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Phytoremediation potential of selected grass species in the Mine Tailing Pond of Sitio Manlauyan, Gango, Libona, Bukidnon, Philippines

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Abstract

Generally, the study aims to investigate the absorptive capacity of the three dominant grass species namely *Imperata cylindrica L.* (Cogon grass), *Megathyrsus maximus J.* (Guinea grass), and *Pennisetum purpureum S.* (Napier grass) in remediating mercury contamination from a mining tailing pond of barangay Gango, Libona Bukidnon, Philippines. It also assessed the level of mercury contamination in the soil within the study area. The study made used of a descriptive comparative method and One-way Analysis of Variance for the statistical tool. Composite samplings were made for the soil samples and the presence of mercury in both the grass and soil samples were analyzed using a Cold Vapor Atomic Absorption Spectroscopy (CVAAS). Based on the findings of the study, the three grass species showed absorptive capacity and were able to remediate mercury from the soil. The highest mercury uptake was cogon grass with an average concentration of 10.473 ppm followed by guinea grass with an average of 7.521 ppm then napier grass with an average of 3.012 ppm. It also showed that the soil sample without vegetation has greater concentration of mercury than the soil sample with vegetation.

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Introduction

Mining industries which are unregulated pose potential hazards to the environment due to the generated waste coming from the mining processes which could create problems in air and water pollution. Mining is one of the most destructive man-made activities that brought negative implications to the environment. The tailing pond of the mining industries is considered as a home of pollution and contaminants that contributed negative effects to the health of the environment. A tailing pond may possibly contaminate water bodies when runoff occurs during heavy rain or through leaching into nearby rivers and ground waters.

In Northern Mindanao, specifically in Sitio Manlauyan, barangay Gango, Libona, Bukidnon, gold mining is considered the most common activities of the residents due to its immediate income from this activity. According to the locals in the barangay, the gold mining in Gango, Libona started in the early 1960's and became more famous in which the miners organized a cooperative known as the Bukidnon Integrated Small-scale Mining Corporation (BISMC). The methods used in Gango Mining are tunneling and Ball Milling. Particles from milled ore are amalgamated with mercury to segregate pure gold from ore. Due to this gold separation procedure, some of the amalgamated gold is not totally captured by the miners and ends up in a tailing pond. A tailing pond is a man-made pond which serves as a catchment basin of all the wastewater coming from the gold mining process. Inside the tailing pond, mercury particles from the amalgamation procedures are accumulated over time depending on how long the tailing pond has been used.

Mercury is a huge threat to human health and its destruction is irreversible (Henry, 2000). It is toxic and could damage vital organs of the body like brain, heart, nerves and lungs. The problem with tailing pond occurs during heavy rains, when there is a danger of possible overflow. If this happens, a tailing pond overflow may inevitably contaminate nearby rivers and other water bodies with mercury.

To address environmental, heavy metal contamination like mercury, phytoremediation proves effective and has been used by many recent studies. Phytoremediation is characterized by the use of vegetative species for *in situ* treatment of land areas polluted by a variety of hazardous substances. Plants are especially useful in the process of bioremediation because they prevent erosion and leaching which can spread the toxic substances to surrounding areas (Vidali, 2001). These plants could help in cleaning up contaminated soil environs by means of absorbing contaminants on its roots and biomass.

The main objective of this study is to investigate the potential of selected grass species which are dominantly present in the mine tailing pond to evaluate their capacity to absorb mercury on its roots. It also assess the amount of mercury content on the soil without vegetation within the mine tailing pond.

Materials and methods

Research Design

The study is a descriptive-comparative research wherein the researchers conducted a composite sampling method for the sediments in the tailing pond and also for the most abundant grass species that grow in the tailing pond area which has an ability to remediate pollutants such as mercury contamination. The study primarily focuses on the efficiency of the plants to absorb mercury (Hg), through its root uptake and to compare which among the three dominant grass species has the higher capability in absorbing or extracting mercury contaminant in the soil.

Description of Study Area

The study was conducted in Sitio Manlauyan, Gango, Libona, Bukidnon (see Fig. 1). The municipality of Libona, has a total population of about 35,670 and its 14 barangays belong to the partly urban areas in the Philippines. While some of the barangays developed modern urban structures, some others, especially those which are seated in the outlying areas, remained rural. The Mine Tailing Pond of Sitio Manlauyan, Gango, Libona, Bukidnon is located with the coordinates of $8^0$248 19"N–124^0 40'33.35"E.

