metals is analysed. The plant parts which are roots, leaves and stems are separated and converted into ash and digested as in case of soil samples.



3.1.3. Plant Sampling

The plant parts which are roots, leaves and stems are separated and converted into ash and digested as in case of soil samples.



3.2. Raw Materials and Chemicals Needed

In the experiments that are going to be conducted, several raw materials and chemicals are needed. There are:

TABLE 2 : APPARATUS AND MATERIALS

No.	Category	Items
1.	Planting Purposes	*Jatropha Curcas L.*plant
		Healthy fresh soil
		Landfill soil
		Plastic bucket
		Shovel
2.	Laboratory Purpose	1M of Nitric Acid
		1M of Hydrochloric Acid
		1M of Perchloric Acid
		Distilled water
		Digestion tube
		Atomic Adsorption Spectrometer (AAS)
		Flame Atomic Adsorption Spectrometer (FAAS)
		Measuring Cylinder
		Volumetric Flasks

3.3. Atomic Absorption Spectroscopy Analysis

For analysis of the heavy metal content in the soil and plant, there is preparation need to be done such as preparation of Standard Solution for each heavy metal.

The equilibrium formula of Molarity as shown below is used to measure the concentration of the heavy metal in the Standard Solution.

$$M_1V_1 = M_2V_2$$

M_1 = molarity of the concentrated solution

M_2 = molarity of the concentrated solution

V_1= molarity of the concentrated solution

V_2 = molarity of the concentrated solution

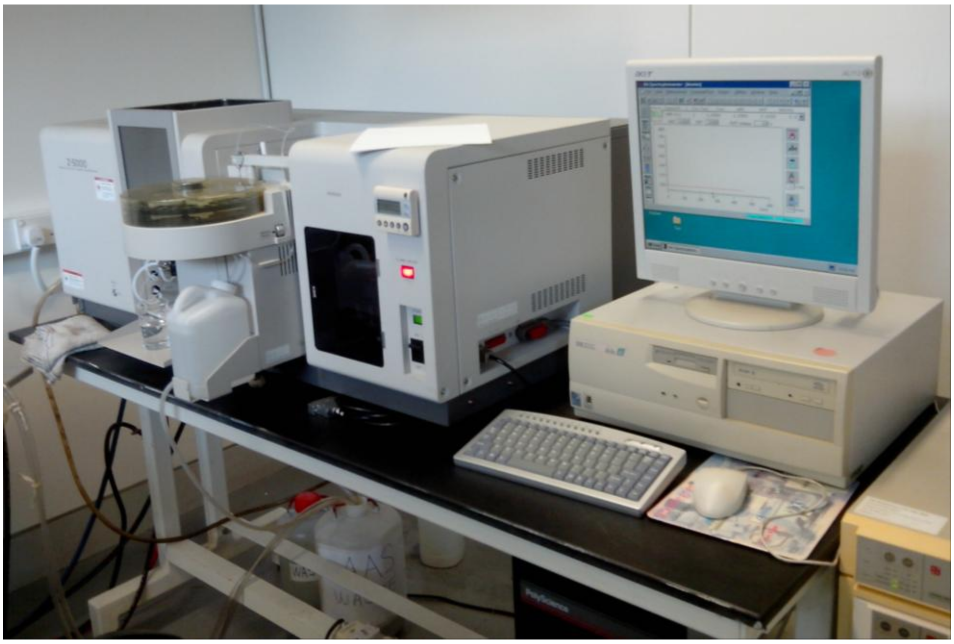


Figure 5: AAS equipment that being used for analysis of sample.

Figure 6: Preparation of Standard Solution for analysis of Pb and Cd.

The preparation of the standard solution is needed to calibrate the value of heavy metal in the sample. The value of concentration prepared for each metals are shown in the table below:

Table 3: Concentration of Standard Solution.

