SEARCA Regional Professorial Chair Lecture on

Phytoremediation: A Green Technology To Remove Pollutants For Soil and Water Conservation

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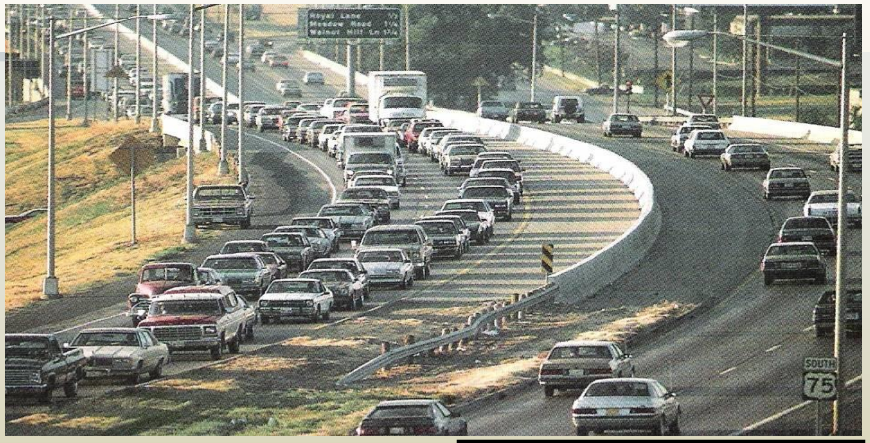
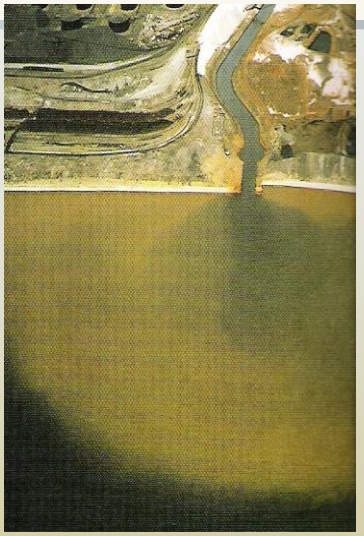
Background, Aims and Scope

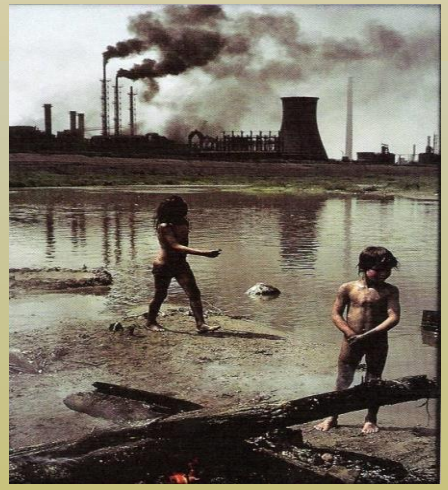
- The global problem concerning contamination of the environment as a consequence of human activities is increasing.



Background, Aims and Scope

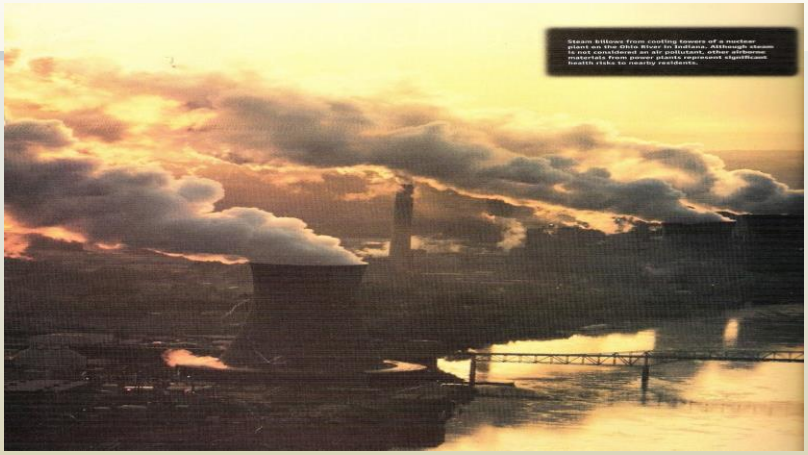
- **Most of the environmental contaminants are :**
  - ✓ **heavy metals such as lead (Pb), copper, chromium, cadmium, etc.**
  - ✓ **chemical by-products such as acrylamide**
  - ✓ **mutagenic agents such as ethidium bromide**

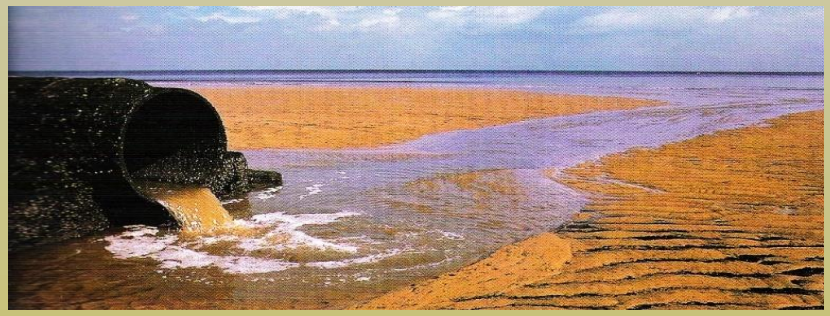




Background, Aims and Scope

- The human activities that contaminate soil, sediments and water with large quantities of heavy metals and toxic chemicals are :
  - industrial and mining industries
  - fuel burning and fuel production
  - intensive agriculture
  - sludge dumping
  - open dumpsites





Background, Aims and Scope

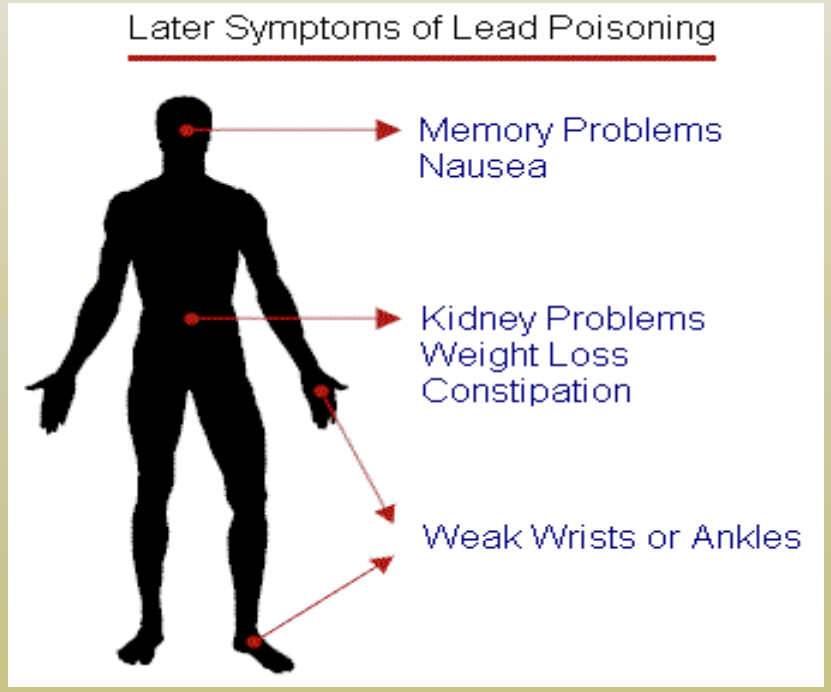
- Open dumpsite is one of the environmental problems that posed various risks and impacts to all kinds of life forms.
- It is the uncontrolled disposing of various solid or water wastes from individuals or industries without proper treatment and pollution controls.
- Open dumping could result in the accumulation of heavy metals in soil, water or air due to improper disposal of waste products.

Background, Aims and Scope

- **Heavy metals and toxic chemicals released into the environment makes it way into the air, soil and water which could affect the flora, fauna and humans especially children.**

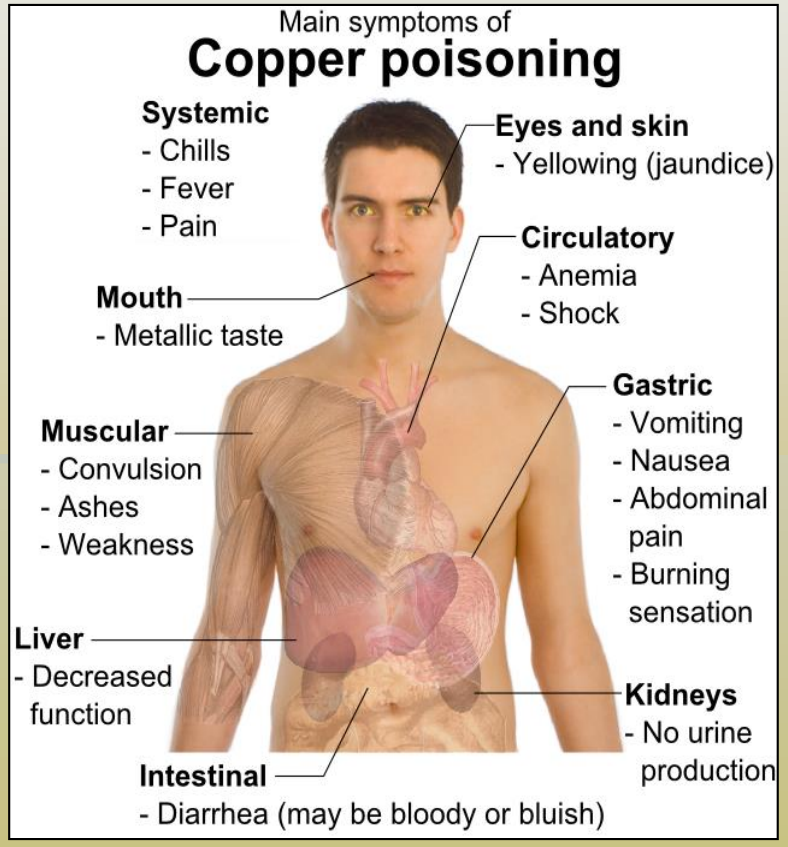
Background, Aims and Scope

- Toxic pollutants contribute to a variety of health effects such as
  - decline in mental, cognitive and physical health of the individual
  - human diseases such as cancer, liver damage , kidney problems, etc.



Background, Aims and Scope

- **Toxic pollutants like copper could bring harmful effects to human health.**



Background, Aims and Scope

- An alternative way of reducing toxic chemicals and heavy metal concentrations from the soil, sediments and water is through phytoremediation.

Background, Aims and Scope

- Phytoremediation is an alternative method that uses plants to clean up contaminated area.
- Phytoremediation is an environment friendly and cost effective technology to lessen the levels of heavy metals and other pollutants in the environment which can give harm to the people.

Background, Aims and Scope

- Plants play an important role in filtering ambient air by adsorbing pollutants such as particulate matter onto leaf surfaces (Dzierzanowski et al., 2011).
- Plants are known to scavenge significant amounts of pollutants on their roots and aboveground plants parts.
- The plants can metabolize, sequestrate and /or excrete pollutants.
- Plants are unique organisms equipped with remarkable metabolic and absorption capabilities, as well as transport systems that can take up nutrients or contaminants selectively from the growth matrix, soil or water.

Background, Aims and Scope

Objectives

- To determine potential tropical plants to remove and lessen contamination of heavy metals such as lead, copper, cadmium, nickel and zinc as well as ethidium bromide and acrylamide from soil .
- To assess the potential of aquatic plants as phytoremediators of heavy metals such as lead, chromium and copper.

