Eco. Env. & Cons. 30 (January Suppl. Issue) : 2024; pp. (S231-S234)

ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i01s.047

Phytoremediation Performance of *Syngonium sp.* for Selected Heavy Metal Contaminated Water by Hydroponic Method

Abhijeet A. Salve[1] and Umesh B. Kakde[2]*

Department of Botany, The Institute of Science, Mumbai, 400 032, India

(Received 28 June, 2023; Accepted 20 August, 2023)

ABSTRACT

Many industrial activities have contributed in heavy metal accumulation in water bodies. These metals are considered as major pollutant of water ecosystem due to its toxic nature which can lead to environmental problems. In the aquatic ecosystem heavy metals are absorbed, deposited and accumulated in plant and animal bodies and subsequently infect the ecological food chains and leads to biomagnification. There is a need for a reliable and cost-effective method of cleaning the water environment. Phytoremediation is referring to the use of plants and microbes to reduce the concentrations of heavy metals or toxic contaminants. Contaminants such as metals, pesticides etc. have been mitigated in plant parts as many plants having hyperaccumulating capacities. In the present investigation *Syngonium* (ornamental plant) was used as a phytoremediation agent using hydroponic system. *Syngonium* shows 100% survival rate in each treatment at a different concentration (10 to 100 ppm) and shows no adverse symptoms during growth. After thirty days of treatment, it is observed that, copper was removed most often (96%) followed by mercury (60%) and cobalt (36%), while manganese was the least frequently removed (14%). In 100 ppm treatment the root of *Syngonium* showed the highest absorption rate of Hg (96.3%). In 50 ppm treatment with Mn the highest Mn accumulation (75.2%) was registered in the root. While, in 100 ppm treatment only 8.9% of Co has been accumulated in the roots. The higher concentration of Cu (28.4%) was found in leaves treated with 100 ppm, while lowest concentration of Hg (1.5%) registered in the leaves.

Key words: *Phytoremediation, Heavy metal, Hydroponic, Water Pollution, Biomagnification*

Introduction

Heavy metals are naturally present in soil, but geologic and anthropogenic processes increase their concentration to levels that are hazardous to plants and animals. The activities include mining and smelting of metals, burning fossil fuels, using fertilizers and pesticides in agriculture, manufacturing batteries and other metal products, and disposing of sewage sludge (Raskin *et al.*, 1994). Plants growing in heavy metal polluted soils have reported growth reductions due to physiological and biochemical changes. Eventually, food insecurity is caused by a decline in plant growth, resulting in lower yields (Chibuike and Obiora, 2014). Industrial, municipal, and urban runoff usually contains toxic metals, which can be harmful to humans and biotic life. As a result of urbanization and industrialization, waterways are becoming more polluted with trace metals, especially heavy metals. According to (Jobby and Desai, 2018) there is evidence that drinking water contaminated with heavy metals can lower energy

([1]Research Scholar, [2]Professor)

levels and damage the central nervous system. Also, they alter the blood's composition in a negative way, harming crucial organs like the liver and kidneys.

Overexposure to heavy metals causes muscular, physical and neurological degenerative processes that end in Alzheimer's disease, Parkinson's disease, and muscular dystrophy. Moreover, lead is one of the most prevalent heavy metals in drinking water, can cause general metabolic poisoning and enzyme inhibitors when more than its permissible limit (Mohod and Dhote, 2013). Therefore, heavy metal polluted water must be remedied.

A new green technology for water decontamination has emerged called phytoremediation. Plant bioremediation, which exploits the hyperaccumulating trait exhibited by some plants species, is an eco-friendly, non-expensive technique that either contains the contaminants in the water or removes them from the soil matrix. It included various processes such as rhizofiltration, phytoextraction, phytodegradation, phytostabilization, etc. (Rajalakshmi and Sudha, 2011). A plant's ability to remove heavy metals from soil depends on the mechanisms it uses to absorb heavy metals, which are influenced by its genetic background, external, internal and physiological characteristics (Murtic *et al.,* 2019).

Research is needed to develop an effective, cheap, and economical way to treat water using natural adsorbents. In view of this, the present work aims to treat waste-water using *Syngonium* plant species.