The study area is in Gango, Libona Bukidnon where small scale mining area is shown in the map (see Fig. 2). The tailing pond (see Fig. 3) has a total area of approximately 8,000 square meters. Based on interview from the locals the possible passage way of the overflow water coming from the tailing pond is in Bigaan River.

Fig. 1. Map of Sitio Manlauyan, Gango, Libona, Bukidnon.

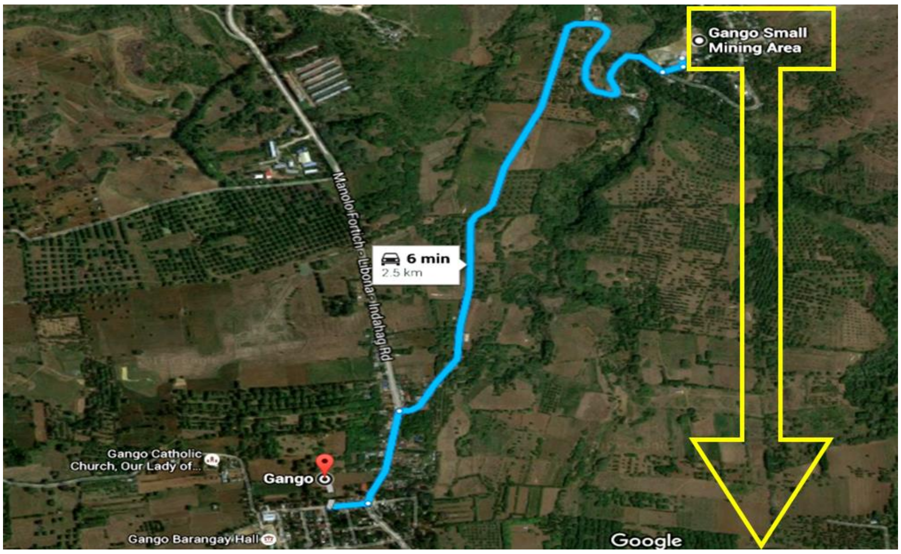

Fig. 2. Map of Gango, Libona, Bukidnon showing Gango Small Mining Area.

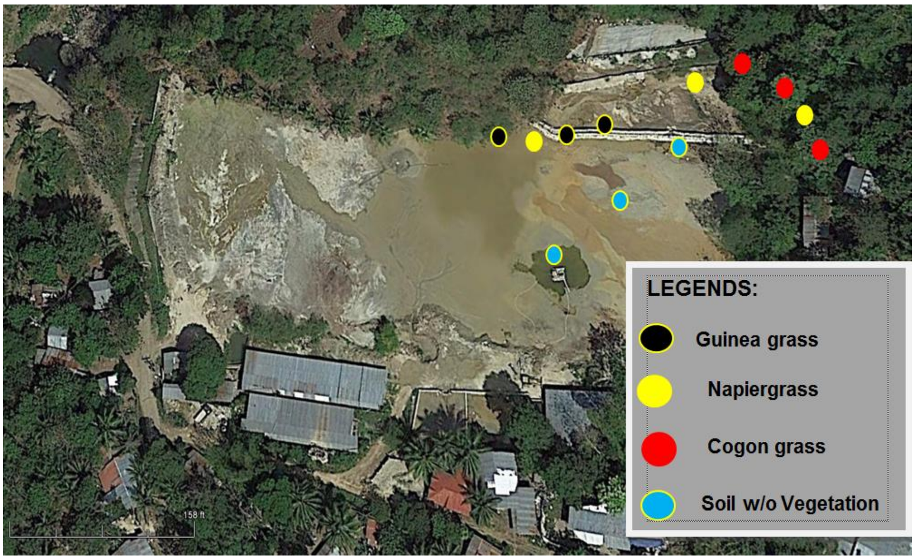

Fig. 3. Showing sampling point of each grass species in the tailing pond.

Fig. 4. Dominant Grass Species in Gango Tailing Pond a.) cogon grass b.) napier grass c.) guinea grass.