Methodology

Phytoremediation Potential of Tropical Plants

Diversity Assessment/ Survey Method

- Mining Site
- Freshwater Ecosystem
- Mangrove Ecosystem
- Seagrass Ecosystem
- Urban Areas

Sampling and Collection

- Quadrat Method
- Line Transect Method

Heavy Metal Analysis

- Soil
- Sediments
- Water
- Test Plants

Methodology

Phytoremediation Potential of Tropical Plants

Experimental Method

- CLSU
- PHILRICE

Growth of test plants in individual plastic bags:

- Pb and Other Heavy Metals
- EtBr
- Acrylamide for 30, 45 and 60 days

Analysis of:

- Pb and Other Heavy Metals
- EtBr
- Acrylamide before and after experimental treatments for soil and test plants

Phytoremediation Potential of Tropical Plants To Remove Heavy Metals, Mutagenic Agents and Toxic Chemicals In Soil For Soil Conservation

RESULTS

Phytoextraction of Lead-Contaminated Soil Using Vetivergrass (*Vetiveria zizanioides L.*), Cogongrass (*Imperata cylindrica L.*) and Carabaograss (*Paspalum conjugatum L.*)

- **Vetivergrass obtained the highest rate of Pb absorption.**

Vetivergrass

Plant survival (%) and levels of Pb absorbed by whole plants (roots+shoot) of vetivergrass, cogongrass and carabaograss at planting and at harvest

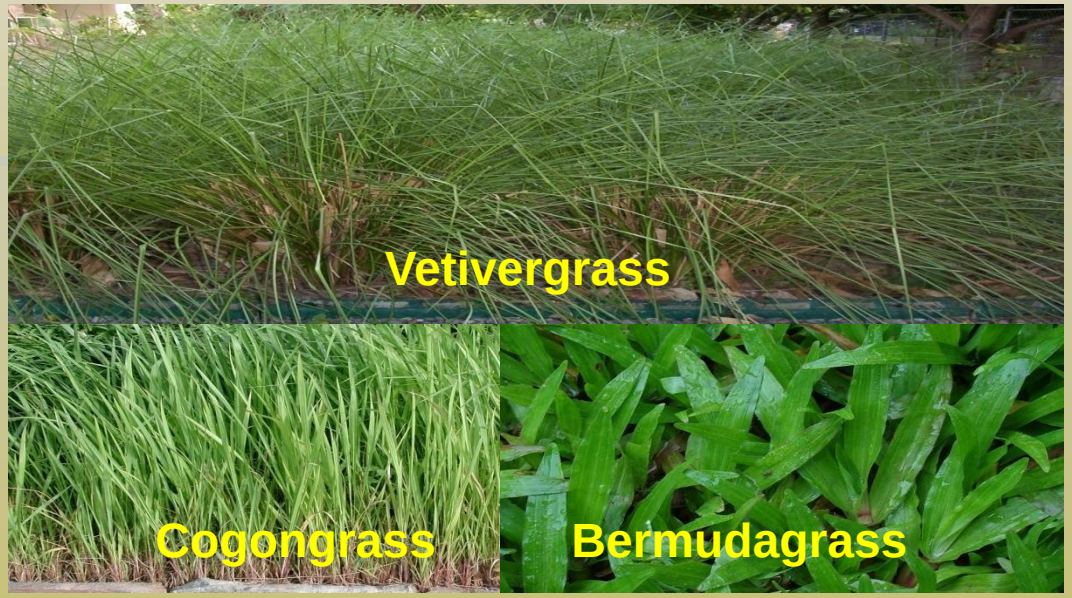
Grass Types	Plant Survival	Initial level of Pb at planting (mg ha $^{-1}$)	Levels of Pb adsorbed (mg kg $^{-1}$)
Vetivergrass	97.50±4.20^{a§}	0.91	10.16±2.81^{a}
Cogongrass	52.50±18.1^{b}	0.55	2.34±0.52^{b}
Carabaograss	87.50±11.7^{a}	0.01	0.49±0.56^{c}
$LSD_{0.05}$	17.2		1.8

§ Means in respective column with the same letter(s) are not significantly different at 5% level of significance
a significant at p 0.0001
b significant at p 0.001
c not significant

RESULTS

Phytoextraction of Lead-Contaminated Soil Using Vetivergrass (*Vetiveria zizanioides L.*), Cogongrass (*Imperata cylindrica L.*) and Carabaograss (*Paspalum conjugatum L.*)

- **Vetivergrass obtained the highest Pb uptake (31.74 ± 9.01) compared with cogon grass (2.33 ± 0.53) and carabaograss (0.27 ± 0.03)**



RESULTS

Phytoextraction of Lead-Contaminated Soil Using Vetivergrass (*Vetiveria zizanioides L.*), Cogongrass (*Imperata cylindrica L.*) and Carabaograss (*Paspalum conjugatum L.*)

- **Vetivergrass had the significantly higher amount of Pb absorbed due to:**
  - ✓**Heavier biomass**
  - ✓**Highly extensive roots system**

Vetivergrass roots

RESULTS

Phytoextraction of Lead-Contaminated Soil Using Vetivergrass (*Vetiveria zizanioides L.*), Cogongrass (*Imperata cylindrica L.*) and Carabaograss (*Paspalum conjugatum L.*)

- **Higher biomass of vetivergrass means a greater amount of Pb absorbed by the plant and greater Pb uptake.**
- **Highly extensive root system denotes more contact to nutrients in soil hence, more likelihood of nutrients absorption and Pb uptake.**
- **Combination of high metal accumulation and high biomass production results in the most metal removal from the soil.**

Alberto, A.M.P., G.C. Sigua, B.G. Baui and J. A. Prudente. 2007. Phytoextraction of Lead-Contaminated Soil Using Vetiver grass (*Vetiveria zizanoides* L.) , Cogon grass (*Imperata cylindrica* L.) and Carabao grass (*Paspalum conjugatum* L.). Environmental Science Pollution Research 14(7): 498-504 and in http://dx.doi.org/10.1065/espr2007.05.415 (On Line Publication)

RESULTS

Survey of Potential Phytoremediation Species in Mine Tailings in Mankayan, Benguet Province, Philippines

- **The following plants were found to absorb high amount of copper:**
  - ***Amaranthus spinosus*** **(20.5 ppm)**
  - ***Eleucine indica*** **(16.25 ppm)**
  - ***Portulaca oleracea*** **(14.875 ppm)**

Portulaca oleracea

Eleucine indica

Amaranthus spinosus

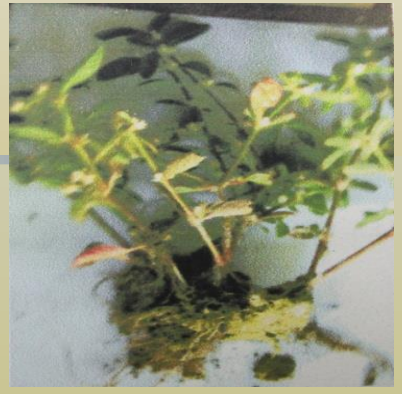
RESULTS

Survey of Potential Phytoremediation Species in Mine Tailings in Mankayan, Benguet Province, Philippines

- **The following plants were found to absorb high amount of lead**
  - ***Amaranthus spinosus*** **(31.71 ppm)**
  - ***Achyrantes aspera*** **(8.35 ppm)**
  - ***Portulaca oleracea*** **(26.60 ppm)**
  - ***Alternanthera sessilis*** **(17.41 ppm)**

Achyrantes aspera

Portulaca oleracea



Alternanthera sessilis

Amaranthus spinosus

RESULTS

Survey of Potential Phytoremediation Species in Mine Tailings in Mankayan, Benguet Province, Philippines

- **The following plants were found to absorb high amount of zinc:**

➢ ***Eleucine indica*** *(178.13 ppm)*

Eleucine indica

➢ ***Amaranthus spinosus*** *(168.16 ppm)*

Amaranthus spinosus

RESULTS

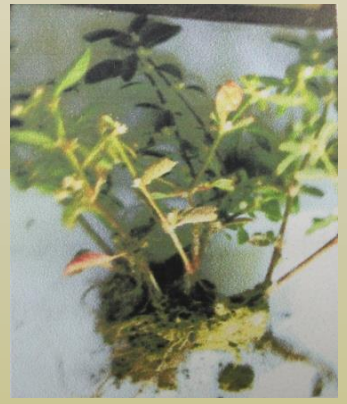
Survey of Potential Phytoremediation Species in Mine Tailings in Mankayan, Benguet Province, Philippines

- **The following plants were found to absorb high amount of cadmium:**

- ***Crassocephalum crepidioides*** **(4.0 ppm)**
- ***Portulaca oleracea*** **(3.125 ppm)**
- ***Alternanthera sessilis*** **(1.5 ppm)**
- ***Cyperus alternifolius*** **(1.375 ppm)**

Crassocephalum crepidioides

Portulaca oleracea



Alternanthera sessilis

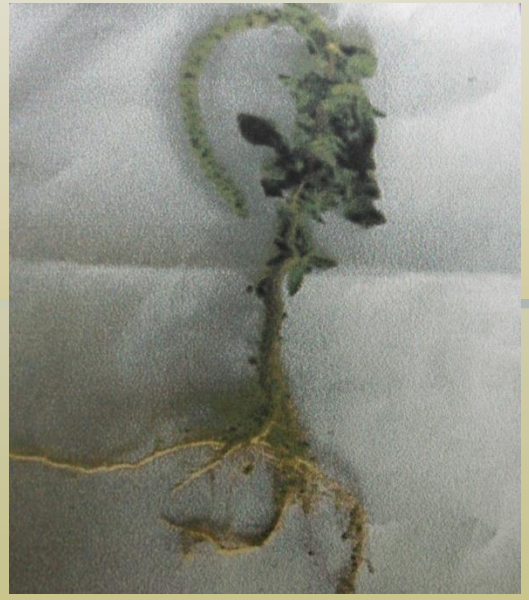
Cyperus alternifolius

RESULTS

Survey of Potential Phytoremediation Species in Mine Tailings in Mankayan, Benguet Province, Philippines

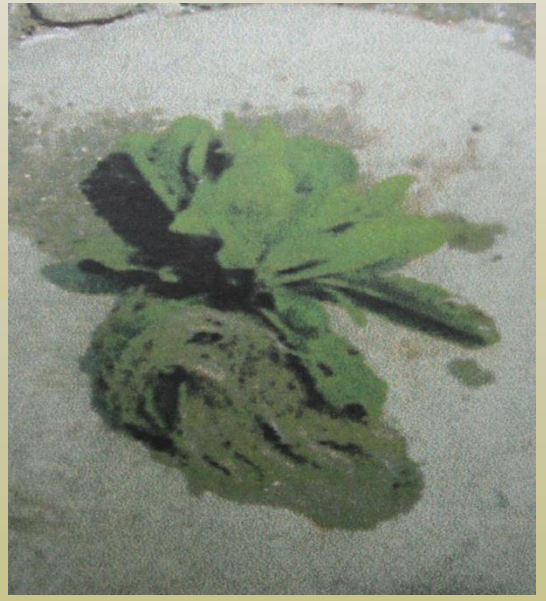
- **The following plants were found to absorb high amount of nickel:**

➢ ***Amaranthus spinosus*** **(5.88ppm)**



Amaranthus spinosus

➢ ***Blumea*** **sp. (2.50 ppm)**



Blumea sp.

