



Copper Ions Removal from Polluted Solution by Ceratophyllum Dried Micro Particles

Wafaa Razzaq Hilal , Karima F. Abbas, Zainab Saleh Mahdi,
Hasnaa Maher Idan, Jaafar Subaih Awad

Department of Environmental Health, College of Applied Medical Sciences, Kerbala University, Iraq

Suggested Citation

Hilal, W.R., Abbas, K.F., Mahdi, Z.S., Idan, H.M., & Awad, J.S. (2024). Copper Ions Removal from Polluted Solution by Ceratophyllum Dried Micro Particles. *European Journal of Theoretical and Applied Sciences*, 2(5), 127-133.
DOI: [10.59324/ejtas.2024.2\(5\).12](https://doi.org/10.59324/ejtas.2024.2(5).12)

Abstract:

Objective: The study focuses on copper toxicity to monitor river and marine water contamination by utilizing low-cost materials as potential adsorbents for removing hazardous metals. Copper toxicity is a significant concern due to its role in generating free radicals, which disrupt biogeochemical cycles. **Method:** Ceratophyllum demersum plant was collected from the Husseinayah River, in Kerbala city, two concentration of copper (50 ppm and 100 ppm) were used in this experiment, different size of dried plant particles was (<125 μm , 125-250 μm , 250-600 μm , and 600-1000 μm) in research. Copper concentrations in solutions was examined by using Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-

OES) Thermo Fisher scientific. **Results:** The results showed there were significant differences between treatments, high adsorption was (6.92 ,14.24ppm) in <125 μm for 50 and 100 ppm respectively while the less adsorption was (18.60,37.37ppm) In 600-1000 μm for 50 and 100 ppm respectively. The results indicated that the highest removal percentage of copper in solutions was 86.146% at concentration of 50 ppm , and < 125 μm size of plant particle while the lowest removal percentage was 62.6207 at 100 ppm and 600-1000 μm . **Conclusion:** ceratophyllum demersum showed high efficiency in adsorption of copper element from aquatic environment, the amount of copper ions removed by dried plant increase with increase of metal ion concentration , on other hand ,the percentage of metal ion removed decrease with increase of metal ion concentration.

Keywords: *Microparticles, Adsorbent, Dry plant, Copper removal*

Introduction

There has been increase efforts in the last few years to offer low-cost, eco-friendly, and efficient methods of treating heavy metals present in wastewater. The majority of facilities currently use costly chemical precipitation processes that generate their own hazardous waste (Eisazadeh, 2008; Mohammed, & M-Ridha, 2019).

It is possible to classify heavy metals as either necessary or non-essential for biological

processes. Non-essential elements include Cd, Pb, Cr, As, and Hg, among others, whose biological significance is uncertain for all organisms. Living beings require trace levels of essential metals, such as Fe, Mn, Cu, Ni, and Zn, which are crucial for numerous physiological and biochemical processes. Although copper is a necessary metal for all living things and is involved in many physiological processes, excessive amounts of it can have negative health effects (Eisazadeh, 2008). Excessive consumption of Cu can cause serious health



problems in humans, including kidney damage, vomiting, cramps in the intestines, and in severe cases, death after prolonged exposure (Abdulkareem, & Alwared, 2019; Taha, et al., 2019). Industrial producers like tanneries, electronics producers, plating plants, and household copper plumbing are the main anthropogenic sources of copper that find their way into the waste stream. Mining and refining plants may also release significant amounts of copper straight into freshwater systems. Copper is a necessary metal for the synthesis of hemoglobin and numerous metabolic processes, and at low amounts ($< 4.0 \text{ mg/L}$), it appears to pose little risk to humans (Agency for Toxic Substances and Disease Registry, 2010). Researchers in the field of bio-absorption have studied copper, a form of inorganic contaminant. In acidic environments, this metal exists as the free cation Cu^{2+} , while in neutral or basic environments it exists as traces of soluble $\text{Cu}(\text{OH})_2$ and $[\text{Cu}(\text{OH})]^+$. To address the negative effects of heavy metals, environmental organizations set acceptable levels for their concentrations in various types of water, including drinking water. As an example, the World Health Organization (Kadirvelu, Faur-Brasquet, & Cloirec, 2000; Chiban, et al., 2011).

