PHYTOREMEDIATION METHODOLOGY OF METALS CONTAMINATED SURFACE SOIL BY TAETES ERECTA

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PROSIDING KEBANGSAAN AWAM 2007
29 – 31 MEI 2007
LANGKAWI KEDAH

Phytoremediation Methodology of Metals Contaminated Surface Soil by Tagetes Erecta

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Abstract

In current day, the land for development has been greatly exhausted, and it is caused mainly by the consumption of metals spillage to the surface soil. However, the code for metals extraction from the surface soil has not yet established. Thus, it is acknowledged that the purpose of this research is to conduct the main reason of suitability and efficiency of the current trends of high costing in conserving the environment by plant, such as shrub on surface soil to a much lesser expenses. The technique is to actually curb the contamination by using the technology of phytoremediation in real situation of containing; by means of removing, relocating, stabilizing or even perishing the five specific contaminants of Cadmium (Cd), Chromium (Cr) and Lead (Pb) in Tagetes erecta under a conserved environment of this study. The purpose of this studying is to determine Tagetes erecta availability of treating the contaminated surface soil of the five types of metals. The analysis will be using digestion procedures of the Environmental Protection Agency (EPA) mild digestion in hot plate for metals analysis of using Atomic Absorption Spectroscopy (AAS) in determining the metals in interest. The leave have been recorded with the increasing polar of absorption upon Lead < Cadmium < Chromium at the concentration of 5594 μg/g < 741 μg/g < 170 μg/g, while the concentration of the stem has the value of 2824 μg/g < 204 μg/g < 100 μg/g. Yet, the content of root has Lead < Chromium < Cadmium concentration as the orientation, whereby, the concentration of the elements as 8116 μg/g < 250 μg/g < 156 μg/g. The category of the highest metal absorption to the Tegetes erecta rallied on Lead < Cadmium < Chromium as of 91% < 6% < 3%.

Keywords: Tagetes *erecta*, Metals and Phytoremediation.

1.0 Introduction

Disposal practices are far from adequate and indiscriminate dumping is on the increase. Therefore, study on pressurising condition has made a progress in detail about the beneficial utilization of treating this waste on surface soil in particular. There are considerable technical, social, financial and institutional which are less constraint to ensuring a greater degree of control over waste generation and disposal.

Soils are an important medium for these metals due to soils' high metal retention capacities. Important metals such as Pb, Cr, and Cd which are posing threats to soil quality and human health. They are used in a wide variety of industrial, urban, and agricultural applications and a toxic to humans (Forstner, 1995). Such as, people exposed to low levels of Cadmium over time may incur kidney damage as well as lung, bone, cardiovascular system, liver, reproductive system damage, abnormal vitamin D metabolism, and in some situations death (Hrudey et al., 1995).

Understanding the mechanisms of metal sorption in soils is important as these reactions dictate the strength of the metal–soil surface interaction (plant in phytoremediation methods). The stronger the interaction of metals with the soil surface, the less the likelihood of environmental contamination (plant and ground water) (McBride, 1994).

2.0 Statement of Problems

The problem statements in the research are as accordingly;

a. Oxidation Ponds are less expensive, but they need very large areas to store sewage water in the shallow depths. These invariably generate foul smell and cater to breeding of mosquitoes and other pathogens. While phytoremediation is much safer and yet cheaper to conduct on the soil form, where mosquitoes are unable to breed at, besides, it provides studied extraction of metals rather than the ponds which do not have an extensive study on metals removal.
b. Incineration and landfill in urban or rural areas caused ashes and leachage of metals. It is this reason the practical point of using the unique phytoremediation technology will be useful, and will be cleaner for the public to live in.
c. Massive cultivation of vegetations caused the uses of pesticides, fungicides, and weedicides. Therefore, the role of phytoremediation is to clean up some of these contaminants which present in the studied metals from the surface soil and to prevent further percolation into ground soil.