RESULTS

Survey of Potential Phytoremediation Species in Mine Tailings in Mankayan, Benguet Province, Philippines

- **Plant species in the mine tailings were found to be selective in terms of metal relations and the absorptive mechanism of the plants in certain specific metals.**
- **Phytoremediation depends on its ability to accumulate heavy metals from the soils in mine tailings and tolerance mechanism works on the different species of plants.**

Paz-Alberto, A.M.P. and Gilbert C. Sigua. 2013. Phytoremediation: A Green Technology to Remove Environmental Pollutants. American Journal of Climate Change http://dx.doi.org/10.4236/ajcc.2013.21008 or www.scirp.org/journal/PaperInformation.aspx?paperID=29110 (On Line Publication)

RESULTS

Phytoremediation Potential Of Selected Plants On Lead In Nueva Ecija

- **The plants identified in the heavy traffic areas in Cabanatuan City which can absorb lead are the Balite (*Ficus bengalensis*) with 2.822 ppm and Espada (*Sanseviera trifasciata) with* 2.352 ppm.**

Balite

Espada

RESULTS

Phytoremediation Potential Of Selected Plants On Lead In Nueva Ecija

- **In the heavy traffic areas of San Jose City, the common plants that absorbed lead are the Bougainvillea (*Bougainvillea* sp.) with 1.521 ppm and the Cherry Pink plant with 4.803 ppm .**

Bougainvillea

Cherry Pink Plant

RESULTS

Phytoremediation Potential Of Selected Plants On Lead In Nueva Ecija

- **The Indian tree (*Polyalthia longifolia*) with 0.217 ppm and the Bougainvillea (*Bougainvillea* sp.) with 0.528 ppm are the common plants found along the traffic islands of the Science City of Muñoz that could absorb lead.**

Bougainvillea

Indian Tree

RESULTS

Phytoremediation Potentials of Selected Tropical Plants for Ethidium Bromide

- **Mustard registered the highest absorption of EtBr with 0.0014 ppm.**
- **Mustard is the best phytoremediator of EtBr in soil.**

Mustard plants

RESULTS

Phytoremediation Potentials of Selected Tropical Plants for Ethidium Bromide

- **Tomato and vetivergrass can also serve as phytoremediators of ethidium bromide.**

Tomato plants

Vetivergrass

RESULTS

Phytoremediation Potentials of Selected Tropical Plants for Ethidium Bromide

- **Results showed that ethidium bromide content of soil planted to mustard was reduced by 10.66%.**
- **Soils had a reduction of 8.12% and 5.58% in soils planted to tomato and vetivergrass, respectively.**
- **Mustard, tomato, and vetivergrass have shown their ability to absorb EtBr in contaminated soil.**

Uera R. B., Paz-Alberto, A. M. and Sigua G. C. 2007. Phytoremediation potentials of selected tropical plants for ethidium bromide. Environmental Science Pollution Research 14 (7): 505-509. http://dx.doi.org/10.1065/espr2007.02.391 (On Line Publication)

RESULTS

Assessing phytoremediation potentials of selected tropical plants for acrylamide

- **Mustard and pechay were the most effective plants for they absorbed the highest acrylamide concentration in their roots, shoots and the whole plants.**
- **These two plants are considered as hyperaccumulators of acrylamide.**

Mustard plants

Pechay plants

Average (± Std. Deviation) acrylamide absorption in the roots, shoots and whole plants of the test plants.

Test Plants	Roots [mg kg^{-1}]	Shoots [mg kg^{-1}]	Whole Plants [mg kg^{-1}]
Mustard *(Brassica juncea* L.*)*	**2,431.7±98.96a†**	**4,081.1±84.63a**	**6,512.8a**
Pechay *(Brassica chinensis* L.*)*	**1,195.2±10.61b**	**2,287.5±87.64b**	**3,482.7b**
Hogweed *(Portulaca oleracea* L.*)*	**529.6±75.48c**	**1,275.6±44.86d**	**1,805.2c**
Vetiver *(Vetiveria zizaniodes* L.*)*	**1,113.1±186.02b**	**272.4±9.43e**	**1,385.5d**
Fern *(Nephrolepsis cordifolia* L.*)*	**282.9±48.22d**	**1,741.4±70.66c**	**2,024.3c**
Snake plant (*Sanseviera trifasciata* Prain*)*	**427.2±172.48c**	**460.3±178.19e**	**887.5e**

†Means in column followed by common letter(s) are not significantly different from each other at p≤0.05.

Paz-Alberto, A.M.P., MJJ De Dios, RT Alberto and GC Sigua. 2011. Assessing phytoremediation potentials of selected tropical plants for acrylamide. Journal of Soils and Sediments Vol.11 Number 7, 1190-1198. http://dx.doi.org/10.1007/s11368-011-0390-z (On Line Publication)

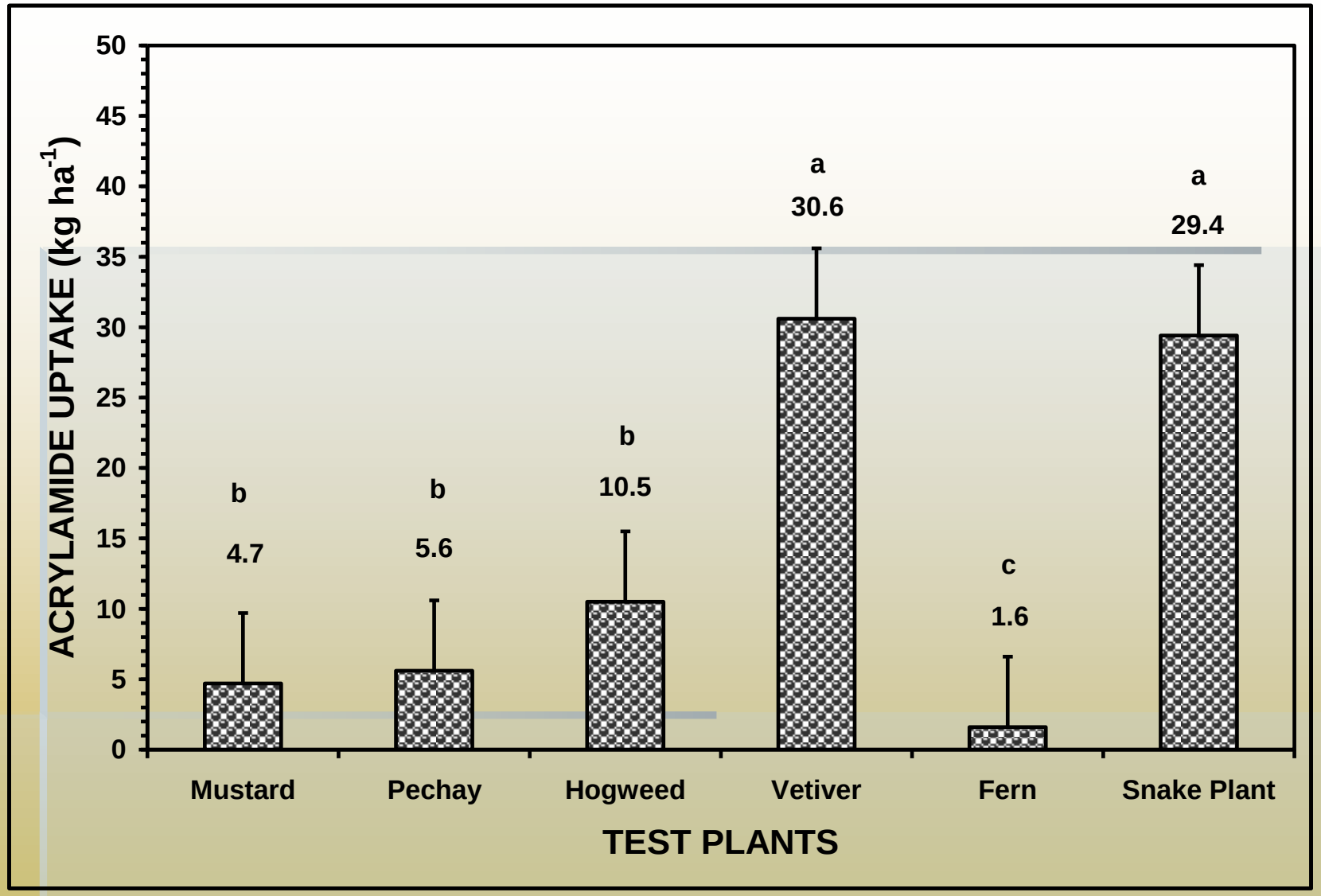
RESULTS

Assessing phytoremediation potentials of selected tropical plants for acrylamide

- **Vetivergrass and snake plant obtained the highest uptake of acrylamide although these plants did not absorb the highest acrylamide concentration.**
- **These two plants can be considered as the best phytoremediator of acrylamide because they are perennial plants with heavier biomass, long, dense and extended root system.**

Vetivergrass

Snake plants



Comparative amount of acrylamide uptake among the different tropical plants. Acrylamide uptakes among the different tropical plants are significantly different ($p \leq 0.05$) when superscripts located at top of bars are different.

RESULTS

Assessing phytoremediation potentials of selected tropical plants for acrylamide

- All the test plants are potential phytoremediators of acrylamide.

Mustard, Hogweeds, Snake plants, Vetiver grass, Common Sword Ferns and Pechay

Phytoremediation Potential of Aquatic Plants To Remove Heavy Metals In Water and Sediments For Water Conservation

RESULTS

Assessment and Phytoremediation of Pollutants in the Panlasian Creek, San Jose City, Nueva Ecija

RESULTS

Assessment and Phytoremediation of Pollutants in the Panlasian Creek, San Jose City, Nueva Ecija

- ***Ipomea aquatica*** **(Kangkong) and** ***Ottelia alismoides*** **(Hydrocharitaceae) are efficient in phytoremediating lead.**

Ipomea aquatica

Ottelia alismoides

Paz-Alberto, A.M.P. and Gilbert C. Sigua. 2013.Phytoremediation: A Green Technology to Remove Environmental Pollutants. American Journal of Climate Change http://dx.doi.org/10.4236/ajcc.2013.21008 or www.scirp.org/journal/PaperInformation.aspx?paperID=29110 (On Line Publication)

RESULTS

Phytoremediation of Pb in the Sediment of a Mangrove Ecosystem

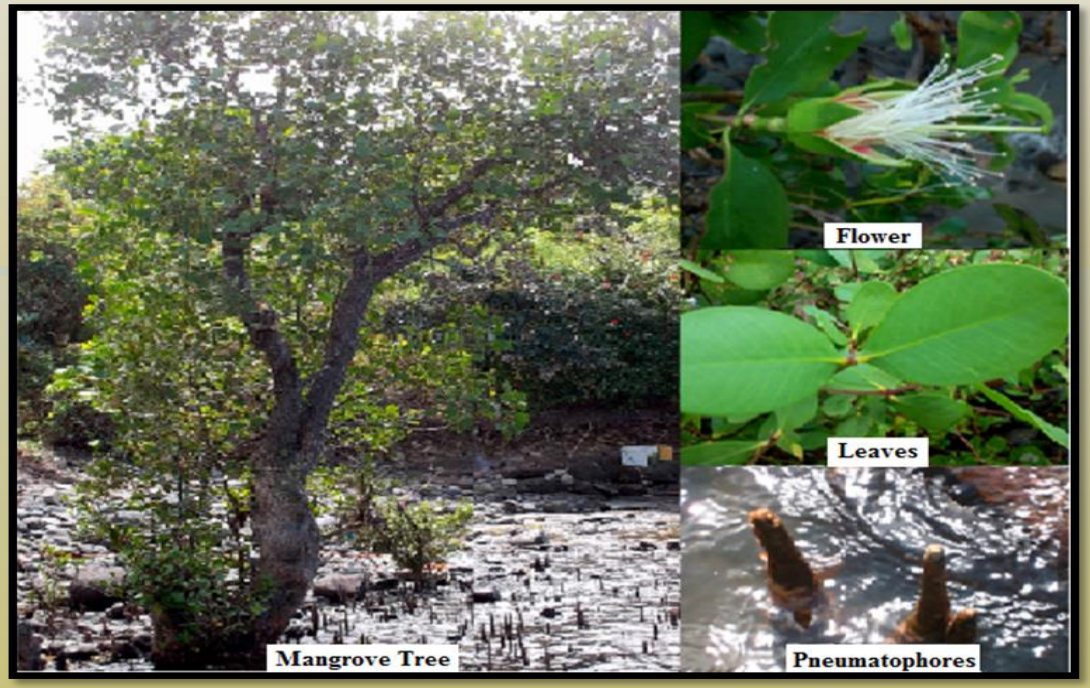
Sitio Oyon, Brgy. Baloganon, Masinloc, Zambales