The development of novel technologies capable of eliminating metals from contaminated water has grown to be a significant area of study. Adsorption has been demonstrated to be a cost-effective method (when compared to ion exchange, extraction, or electrodialysis) and a simple technique (when compared to chemical precipitation or reverse osmosis) among the techniques frequently employed for this purpose (Van Cutsem, et al., 2002; Al-Asheh, et al., 1984).

To lower the concentrations of hazardous metal cations, the sorption of heavy metals by these particles of inert organic matter (IOM) may be mainly due to their protein, carbohydrates, and phenolic compounds (Faur-Brasquet, et al., 1999) which include metal-binding functional groups such as carboxyl, hydroxyl, sulfate, phosphate, and amino groups. (Al-Asheh, et al., 1984; Rivera-Utrilla, et al., 2002; Davila-Jiménez, et al., 2002; Adsorption of metal cations).

Ceratophyllum demersum is a cosmopolitan, perennial, obligate sea plant. It is universally referred to as Coontail for the reason that its compact whirls resemble a racoon's tail, or as Hornwort (Valko, Morris, & Cronin, 2005). Underwater persistent macrophyte *Ceratophyllum demersum* will generally produce with the base of its stem concealed in muddy or dirty substrates. It doesn't produce roots. It is easy to move, and its lanky stems have the potential to become free-floating. It can form a dense subsurface layer, communicate up to 5–6 m, and often grows as a mono-specific cooperative spirit (reports from Maraetai, New Zealand indicate that it can reach heights of 10 m). When *C. demersum* grows close to the lake bottom, it can produce modified leaves that it uses as an anchor in the mud (Syed, et al., 2018).

Methods

The research was conducted in Health Laboratory, Environmental Health Department, at the College of Applied Medical Sciences. *Ceratophyllum demersum* plant was collected from the Husseinayah River, in Kerbala city, it washed and dried at room temperature for 4 weeks. Micro particles of dry plant were prepared by grind with a ceramic mortar then sieved by different sizes Sieves ($<125 \mu\text{m}$, $125-250 \mu\text{m}$, $250-600 \mu\text{m}$, $600-1000 \mu\text{m}$). Two concentrations of Cu were used in this experiment, the metal solution 50 ppm was prepared by dilution from 100 ppm Cu.

1 gram of dry matter particles of different sizes were taken and placed in direct contact with 40 ml of concentrations in sealed plastic bottles for each size of the particles, in three replicates for each treatment. Samples were shaken using a rotary shaker for 2 hours at 60 rpm (Yassen, M. & Fakhar, 2015) then filtered and examined using an ICP-OES, Thermo Fisher scientific, Germany to determine the residual concentration of copper (Cu) in aqueous solution. Removal of elements was measured by following equation:

$$\% \text{Removal} = \frac{(Cu^{+2})_0 - (Cu^{+2})_t}{(Cu^{+2})_0} \cdot 100 \quad (1)$$

$(Cu^{+2})_0$: the concentration of copper at 0 time

$(Cu^{+2})_t$: the concentration of copper at 2 hours

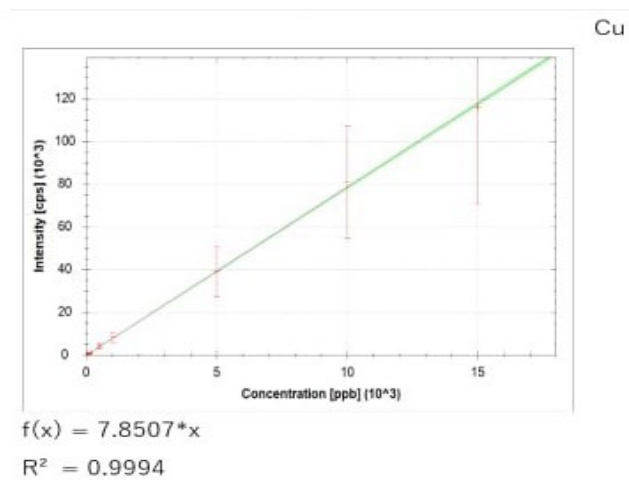


Figure 1. Standard Curve of Copper

Experiment Design and Data Analysis

The experiment was designed according to a two-way anova and the results were statistically analysed using a program spss.