Metal	Concentration 1	Concentration 2	Concentration 3
Lead, Pb	2.50	5.00	10.00
Cadmium, Cd	1.50	3.00	0.60

CALCULATION OF HEAVY METAL CONTENTS IN LANDFILL SOIL AND PLANTS PARTS

The raw data obtain in from AAS need to be extract to produce information which equivalent to the sample that being analysed. In order to get the exact value of the Lead, Pb and Cadmium, Cd in the amount of sample, the following formula was used.

$$Concentration\ of\ Heavy\ Metal = \frac{Conc.\ of\ sample\ \frac{mg}{l}\ \ x\ vol.of\ solution\ x\ dilution\ factor}{weight\ of\ sample\ (kg)}$$

3.4. Key Milestones

Several key milestones for this research project must be achieved in order to meet the objective of this project:

Problem Statement and Objective of the project

Identifying the purpose of this research project

Literature Review

Gathering as much information as possible from various sources such as journals and websites

Experiment Design

Identifying the subjects that need to be investigated and the experimental procedures, as well as the chemicals needed and the collection of results

Data Analysis and Interpretation

The findings obtained are analyzed and interpreted critically. Comparison with other literature readings will also be done.

Documentation and Reporting

The whole research project will be documented and reported in detail. Recommendations or aspects that can be further improved in the future will also be discussed.

3.5. Gantt chart

TABLE 4: GANTT CHART FOR THE PROJECT ACTIVITIES

NO	WEEK DETAIL WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Find literature														
2	Find the analysis procedure														
3	Soil Sampling at Sitiawan Landfill														
4	Soil Characterisation														
5	Planting process														
6	AAS and FAAS Training														
7	Preparing list of chemical														
8	Analysis of the plant and soil (Lab analysis)														
9	Observe the growth of the plant														

TABLE 5: GANTT CHART FOR THE PROJECT DOCUMENTATION OF FYP I

NO	DETAIL WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Title	■	■												
2	Preliminary Research Work and Literature Review		■	■	■	■									
3	Submission of Extended Proposal Defence						●								
4	Preparation for Oral Proposal Defence							■							
5	Oral Proposal Defence Presentation								■						
6	Detailed Literature Review								■	■	■	■	■		
7	Preparation of Interim Report			■	■	■	■	■	■	■	■	■	■		
8	Submission of Interim Draft Report													●	
9	Submission of Interim Final Report														●

■ Suggested timeline

● Suggested milestone process

TABLE 6: GANTT CHART FOR THE PROJECT DOCUMENTATION OF FYP II

NO	DETAIL WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Project Work Continuous															
2	Submission of Progress Report								●							
3	Project Work Continuous															
4	Pre - SEDEX											●				
5	Submission of draft report												●			
6	Submission of dissertation report (Soft bound)													●		
7	Submission of technical paper													●		
8	Oral presentation														●	
9	Submission of dissertation report (hard bound)															●

CHAPTER 4
RESULTS AND DISCUSSION

SOIL CHARACTERISATION

Landfill soil from Sungai Wangi Landfill was collected and analysed at the laboratory. It shows the presence of heavy metal, Pb and Cd as shown in **Table 6** in the landfill soil that have been analysed.

Table 7: Concentration of Pb and Cd in Landfill Soil.

Sample	Concentration of Pb, mg/kg	Concentration of Cd, mg/kg
Landfill soil	320	N/A

From the analysis it was found that, the concentration of Pb in 1 gram of landfill soil is about 320 ppm. The concentration of Cd was too low and it was not detected probably due to the influence of compacting soils in the sample. The samples should have been thoroughly homogenized.

The expected result for the landfill characterization should higher concentration of Pb and Cd because this landfill gathers all the waste being discharge from various types of industry (Aucoot, 2006).

Figure 7: Preparation for digestion of landfill soil before analysed.

ATOMIC ABSORPTION SPECTROSCOPY OBSERVATION

The analysis by using AAS was carried out each sample during the planting process of the plant into the cultivated media which are T0 (100% healthy soil); T1 (80% healthy soil and 20% landfill soil); T2 (60% healthy soil and 40% landfill soil); T3 (40% healthy soil and 60% landfill soil); T4 (20% healthy soil and 80% landfill soil); and T5 (100% landfill soil). In addition, the plant parts such as shoot, root and stem were also analysed. **Table 7** and **Table 8** shows the raw data obtained from the analysis of AAS.