Sitio Asinan, Brgy. Baloganon, Masinloc, Zambales

RESULTS

Phytoremediation of Pb in the Sediment of a Mangrove Ecosystem

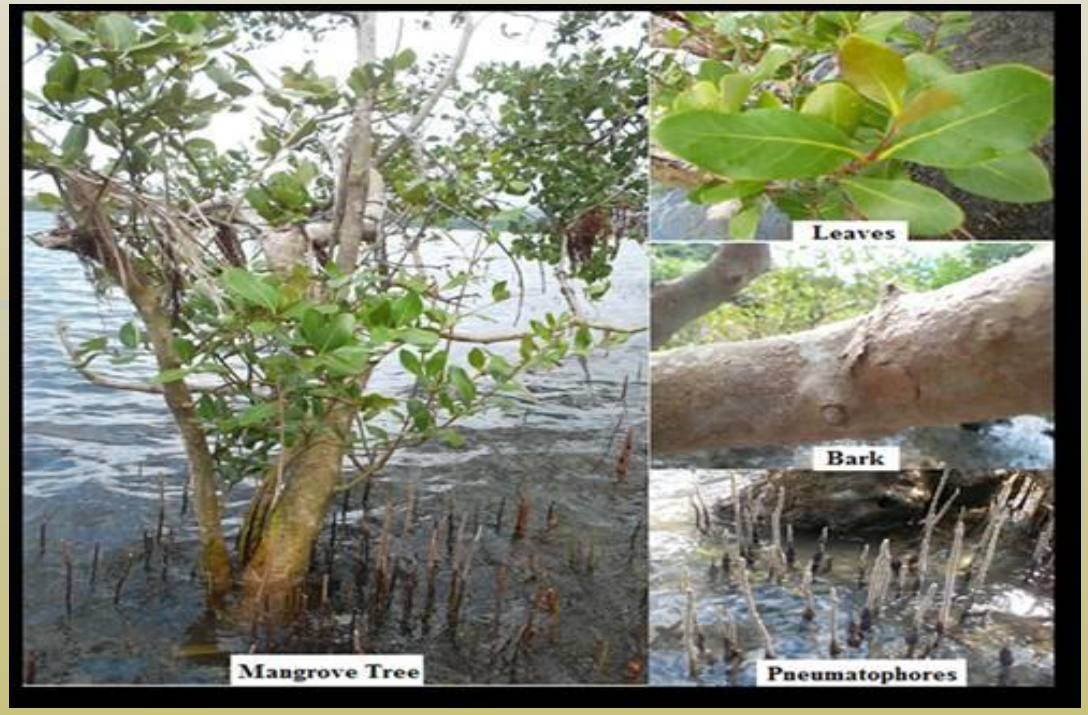
- **The pneumatophores of *Sonneratia alba* achieved the highest lead absorption of 98.5 ppm.**



RESULTS

Phytoremediation of Pb in the Sediment of a Mangrove Ecosystem

- ***Avicennia marina*** **leaves had lead content of 63 ppm .**



RESULTS

Phytoremediation of Pb in the Sediment of a Mangrove Ecosystem

- ***Rhizophora stylosa*** **leaves obtained 20.5 ppm lead content.**

RESULTS

Phytoremediation of Pb In The Sediment Of A Mangrove Ecosystem

- The three mangrove species present in the coastal ecosystem near the electric power plant— *A. marina*, *R. stylosa*, and *S. alba* — are potential phytoremediators of sediment Pb.

Sonneratia alba

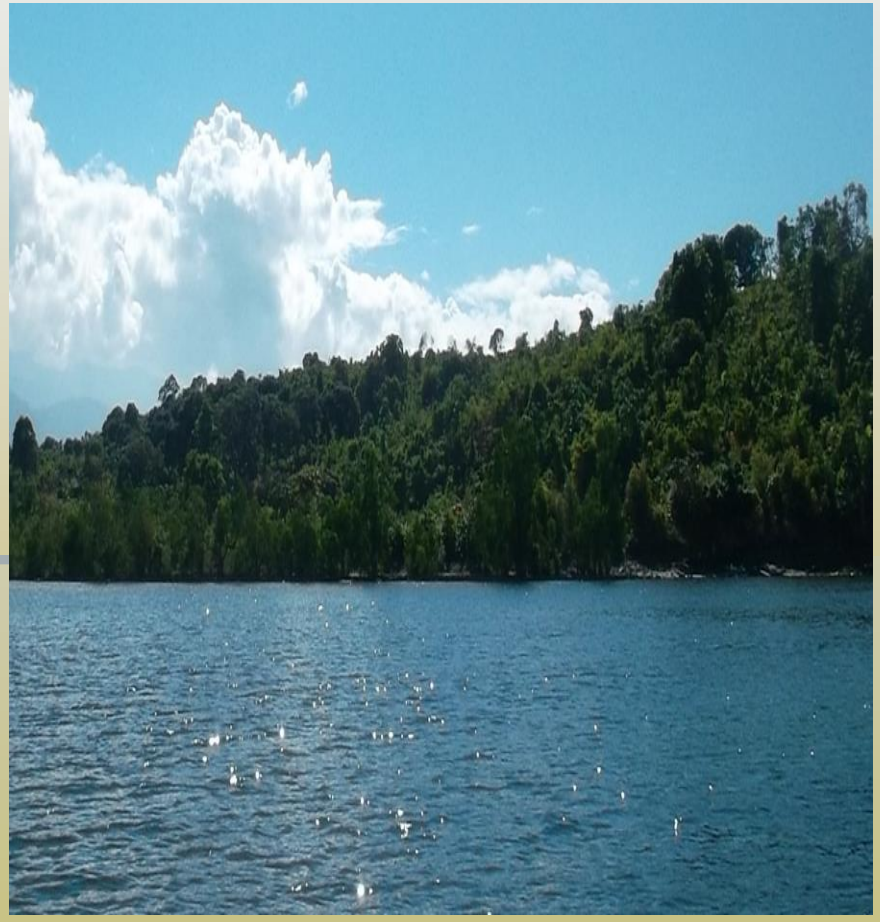
Avicennia marina

Rhizophora stylosa

RESULTS

Phytoremediation of Pb In The Sediment Of A Mangrove Ecosystem

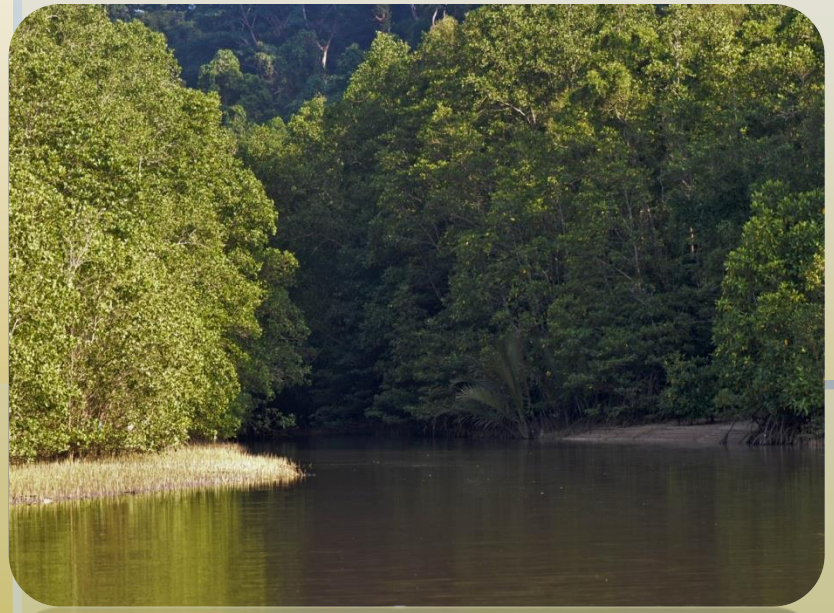
- Mangroves possess beneficial characteristics that remove Pb from contaminated sediments in areas directly affected by coal-fired power plants, and thus have potential phytoremediation properties.



Paz-Alberto, A.M., A. B. Celestino and G. C. Sigua. 2013. Phytoremediation of Pb in the Sediment of a Mangrove Ecosystem. Journal of Soils and Sediments. http://dx.doi.org/10.1007/s11368-013-0752-9 (On Line Publication)

RESULTS

Diversity and Phytoremediation Potential Of Mangrove On Copper In Subic Bay, Zambales



RESULTS

Diversity and Phytoremediation Potential Of Mangrove On Copper In Subic Bay, Zambales

- No copper was present in the water samples in Subic Bay, Zambales.
- Sediment samples contained large amount of copper with 81.6 ppm.

RESULTS

Diversity and Phytoremediation Potential Of Mangrove On Copper In Subic Bay, Zambales

- ***Sonneratia alba*** **and** ***Barringtonia racemosa*** **accumulated copper in their roots with 2.8 ppm and 2.7 ppm, respectively.**

Barringtonia racemsa (Linn.) Sprengelo

Sonneratia alba J. Smith

Paz-Alberto, A.M.P., J.L. D. Vizmonte and G. C. Sigua. 2015. Assessing Diversity and Phytoremediation Potential of Mangroves For Copper Contaminated Sediments in Subic Bay, Philippines. International Journal of Plant, Animal and Environmental Sciences. Volume 5:50-59. www.ijpaes.com

RESULTS

Diversity and Phytoremediation Potential Of Mangrove On Copper In Subic Bay, Zambales

Mangrove Species	Copper Absorption (ppm)
Sonneratia alba	73.6[a]
***Bruguiera* sp.**	13.4[b]
Barringtonia racemosa	7.3[c]
Rhizophora apiculata	2.8[d]
Calophyllum inophyllum	0[e]

Sonneratia alba

Rhizophora apiculata

Bruguiera sp.

Barringtonia racemosa

RESULTS

Seagrass Ecosystems' Biodiversity In Selected Municipalities In Zambales, Philippines: Status, Impact and Phytoremediation Potential

Oyon Bay, Baloganon, Masinloc

Potipot Island, Uacon, Candelaria

RESULTS

Seagrass Ecosystems' Biodiversity In Selected Municipalities In Zambales, Philippines: Status, Impact and Phytoremediation Potential

- **Lead and chromium were not present in the water of the seagrass ecosystems in Candelaria and Masinloc, Zambales**

Paz-Alberto, A.M.P., M.P. Hechanova and G. C. Sigua. 2015. Assessing Diversity and Phytoremediation Potential of Seagrass in Tropical Region. International Journal of Plant, Animal and Environmental Sciences. Volume 5:24-35. www.ijpaes.com

RESULTS

Seagrass Ecosystems' Biodiversity In Selected Municipalities In Zambales, Philippines: Status, Impact and Phytoremediation Potential

- **Chromium was present in the sediments of seagrass ecosystems of Potipot Island, Candelaria (15mg/kg) and Oyon Bay, Masinloc (10.3mg/kg) in Zambales.**
- **Lead (119mg/kg) was present only in the sediment of Masinloc, Zambales which had a muddy substrate.**
- **Chromium can be accumulated in either sandy or muddy substrate while lead can only be accumulated in a muddy fine grain substrate.**

RESULTS

Seagrass Ecosystems' Biodiversity In Selected Municipalities In Zambales, Philippines: Status, Impact and Phytoremediation Potential

Site/ Heavy metals	Seagrasses/ Heavy metals		
	C. rotundata (mg/kg)	*T. hemprichii* (mg/kg)	*S. isoetifolium* (mg/kg)
Candelaria			
a. Chromium (total)	0	0	0
b. Lead	112*	57*	0
Masinloc			
a. Chromium (total)	0	0	0
b. Lead	83*	0	0

*Average of two readings

RESULTS

Seagrass Ecosystems' Biodiversity In Selected Municipalities In Zambales, Philippines: Status, Impact and Phytoremediation Potential

- ***Cymodocea rotundata*** **is a good phytoremediator for lead because it has the ability to accumulate higher amount of lead in both study sites due to its fast rhizome elongation rate of 210 cm per year.**

Cymodocea rotundata

RESULTS

Seagrass Ecosystems' Biodiversity In Selected Municipalities In Zambales, Philippines: Status, Impact and Phytoremediation Potential

- *Thalasia hemprichii* only absorbed lead in Candelaria seagrass ecosystem due its sandy coralline substrate.
- The coarser grain sediment had a lesser capacity to withhold heavy metal than fine grain sediment.
- Lead was readily available in the sandy coralline substrate for easy uptake by the seagrasses.