Results and Discussion

Effect of Dry Plant Particles on Copper Adsorption from Solutions

Residual concentration of copper metal in aqueous polluted solution explained in results after being exposed to plant particles , Figure 2 showed there were significant differences between treatments , high adsorption was (6.92 , 14.42ppm) in particle size $< 125\mu m$ for 50 and 100 ppm respectively , while the less adsorption was (18.60 , 37.37 ppm) In 600-1000 μm for 50 and 100 ppm respectively.

Figure 3, shows the effect of concentration 50 and 100 ppm on the efficiency of adsorption and the residual concentration of copper metal in aqueous polluted solution. The effect of dry plant particles size on the adsorption of copper in the aqueous solution appears in figure 4 , the residual copper element in the aqueous solution increases with increasing size of the particles, Highest residual was (27.994ppm) at 600-1000 μm plant particles size ,while the lowest in $< 125\mu m$ was (10.674ppm).

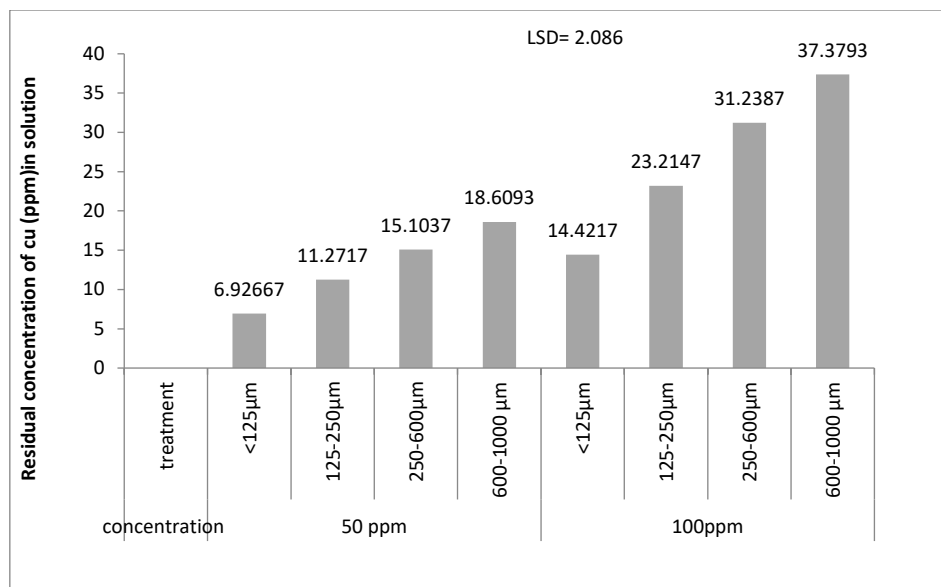


Figure 2. Residual Concentration of Copper Metal in Aqueous Polluted Solution

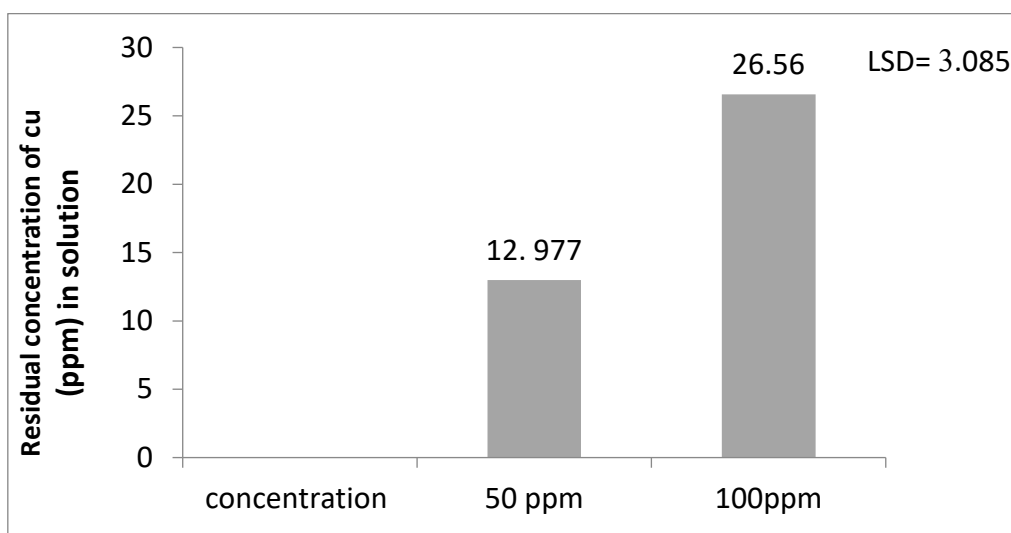


Figure 3. Effect of Copper Concentration on Removal Efficiency

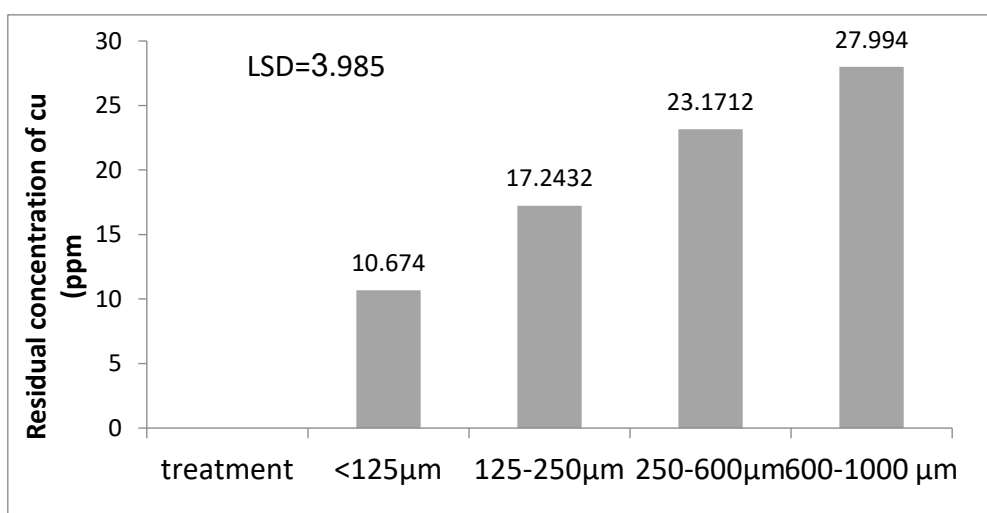


Figure 4. Effect of Plant Particles Size on Removal Efficiency

Removal Percentage of 50ppm and 100ppm Copper Solutions by Plant Micro Particles