3.0 Objectives

The objectives of this research are as the following;

a. To determine the maximum application of metals by the Tegetes *erecta.*
b. To measure the metals uptake by Tegetes *erecta.*
c. To determine the metal content within the different parts of the Tegetes erecta.
d. To determine the metal contents in soil of planting the Tegetes erecta with the depth of 5 cm, 10 cm and 15 cm.

4.0 Scope/Limitation of Study

The scopes or limitations of study in this research are as stated below;

a. Landscape and terrestrial shrub of Tegetes *erecta* at 5 cm radius and 15 cm depth beneath the soil of the plastic beg.
b. Metals analysed are Pb, Cd and Cr under observation of obtaining suitable concentration.
c. Metabolic processes within the plant might alter the form of the contaminant, and in some cases transform it to less toxic forms, i.e., lost of metals trace.

5.0 The Importance of This Research

The importance of the research is as followed;

a. Determination of the metals maximum burden uptake in the survival of Tegetes *erecta* before dying.
b. Determination of the rates of metals intake in Tegetes *erecta* of enhancing soil fertility in commercial, i.e., corn fields, and flower farms.
c. Determination of metals content in different parts of Tegetes *erecta* for disposal handling purposes, i.e., roots, leaves, stems, and possible flower.
d. Data collection, analysis, reporting and writing scientific articles of the research activities.
e. Determination of Tegetes *erecta* suitability as absorbent shrub for metals in surface soil.

6.0 Methodology

6.1 Sowing and Planting Procedure

The germination process has been the start of all the beginning of the experiments. By far, it is necessary to control all new infestations prior to seeding. A standard sizes of black plastic beg with the spreading diameter of 10 cm will be used to plant the samples vegetation with the depth of 15 cm and each layer of 5 cm, 10 cm and

15 cm will be taken for analysis of concentration of trace elements. Seeds are sowed in the main vase to determine the period of self-sustaining capability of the samples to withstand the condition of the temperate environment. The observation is only conducted after the fourth weeks. The sowing and the growing needs time to establish the seeds into plants. As soon as the main criteria have been chosen, of which the samples belong to be inherited with the durability to the environment, strong stem, and proper height, its are transferred into the plastic beg for the further examination.

Soil is taken from the surface of the earth (disturbed soil), in order to comply with the term of surface soil phytoremediation. The soil is taken from the palm oil farm, as the area of Parit Raja consisted mainly of the sources of plantation regarding farms. Periodic tests are conducted with the concentration of the metals in the soil, in term of the absorption of metals from the roots to the distribution of the overall compartments of the samples.

In first each week after transplantation, metals solution is poured into the soil. Changes of the samples are recorded in order to find the limit of the metals concentration that allows the trees to keep surviving, instead of dying. The controlled metals add-in is Pb, Cd and Cr.

The maximum requirement of the samples will be reached. Therefore, the rest of the zero contaminated samples are supplied with the metals contents directly into the soil strata of the roots. The grounds will be maintained at 30% moisture (twist a day of watering). Each of the samples will be provided with the distilled water and add-in grown nutrients as supplement needs.

In the fortnightly, five samples will be harvested to test for the heavy metal contents in each of its compartments; root, stem, leave, and if possible flower. Notwithstanding, the control samples (without metals) will also be tested as the standard controls for the complete assignments. The tests will be carried up for eight conservative weeks; four tests will be conducted in the periods of exercises.

6.2 Nutrients and Metal Contents

The applied contents of the nutrient are for watering purposes and grown. There are five importance metals of Pb, Cr and Cd in the provision of plants absorption, prepared in solution for plants addition in the beginning, until the process for determination of maximum uptake have reached. Consecutively, the nutrients will add up the rest of the study with twice-a-day watering as grown supplement needs.