Thalasia hemprichii

PHYTOREMEDIATION POTENTIAL OF TROPICAL PLANTS FOR HEAVY METAL ABSORPTION IN OPEN DUMPSITES

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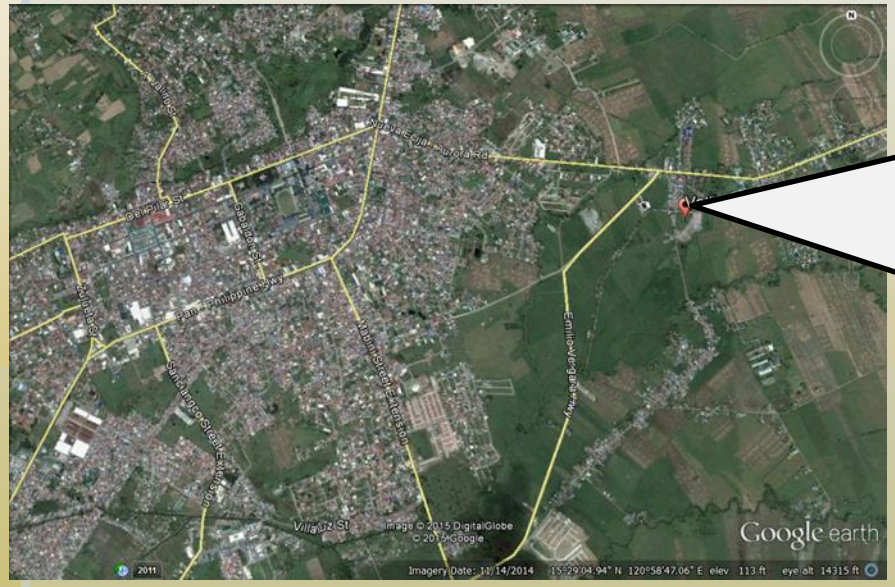
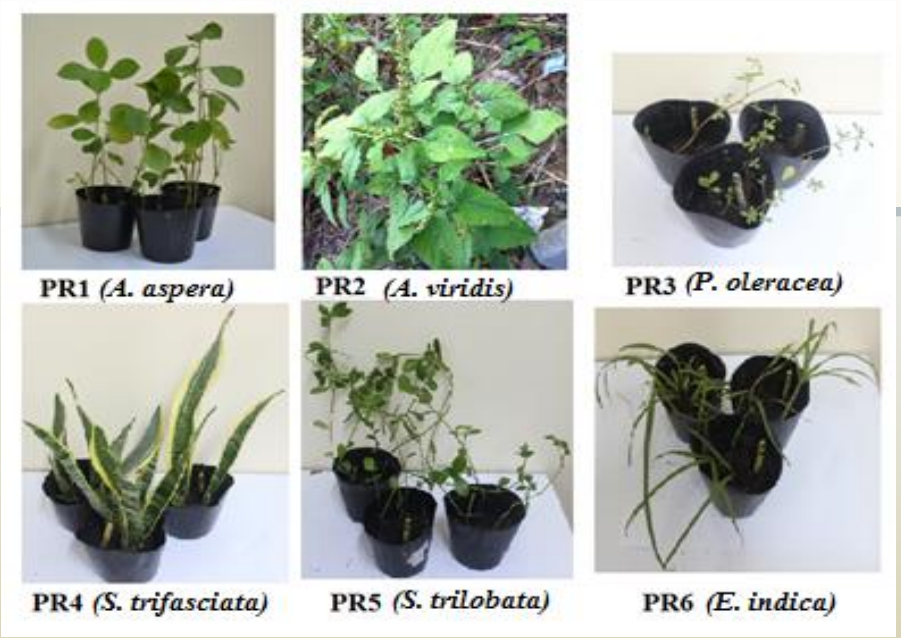
Central Luzon State University

Location of Open Dumpsite



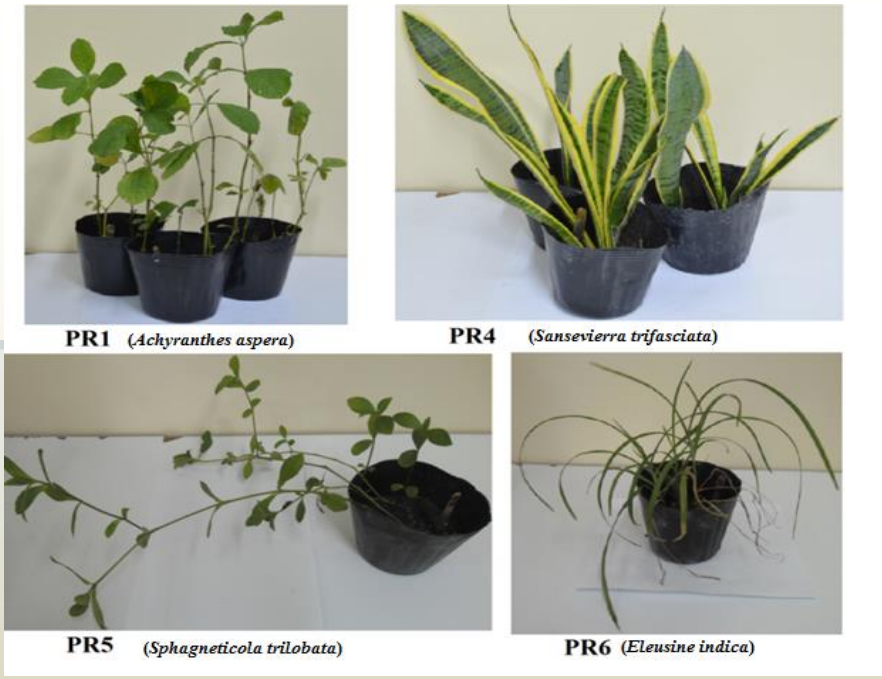
Brgy. Valle Cruz, Cabanatuan, Nueva Ecija

Screening of Potential Phytoremediators



Set up of different potential phytoremediators under greenhouse

Different Potential Phytoremediators



Pot experiment for the determination of the accumulation heavy metals in different plant parts of potential phytoremediators

RESULTS

Concentration of Heavy Metals and its Safe Level in Soil of the Open Dumpsite in Cabanatuan, Nueva Ecija

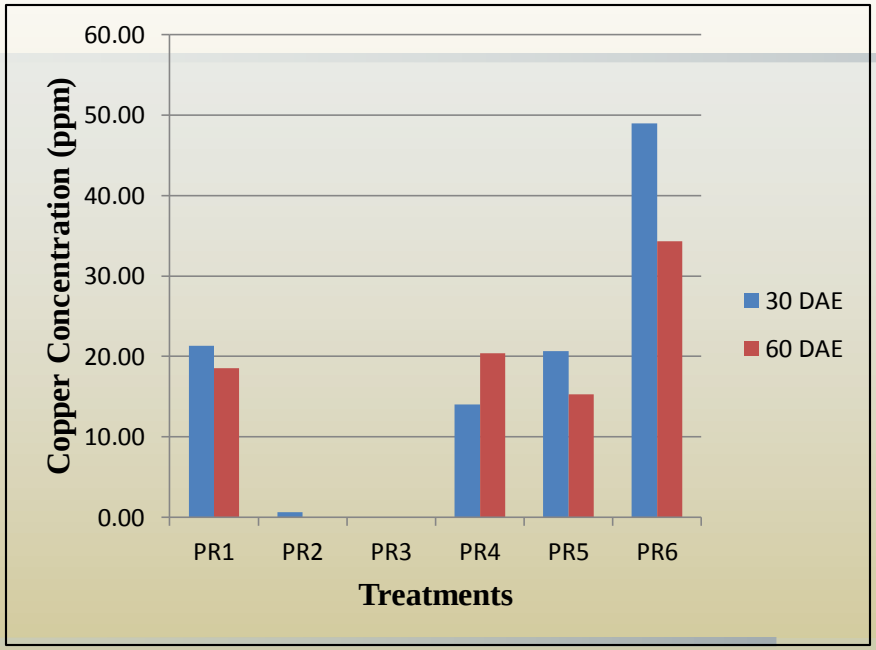
HEAVY METALS	METAL CONCENTRATION (ppm)	SAFE LEVEL (ppm)
Cadmium (Cd)	10	0.01 – 2.0[c]
Chromium (Cr)	43	14 – 70[a]
Copper (Cu)	650	2 – 250[c]
Iron (Fe)	36,600	100 – 5,000[d]
Lead Pb)	1,460	2 – 300[c]
Nickel (Ni)	62	4 – 80[b]
Zinc (Zn)	2,130	5 – 770[e]

a – WHO Europe (2000), b – ASTRD (2005), c – Gardea-Torresdey, et.al., (2005) d – EcoSSL (2003)
e – Zhao, et. al., (2012)

- Soil from the open dumpsite was heavily contaminated with different heavy metals such as **Cadmium, Copper**, **Iron, Lead and Zinc.**
- Presence of **Chromium and Nickel** were also found, though, their concentrations in soil were in the safe level.

RESULTS

Heavy Metal Concentration in the Different Tropical Plants

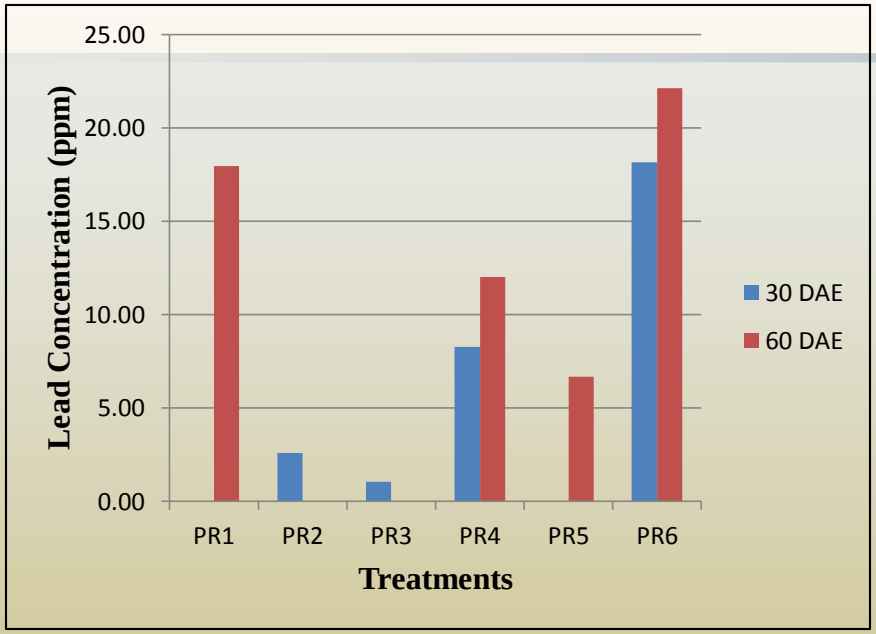


PR1 – *Achyranthes aspera*
PR2 – *Amaranthus viridis*
PR3 – *Portulaca oleracea*
PR4 – *Sansevierra trifasciata*
PR5 – *Sphagneticola trilobata*
PR6 – *Eleusine indica*

- PR1 (21.33 ppm at 30 DAE), PR4 (20.41 ppm at 60 DAE), PR5 (20.67 ppm at 30 DAE) and PR6 (48.93 & 34.40 ppm at 30 & 60 DAE) absorbed **Copper** above the normal range in plants (2-20 ppm).