Entry protocol was observed prior to ocular inspection. During ocular inspection in the study area, dominant grass species were seen present within the perimeter of the tailing pond. These three grass species were identified by an expert as cogon grass, napier grass and guinea grass (see).

Collection of Grass Species

The researchers collected three samples of selected dominant grass species that grows abundantly around the tailing pond through a composite sampling method. In plotting and measuring the distance of every grass samples, plastic straw string was used. Every sampling point was labeled using a masking tape with a marking point in the plastic straw string as an indication of how far is every sample from one another. After pointing each sampling point with the labeled straw, the researcher removed the straw in the sampling area and measured the distance of each grass sampling point with the use of transect line.

The grass with their roots including the soil were dug and being cut using a large single- edged knife known as "bolo" and the soil from the roots are separated which serves as the soil sample with vegetation. Only matured grass roots of the three dominant grass species were taken, while the upper portion of the grass has been discarded (see Fig. 5).

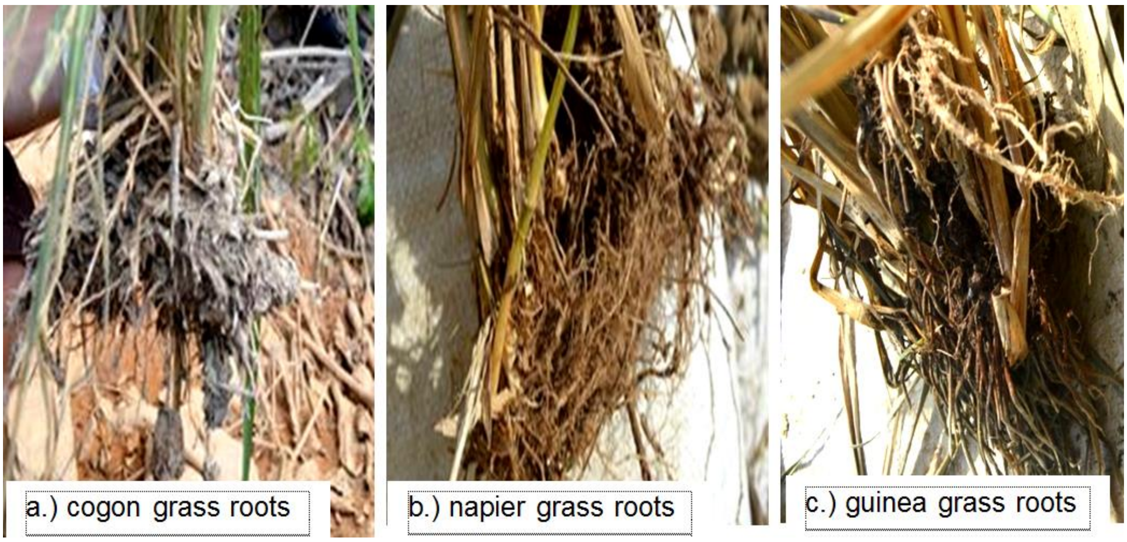

Fig. 5. Grass roots collected from the mine tailing pond area.

Collection of Soil Sample & Preparation

Composite sampling method were used in the collection of soil samples. Three sampling points were identified from the center of the tailing pond where soil sample without vegetation was collected. Equal amount of soil sample, about 200 grams were taken from each sampling site, mixed and homogenized by removing small stones and other materials which are not part of the soil. From the mixed soil sample, three subsamples of about 100 grams each (see Fig. 6) were placed inside a plastic container for laboratory preparation and digestion. Soil samples attached at the roots of the three dominant grass species were also collected, placed inside a zip –locked plastic container and brought to the lab for mercury content analysis for the sample on soil with vegetation. These soil samples, along with the plant roots of about 50 grams per plant species (see Fig. 6) were analyzed for mercury content using a cold vapor atomic absorption spectroscopy (CVAAS).

The Fig. 6 below shows the schematic diagram on the preparation of sample for mercury content analysis.