6.3 Field Experiment Setup

The location for the experiments is set up in KUiTTHO compound besides the tennis courts and the HEP (Student Affair Complex building). The space of 15 ft x 15 ft (255 ft^2) of shed in KUiTTHO compound will be sufficient for the landscape and terrestrial shrub of Tagetes *erecta*. The fences are erected to restrict the human interruptions and animals trespassing, in order to condemn the process of the growing. And the shrub will be restricted in the ground of the licensed plot for experiments. Any leakage will be just in the local area of the experiment field. Cleaning can be easily carried up, as the ground is covered with layer of sand and a special plastic cover on the direction of the bottom of the plants that will absorb or contain and secure the underground water from any contamination. The plastic begs with Tagetes *erecta* will be treated uniformly with respect of the distilled water and with the absent of the application of pesticides, herbicides, and weedicides. It is feared that the usage of these will bring undesirable results to the grown and obtained results.

6.4 Harvesting Schedule

The chart of schedule for each five samples will be conducted in the fortnightly, with the roots, stems, and leaves, which will total up as much as 15 procedures of tests, will be conducted at the week for each sample specimens only. Yet, with the tests to determine the contents of metal, shall it turn up to be five metals in interest, therefore, the processes will have to take a total of 75 procedures of tests to be completed.

Table 6.1: Average Ripping Schedule for Analysis

Sample	Ripping Schedule			
	0 – 2 Weeks	0 - 4 Weeks	0 - 6 Weeks	0 - 8 Weeks
Metals Samples +	Sample 1	Sample 1	Sample 1	Sample 1
Nutrients + metals at	Sample 2	Sample 2	Sample 2	Sample 2
$20mL_{(ak)}$ =(1+2+3)/3	Sample 3	Sample 3	Sample 3	Sample 3
Average				
Standard Samples +	Sample 4	Sample 4	Sample 4	Sample 4
Nutrients =(1+2+3)/3	Sample 5	Sample 5	Sample 5	Sample 5
Average				

6.5 Sample Digestion

The analysis will be using digestion procedures of the EPA Mild Digestion with hot plate for metals analysis. There will be one gram of each sample to be divided into four tests. The tests will be conducted at the aftermath soil of the each two weeks, at the roots, stems, and leaves. The methods used will be greatly associated with the strong sulphuric acid and weak nitric acid. The samples will be washed away with the distil water in order to decrease the level of dirt, but the sample itself in the process in return. Each of the samples is put into microwave for 24 hours at 105°C in a drying ceramic pot in the size of a cup.

Upon dealing with drying, the sample should be weighed to determine the mass of the specimen after extracting the contents of the water. Specimen will be put into Agate mortar for punching or grinding until it is absolutely shattered in smooth powder.

By this process of Standard Method, 0.2 to 0.5 g of each specimen will be added with the strong acid nitric at 10 ml, and heated for in the hotplate. The digestion uses acids and heat to break down a substance into components that can be analysed through filtration, centrifugation or total dissolution.

While in the process of digestion of the Aqua Regia, the combination of the mixture to be put into is of the hydrochloric acid and nitric acid at the ratio of 3:1. Therefore, in the process of digesting the soil will require 10 ml of Aqua Regia and it comprises of 7.5 ml and 2.5 ml of acids to be prepared. Upon preparing it in a biker, the container will be heated in the hot plate for an approximated 30 minutes. And the sample will be diluted in the classic volumetric of 100 ml by a mere 0.1 ml of the sample which has gone through filtration. The produce will be kept and be ready for preservation up to six months. And upon those days, the sample can be extracted for metal elements analysis.

6.6 Sample Preservation

Upon taking up the consideration of the time provided for harvesting, sample from the soils are collected in acid-washed plastic bottles. If the condition is of storage, pH will be adjusted to 2 or less with Nitric Acid (HNO_3) (about 2 mL per liter). The preserved samples can be stored up to six months at room temperature.

If only dissolved metal is to be determined, the sample is filtered before adding the acid and adjusted the pH to the required preservation with 5.0 N of Sodium Hydroxide before analysis. The pH requirement can not be exceeded, as this may cause some losses of metals precipitation.

