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RESEARCH ARTICLE

PHYTOEXTRACTION OF COPPER: A CASE STUDY

***Philip Ho**

Student, Researcher, Jakarta Intercultural School, Jakarta, Indonesia

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ABSTRACT

Biological waste water treatment is a decades-old biochemical technique. The treatment of waste water using a natural process has always been desirable. photoextractionis a green remediation technology used to treat polluted soils. This paper discusses the potential for copper photoextraction to use vetiver, a hyperaccumulator plant, on a river barge. Experimental data were obtained in a research experiment in which many vetiver-filled styrofoam boxes were put in buckets filled with copper sulphate. The results of the experiment-which took place over a duration of 2 weeks-demonstrate that the vetiver set-up is more effective than the hydrophytes in copper absorption. The set-up is applicable to clean up metal contaminated lakes and rivers - for this example it will be applied to a copper contaminated pond near a mining site.

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INTRODUCTION

Biological wastewater treatment technique has been used for irrigation by ancient cultures (e.g. Mesopotamian, Indus Valley, and Minoan) since the Bronze Age (approx. 3200–1100 BC). Biological Wastewater is an ancient method and was first used for recycling, irrigation and fertilisation purposes by the Hellenic cultures and later by the Romans in the surrounding cities. The treatment of wastewater following the removal of suspended solids by microorganisms such as algae, fungi or bacteria under aerobic or anaerobic conditions under which organic matter in wastewater is oxidised or introduced into cells that can be dissolved by removal or sedimentation is called biological treatment. Phytoextraction is a process in which plants remove dangerous contaminants from soil or groundwater. This removal of heavy metals from contaminated soil is traditionally done by hyper-accumulators, A plant capable of growing in soil or water with very high concentrations of metals, absorbing these metals through its roots and concentrating exceptionally high levels of metals in its tissues. Phytoextraction or phytomining is typically an advanced technique for the processing of bio-ores and the restoration of soil health. Heavy metals, including Copper (Cu) from an anthropogenic industrial activity, are major sources of emissions that cause soil contamination. Conventional physico-chemical technologies used for the remediation of heavy metals, including dig-and-dumping, soil washing / flushing and vitrification, are typically very expensive, energy-consuming and hazardous to soil resources. Vetiver is extremely adaptive and can grow in all soil types. The preferred type of vetiver is sterile, and so is non-invasive or crop encroaching.

Corresponding author: **Philip Ho,**
Student, Researcher, Jakarta Intercultural School, Jakarta, Indonesia.

BOTANICAL NAME: *Vetiveria zizanioides 'Monto'*

FAMILY: Gramineae

Phytoextraction, a green remediation option that extracts metals through the use of plants, has gained great interest and has provided promising technologies for the removal of heavy metals from the soil. Hyperaccumulator species are plant aerial tissues that can contain > 1000 mg / kg Cu when grown in metal-rich soils. Hyperaccumulation species are usually slow-growing and have limited biomass. Vetiver is known for its efficiency in soil erosion management due to its unique morphological and physiological characteristics. Vetiver is also a high biomass plant with a remarkable photosynthetic ability that makes it tolerant of different harsh environmental conditions. Deep rooted vetiver and higher water use can effectively stabilise soil soluble metals. This technology involves the planting of hyperaccumulator plants, especially in heavy-metal-contaminated soils, and the subsequent harvesting of biomass, leading to permanent removal of heavy metals from the soil. This process can be referred to as 'concentration technology' which produces less waste for disposal compared to traditional engineering, including excavation and landfilling.