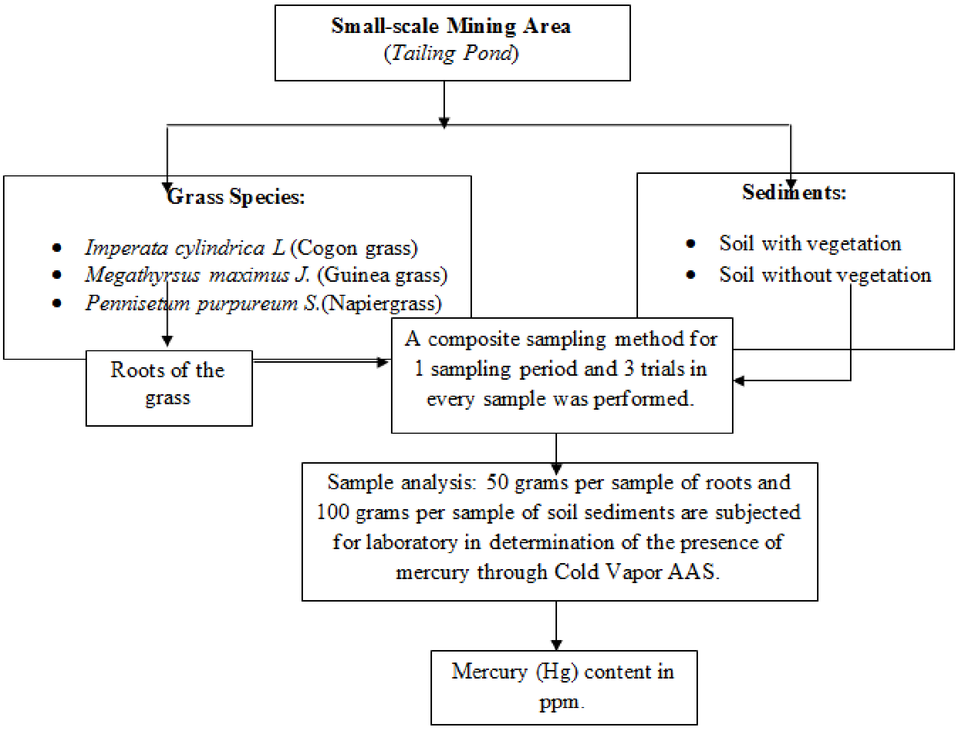

Fig. 6. Schematic Diagram of Data Collection Method.

Statistical Analysis

In order to interpret the gathered data, hypotheses were tested at 5% level of significance. One-way Analysis of Variance (ANOVA) was used to test the significant differences of the absorptive capacity of the three different grass species.

Cold Vapor AAS

An analytical portion (0.5g) is digested with nitric acid in the presence of sodium chloride using multi-step high pressure microwave heating in a closed vessel with feedback program to monitor temperature and pressure.

A 50ml analytical solution containing hydrochloric acid is prepared from the digest. Total mercury is determined in the analytical solution by Cold Vapor Atomic Absorption Spectroscopy (CVAAS) using stannous chloride to reduce mercury (II) ion to mercury.

Results and discussion

Mercury (Hg) content of Grass Roots and Soil Samples

Results for mercury content on grass roots (table 1) varies differently. It showed that the Cogon grass (*Imperata cylindrica* L.) has a higher root uptake that has a total absorption of 10.473ppm, followed by Guinea grass (*Megathyrsus maximus J.*) with a total absorption of 7.521ppm and with the Napier grass (*Pennisetum purpureum S.*) that showed to have the lowest uptake of 3.012ppm. The common reason why they are different on its total absorption of mercury uptake can be explained on its different characteristics of its root morphology. Cogon grass has a deep rooted roots, guinea grass has short root creeping rhizome (Cook *et al.*, 2005) and napier grass has a vigorous root system (DAFF, 2014). Base on the study of Chunilall, *et al.* (2004), mercury is mostly absorbed in the root system of the plant.

Table 1. Concentration of Mercury in the roots of Grass Species.