Materials and Methods

Plant material and design of the experiment

Hydroponic experiments were set up in the laboratory. *Syngonium* plantlets were purchased from Pathare Nursery, Kalyan, Maharashtra. Plant was trimmed and make it in uniform size in length. In order to avoid stress, soil and sediment were carefully removed as frequently as possible with running water and left for one week to acclimatization (Li, 2022). The standard heavy metal solutions were made as per the standard procedure using the following chemicals: A stock of 1000 ppm was prepared using Cobalt chloride ($CoCl_2$), Copper sulfate pentahydrate ($CuSO_4$. $5H_2O$), Manganese sulfate monohydrate ($MnSO_4.H_20$), and Mercury sulfate ($HgSO_4$). Dilutions were made from the stock with 25, 50, 75 and 100 ppm respectively. Plant was also maintained in a beaker without heavy metal as control (Ignatius *et al.*, 2014; Masinire *et al.,* 2021).

Plant analysis for phytoremediation and determination of heavy metal

For phytoremediation studies, the plant sample was transferred to a 250 ml conical flask with heavy metal solution. Each flask's water level decreased over time due to evaporation and uptake by the plants. To ensure that the evaporating water did not contain heavy metals, each flask was topped up with distilled water before sampling (Masinire *et al.*, 2021). Heavy metal concentrations in solution were determined at the initial and final stages of the experiment. Plant rinsing with distilled water before harvesting and divided into their root and leaf portions then dried to a consistent weight in an oven kept at 70 °C for 24 hours (Zahedifar *et al.,* 2019).

Plant material was chopped and processed to make a fine powder with a grinder machine. 0.5 g powered samples were digested for three hours at 150 °C with 25 ml of 2:1 (HNO_3: HCl) in kjelTRON digestor reactor (Deepa *et al.,* 2015). Digested samples were filtered through the Whatman No. 42 filter paper to remove impurities. Distilled water was used to dilute the solution in a volumetric flask and leveled up to 25 ml. Heavy metal content in digests were determined using inductively coupled plasma atomic absorption spectroscopy (ARCOS, simultaneous ICP spectrometer), Germany (Turek *et al.,* 2019).

Results and Discussion

Heavy metal removal by *Syngonium* sp.

Indiscriminate application of heavy metals can change the biochemical balance. Hence, the excess amount of toxic heavy metals like copper, lead, cadmium, nickel, and chromium are directly discharged into the soil and water bodies (Senthil Kumar and Gunasundari, 2018). In each treatment plants were survived after 30 days of treatments with all metals with different concentration. The plant showed no toxicity symptoms, suggesting it had good tolerance capacities for Mn, Co, Cu, and Hg.

There is a general trend in the experiment showing a decrease in the concentration of heavy metals (Cu, Hg, Co, Mn) from the initial to the final stage of the experiment. Figure 1 shows that all the selected heavy metals have been removed by the plants in lower concentrations i.e., 25 ppm. Copper, mercury and manganese were efficiently removed in all the treatments, whereas least removal of cobalt was registered in higher concentration.

The efficiency of heavy metal removal by *Syngonium* in the wastewater contains different heavy metals in different concentrations is Hg>Cu>Mn>Co.

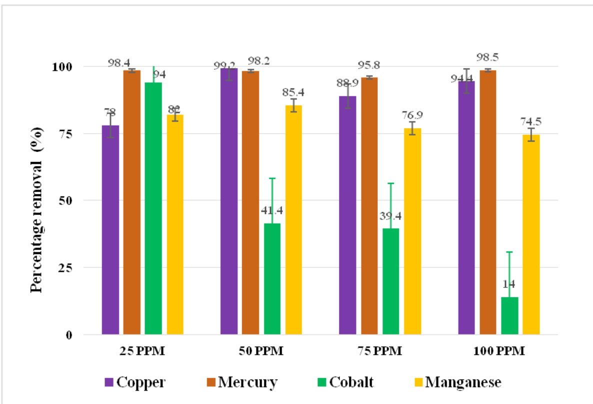

Fig. 1. Percentage of heavy metals removal by *Syngonium* sp. in 30 days of treatment

It is observed that the maximum accumulation of all the heavy metal was observed in the root as compared to leaves and it may be the higher density of roots. Results showed that most heavy metals were being removed within thirty days. Hg has accumulated at the highest concertation (97.6 %) by *Syngonium* even in 100 PPM treatment.