6.7 Sample Dilution and Interfering Substances

Sample dilution may influence the level at which a substance may interfere. The effect of the interferences decreases as the dilution increases. In other words, higher levels of an interfering substance can be present in the original sample if it is diluted before long being analysed in the machine of Spectrometer and AAS.

6.8 DR4000 Spectrometer and Atomic Absorption Spectroscopy (AAS) Analysis

Upon dilution, the metals will be tested for the present of metals. And for the purpose of taking the exact readings, the contents will be applying the catalytic affects of DR4000 Spectrometer reagents.

In these tests, the Atomic Absorption Spectroscopy will be used besides the above method applied in this tests. And the role will play as the important job in determining the precise element of metals in the analysis that can not be detected from the spectrometer.

7.0 Cleaning Apparatus

7.1 Ultrasonic Cleaner

The usage is to clean any contaminants and so does the heavy metal. It is very simple and to a very effective cleaning. The solutions from the tests are poured into the indicating level, and the used apparatus are placed in the punctuated basket or pallet in the bath which is hung on wires or string in it. Metals solution will be effectively cleaned and removed in an environment friendly way.

8.0 Discussion

8.1 Overall Contamination in the Compartments of Tegetes erecta

From the Figure 8.1 of Table 8.1, the figure shows that the elements of contamination have been in the arrangement of the percentage of comparison, of which it involved only the research parameter of leave, stem and root. The plants have been applied with the Cr, Pb and Cd. From the observation and the abstraction of the plant studied elements, the uptake of the Cr into the plants have reach the highest mark when it comes to the root. The roots are able to absorb in greater quantity rather than the rest of the compartment of the Tegetes erecta. The problem in the stem to be so ineffective of accumulating the contamination is basically caused by the condition of the plants which are deprived from the proper nutrition and the not-so-well grown of the plant.

However, the condition of the leave has a greater impact on the tree as it has much greater absorption than the stem. The leave has the capacity to accommodate the Chromium from the contaminated soil.

Table 8.1: The concentration of the differences of sampling and the controlling in among leave, stem and root system

Parts	Element		
	Chromium (µg/g)	Lead (µg/g)	Cadmium (µg/g)
Leave	170.35	5594	740.9
Stem	99.5	2824	204
Root	250.3	8116	195.8

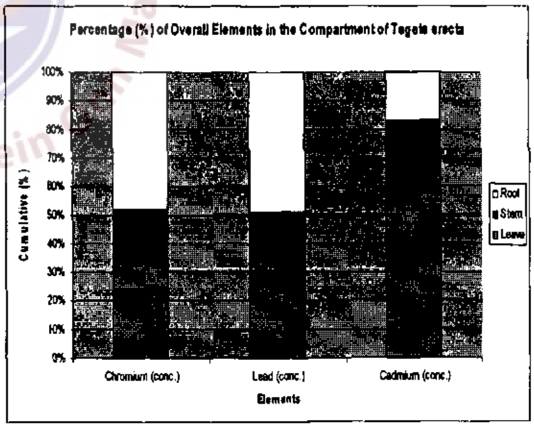

Figure 8.1: Percentage (%) of Overall Elements in the Compartment of Tegetes erecta in the differences of sampling and the controlling among the leave, stem and root system

The purpose of study only covers the overall of the plant. The depth of the soil has not been described thoroughly here, and it is done in the depth of the soil discussion. The study also indicating that the Lead consist the most concentration as the other two elements are less than the Lead. The Lead has the same arrange of accumulation in the plant, as the root managed to keep the highest to itself, and the plant of the interest of leave part has to be the second in the standing, and it has to be the 5594 µg/g of concentration recorded, which the stem has the less reading, with the scope of reaching 2824 µg/g in Table 4.10, that is higher than the other of the elements, but not yet in able to compete with the capability of the other parts of the tree to absorb such an effectively.