Contaminant	Accumula tion rates (in mg/kg dry weight)	Binomial name	English name	H-Hyperacc umulator or A-Accumula tor P-Precipitato r T-Tolerant	Notes
Cu		Athyrium yokoscense	(Japanese spleenwo r t)	Cd(A), Pb(H), Zn(H)	Origin Japan.
Cu	A-	Azolla filiculoides	Pacific mosquito f ern	Ni(A), Pb(A), Mn(A)	Origin Africa. Floating plant.
Cu	H-	Vetiveria zizanioides 'Monto'	Chrysopo gon zizanioide s	Cd(A), Cr(A), Cu(H), Ni(H), Pb(H), Pb(P), U(A), Zn(H)	Origin Tropical Asia. Tropi cal of Both hemispher es
Cu		Brassica juncea	Indian mustard	Cd(A), Cr(A), Cu(H), Ni(H), Pb(H), Pb(P), U(A), Zn(H)	cultivated
Cu	H-	Vallisneria americana	Tape Grass	Cd(H), Cr(A), Pb(H)	Native to Europe and North Africa. Widely cultivated inthe aquarium trade.
Cu		Eichhornia crassipes	Water Hyacinth	Cd(H), Cr(A), Hg(H), Pb(H), Zn(A), Also Cs, Sr, U and pesticides.	Pantropica l/Subtropic al, 'the troublesom e weed'.
Cu	1000	Haumaniast rum robertii (Lamiaceae)	Copper flower		27 records of plants. Origin Africa. This species' phaneroga m has the highest cobalt content. Its distributio n could be governed by cobalt rather than copper.
Cu		Helianthus annuus	Sunflower		Phytoextra ction with rhizofiltrat ion
Cu	1000	Larrea tridentata	Creosote Bush		67 records of plants. Origin U.S.
Cu	H-	Lemna minor	Duckwee d	Pb(H), Cd(H), Zn(A)	Native to North America and widesprea d worldwide .
Cu		Ocimum centraliafricanum	Copper plant	Cu(T), Ni(T)	Origin Southern Africa
Cu	T-	Pistia stratiotes	Water Lettuce	Cd(T), Hg(H), Cr(H)	Pantropica l. Origin South U.S.A. Aquatic herb.
Cu		Thlaspi caerulescens	Alpine pennycres s, Alpine Pennycres s, Alpine Pennygras s	Cd(H), Cr(A), Co(H), Mo, Ni(H), Pb(H), Zn(H)	Phytoextra ction. Cu noticeably limits its growth.

In order to be a good hyper-accumulator, the plant should be able to grow in a metal concentrated environment and absorb extremely high levels of metals into their roots and into their tissues to be referred to as a concentration technique. Man-made ponds in the Batu Hijau mine are full of contaminant metals such as copper. These heavy metals are dangerous because they tend to bioaccumulate; Bioaccumulation refers to the situation in which compounds accumulate and are taken up in living things faster than they can be excreted. Heavy metal toxicity in a human body can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs. These metals can be transferred to humans from basic essentials such as food and water. Vetiver was collected from Jakarta, Indonesia (6°2088'S, 106°8456'E) pre cultured for 5 days and carefully washed. These plants were transferred in 4 boxes of styrofoam experimental tanks filled with soil, vermiculite, arbuscular mycorrhizal fungi, and vetiver plants floating on copper contaminated water. Nutrient solution pH was adjusted to 6.0 with 0ppm, 10ppm and 150ppm of CuSo4 with atomic packing factor. Four individual plants were placed in each tank. Compressed air was gently applied to provide the vetiver with adequate oxygen. Analytical grade of chemical was used to prepare stock solutions. Three heavy metals, Cu, Zn, and Pb (prepared as Pb(NO3)2, CuSO4, and ZnCl2), were prepared as 5 mg/L while three chelators EDDS, citric acid, and EDTA were with the concentration 5 mM. The initial average height and weight of the vetiver were 30 cm and 18 g respectively. The experiment was then conducted in a laboratory at Jawa Barat, Indonesia with the temperature, humidity, and light intensity controlled at 33°C, 60%, 1500 LUX, respectively. The growth responses of vetiver and metal removal efficiency were recorded. The plants were collected for metal uptake evaluation after 7 days. 4 boxes of styrofoam complete with soil, vermiculite, arbuscular mycorrhizal fungi,