Removal of copper from solutions was studied on several dry plant particles sizes (shown in Figure 5), The results indicated that the highest removal percentage of copper in solutions was 86.146% at the concentration of 50 ppm and < 125µm size of plant particles, while the lowest removal percentage was 62.6207 at 100 ppm and 600-1000 µm

In many aquatic ecosystems, aquatic plants are essential for recycling nutrients and heavy

metals. Among these vital plants is *C. demersum*, that is frequently found in bodies of water worldwide and is used in studies on water quality to monitor heavy metals and other pollutants present in sediment and water. It also accumulates pollutants at a higher level than its surrounding (Pourkhabbaz, et al., 2011). The development of plant materials for large-scale use as cleaning media requires an understanding of the effects of various physico-chemical parameters, including particle size, adsorbent substance concentrations, and heavy metal concentrations, on the uptake of heavy metals by

these new adsorbent species. Protein, carbohydrates, and phenolic compounds—which contain metal-binding functional groups like carboxyl, hydroxyl, sulfate, phosphate, and amino groups—may be the primary causes of these particles' sorption of heavy metals (Van

Cutsem, et al., 1984; Al-Asheh, et al., 1999; Faur-Brasquet, et al., 2002). Because of this, *C. demersum* is used to assess the plant's capacity to remove specific heavy metals from aqueous solutions (Al-Asheh, et al., 1999).