Cadmium however, has the reading at the highest point when it comes to the leave, the leave has been able to keep it up to the 740.9 µg/g of concentration, which is higher than the rest of the studies. The component of the tree is managed to overcome the resistance from the other part of the tree and is able to accumulate it the most at the leave. The root and the stem has the almost the same reading as the percentage of the reading turned up that the stem and the root does not coincidence in absorbing the trace medium from the proper examination of such.

Thus, the condition has shown that the compartment of the tree has to be effective when it comes to the root and leave as it come to the medium of Chromium and the lead, while for the condition of the Cadmium medium, the leave has the most effective way to handle the contamination and is applicable to all.

8.2 Overall Contamination in the Compartments of Tegetes erecta Soil Layers

The condition of the percentage of overall elements in the soil strata of 5 cm, 10 cm and 15 cm of the Table 8.2 are made into clearer picture of the Chromium, Lead and Cadmium intake in the individual soil strata from the Tegetes erecta.

Table 8.2: The concentration of the differences of sampling and the controlling in the layer of 5 cm, 10 cm and 15 cm depth

Parts	Element		
	Chromium (µg/g)	Lead (µg/g)	Cadmium (µg/g)
Soil (5cm)	313	3820	41.6
Soil (10cm)	328	2269	146.1
Soil (15cm)	321	2097	101.2

The intake of the Chromium in the 5 cm, 10 cm and 15 cm has about the same level of containment of the contaminants as in Table 8.2, though the intake has been varied in the plant, especially the root which relies greatly on the depth of the root to reach the ground of the capacity of absorption, however has it distributed its contents into the other part of the plant.

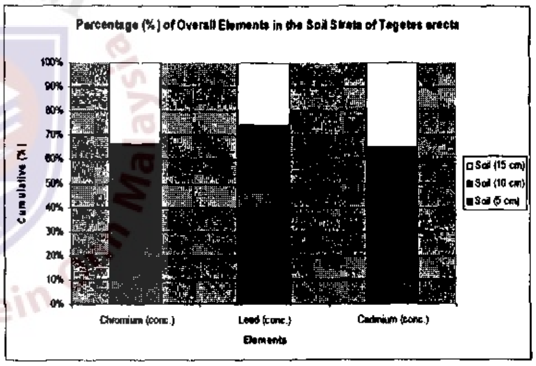

Figure 8.2: Percentage (%) of overall elements in the compartment of Tegetes erecta in the differences of sampling and the controlling in the layer of 5 cm, 10 cm and 15 cm depth

The Lead has the highest content in the soils strata comparing to the other element. The depth of the soil indicated that the soil has a lesser concentration of percentage the moment the depth increase. This indicated that the plant has the capacity to uptake the Lead from the ground as the root has it to the 15 cm depth and so does the effect on the 10 cm depth, although less then the 15 cm as shown in Figure 8.2. While in the depth of 5 cm, the Lead has the highest concentration as from the shown percentage.

8.3 Chromium Uptake in the Soils Strata

The Cadmium, however, has been recorded to have the highest rate of concentration in the layer of 10 cm from the Table 8.4. The percentage of Figure 8.3 has shown that the Cadmium has penetrated the early level from the beginning of the start of the research when the elements were spiked into the soil to be contaminated.

The element however managed to slip through the surface category of the thin layer of 5 cm, into the 10 cm of the soil, which to be retained. And when the condition of the plant has developed into better shape, of which, it has grown, the plant managed or simply only be able to uptake the contamination from the soil.

However, the absorption is not recorded to be very great and it has to be slow comparing to the others element have been able to be uptake easily and effectively by providing a good percentage of element concentration in the increase of the soil strata.