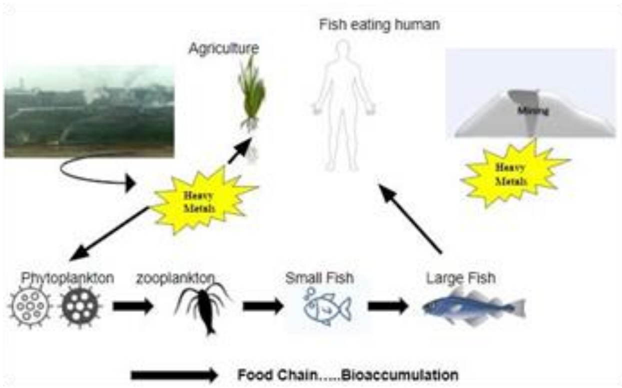

Figure 1. Bioaccumulation - effects

and vetiver plants floating on copper contaminated water. 1 box of styrofoam unfilled as a control. 1 box will be placed in a solution of copper sulfate with 10 ppm of copper with ABF;

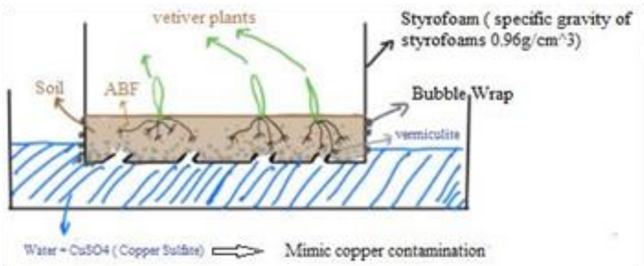

Fig Side View

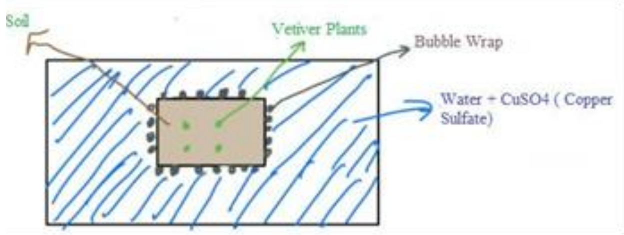

Fig. Top View

1 box will be placed in a solution of copper sulfate with 150 ppm of copper with ABF; 1 box will be placed in a solution of copper sulfate with 0 ppm of copper with ABF; 1 box will be placed in a solution of copper sulfate with 10 ppm of copper without ABF; 1 unfilled box placed in a solution of copper sulfate with 10 ppm of copper acting as control. Vetiver plants are placed in a styrofoam box. Soil and ABF and vermiculite also in a styrofoam box. ABF to make the root area larger. styrofoam box covered in bubble wrap to increase buoyancy. Experiment will run for 2 weeks. Qualitative observations recorded on a daily basis. Measured variables are stated below.

Soil Analysis

Blank: Blank or also known as Reagent Blank performed during analysis to determine contribution reagents and preparative analytical steps to error in the measurement. Blank result acceptance is below detection limit stated on the report (APHA, 2017). Performed during analysis is a reagent water sample to which a known concentration of the analytes of interest has been added. It is use to evaluate laboratory performance (APHA, 2017)

Detection Limit: Smallest amount that can be detected above the noise in a procedure and within stated confidence level. The confidence level are set so that the probabilities of errors are acceptably small (APHA, 2017). Soil Analysis has been executed by me with the help of local labs and the results are hereby attached to see the in-depth analysis of soil. Agro-synthetics (pesticides, herbicides, and even composts) have been accounted for to unfavorably influence soil properties and water quality.

This antagonistic impact is at last communicated in the nature of harvest created. Vetiver has assumed a significant function in the cleaning of agro-synthetic substances because of its capacity to hold them inside its framework, in this manner keeping them from defiling and collecting in soils and yields. Table 3 shows the edge levels of hefty metals to vetiver grass. Exploration led in cabbage crops developed (60%) in Indonesia demonstrated that vetiver supports had a significant function during the time spent imprisonment and sterilization of agro-synthetics, particularly pesticides, for example, carbofuran, monocrotophos and anachlor. Planting vetiver grass across waste lines could fill in as a living channel for catching undesirable unfamiliar synthetic substances or impurities before they arrive at non-dirtied soil and downstream regions.