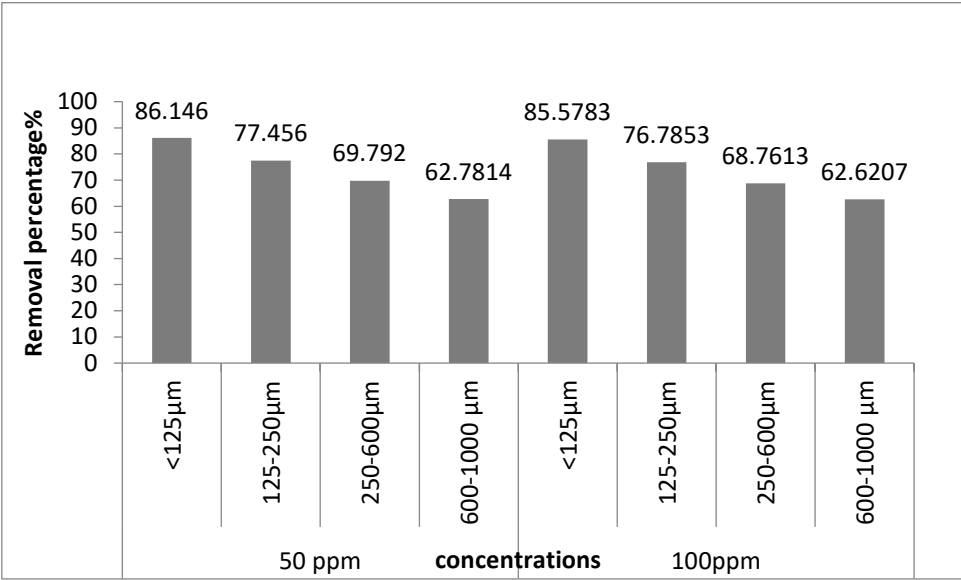


Figure 5. Removal Percentage of 50ppm and 100ppm Copper Solutions by Plant Micro Particle Sizes

Based on the treatment of dried plants with varying particle sizes, the residual content of copper decreased. The adsorption efficiency of smaller particles was higher due to their increased surface area. the result agree with Benhima, et al., (2008), who investigated how particle size affected the adsorption process and can The number of active sites and likelihood of binding to heavy metals increase as the specific surface area increases with decreasing particle size.

The same thing was found by Dhabab, Hussien, & Nasser, (2012) who stated that increased surface area is associated by decreased particle size, but increasing particle size will not result in additional active sites since a metal ion will be saturated and adsorption will be reduced.

The specific surface area of materials utilized as carriers for adsorption of metal ion is dependent on the size of the particles, as several studies have shown (Sarin, & Pant, 2006; Gupta, &

Bhattacharyya, 2006). The results also showed, the amount of metal ion removed from solution increases with the increase of metal ion concentration in solution and the percentage of metal ion removed from solution decreases with increasing metal ion concentration. This result agrees with Salim, & El-Halawa, (2002). Investigated the effectiveness of dry plants in removing lead, cadmium, and copper from aqueous solutions; the amount of metal ions removed from the solution increased as the concentration of the metal ions in the solution increased, and the percentage of the metal ions removed from the solution decreased as the concentration of the metal ions increased.

Conclusion

Ceratophyllum demersum showed high efficiency in adsorption of copper element from aquatic environment, the amount of copper ions

removed by dried plant increase with increase of metal ion concentration, on other hand, the percentage of metal ion removed decrease with increase of metal ion concentration.