Table 8: Raw data from AAS for Pb Concentration and Absorption

Sample	Concentration, ppm	Absorption
STD 1	0.00	-0.0001
STD 2	2.50	0.0200
STD 3	5.00	0.0379
STD 4	10.00	0.1019
Shoot	0.56	0.0009
Root	0.64	0.0017
Stem	0.53	0.0006
T0	1.41	0.0096
T1	2.55	0.0212
T2	3.69	0.0329
T3	4.71	0.0434
T4	3.88	0.0349
T5	6.22	0.0588

Table 9: Raw data from AAS for Cd Concentration and Absorption

Sample	Concentration, ppm	Absorption
STD 1	0.00	0.0002
STD 2	1.50	0.3292
STD 3	3.00	0.4614
STD 4	6.00	0.7196
Shoot	-0.70	0.0005
Root	-0.68	0.0027
Stem	-0.70	0.0003
T0	-0.67	0.0048
T1	-0.67	0.0039
T2	-0.65	0.0065
T3	-0.67	0.0047
T4	-0.66	0.0049
T5	-0.66	0.0051

In the Figure 8 and Figure 9, the results show the initial concentration of the Pb in the plant and also in the planting media.

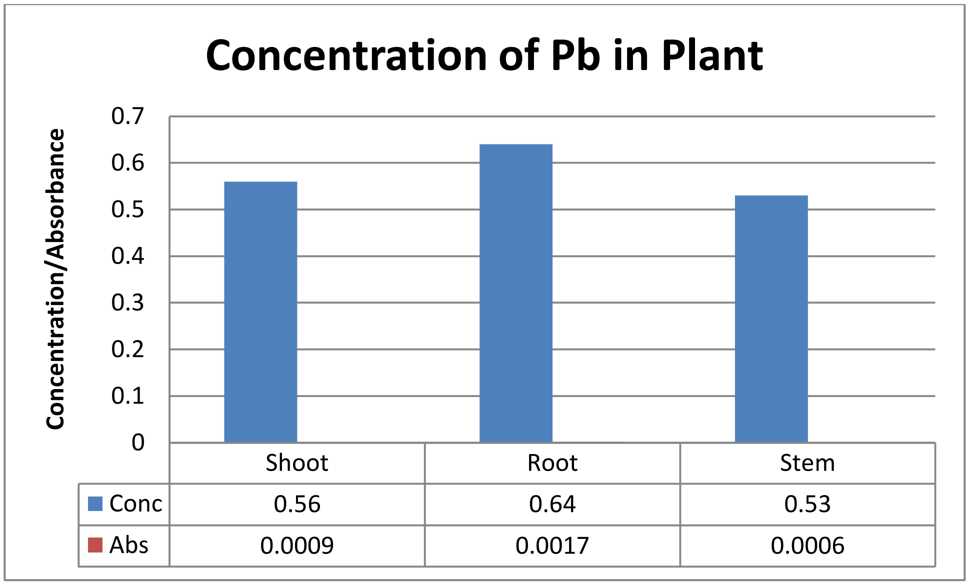


Figure 8: Concentration of Lead in Plant at Before Planting

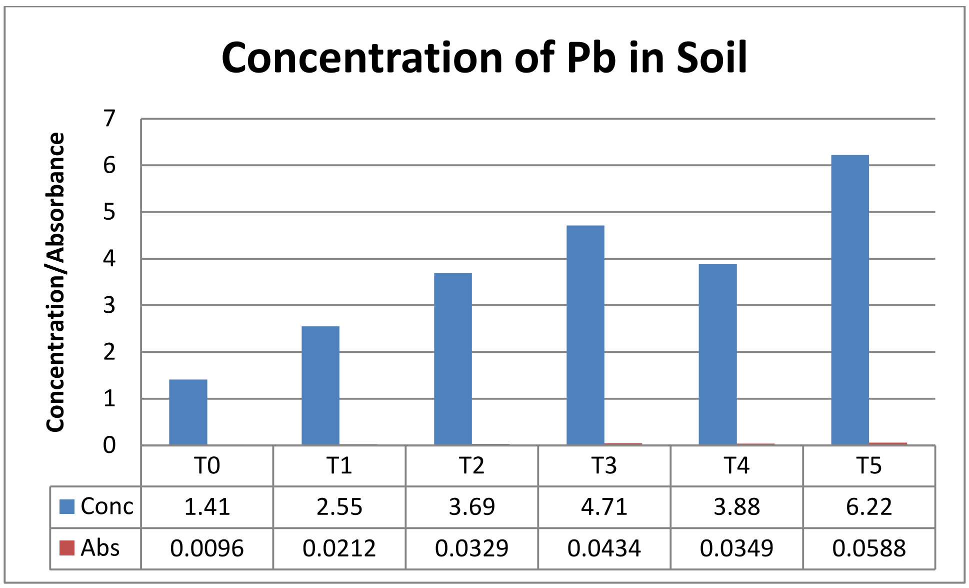


Figure 9: Concentration of Lead in Plant at Initial Stage

The value of Pb in T4 is less than T4 due to some error occurs during sampling. The sample soil was taken at part that has more healthy soil than landfill soil.

Meanwhile, in Figure10 and Figure 11 shows the result of the presence of Cd but in the small quantity. This result occurs due to the influence from the compacting soil that have in the sample but Cd still presence in the sample of plant and also soil.

