

Toxic Effect of Copper on Human Body and Removal by Low Cost Adsorbents

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Abstract

According to U.S. Environmental Protection Agency (EPA) and WHO, the permissible limit of copper in drinking water is 1.3 and 2.0 mg dm³, respectively [1]. However, the divalent copper (Cu²⁺) is toxic and carcinogenic when consumed in excess through ingestion. The excessive Cu²⁺ consumption leads to its deposition in liver and subsequent vomiting, headache, nausea, respiratory problems, abdominal pain, liver and kidney failure and finally gastrointestinal bleeding [6] there has been an increasing research into finding low-cost adsorbents for the removal of heavy metals from wastewaters. Agricultural by-products which have been studied for this purpose include peat, wood, pine bark, banana pith, cotton seed hulls, peanut shells, hazel nut shell, rice husk, saw dust, wool, orange peel, compost, maize cobs and guava leaves Removal of copper from water by bio sorption, using algal waste from agar extraction, either directly or as a composite material and dead biomass of algae Gelidium can be a promising process. Large quantities of algal waste are generated and can be reused before final disposal. The present study demonstrated the phytoremediation potential of water hyacinth " Eichhorniacrassipes .

Keywords: - *Excess through ingestion, Agricultural by-products, present study demonstrated, Deposition in liver and subsequent*

INTRODUCTION

Environmental pollution is currently one of the most important issues facing humanity. It was increased exponentially in the past few years and reached alarming levels in terms of its effects on living creatures. Toxic heavy metals are considered one of the pollutants that have direct effect on man and animals. Rapid growth in human population is one of the major causes of environmental pollution. Increased industrialization and urbanization throughout the world results in consistent release of toxic effluents, several industrial processes generate metal containing wastes. Heavy metals are non-degradable metals. Several industrial wastewater streams may contain heavy metals such as Cr, Cu, Pb, Zn, Ni, etc., including the waste liquids generated by metal finishing or the mineral processing industries. Heavy metals are natural components of the Earth's crust.

They cannot be degraded or destroyed. To a small extent they enter our bodies via food, drinking water. Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers and groundwater. As trace elements, some heavy metals (e.g. copper, selenium, zinc)

are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metals poisoning could result, for instance, from drinking water contamination. The removal of heavy metals can be accomplished by a variety of techniques. Conventional methods typically involve the use of processes such as coagulation, precipitation, ion-exchange, electro-chemical methods, membrane processes, extraction, adsorption, etc. Among these methods, adsorption is currently considered to be very suitable for wastewater treatment because of its simplicity and cost effectiveness. Heavy metal pollution produced in industrial wastewater has become a major issue throughout the world. In particular, copper (II) ions, whose effects on human health and aquatic life are regarded as harmful, and of course are not biodegradable; therefore, they must be removed from effluents so as to achieve environmental quality standards.

According to U.S. Environmental Protection Agency (EPA) and WHO, the permissible limit of copper in drinking water is 1.3 and 2.0 mg dm³, respectively [1]. Contamination caused by heavy metals is mostly found in waste waters that emerge from metal plating, mining, and

car radiator manufacturing industries. It is also found in areas where fertilizers are intensively used. It is thus important to remove heavy metals from water and wastewater due to their persistence nature amongst others. The effective removal of heavy metals from aqueous wastes is among the most important issues for many industrialized countries. Rapid industrialization and poor effluent treatment processes in many industries have led to a substantial lowering of water quality that is fed to water bodies. Presence of heavy metals is one of the many factors that lower water quality.

These heavy metals cause harmful effects on health, increase environmental toxicity and affect the aesthetic quality of water. The use of agricultural products and by-products has been widely investigated as an alternative for costly methods of removing heavy metals from water and wastewater. Modification of agricultural by-products could enhance their natural capacity and add value to these by-products. There has been an increasing research into finding low-cost adsorbents for the removal of heavy metals from wastewaters. Agricultural by-products which have been studied for this purpose include peat, wood, pine bark, banana pith, cotton seed hulls, peanut shells, hazel nut

shell, rice husk, saw dust, wool, orange peel, compost, maize cobs and guava leaves. This review is aimed at investigating the use of low-cost adsorbents as an alternative to expensive activated carbon adsorbents used in removing Cu(II) from water and wastewater.

TOXIC EFFECT OF COPPER [1]

Copper is a widely used material. It can be found as contaminant in food. This form of contamination emanates from the use of copper material in the packaging of food. Copper is released into the environment in a number of different ways; it finds its way into water-streams resulting in environmental contamination that poses threat to humans, animals, and plants. This can cause serious and complex ecological problems. In spite of the essential nature of copper to human life and health, it is potentially toxic. Copper as trace element is essential to living organisms. It is essential for the proper functioning of organs and metabolic processes, its role in enzyme synthesis, tissues and bones development [6].