RESULTS

Heavy Metal Concentration in the Different Tropical Plants

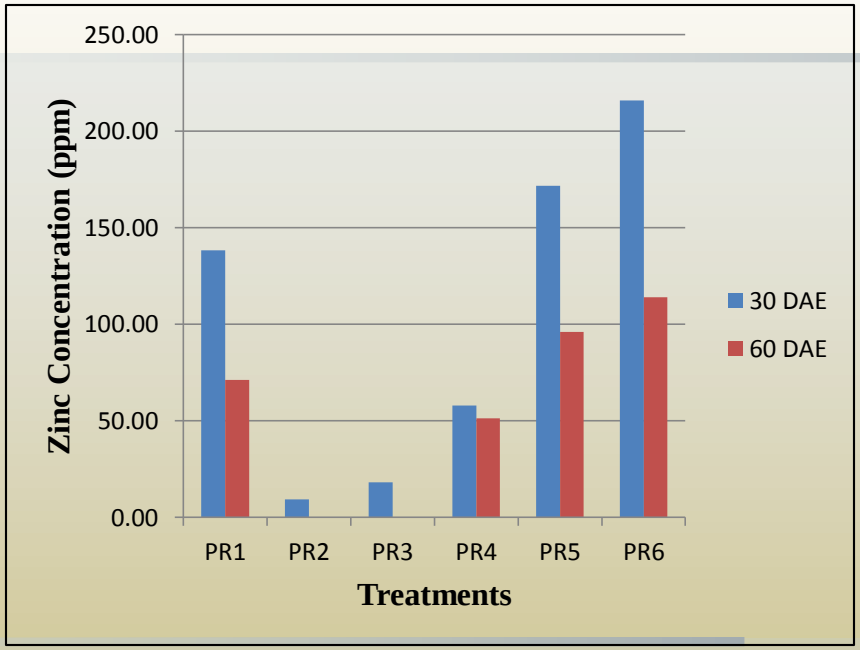


PR1 – *Achyranthes aspera*
PR2 – *Amaranthus viridis*
PR3 – *Portulaca oleracea*
PR4 – *Sansevierra trifasciata*
PR5 – *Sphagneticola trilobata*
PR6 – *Eleusine indica*

- PR1 (17.97 ppm at 60 DAE), PR4 (8.27 & 12.03 ppm at 30 & 60 DAE), PR5 (6.67 ppm at 60 DAE) and PR6 (18.17 & 22.14 ppm at 30 & 60 DAE) accumulated **Lead** above the normal range in plants (0.1-5 ppm).

RESULTS

Heavy Metal Concentration in Different Tropical Plants



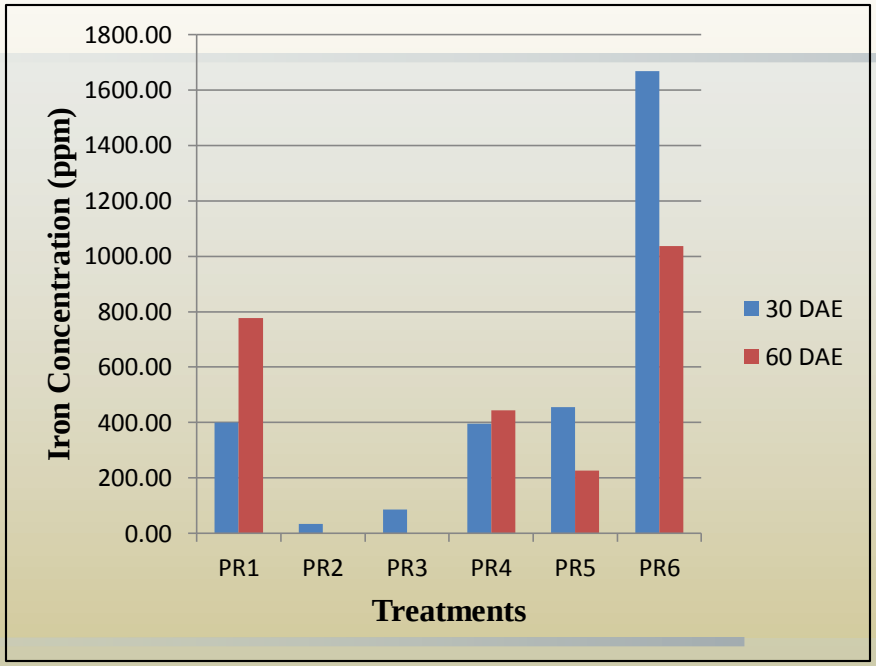
*

PR1 – *Achyranthes aspera*
PR2 – *Amaranthus viridis*
PR3 – *Portulaca oleracea*
PR4 – *Sansevierra trifasciata*
PR5 – *Sphagneticola trilobata*
PR6 – *Eleusine indica*

- PR5 and PR6 were able to accumulate **Zinc** with 171.65 ppm & 215.79 ppm, respectively which are above the normal range in plants (15-150 ppm).

RESULTS

Heavy Metal Concentration in the Different Tropical Plants

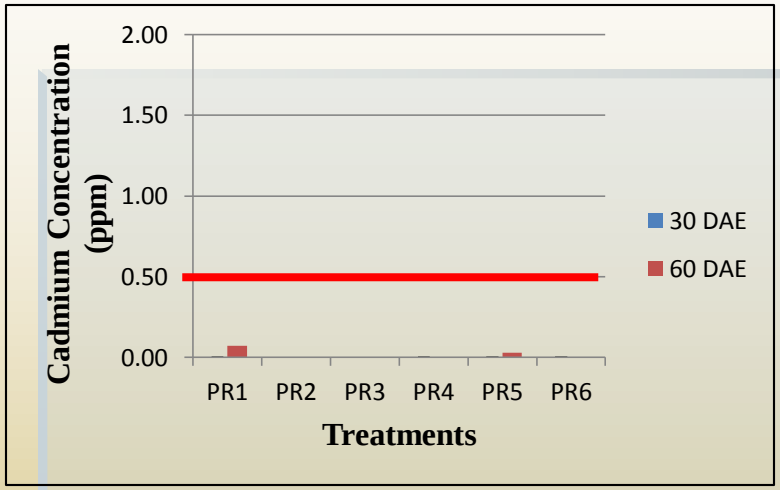


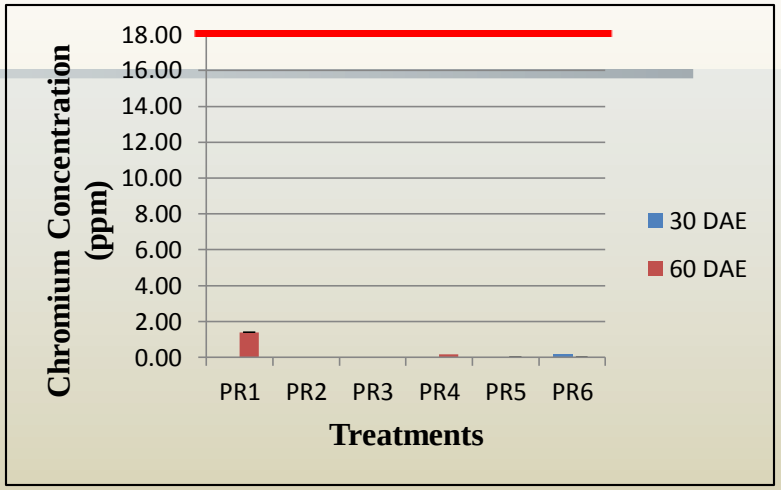
PR1 – *Achyranthes aspera*
PR2 – *Amaranthus viridis*
PR3 – *Portulaca oleracea*
PR4 – *Sansevierra trifasciata*
PR5 – *Sphagneticola trilobata*
PR6 – *Eleusine indica*

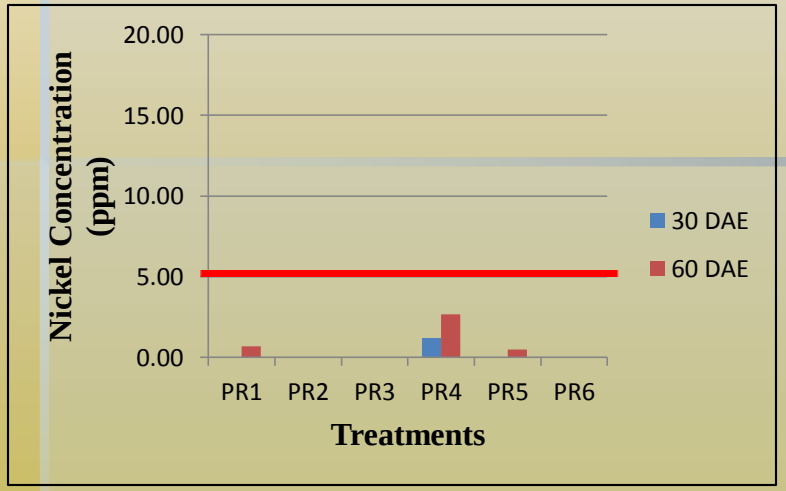
- Only PR6 was able to absorb **Iron** with 1667 & 1036 ppm at 30 & 60 DAE which are above the normal range in plants (18-1000 ppm).

RESULTS

Heavy Metal Concentration in Tropical Plants





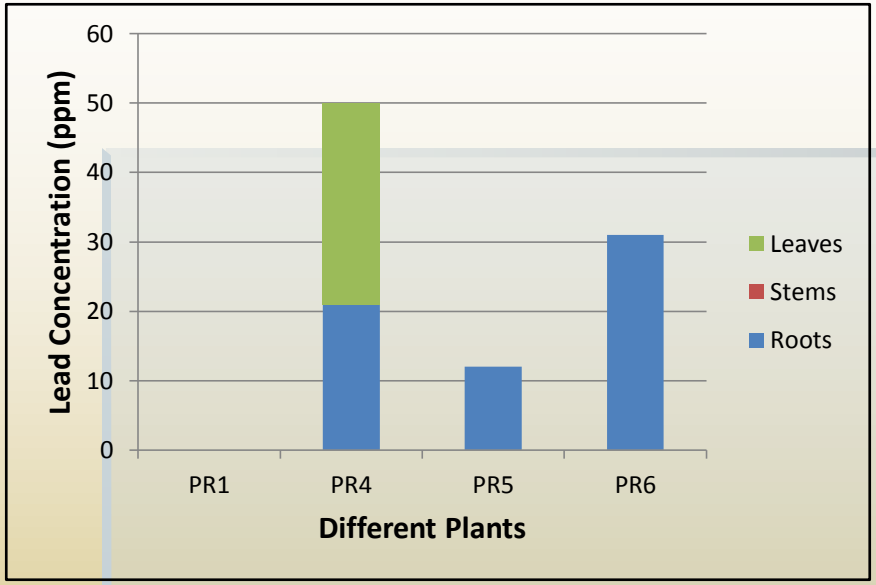


- **All plants absorbed Cadmium, Chromium and Nickel within the normal range.**

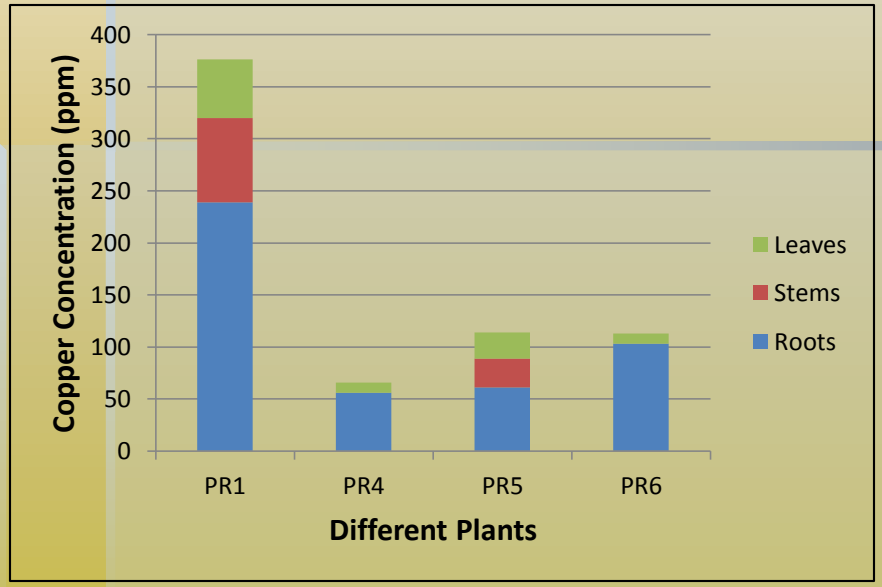
***Above red line means above the normal range**