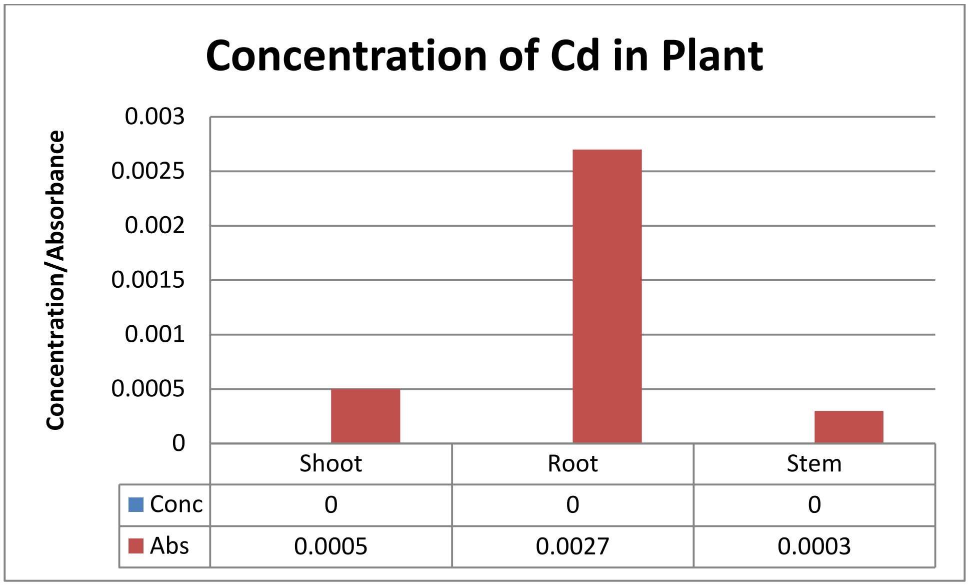


Figure 10: Concentration of Cadmium in Plant at Initial Stage

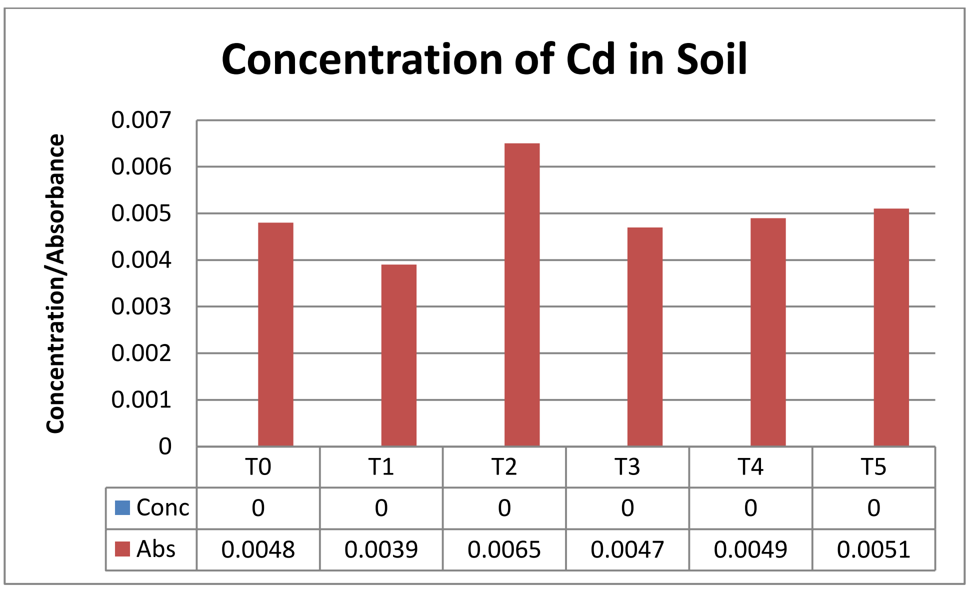


Figure 11: Concentration of Cadmium in Soil at Initial Stage

The concentration of Pb and Cd in plant is shown in Table 10. The tabulated data shows that the amount of Pb is difference in every part of the plant. For Cd, the tabulated date did not show a consistence result due to the error occurring from the equipment which are systematic error about the blockage in the equipment.