References

- Abdulkareem, H. N., & Alwared, A. I. (2019). Immobilization dried mix of algae for copper removal. *Iraqi Journal of Agricultural Sciences*, 50(3), 800–808.
- Adsorption of metal cations from aqueous solution onto a natural and a model biocomposite. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 2003.
- Agency for Toxic Substances and Disease Registry. (2010). Background and environmental exposure to copper in the United States. Retrieved February 19, from <http://www.atsdr.cdc.gov/toxprofiles/tp132-c2.pdf>.
- Al-Asheh, S., et al. (1984). Preliminary ESR study and relation with ion exchange thermodynamics of copper adsorbed on a biological ion exchanger, the *Nitella flexilis* cell wall. *Reactive Polymers*.
- Al-Asheh, S., et al. (1999). Sorption of copper and nickel by spent animal bones. *Chemosphere*, 38(3), 517-528. [https://doi.org/10.1016/S0045-6535\(98\)00312-0](https://doi.org/10.1016/S0045-6535(98)00312-0)
- Benhima, H., et al. (2008). Removal of lead and cadmium ions from aqueous solution by adsorption onto micro-particles of dry plants. *Colloids and Surfaces B: Biointerfaces*, 61(1), 10-16. <https://doi.org/10.1016/j.colsurfb.2007.06.026>
- Chiban, M., Soudani, A., Sinan, F., Tahrouch, S., & Persin, M. (2011). Characterization and application of dried plants to remove heavy metals, nitrate, and phosphate ions from industrial wastewaters. *Clean–Soil, Air, Water*, 39(4), 376–383. <https://doi.org/10.1002/clen.201000270>
- Davila-Jiménez, M. M., et al. (2002). Bioadsorption of Pb(II), Cd(II), and Cr(VI) on activated carbon from aqueous solutions. *Carbon*.
- Dhabab, J. M., Hussien, K. A., & Nasser, T. (2012). Removal of cadmium ions from industrial wastewater using Iraqi *Ceratophyllum demersum*. *AlMustansiriyah Journal of Science*, 23(8), 71-84.
- Eisazadeh, H. (2008). Removal of arsenic in water using polypyrrole and its composites. *World Applied Sciences Journal*, 3(1), 10-13.
- Faur-Brasquet, C., et al. (1999). Sorption of copper and nickel by spent animal bones. *Chemosphere*, 38(3), 517-528. [https://doi.org/10.1016/S0045-6535\(98\)00312-0](https://doi.org/10.1016/S0045-6535(98)00312-0)
- Faur-Brasquet, C., et al. (2002). Removal of metal ions from aqueous solution by adsorption onto activated carbon cloths: Adsorption competition with organic matter. *Carbon*, 40(13), 2671-2677. [https://doi.org/10.1016/S0008-6223\(02\)00171-4](https://doi.org/10.1016/S0008-6223(02)00171-4)
- Gupta, S. S., & Bhattacharyya, K. G. (2006). Removal of Cd (II) from aqueous solution by kaolinite, montmorillonite, and their poly (oxo zirconium) and tetrabutylammonium derivatives. *Journal of Hazardous Materials*, 128(2-3), 247–257. <https://doi.org/10.1016/j.jhazmat.2005.08.011>
- Kadirvelu, K., Faur-Brasquet, C., & Cloirec, P. L. (2000). Removal of Cu (II), Pb (II), and Ni (II) by adsorption onto activated carbon cloths. *Langmuir*, 16(22), 8404–8409. <https://doi.org/10.1021/la000116x>
- Mohammed, O., & M-Ridha, M. (2019). Phytoremediation of organic pollutants in wastewater using native plants. *Association of Arab Universities Journal of Engineering Sciences*, 26(2), 54–65.
- Pourkhabbaz, A. R., et al. (2011). Assessment of heavy metal accumulation in Anzali wetland, Iran, using a submerged aquatic plant, *Ceratophyllum demersum*. *African Journal of Aquatic Science*, 36(3), 261-265. <https://doi.org/10.2989/16085914.2011.633380>

Rivera-Utrilla, J., et al. (2002). Removal of metal ions from aqueous solution by adsorption onto activated carbon cloths: Adsorption competition with organic matter. *Carbon*, 40(13), 2671-2677. [https://doi.org/10.1016/S0008-6223\(02\)00171-4](https://doi.org/10.1016/S0008-6223(02)00171-4)

Salim, R., & El-Halawa, R. A. (2002). Efficiency of dry plant leaves (mulch) for removal of lead, cadmium, and copper from aqueous solutions. *Process Safety and Environmental Protection*, 80(5), 270-276. <https://doi.org/10.1205/095758202762277604>

Sarin, V., & Pant, K. (2006). Removal of chromium from industrial waste by using eucalyptus bark. *Bioresource Technology*, 97(1), 15–20. <https://doi.org/10.1016/j.biortech.2005.02.019>

Syed, I., et al. (2018). Ceratophyllum demersum: A free-floating aquatic plant: A review. *Indian Journal of Pharmaceutical and Biological Research*, 6(2), 10-17.

Taha, A. A., Hameed, N. J., & Rashid, F. H. (2019). Study of toxic heavy metal removal by

different chitosan/hyacinths plant composite. *Iraqi Journal of Agricultural Sciences*, 50(5), 1416-1424.

Valko, M. M. H. C. M., Morris, H., & Cronin, M. T. D. (2005). Metals, toxicity, and oxidative stress. *Current Medicinal Chemistry*, 12(10), 1161–1208. <https://doi.org/10.2174/0929867053764635>

Van Cutsem, P., et al. (1984). Preliminary ESR study and relation with ion exchange thermodynamics of copper adsorbed on a biological ion exchanger, the Nitella flexilis cell wall. *Reactive Polymers*.

Van Cutsem, P., et al. (2002). Evaluation of heavy metal removal from aqueous solution onto scolecite. *Water Research*.

Yassen, M. M., & Fakhar, S. J. (2015). Removal of lead and cadmium ions from aqueous solution by adsorption onto micro-particles of dry plants. *Journal of Biology, Chemistry, and Environmental Sciences*, 10(1), 299-314.