Table 8.3: The concentration of the differences and percentage of sampling and the controlling in the soil layer of 5 cm depth

Chromium	Soil (5cm)			
Duration (week)	Control (k)	Sample (p)	Conc diff. (μg/g)	Percentage (%)
0-2	470	568	98	31.31
0-4	505	581	76	24.28
0-6	454	664	71	22.68
0-8	515	583	68	21.73
Total			313	100

Table 8.4: The concentration of the differences and percentage of sampling and the controlling in the soil layer of 10 cm

Chromium	Soil (10cm)			
Duration (week)	Control (k)	Sample (p)	Conc diff. (μg/g)	Percentage (%)
0-2	313	531	218	66.41
0-4	509	549	40	12.18
0-6	485	542	57	17.36
0-8	425.2	438.5	13.3	4.05
Total			328.3	100

Table 8.5: The concentration of the differences and percentage of sampling and the controlling in the soil layer of 15 cm

Chromium	Soil (15cm)			
Duration (week)	Control (k)	Sample (p)	Conc diff. (μg/g)	Percentage (%)
0-2	537	654	117	36.44
0-4	484	593	109	33.96
0-6	417	507	90	28.04
0-8	442	447	5	1.56
Total			321	100

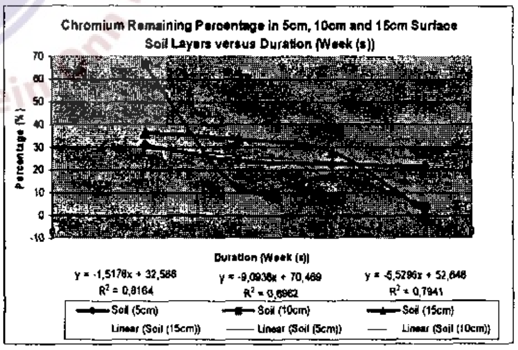

Figure 8.3: Chromium remaining percentage in 5cm, 10cm and 15cm surface soil layers versus duration (week (s))

From the Figure 8.3 above, the reading from the depth of the 5 cm of the surface soil has been in about the linear form as the percentage of the differences of concentration to be provided in the same stage of the duration from the second week to the eighth week as the checking shows the correlation coefficients have the reach $R^2 = 0.5$ above. The regression method was used to determine the efficiency of plotting. The soil show in 5 cm depth has a much linear application then the others.

At the depth of eighth week of Figure 8.3, the contamination has been taken up to almost perfect percentage of the differences between sample and the controlled sample. Each of the contamination has a great value of differences. However, each of them indicated that the value at the eighth week has been effective to absorb the sample from the contamination.

Desorption of Chromium was greatest in the sample with the lowest pH (>80%), whereas less 1.25% Chromium was desorbed from the other soils with much higher pH., that it is also found that desorption decreased as pH increased, and was virtually nil at pH greater than 6. There were also distinct differences in the amounts of Chromium desorbed between different soil types, and it is stressed that the differences in desorption are a result not only of pH but also of the physio-chemical characteristics of the soil matrix (Pardo, 1997).

8.4 Lead Uptake in the Soils Strata

Table 8.6: The concentration of the differences and percentage of sampling and the controlling in the layer of 5 cm depth

Lead	Soil (5cm)			
Duration (week)	Control (k)	Sample (p)	Conc diff. (µg/g)	Percentage (%)
0-2	1450	3113	1663	43.53
0-4	505	698	193	5.052
0-6	905	1902	997	26.1
0-8	1690	2657	967	25.31
Total			3820	100

Table 8.7: The concentration of the differences and percentage of sampling and the controlling in the layer of 10 cm depth

Lead	Soil (10cm)			
Duration (week)	Control (k)	Sample (p)	Conc diff. (µg/g)	Percentage (%)
0-2	1681	2212	531	23.4
0-4	529	1179	650	28.65
0-6	954	1696	742	32.7
0-8	1152	1498	346	15.25
Total			2269	100

Table 8.8: The concentration of the differences and percentage of sampling and the controlling in the layer of 15 cm depth

Lead	Soil (15cm)			
Duration (week)	Control (k)	Sample (p)	Conc diff. (µg/g)	Percentage (%)
0-2	805	1767	962	45.88
0-4	484	1301	817	38.96
0-6	1056	1224	168	8.01
0-8	744	894	150	7.15
Total			2097	100