Table 10: Concentration of Pb and Cd in Plant at Initial Stage

Sample	Concentration of Pb (mg/kg)	Concentration of Cd (mg/kg)
Shoot	280	nd
Root	320	nd
Stem	265	nd

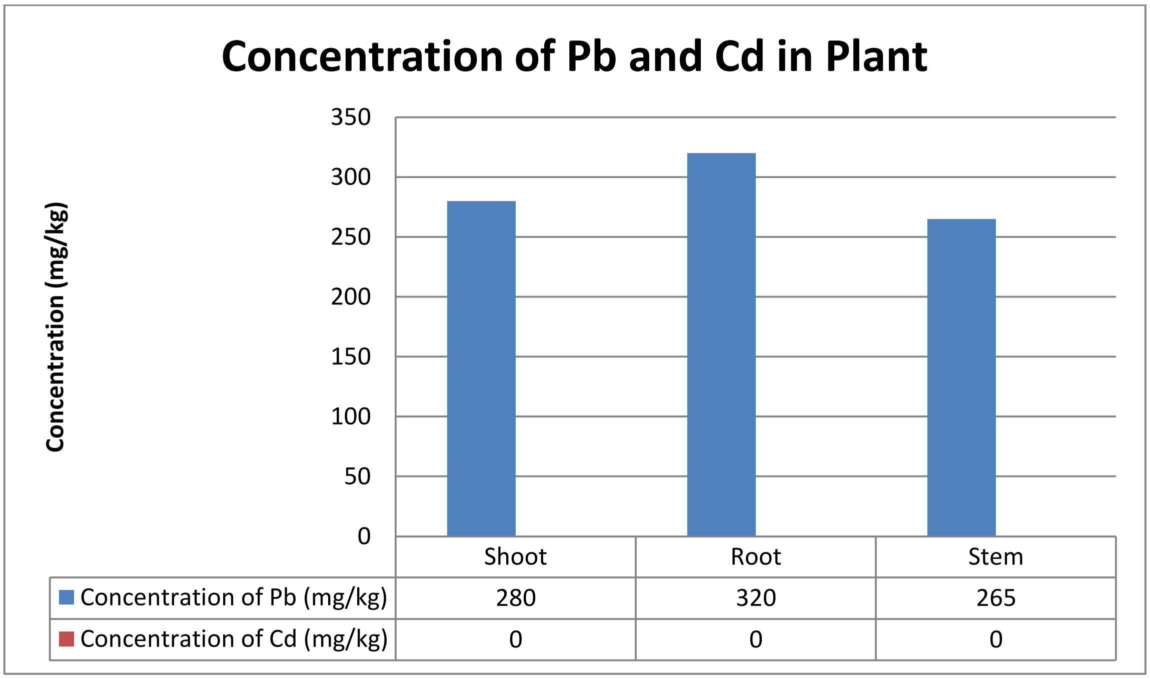


Figure 12: Concentration of Pb and Cd in the Plant at the Initial Stage

Figure 12 shows the graph of the concentration and absorbance for each metal and plants. From this graph, the result shows there are Lead in the plant parts which in the root contain the highest value of Lead about 320 mg/kg.