The maximum accumulation of Hg (96.3%) was recorded in the root of *Syngonium* in 100 PPM treatment. While the maximum accumulation of Mn (75.2%) was detected in root in 50 PPM treatment, whereas *Syngonium* root accumulation of Co (8.9 %) is significantly low in the 100 PPM treatment. It also revealed that that *Syngonium* plant accumulates all the heavy metals in the roots except Cobalt and showed deficiency in the accumulation of cobalt. The plant binds most of the mobile metals and stores them in the roots, thereby reducing the bioavailability of heavy metals (Pandey *et al.*, 2016). In leaves, concentrations of Cu was higher (28.4%), whereas lower in Hg (1.5%) in 100 ppm treatment. Effective phytoremediation capacity of *Syngonium* for metals such as Cu, Hg and Mn is proven whereas it is not an efficient accumulator of Co. In a case study on *Vallisneria natans* (Lour.) there was a decrease in chlorophyll content, and an increase in MDA level and antioxidant enzymes (SOD, CAT, and POD) activities (Li *et al.*, 2018). In Figure 2 the graph shows the mean concentration of heavy metal in the root (a) and in leaves (b).

In the present investigation, we have used *Syngonium* plants which showed unique characteristics as this plant shows much greater capacity to take up heavy metals from the water and have the to grow fast; and a profuse root system (Jabeen *et al.*, 2009; Rascio and Navari-Izzo, 2011; Muszyñska and Hanus-Fajerska, 2015). Terrestrial plants are more efficient for rhizofiltration compared to aquatic plants because they employ natural solar-driven pumps to take up particular elements from the environment.

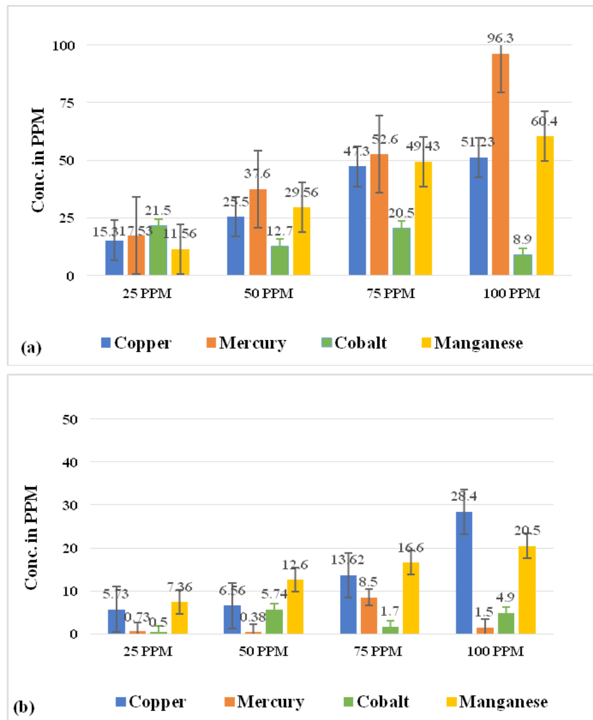

Fig. 2. Mean concentration of heavy metal in root (a) and in leaves (b)

Conclusion

Anthropogenic activities continuously contaminate the water; therefore, it threatens the survival of all living organisms. The increasing population and the demand for water has created awareness for search for new techniques to reuse waste water. Bioremediation is an effective and eco-friendly technology for removing heavy metals and other toxic chemicals from the soil and aquatic environment. This method of employing *Syngonium* to clean heavy metal-contaminated water proved cost effective and efficient. It has been shown that *Syngonium* is significantly effective to reduce Cu, Hg and Mn metals from water. Syngonium reduces selective heavy metals, so it should be considered a solution for cleaning up pollution in the water environment. In Syngonium, metals were mainly found in the organs below ground. The plant has the ability to stabilize metals effectively, which indicates that it can be used as a phytostabilizer. While setting up research on phytoremediation, we must focus on identify hyperaccumulating plants that are fast-growing with abundant biomass and be tolerant to several metals.

Conflict of interest: Nil

References

Chibuike, G. U. and Obiora, S. C. 2014. Heavy metal polluted soils: Effect on plants and bioremediation methods. *Applied and Environmental Soil Science*, https://doi.org/10.1155/2014/752708

Deepa, P., Sheetal, B., Ashok, K. and Nisha, D. 2015. Phytoremediation potential of *Lantana camara* and *Polygonum glabrum* for arsenic and nickel contaminated soil. *Research Journal of Chemical Sciences*. 5(8): 18–22.