However, the divalent copper (Cu^{2+}) is toxic and carcinogenic when consumed in excess through ingestion. The excessive Cu^{2+} consumption leads to its deposition

in liver and subsequent vomiting, headache, nausea, respiratory problems, abdominal pain, liver and kidney failure and finally gastrointestinal bleeding [6]... For instance, continuous inhalation of copper-containing spray is linked with an increase in lung cancer among exposed workers. Wilson disease and insomnia. Ingestion of high concentrations of copper salts is associated with symptoms relating to abdominal pain, headache, nausea, dizziness, vomiting and diarrhoea, tachycardia, respiratory difficulty, hemolytic anemia, massive gastrointestinal bleeding, liver and kidney failure, and death.

These symptoms subside when copper in the drinking water source is reduced. Chronic copper poisoning leading to liver failure was reported in a young adult male with no known genetic susceptibility who consumed 30–60 mg/l of copper as a mineral supplement for 3 years. Like other heavy metals, copper in trace amount is necessary for life processes.

However, with higher concentrations of this element in the environment and the consequent increase in human use, copper concentrations have reached toxic levels causing various diseases and disorders in aquatic life. It has known detrimental

deleterious effects on the soil biota and damages to many plant species including some of the endemic Australian native plant species (*Acacia holosericea* and *Eucalyptus crebra*). The excessive amounts of Cu^{2+} in fresh water resources and aquatic ecosystem damage the osmoregulatory mechanism of the fresh water animals and cause mutagenesis in humans. Large quantities of Cu^{2+} are released by the disposal of untreated industrial waste. United State Environmental Protection Agency has set its Cu^{2+} permissible limits as 1.3 mg/L in industrial effluents. World Health Organization (WHO) defines the Cu^{2+} permissible limit of 1.5 mg/L in drinking water

Excess Cu(II) in water may damage marine and freshwater organisms such as fish and mollusks. Fish species vary in their sensitivity to copper, with the LD50 for 96-h exposure to copper sulphate reported to be in the order of 58 mg per litre for *Tilapia (Oreochromis niloticus)* and 70 mg per litre for catfish (*Clarias gariepinus*). The chronic effect of sub-lethal concentrations of Cu (II) on fish and other creatures is damage to gills, liver, kidneys and the nervous system. It also interferes with the sense of smell in fish, thus preventing them from choosing good mates or finding their way to mating areas.

TECHNOLOGIES FOR THE REMOVAL FROM WATER

Table 1. List of Low Cost Adsorbents for Copper Removal [2]

Low-cost adsorbents	Adsorption capacities (mg/g)	References
Diatomite	27.55	63
Modified diatomite	55.56	63
Sawdust	1.79	64
Peat	12.07	15
Low-rank Turkish coals	1.62	65
Tea-industry waste	8.64	66
Lentil Shell	9.59	27
Wheat shell	17.42	27
Rice shell	2.95	27
Grape stalk wastes	0.78	67
Citric acid modified soybean hulls	154.90	68
Cassava waste	56.82	69
Peanut hulls pellets	9.11	70
Banana peel	4.75	34
Orange peel	3.65	34
Cocoa shell	2.87	71
Teak leaves powder	13.14	72
Wheat shell	10.87	73
Herbaceous peat	4.84	74
Peanut hulls	10.17	75
Tobacco dust	36	76
Modified rice husk	29	77
Raw pomegranate peel	1.3185	78
Unmodified jute	4.23	79
Dye loaded jute	8.40	79
Oxidized jute	7.73	79
RSAC	5.729	80
RSD	8.1103	51
PMSD4	2.6631	51
SMDS3	12.484	51

Various technologies for the removal of heavy metals from wastewater had been established and reported by researchers in their works. They include precipitation, flotation, bio sorption, membrane separation, adsorption on minerals and

adsorption using activated carbon. Among the various methods described in literature, adsorption is the most effective method that has been successfully applied in the purification and recovery of Cu (II) ions from effluents due to its high efficiency

and easy handling. In spite of its prolific use, activated carbon remains an expensive material since the higher the quality of activated carbon, the greater its cost. The use of complexing agents are also required to enhance the removal performance of

activated carbon when used for inorganic matters this makes the use of activated carbon expensive and thus not suitable for small-scale industries. Removal of copper from water by bio sorption can be another method.