The concentration of Pb and Cd in soil is shown in Table 11. The tabulated data shows the concentration of Pb in the soil increased with the percentage of landfill soil in the planting media

After make comparison with the landfill soil, it shows that the concentration of Lead still low in the plant compare with the concentration in the landfill soil.

Table 11: Concentration of Pb and Cd in Soil at Initial Stage

Sample	Concentration of Pb (mg/l)	Concentration of Cd (mg/l)
T0	72.0	nd
T1	127.5	nd
T2	184.5	nd
T3	235.5	nd
T4	194.0	nd
T5	311.0	nd

Figure 13 shows the concentration of Cadmium still cannot be observed due to the error to the result. The initiative to reduce the error is to increase the volume of sample collected and to produce multiple reading to compare the result.

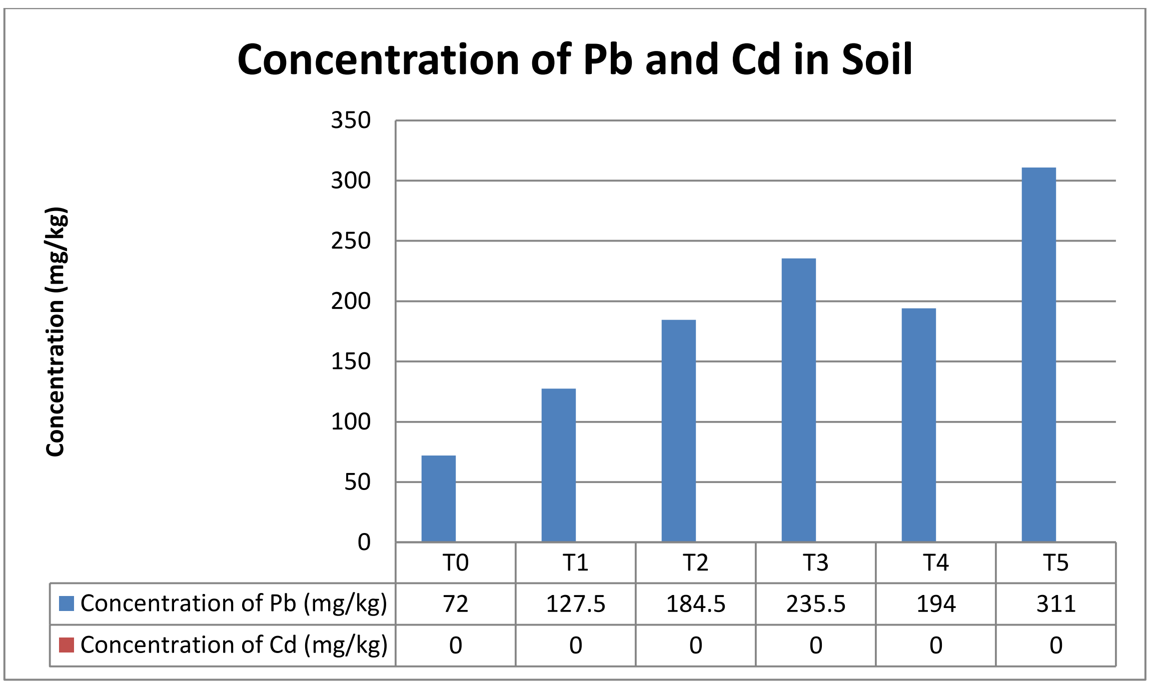


Figure 13: Concentration of Pb and Cd in Soil at Initial Stage

AFTER HARVESTING

After one month, the plants in each planting media were analysed together with planting media in each pot. The result of analysis were calculated and tabulated in **Table 12** and **Table 13.**

Table 12: Concentration of Pb in plant after one month

Sample	Shoot (mg/kg)	Root(mg/kg)	Stem(mg/kg)
T0	405	388.5	304.3
T1	398	376	302
T2	411	383	311
T3	420	384	309.5
T4	409.5	377.5	299
T5	402	382	303

Based on the result tabulated in Table 12, the plant can accumulate Pb in the highest amount at the shoot if compare to the other parts of the plant. The shows that the accumulation of the Pb happens at the growth part of the plants such as shoot.