Data and Statistical Analysis

The development execution was assessed utilizing the root-shoot (R/S) proportion, resistance list (TI), and relative development rate (RGR) recipe, while the capacity for metal amassing and movement upward in the plant species was surveyed by deciding the movement factor (TF), metal aggregation proportion (MAR), and level of metal take-up adequacy as follows:

R/S ratio=Dry matter yield root/Dry Matter Yield in shoot

TI=Total Dry Matter Yield In Treatment / Total Dry Matter Yield Control

RGR=[ln (Final Biomass Of Treatment)− ln(Initial Biomass Of Treatment)] / Days Of Growth

TF=Metal Concentration Accumulated Shoot/ Metal Concentration Accumulated Root

MAR=[Metal Concentration accumulated Shoot ×Dry Matter Yield Shoot]/[Metal Concentration Accumulated Root ×Dry Matter Yield Root]

Metal uptake efficacy (%)=[Metal Concentration Accumulated Shoot / Total Metal Concentration Removed from the growth media]×100

All exploratory information was examined by playing out the 1-route investigation of change and further measurable legitimacy test for noteworthy contrasts among treatment implies was led by utilizing the Fisher least critical distinction tests at 95% degree of certainty with the guide of Microsoft Excel Office 365 variants 2016 programming.

No	Sample ID	Sample Matrix		Sampling Date
1	Soil Sample 1	Soil		7-Oct-20
No	Test Description	UoM	Result	Method Reference
	Anions			
1	pH (extractable H2O 1:1)	mg/kg.dr y	7.43	ASTM D 497295A
2	Sulphate-extractable with H2O 1:10	mg/kg.dr y	< 2	ASTM C1580
	Nutrients			
3	Total Nitrogen 1)	%	0.25	Inhouse Calculation
	Metals			
4	Copper	mg/kg.dr y	1030	USEPA 3050 B 1996 dan APHA 3125 B 2017 (ICP MS)
	Organic			
5	Total Organic Carbon (TOC) 1)	%	16.7	SNI 136-4720-1998
	Grain Size2)			
6	Sand (2000-1000 µ)	%	0.00	Inhouse Method (Pipet)
7	Sand (1000-500 µ)	%	4.56	Inhouse Method (Pipet)
8	Sand (500-250 µ)	%	1.23	Inhouse Method (Pipet)
9	Sand (250-150 µ)	%	5.46	Inhouse Method (Pipet)
10	Sand (125-50 µ)	%	9.56	Inhouse Method (Pipet)
11	Silt (50-20 µ)	%	22.3	Inhouse Method (Pipet)
12	Silt (20-5 µ)	%	18.9	Inhouse Method (Pipet)
13	Silt (5-2 µ)	%	7.07	Inhouse Method (Pipet)
14	Clay (2-0.5 µ)	%	13.5	Inhouse Method (Pipet)

Table 3. Tolerance levels of vetiver grass and other plants to heavy metals.

Heavy metals	Threshold levels in soil (mgkg−1)		Threshold levels in plant (mg kg−1)	
	Vetiver	Other plants	Vetiver	Other plants
Arsenic	100–250	2	21–72	1–10
Cadmium	20–60	1.5	45–48	5–20
Copper	50–100	NA	13–15	15
Chromium	200–600	NA	5–18	0.02–0.20
Lead	>1500	NA	>78	NA
Mercury	>6	NA	>0.12	NA
Nickel	100	7–10	347	10–30
Selenium	>74	2–14	>11	NA
Zinc	>750	NA	880	NA

Conclusion

Vetiver grass innovation has been applied universally for controlling soil disintegration, balancing out land and water assets and remediating defiled grounds to improve crop development and yields. It is utilized as grain for creature feed, mulch for improving soil dampness and ripeness, and sinewy root framework for holding soils set up could ensure food creation on a supportable premise attributable to the way that this grass can withstand unfavorable natural and climatic conditions, combined with snappy recovery in the wake of pruning. In this way, when vetiver grass is applied suitably, it very well may be a minimal effort, basic and effectively relevant multi-reason soil and water protection device for supportable agribusiness. It is likewise a grass of incredible utility that could give different methods for income to neighborhood ranchers.

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