RESULTS

Heavy Metal Concentration in Different Plant Parts

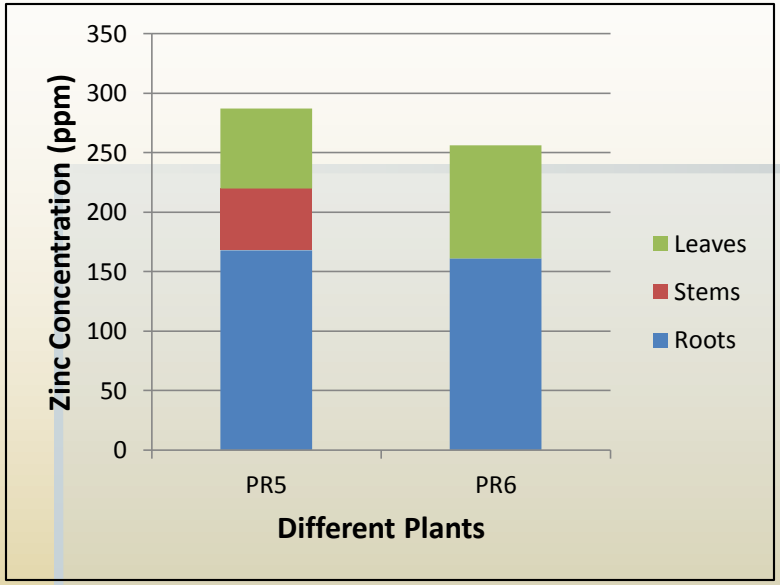


- **PR4, PR5 and PR6 were able to absorb lead with 21 ppm, 12 ppm & 31 ppm, respectively in their roots**
- **PR4 accumulated 29 ppm lead in the leaves.**

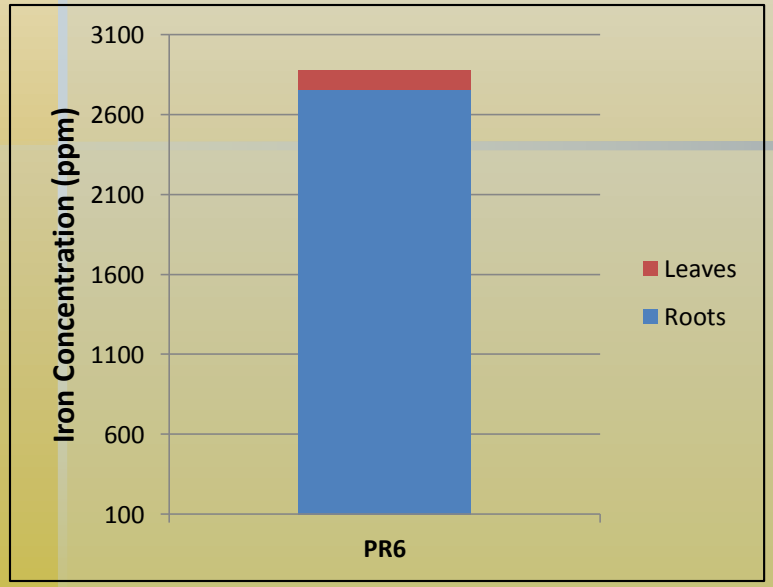


- **All plants accumulated copper mostly in the roots and were able to transport the metal into the aboveground parts.**

Heavy Metal Concentration in Different Plant Parts



- PR5 was able to uptake zinc with 168 ppm, 52 ppm & 67 ppm in the roots, stems and leaves, respectively.
- PR6 absorbed zinc with 161 ppm in the roots and 95 ppm in the leaves



- PR6 accumulated iron with 2750 ppm & 126 ppm in the roots and leaves, respectively.

RESULTS

- **Heavy metal concentration generally decreased from roots to stems and leaves for all the plants tested with the exception of PR5 (*S. trilobata*) for zinc at the order of root>leaves>stem and PR4 (*S. trifasciata*) which obtained higher lead concentration in leaves than in roots.**
- **PR4 can phytoextract/absorb lead in its roots and can transport lead in its leaves with high concentration while PR5 and PR6 can phytostabilize lead due to accumulation of lead in their roots but restrict translocation of lead to the shoot parts.**

Characteristics of Potential Phytoremediators

- **PR1 – *Achyranthes aspera***
  - **Long tap root system that have different zones of active growth**
  - **Found to be thriving in harsh condition such as wasteland areas**
- **PR4 – *Sansivierra trifasciata***
  - **Fibrous root system that have fine and continuous root mass**
  - **Fleshy leaves that function for storage of water and may as well as non essential substances such as heavy metals**
  - **Can live in waste areas**
- **PR5 – *Sphagneticola trilobata***
  - **Tap root system and capable of producing adventitious roots on stem nodes that increases the surface for absorption**
  - **Contains high proportion of parenchyma which heavy metal mostly bind**
- **PR6 – *Eleusine indica***
  - **Fibrous root system that have fine and continuous root mass**
  - **Can be found in wasteland areas**

IEC and Technology Transfer for Biodiversity Conservation and Green Technology in Central Luzon

Project Leader: Dr. Annie Melinda Paz-Alberto
Ms. Shirly C. Serrano, CLSU
Ms. Roann P. Alberto
Ms. Janice Faye S. Ang
Research Assistants: Daryl A. Juganas
Princess Joy C. Hernando
Kathrina M. Mapanao

Objectives

- **To produce brochures, fact sheets and comics and jingle on Biodiversity and Nature Conservation and Green Technology (Phytoremediation).**

- **To enhance public awareness on the importance of biodiversity and green technology (phytoremediation) for better appreciation and participation in conservation programs.**

- **To undertake green technology promotion/ transfer to farmers, NGOs, LGUs, students and interested individuals/organizations for possible adoption.**

Enhancement of Public Awareness on the Importance of Biodiversity Conservation

- 3 Seminar-workshops on Biodiversity Conservation and Green Technology in Central Luzon with the theme on

"*Sama-samang Pagkilos Tungo sa Pagpapaunlad at Pangangalaga sa Kabundukan at Tubig Kanlungan*".

- Carranglan Watershed- March 14, 2014
- Baler Forest Reserve- February 26, 2015
- Bataan Natural Park-January 15, 2015

Seminar-Workshop on Biodiversity Conservation and Green Technology

Carranglan, Nueva Ecija
March 14, 2014

Seminar-Workshop on Biodiversity Conservation and Green Technology

BPSU, Abucay, Bataan

January 15, 2015

Seminar-Workshop on Biodiversity Conservation and Green Technology

ASCOT, Baler, Aurora

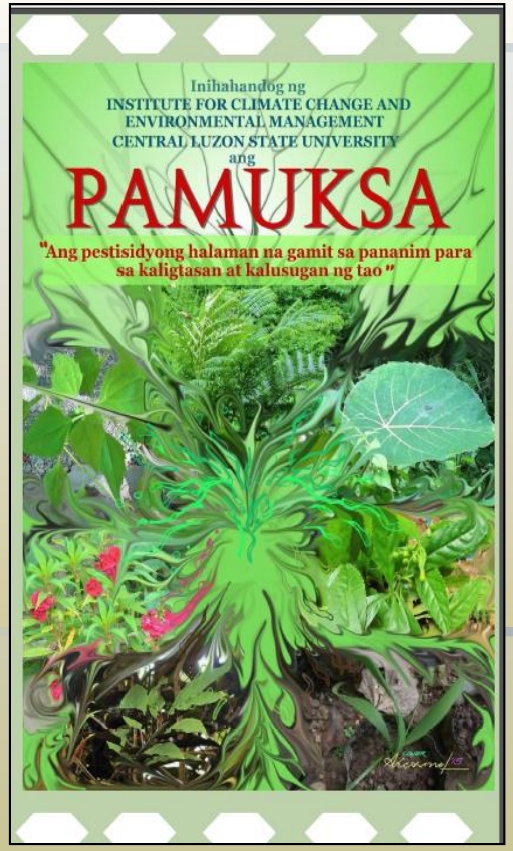
February 26, 2015

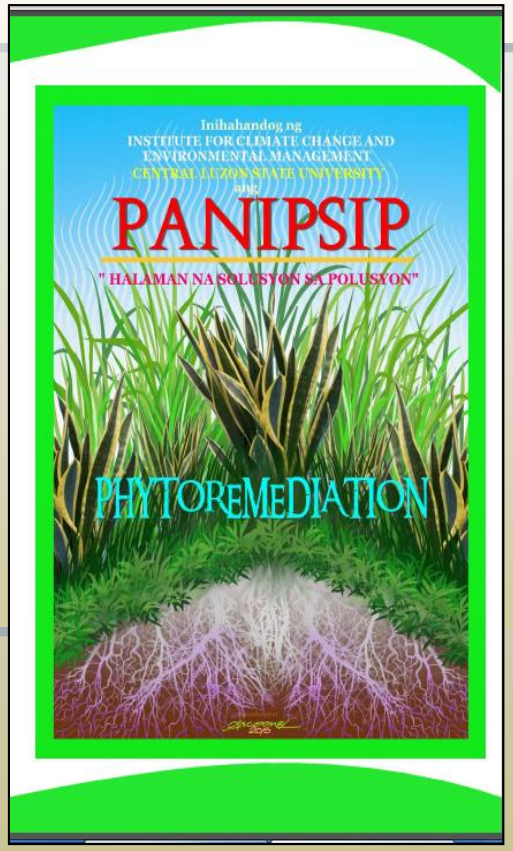
Green Technology Promotion

- IEC materials such as brochure, comic books, and jingle on phytoremediation were also prepared, developed and produced

  - Phytoremediation
  - Panipsip (Phytoremediation)
  - Jingle (Phytoremediation)