Table. 2 Micro-Organisms That Can Bind Metals [3]

MICRO ORGANISM	WHICH CAN BIND METALS	IN THEIR BIOMASS
	METAL	SITE OF BINDING
Rhizopus arrhizus	U , [180 mg more than biomass]	Cell wall [Chitin]
Pencilum sp	U , [80- 120 \ kg biomass]	Cell wall
Bacillus subtilus	Fe ,Mn ,Cu , Zn , Mg , Ni Pb	Cell wall [Peptidoglyan]
Mucor flavus	Fe (OH) ₂	Chitosan
Bacillus lichenforms	Cu, Fe III , Ni ,Mn , Au .	Cell wall [Teichoic acids]
Denitrifying bacteria	U [140 mg \ g biomass]	
Pseudomonas aeruginosa	U	Li poly saccharides
Sacchromyces cerevisiae	U, Zn , Mg	Cell wall
Cyano bacteria	Ni	
Entero bacter cloaca	U, Cr (IV) - Cr (III) -	
Ganoderma lucidum	Cu	Cell wall
Micro coccus luteus	Sr	Peptidoglyan content [Glutamic acid]
Ascophyllum nodosum	Co	
Arthro bacter ,Klebsilla	Ag 30 % of biomass	
Consortia of bacteria , Staphylococcus aureous		
P .maltophilia		
Citro bacter sp	Cd	Envelope bound Phosphatase at cell surface
Aspergillus niger	Cd	

Table 3 Uptakes of Metals on Algae [3]

UPTAKE OF HEAVY METALS TO ALGAE		
	METAL ION	MAXIMUM [ug/ml] CONCENTRATIONS THAT FAVOURED GROWTH
Oscillatoria peromata var attenuate	Fe (III),	27.56
	Zn (II),	0.833
	Cu (II)	0.0207
Scenedesmus quadricauda var longispua	Fe (III),	20.67
	Zn (II),	0.595
	Cu (II)	0.0188
ALGAE	METAL ION	MAXIMUM UPTAKE ug/ml
Oscillatoria peromata var attenuate	Fe (III),	07.506
	Zn (II),	0.1086
	Cu (II)	0.0111
Scenedesmus quadricauda var longispua	Fe (III),	06.449
	Zn (II),	0.1086
	Cu (II)	0.0076

BIOSORPTION

Bio sorption is a promising technology, defined as a passive uptake of heavy metals from aqueous solutions by biological materials. Removal of copper from water by bio sorption, using algal waste from agar extraction, either directly or as a composite material and dead

biomass of algae Gelidium can be a promising process. Large quantities of algal waste are generated and can be reused before final disposal. On the other hand, the waste material is cheaper than other commercially available adsorbents.[10] Biomass of non - living dried water hyacinth roots,

Eichhorniacrassipes, showed high sorption for copper from aqueous solutions. Maximum sorption was 20.90 mg Cu/g as determined from Langmuir isotherm. Several factors affecting sorption were investigated. They include effect of pH, initial concentrations, presence of chelators and other metals. The feasibility of removing copper from electroplating waste using this material in a packed - bed system was also discussed. [5]

Factors affecting Cu²⁺ uptake by the water hyacinth (Eichhorniacrassipes) were examined. Two phases of copper uptake were observed throughout the uptake range (1–1000 mg/l). An initial rapid uptake phase of 4 hours followed by a slower, near linear uptake phase extending past 48 hours was observed. Stirring the solution enhanced uptake, suggesting copper removal is partially diffusion limited. Variations in pH over the range of 3 to 10 did not significantly affect uptake. Increasing the root mass of the plant increased the amount of copper taken up. As solution volume was increased more copper was removed.

The presence of complexing agents during the uptake phase reduced copper uptake. The inability of complexing agents to recover all copper initially removed by a

plant suggests a migration to sites within the plant. The present study demonstrated the phytoremediation potential of water hyacinth " Eichhorniacrassipes ", for the removal of copper (Cu) and Cadmium (Cd). Young plants of equal size were grown in tap water and supplemented with 0.35, 0.70 and 1.05 mg/L of Cu and 0.27, 0.54 and 0.81 mg/L of Cd individually for 25 days. The experiment showed that both Cu and Cd had effects on plant relative growth. The plant at all the concentrations used in the experiment removed approximately more than 90% of Cu and Cd. Removal of metals from water was fast especially in the first five days. The accumulation of Cu and Cd in roots and stems increased with the initial concentration.

At all levels the plants accumulated the highest concentration of Cd in roots, while the highest concentration of Cu was accumulated in stems. The bioconcentration factor (BCF) of Cu was higher than that of Cd at the same duration, suggesting that the accumulation potential of " Eichhorniacrassipes " for Cu was higher than that for Cd and could be used to treat wastewater contaminated with low Cu and Cd accumulations.[3,5,11,12, 13]

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