Grass species	Mean (T_1)	Mean (T_2)	Mean (T_3)	Mean Average
Imperata cylindrica L. (Cogon grass)	14.044	10.573	6.803	10.473
Megathyrsus maximus J. (Guinea grass)	3.809	11.152	7.601	7.521
Pennisetum purpureum S.(Napier grass)	1.787	4.067	3.181	3.012

According to a study of Paz-Alberto *et al.*, (2007) cogon grass, is a good phytoremediator and has the ability to absorb heavy metals in the soil because its root system is deep-rooted which can accumulate more nutrients and also heavy metal absorption. Guinea grass with an average mercury uptake of 7.521ppm and also shows good phytoremediation of heavy metal. Its root has a short but creeping rhizome and show capability of absorbing contaminant from the soil. According to study of Raskin *et al.* (2000) in his experiment, it shows significant concentration of heavy metals Pb, Cr, and Cd accumulated on the roots rather than its stem and foliar tissues. Napier grass on the other hand, has an average uptake of 3.012ppm. Just like other native species under study, it also accumulates mercury on its roots system. From the study of Ma *et al.* (2016), hybrid giant napier grass was able to absorb heavy metal to all parts of the plants which are the roots, stem and shoots. Base on the study of Marrugo *et al.* (2014), the longer the exposure of the plant species to the heavy metal contaminated area, the higher is its cumulative absorption. Fig. 7 shows the mean average of mercury (Hg) uptake in the three different grass species namely; *Imperata cylindrica L.* (Cogon grass), *Megathyrsus maximus J.* (Guinea grass) and *Pennisetum purpureum S.* (Napier grass).

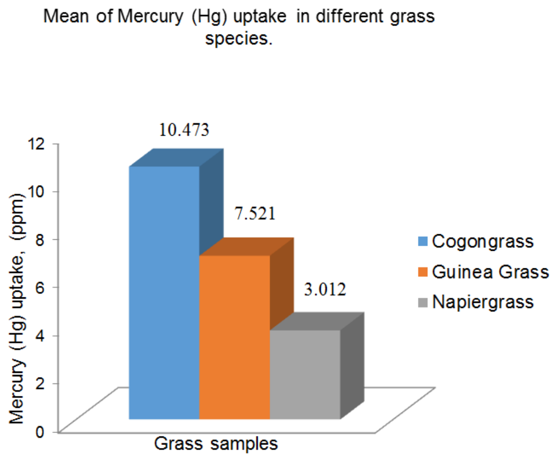

Fig. 7. Mean of mercury (Hg) uptake among three native grass species.

One-way Analysis of Variance (table 2) of the mercury (Hg) uptake on grass roots at 5% level of significance, indicated no significant difference (p>0.5) on the mercury uptake among the three grass species namely; *Imperata cylindrica L.* (Cogon grass), *Megathyrsus maximus J.* (Guinea grass) and *Pennisetum purpureum S.* (Napiergrass). This means that the three different grass samples showed almost similar absorptive capacity of remediating mercury from the soil. However, based on its mean value, cogon grass showed the highest uptake of mercury with an average of 10.473ppm.

Table 2. One-way Analysis of Variance (ANOVA) of Mercury (Hg) root uptakes of three grass species.

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	84.7257908	2	42.3628954	4.5516705	*0.062	5.1432
Within Groups	55.84265	6	9.30710933			
Total	140.568446	8				

This can be attributed to the grass roots system of cogon grass which is deep – rooted and a hardy species, unlike napier grass where the roots system thrives near the surface soil only. According to the study of Paz-Alberto *et al.* (2007), extensive root system denotes more contact to nutrients in soils, therefore more likelihood of nutrient absorption and mercury uptake.

Tailing Pond Soil Samples

Results on the analysis of soil sample showed that the soil without vegetation has a higher content of mercury with a total amount of 26.379ppm as compared to soil with vegetation with an amount of 7.711ppm (see Fig. 8). The common reasons why they vary on its mercury content can be explained by the presence of the grass species. The presence of the native grass species absorbs most of the mercury found in the soil thus decreasing the concentration of mercury in the sediments. On the other hand, in the soil without vegetation, all mercury content is concentrated in the sediments. According to the study of Heaton, *et al.* (1998) Inorganic mercury in contaminated soils and sediments is relatively immobile, but biological and chemical processes within the soil can transform it to more toxic and bioavailable methyl mercury. There are plants which are capable of converting ionic mercury and methyl mercury into volatile mercury, (Hg^o), which is released into an enormous atmospheric mercury (Hg^o) pool. The absorption of mercury into the plant roots and biomass reduces the concentration of mercury in the soil.