IEC Materials for Green Technology Promotion and Field Demonstration





Comics on Botanical Pesticide and Phytoremediation

Enhancement of public awareness on the importance of green technology

Green Technology Promotion and Field Demonstration

Municipal Agriculture Office, Carranglan, Nueva Ecija

May 15, 2015

Enhancement of public awareness on the importance of green technology

Green Technology Promotion and Field Demonstration

Municipal Agriculture Office, Baler, Aurora

May 19, 2015

Enhancement of public awareness on the importance of green technology

Green Technology Promotion and Field Demonstration

City Agriculture Office, Balanga, Bataan

May 21, 2015

Logo Used for Phytoremediation Promotion

Jingle for Phytoremediation

IEC

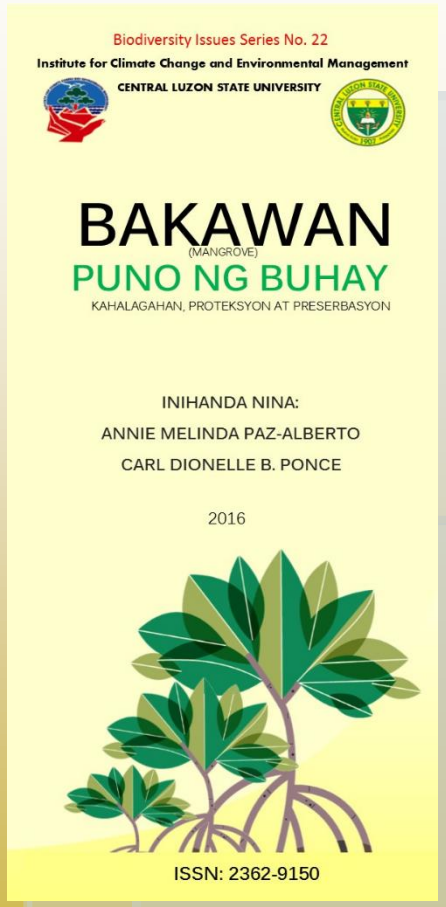
INFORMATION, EDUCATION AND COMMUNICATION

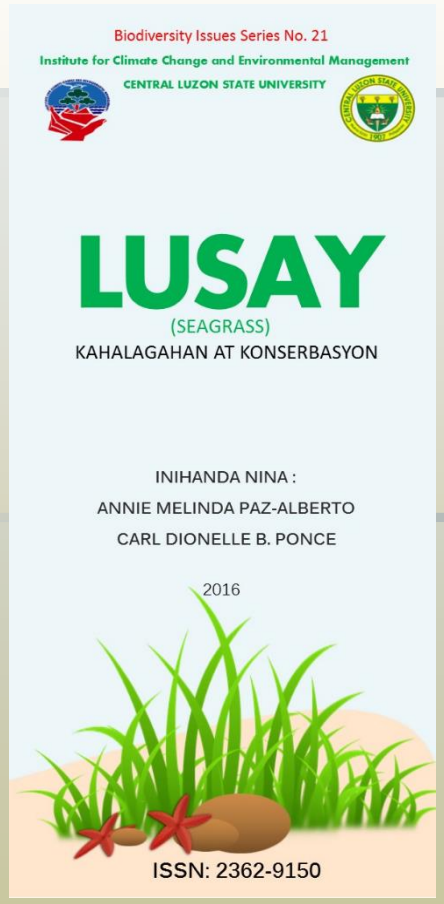
MATERIALS

Prepared

Produced

Published


Biodiversity Issues Series No. 22
Institute for Climate Change and Environmental Management
CENTRAL LUZON STATE UNIVERSITY
BAKAWAN
(MANGROVE)
PUNO NG BUHAY
KAHALAGAHAN, PROTEKSYON AT PRESERBASYON
INIHANDA NINA:
ANNIE MELINDA PAZ-ALBERTO
CARL DIONELLE B. PONCE
2016
ISSN: 2362-9150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(SEAGRASS)
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INIHANDA NINA :
ANNIE MELINDA PAZ-ALBERTO
CARL DIONELLE B. PONCE
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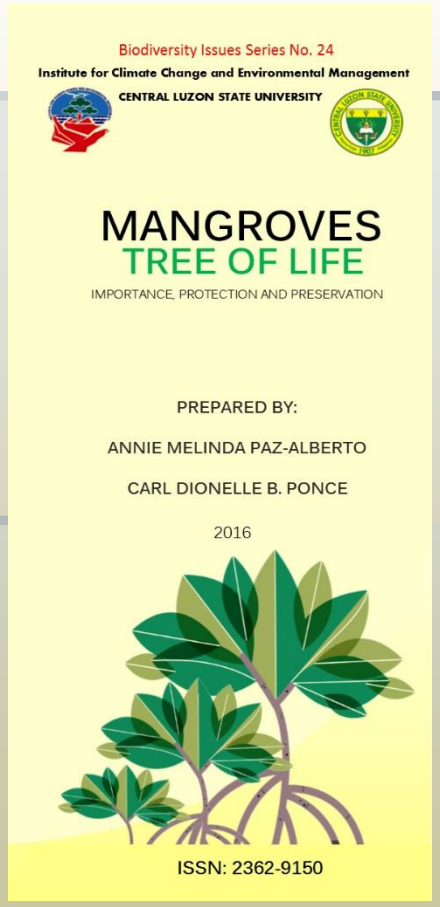
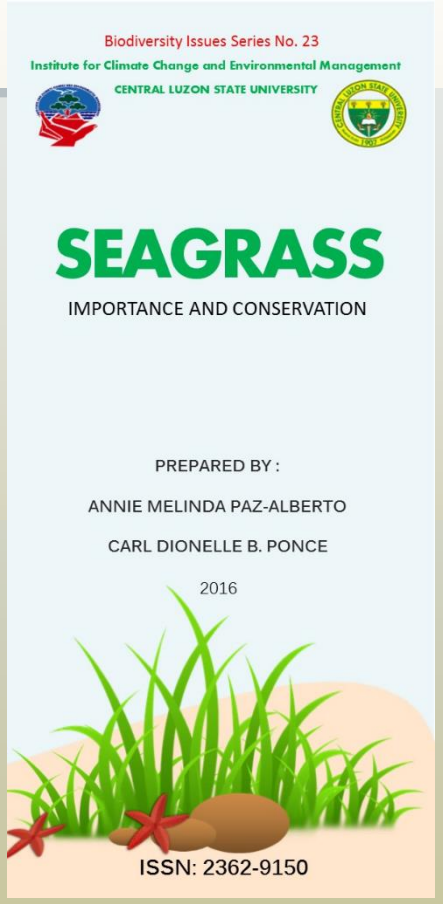

Biodiversity Issues Series No. 24
Institute for Climate Change and Environmental Management
CENTRAL LUZON STATE UNIVERSITY
MANGROVES
TREE OF LIFE
IMPORTANCE, PROTECTION AND PRESERVATION
PREPARED BY:
ANNIE MELINDA PAZ-ALBERTO
CARL DIONELLE B. PONCE
2016
ISSN: 2362-9150


Biodiversity Issues Series No. 23
Institute for Climate Change and Environmental Management
CENTRAL LUZON STATE UNIVERSITY
SEAGRASS
IMPORTANCE AND CONSERVATION
PREPARED BY :
ANNIE MELINDA PAZ-ALBERTO
CARL DIONELLE B. PONCE
2016
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Promotion for Public Awareness

- 7,234 Brochures were distributed and promoted:
  - 5 Elementary and High Schools in Zambales
  - 72 Barangays in 8 municipalities in Zambales namely :
    - San Antonio
    - San Marcelino
    - San Narciso
    - Cabangan
    - Castillejos
    - San Felipe
    - Palauig
    - Botolan

Promotion for Public Awareness

- Distribution of IEC Materials to various municipalities during the PCIEERD-DOST Anniversary at Widus Hotel, Angeles City,Pampanga on June 29, 2016

- Distribution of IEC Materials in various barangays in Zambales in December 2015.

Promotion for Public Awareness

- Distribution of IEC materials to various stakeholders during the National Science and Technology Week “Juan Science, One Nation” on July 25-29, 2016 at Walter Mart, San Fernando, Pampanga .

Conservation and Planting of Phytoremediators in CLSU

Conservation and Planting of Phytoremediators in CLSU

Conclusions

- **Several species of tropical plants are potential phytoremediators for certain metals and toxic chemicals and can be used to remove and lessen pollutants in contaminated urban soils and mining sites.**
- **Freshwater plants such as *Ipomea aquatica* (Kangkong) and *Ottelia alismoides* can absorb lead which can be utilized to get rid of toxic pollutants in freshwater ecosystems.**

Conclusions

- **Several species of mangroves possess beneficial characteristics that remove lead (Pb) and copper (Cu) from contaminated sediments in coastal ecosystems , and thus have potential phytoremediation properties.**
- **Some seagrass species are potential phytoremediators of Pb which can be used to reduce the presence of toxic heavy metals in the coastal ecosystems for water conservation.**

Conclusions

- **The four plants, PR1 (*Achyranthes aspera*), PR4 (*Sansivierra trifasciata*), PR5 (*Sphagneticola trilobata*) and PR6 (*Eleusine indica*) were able to absorb various heavy metals (Cu, Fe, Pb and Zn) above the normal range and are potential phytoremediators of heavy metal contaminated soil in the open dumpsite.**

Conclusions

- **Human exposure to heavy metals and toxic chemicals will be lessened through the use of these tropical plants to phytoremediate contaminated soil and water.**
- **The use of tropical grasses and plants is a very cost effective, environment friendly and practical tool for the control and remediation of toxic chemicals and heavy metals contamination in soil and water.**

CONCLUSIONS

- The IEC materials and other promotional campaign materials are very effective and important instruments for public awareness and education.
- Hence, they are very potent tools in biodiversity conservation and green technology transfer for possible adoption.

Recommendations and Perspectives

Local government units of highly urbanized areas should plant these tropical grasses and plants particularly in the

- **center islands**
- **highways**
- **parks**
- **lawns along roadsides**
- **open landscapes to remove or remediate the heavy metals that accumulate in the soil.**

Recommendations and Perspectives

- **Local governments units, industrial and mining companies must include planting of these tropical plants as part of every project proposal and comprehensive development plan for the wellbeing and protection of urban and rural communities.**
- **Restoration of degraded mangrove and seagrass ecosystems should be done to ensure the stability, sustainability and protection of coastal ecosystems and coastal communities for human health and safety .**

Recommendations and Perspectives

- The conservation and ecorestoration of the freshwater ecosystems and mangrove ecosystem should be promoted and implemented.
- Plant more mangrove trees in sites with heavy metal contamination particularly lead, copper, arsenic, chromium, nickel, etc.
- Local policies on the conservation of mangroves, seagrasses and seaweeds should be formulated and strict implementation and imposition of the green policies should be followed in coastal communities for rural development.

Recommendations and Perspectives

- Due to the risk of bio magnification/bioaccumulation of toxic substances such as heavy metals, it is recommended that planting crops such as rice plants and other vegetables as well as harvesting weeds as feeds for animals should not be encouraged within the vicinity of open dumpsites and near contaminated/polluted areas .

Recommendations and Perspectives

- **Policy Formulation and Implementation**
  - Policy formulation on the utilization of phytoremediators particularly endemic plants to lessen pollution and recommendation to DENR and LGUs for adoption and implementation should be done.
  - Formulation of local policies should be prepared on the use of phytoremediation as green technology for rural and urban ecosystems management and development.
  - The local barangay councils should take the lead in the implementation and imposition of the policy on the use and adoption of PHYTOREMEDIATION in their localized areas to make their areas pollution free for the health and safety of local communities for rural development .

ACKNOWLEDGEMENT

- **To all my students and advisees:**
  - **Ms. Bellrose Baui**
  - **Mr. Raynato Uera**
  - **Dr. Jerwin Undan**
  - **Mr. Markville Bautista**
  - **Mr. Paul Christian Cortez**
  - **Mrs. Maria Johanna De Dios**
  - **Mr. Arnel Celestino**
  - **Mr. Jose Lorenzo Vizmonte**
  - **Ms. Marietta P. Hechanova**
- **PHILRICE**
- **DENR**
- **ICCEM, CLSU**

ACKNOWLEDGEMENT

- Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development (PCAARRD), Department Science and Technology for the provision of funding for the projects on Molecular Identification and Green Technology Development of High Valued Plants in Central Luzon and IEC and Technology Transfer for Biodiversity Conservation and Green Technology in Central Luzon
- PCIEERD, DOST for the funding assistance of IEC Materials Production about Conservation of Various Ecosystems in Central Luzon and Disaster Management

ACKNOWLEDGEMENT

- Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) for giving the Regional Professorial Chair Lecture Award for School Year 2016-2017.


Thank you very much
and Good day!!