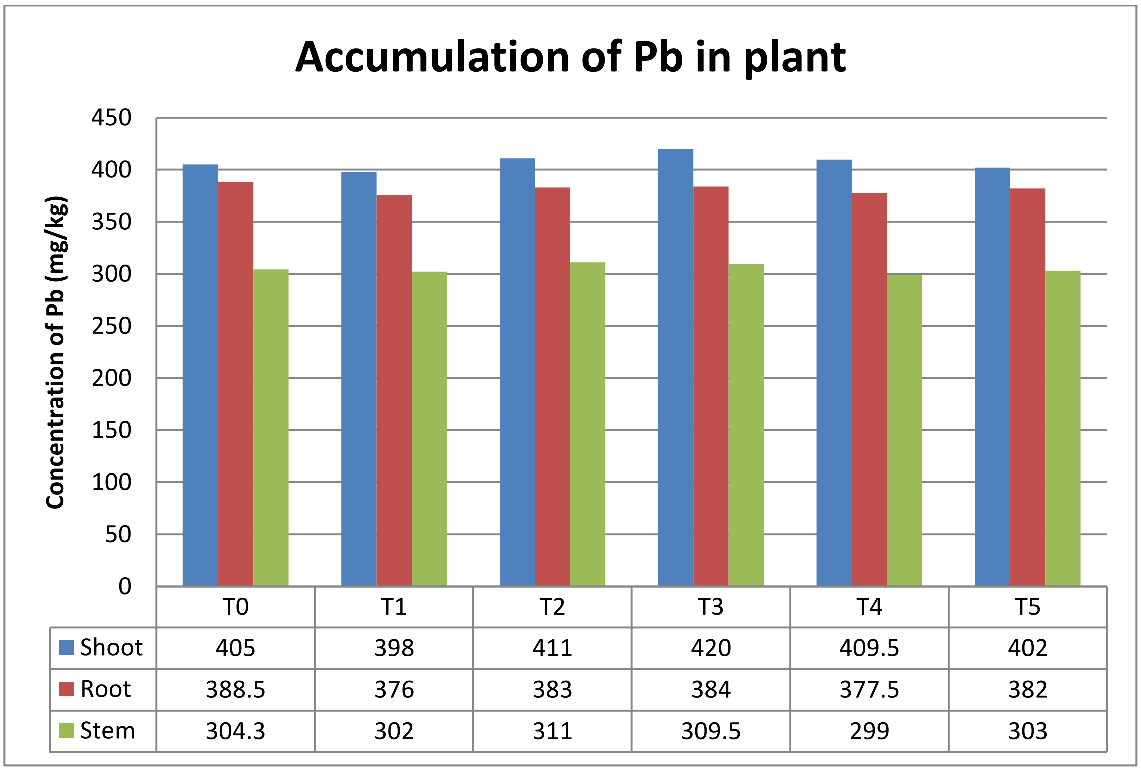


Figure 14: Accumulation of Pb in plant after one month planting period

Table 13: Concentration of Pb in soil after one month

Sample	Week 0, mg/kg	Week 2, mg/kg	Week 4, mg/kg
T0	72.0	69.5	64.6
T1	127.5	125.0	112.3
T2	184.5	173.2	160.0
T3	235.5	210.4	176.0
T4	194.0	190.0	187.5
T5	311.0	284.0	263.5