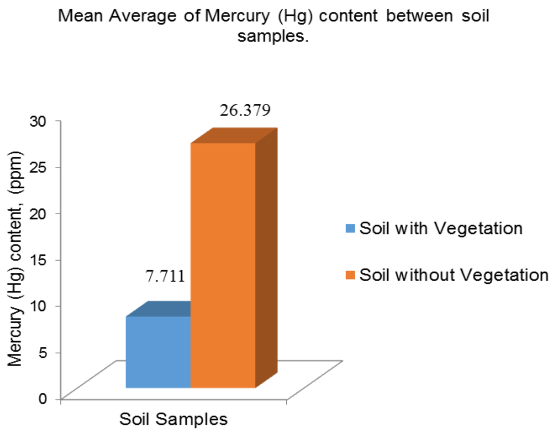

Fig. 8. Mercury (Hg) content between soil samples, with and without vegetation.

Conclusion

Based on the findings of the study, cogon grass has a total absorption of 10.473ppm of mercury followed by Guinea grass that has a total absorption of 7.521ppm and napier grass with a total absorption of 3.012ppm of mercury. Based on the result of the analysis, cogon grass showed the highest root uptake of the mercury contaminant. One-way Analysis of Variance (ANOVA), showed that there is no significant difference on the value of mercury root uptake from the three grass species *Imperata cylindrica L.* (Cogon grass), *Megathyrsus maximus J.* (Guinea grass) and *Pennisetum purpureum S.*(Napier grass). However, the three grass species have the absorptive capacity towards mercury contaminant from the soil. The soil analysis from the mine tailing pond with vegetation has a total absorption of 7.711ppm and soil without vegetation has a concentration of 26.379ppm. The difference of this measured values is explained with the presence of grass species in the study area which has contributed in the reduction of mercury concentration in the soil. It showed that the three native grass species *Imperata cylindrica L.* (Cogon grass), *Megathyrsus maximus J.* (Guinea grass) and *Pennisetum purpureum S.* (Napiergrass) is a good accumulator of heavy metal like mercury from the soil and could be a solution for environmental clean-up thus reducing mercury contamination in the soil.

References

Chunilall V, Kindness A, Jonnalagadda SB. 2004. Heavy metal uptake by spinach leaves grown on contaminated soils with lead, mercury, cadmium, and nickel. Journal of Environmental Science and Health, Part B **39(3),** 473-481.

Cook BG, Pengelly BC, Brown SD, Donnelly JL, Eagles DA, Franco MA, Hanson J, Mullen BF, Partridge IJ, Peters M, Schultze-Kraft R. 2005. Tropical forages. CSIRO, DPI & F (Qld), CIAT and ILRI, Brisbane Australia.

DAFF. 2014. Elephant grass (*Pennisetum purpureum*). Dept. Agric. Fish. Forest., PP67 Factsheet, Queensland Gov Australia.

Heaton AC, Rugh CL, Wang NJ, Meagher RB. 1998. Phytoremediation of mercury-and methylmercury-polluted soils using genetically engineered plants. Journal of Soil Contamination **7(4),** 497-509.

Henry JR. 2000. An overview of the phytoremediation of lead and mercury (pp. p3-9). Washington, DC: US Environmental Protection Agency, Office of Solid Waste and Emergency Response, Technology Innovation Office.

Ma C, Ming H, Lin C, Naidu R, Bolan N. 2016. Phytoextraction of heavy metal from tailing waste using Napier grass. Catena **136,** 74-83.

Marrugo-Negrete J, Durango-Hernández J, Pinedo-Hernández J, Olivero-Verbel J, Díez S. 2015. Phytoremediation of mercury-contaminated soils by Jatropha curcas. Chemosphere **127,** 58-63.

Paz-Alberto AM, *et. al.* 2007. "Phytoextraction of Lead-Contaminated Soil Using Vetiver grass (*Vetiveria zizanioides* L.), Cogon grass (*Imperata cylindrica* L.) and Carabao grass (*Paspalum conjugatum* L.)," Environmental Science and Pol- lution Research, Vol. **14,** No. 7, pp. 498-504. doi:10.1065/espr2007.05.415

Raskin I, Ensley BD. 2000. Phytoremediation of Toxic Metals: Using Plants to Clean Up the Environment. John Wiley & Sons, Inc., New York.

Table 1. The table below shows the total absorption of mercury uptake in roots using a Cold Vapor AAS as shown in.

Vidali M. 2001. Bioremediation. An overview. Pure and Applied Chemistry **73(7),** 1163-1172.