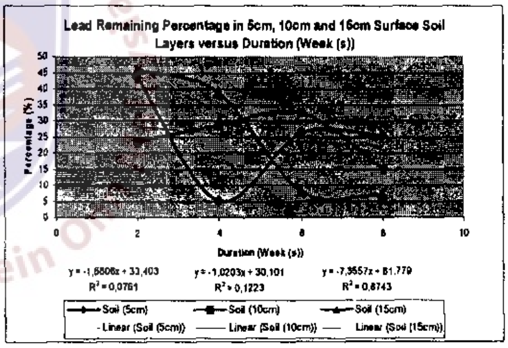

Figure 8.4: Lead remaining percentage in 5cm, 10cm and 15cm Surface soil layers versus duration (week (s))

The graph at Figure 8.4 of the percentage from the lead remaining percentage has the condition of the soil from the depth of the 5 cm of Table 8.6, 10 cm of Table 8.7 and to the 15 cm of the layers at Table 8.8. The duration indicated that the percentage uptake has been reduced to the lowest point for the week of eighth. Data obtained from the computer program was used to indicate that the condition of the soil at 5 cm and 10 cm depth have weak plots, which mean the test is not providing the smooth uptake of the traces. While in the 15 cm depth, the condition has changed, where, the coefficient has $R^2 = 0.5$ and above, therefore, it is linear up to the mark of metal uptake.

The fourth week, has seen the drop of 5 cm soil layer, which it mean the possibility of the soil has been ward off from the element of the soil which has not been able to let the lead to come across and be contacted with the soil layer, and therefore, the condition of the soil to be unstable and the detection of both the sample and the controlled sample to be stated in the lowest concentration differences.

8.5 Cadmium Uptake in the Soils Strata

Table 8.9: The conc. of the differences and percentage of sampling and the controlling in the layer of 5 cm depth

Cadmium	Soil (5cm)			
Duration (week)	Control (k)	Sample (p)	Conc diff. (µg/g)	Percentage (%)
0-2	34.2	49.9	15.7	37.74
0-4	2	15.9	13.9	33.41
0-6	53	62.2	9.2	22.12
0-8	50.1	52.9	2.8	6.73
Total			41.6	100

Table 8.10: The conc. of the differences and percentage of sampling and the controlling in the layer of 10 cm depth

Cadmium	Soil (10cm)			
Duration (week)	Control (k)	Sample (p)	Conc diff. (µg/g)	Percentage (%)
0-2	39.0	80.95	41.95	28.72
0-4	10.2	62.70	52.5	35.95
0-6	385	68.40	29.9	20.47
0-8	55.6	77.30	21.7	14.86
Total			146.1	100

Table 8.11: The conc. of the differences and percentage of sampling and the controlling in the layer of 15 cm depth

Cadmium	Soil (15cm)			
Duration (week)	Control (k)	Sample (p)	Conc diff. (µg/g)	Percentage (%)
0-2	6.9	96.2	89.3	88.28
0-4	53.2	53.5	0.3	0.30
0-6	40.75	49.5	8.75	8.65
0-8	46.6	49.4	2.8	2.77
Total			101.2	100

From the line graph, the indication has been provided that the percentage of the content in the soil has a high percentage of the differences of concentration from the start till the end of the eighth week. Till then, the intake that has shown the greatest difference has to be the soil at the layer of 15 cm of Table 8.11 from the Figure 8.5. It has recorded the intake to be at the lowest plummeting condition as such during the duration of the fourth week. The reading should be basically base on the mistaken intake of the reading or simply the problem of the hygiene that has to be taken to avoid any possible misleading of the record. The definition of $R^2 = 0.5$ and above as stated above means, the graph has a proper linear coverage on the indication of the plant uptake of the metals. Follow as accordance to 15 cm < 10 cm < 5 cm.