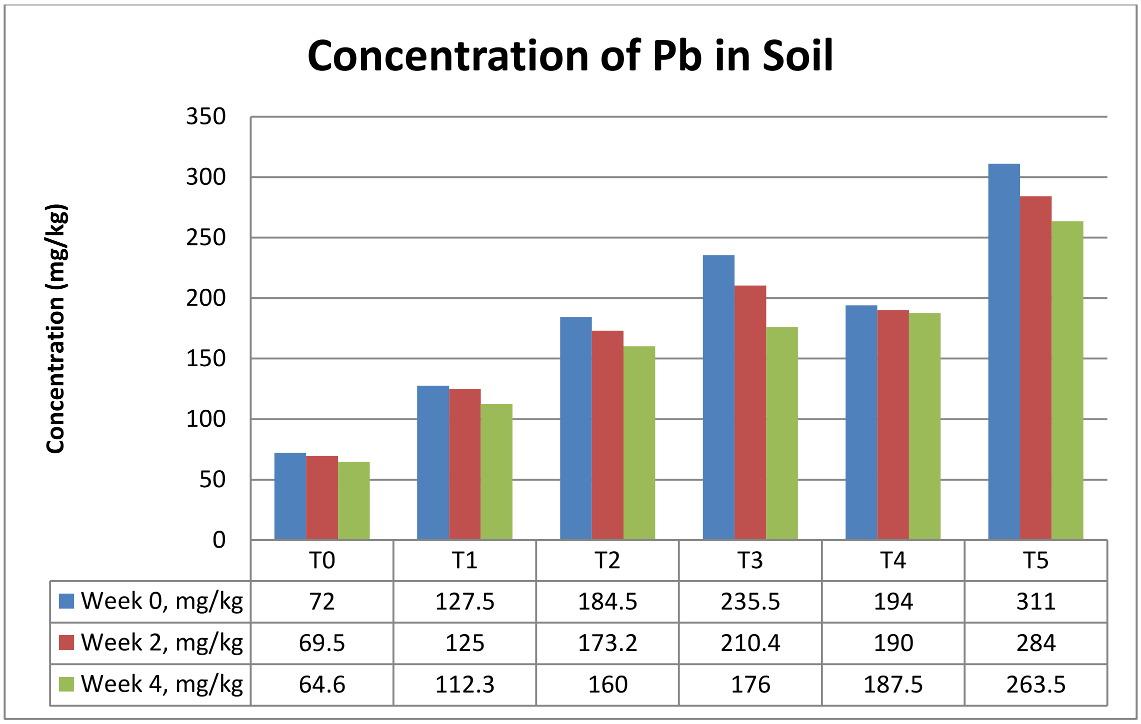


Figure 15: Concentration of Pb in soil after one month planting period

The result also shows that the composition of planting medium with 60% of landfill soil is the optimum composition to used phytoremediation process with *Jatropha Curcas L*. plant. The author conclude that due to the healthy growth of the plant in this composition planting media and it also can extract high amount of Pb from the soil.

THE GROWTH DEVELOPMENT OF THE PLANT.

Besides heavy metal concentration, the growth development of the plant also being observed and recorded as follows.

Table 14: The growth development of plant in each planting media

Data	**T0**		**T1**		**T2**		**T3**		**T4**		**T5**	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
No. of leaves	12	17	13	16	11	14	10	15	11	14	10	12
Difference of Height	± 2.5 cm		± 2.3 cm		± 2.0 cm		± 1.9 cm		± 1.4 cm		± 0.8 cm	

From the Table 14, the result shows that the plant still grow even though the soil is high in heavy metals. Planting media T5 contain 100% of landfill soil but it still can growth normally with the increment on the number of leaves and the height of the plant.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This dissertation reports the experimental investigation into ability of *Jatropha Curcas L.* plant to uptake Pb and Cd. Several conclusions that can be made are:

- The optimum amount for composition of planting media is 60% landfill soil with 40% of healthy soil.
- The highest accumulation of Pb in the plant is at the shoot.
- *Jatropha Curcas L.* plant have ability to live in the contaminated soil and can growth normally in the contaminated soil

5.2 Recommendations

There are several recommendations that can be implemented to this project for further researches which are:

- Analyse the accumulation of heavy metals in the seeds.
- Study on the range that the plant can uptake heavy metals which can be determine the depth that this plant can extract heavy metals and the width of the land that it can cover.

This species of plant can be valuable for the usage of green technology which it can be used for production of biodiesel from its seeds which can generate economy during the process of remediation for the contaminated landfill soil

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APPENDICES

Figure 16: Plant sample on the first day planting

Figure 17: Plant sample after two weeks planting

Figure 18: Plant sample after fourth weeks planting

Figure 19: Preparation of sample before analysis.

Figure 20: Samples being digested.

Figure 21: Sample in hot block for digestion.

Figure 22: Preparation of Standard Solution for analysis using AAS