Ignatius, A., Arunbabu, V., Neethu, J. and Ramasamy, E. V. 2014. Rhizofiltration of lead using an aromatic medicinal plant *Plectranthus amboinicus* cultured in a hydroponic nutrient film technique (NFT) system. *Environmental Science and Pollution Research*. 21(22): 13007-13 a nutrient film technique (NFT) experimen. https://doi.org/10.1007/s11356-014-3204-1

Jabeen, R., Ahmad, A. and Iqbal, M. 2009. Phytoremediation of heavy metals: Physiological and molecular mechanisms. *Botanical Review*. 75(4): 339–364. https://doi.org/10.1007/s12229-009-9036-x

Rajalakshmi, K. and Sudha, P.N. 2011. Evaluation of lead phytoextraction potential of *Calendula officinalis I*. (Marigold) from heavy metal polluted soils. *The Ecoscan, an International Journal of Environmental Sciences. Specal.* 1: 347-351.

Li Shuhu, Guangyi Liu and Ting Zhang 2022. Phytoremediation potential of *Acorus calamus* L ., an emergent macrophyte, to remove inorganic arsenic from water. *Resarch square*, ;1:1-18. https://doi.org/10.21203/rs.3.rs-2131501/v1

Li, B., Gu, B., Yang, Z. and Zhang, T. 2018. The role of submerged macrophytes in phytoremediation of arsenic from contaminated water: A case study on *Vallisneria natans* (Lour.) Hara. *Ecotoxicology and Environmental Safety.* 165: 224–231

Masinire, F., Adenuga, D. O., Tichapondwa, S. M. and Chirwa, E. M. N. 2021. Phytoremediation of Cr(VI) in wastewater using the vetiver grass (*Chrysopogon zizanioides*). *Minerals Engineering*. 172. https://doi.org/10.1016/j.mineng.2021.107141

Mohod, C. V. and Dhote, J. 2013. Review of Heavy Metals in Drinking Water and Their Effect on Human Health. *International Journal of Innovative Research in Science, Engineering and Technology*. 2(7): 2992–2996.

Murtic, S., Jurkovic, J., Basic, E. and Hekic, E. 2019. Assessment of wild plants for phytoremediation of heavy metals in soils surrounding the thermal power station. *Agronomy Research*. 17(1): 234–244. https://doi.org/10.15159/AR.19.005

Muszyñska, E. and Hanus-Fajerska, E. 2015. Why are heavy metal hyperaccumulating plants so amazing? *Biotechnologia*, *96*(4), 265–271. https://doi.org/10.5114/bta.2015.57730

Pandey, S. K., Bhattacharya, T. and Chakraborty, S. 2016. Metal phytoremediation potential of naturally growing plants on fly ash dumpsite of Patratu thermal power station, Jharkhand, India. *International Journal of Phytoremediation*. 18(1): 87–93. https://doi.org/10.1080/15226514.2015.1064353

Patra, D. K., Pradhan, C. and Patra, H. K. 2018. Chromium stress impact on Lemongrass grown in Over Burden Soil of Sukinda Chromite Ore Mine (Odisha), India. *Annals of Plant Sciences*. 7(8): 2394. https://doi.org/10.21746/aps.2018.7.8.5

Rascio, N. and Navari-Izzo, F. 2011. Heavy metal hyperaccumulating plants: How and why do they do it? And what makes them so interesting? *Plant Science*. 180(2): 169–181. https://doi.org/10.1016/j.plantsci.2010.08.016

Renitta Jobby and Neetin Desai. 2018. Bioremediation of Heavy Metals. *Biodegradation and Bioremediation. Environmental Science and Engineering*. 8: 165–195. https://doi.org/10.1007/978-981-10-7485-1_9

Senthil Kumar, P. and Gunasundari, E. 2018. *Sustainable Wet Processing—An Alternative Source for Detoxifying Supply Chain in Textiles*. 37–60. https://doi.org/10.1007/978-981-10-4876-0_2

Turek, A., Wieczorek, K. and Wolf, W. M. 2019. Digestion procedure and determination of heavy metals in sewage sludge-an analytical problem. *Sustainability (Switzerland)*. 11(6): 4–10. https://doi.org/10.3390/su11061753

Zahedifar, M., Moosavi, A. A., Zarei, Z., Shafigh, M. and Karimian, F. 2019. Heavy metals content and distribution in basil (*Ocimum basilicum* L.) as influenced by cadmium and different potassium sources. *International Journal of Phytoremediation*. 21(5): 435–447. https://doi.org/10.1080/15226514.2018.1537253s