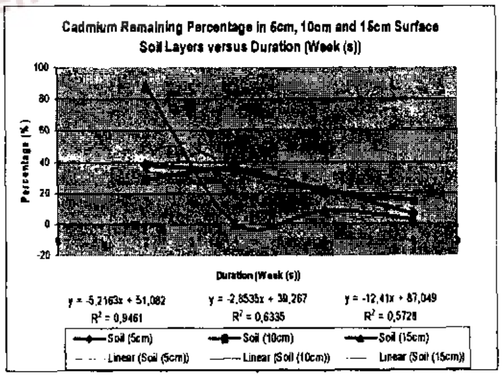

Figure 8.5: Cadmium remaining percentage in 5cm, 10cm and 15cm Surface soil layers versus duration (week (s))

Thus far, the condition can be concluded that the plant has the efficiency to absorb the Cadmium from the soil and is able to contribute to the real world for simple and cheap application of the uptake of the contaminant from the contaminated surface soil.

9.0 Conclusion

Coming to the conclusion, the understanding of the mechanisms of metals absorption in the surface soils by Tegetes erecta is important as these reactions dictate the strength of the metal–soil surface-plant interaction to extract the contaminants of the specific metals of Cadmium (Cd), Chromium (Cr) and Lead (Pb).

The quantitative measurements of the plant from the objectives require the maximum application of the metals to be taken and preserved in the plant. The category of the highest metal absorption to the Tegetes erecta rallied on Lead < Cadmium < Chromium as of 91% < 6% < 3%.

The intake has been provided that the plants have the most effective channel of storage and the tendency of identifying the certain parts of the Tegetes erecta are at the mean orientation of Root < Leave < Stem as of 47% < 36% < 17% of metals are taken to storage at the various parts.

The concentration of metal content within the different parts of the Tegetes erecta has been divided into leave, stem and root. The leave have been recorded with the increasing polar of absorption upon Lead < Cadmium < Chromium at the concentration of the research as 5594 µg/g < 741 µg/g < 170 µg/g, while the concentration of the stem has the standing of 2824 µg/g < 204 µg/g < 100 µg/g. Yet, the contents of root has Lead < Chromium < Cadmium concentration as the orientation, whereby, the concentration of the elements stand as 8116 µg/g < 250 µg/g < 156 µg/g.

Analogically, the metals content in the depth of different level as of the soil at 5 cm, 10 cm and 15 cm have provided the overall elements concentration to be as Lead < Chromium < Cadmium as the orientation. As at 5 cm until 10 cm, the concentration has recorded a jump of content at the Cadmium and Chromium at the value of 42 µg/g to 146 µg/g and 313 µg/g to 328 µg/g. There after, at the depth of 15 cm, the concentration has been reduced, though in the slight changes, yet, it has provided the condition that the plants has a depth until 15 cm and are able to absorb at that depth. The Lead has a stable plummeting value as of 3820 µg/g to 2097 µg/g as the depth reached its bottom.

References

Forstner, U. (1995). "Land contamination by metals: global scope and magnitude of problem." Journal of Metal speciation and contamination of soil. 132-133.

Hrudey, S.E., W. Chen, and C.G. Rousseaux (1995). "Bioavailability in speciation of lead (II): Effects of organic matter and pH." Journal of Soil Science environmental Risk Assessment. Florida, USA: Lewis Publication.

McBride, M. B. (1994). "Toxic metal accumulation from agricultural use of sludge: Are USEPA regulations protective?" Journal of Environmental Quality. 24(1): 5-18.

Youventharan a/l Duraisamy (2004). "Domestic Waste Water Sludge Treatment Using Kangkung (Ipomoea Aquatica)." KUiTTHO. Honorary Degree Thesis.

Pardo, M. T. (1997). "Influence of electrolyte on Cadmium Interaction with selected andisols and alfisols. Soil Science, 162, 733-740.

Mohd Baharudin Ridzuan (2005). "Pengolahan Kandungan Logam Berat Daripada Tanah Yang Diaplikasi Dengan Enapcemar Domestik Melalui Kaedah Tanah Pertanian." KUiTTHO. Master Degree Thesis.