ISSN 2664-4169 (Print) & ISSN 2664-7923 (Online)
South Asian Research Journal of Biology and Applied Biosciences
Abbreviated Key Title: South Asian Res J Bio Appl Biosci

| Volume-8 | Issue-3 | May-Jun -2026 | **DOI: https://doi.org/10.36346/sarjbab.2026.v08i03.006**

Original Research Article

Effects of Cadmium Chloride and Lead Chloride on Physiological Status for *Ceratophyllum submersum* & *Ceratophyllum demersum*

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Article History
Received: 18.02.2026
Accepted: 10.04.2026
Published: 27.05.2026

Abstract: Aquatic plants exhibit the ability to bioaccumulate heavy metals, including cadmium and lead. However, the various physiological effects have not been studied in detail. Therefore, the current study aims to investigate the effects of cadmium chloride and lead chloride on the physiological status of *Ceratophyllum submersum* and *Ceratophyllum demersum*. The results of the study showed the effect of different heavy metal concentrations on the physiological state of the studied aquatic plants, *Ceratophyllum submersum* and *Ceratophyllum demersum*. There was a decrease in chlorophyll concentration and protein concentration in aquatic plants compared to the control group exposed to heavy metal concentrations. The study concludes that heavy metals affect the phylogenetic state of the plants *Ceratophyllum submersum* and *Ceratophyllum demersum* through loss of pigmentation, oxidative stress responses, or enzymatic changes. The current study aims to investigate the effects of cadmium chloride and lead chloride on the physiological status of *Ceratophyllum submersum* and *Ceratophyllum demersum*.

Keywords: Cadmium, Lead, *C. Submersum and C. Demersum*.

INTRODUCTION

Cadmium exposure reduces photosynthetic pigments (chlorophyll a and Gb, carotenoids) and damages photosystem II (PSII) light reactions, lowering photosynthetic efficiency. The metal can even replace Mg in chlorophyll molecules, disrupting light harvesting (Lin, *et al.,* 2019). Cd increases production of reactive oxygen species (ROS), leading to malondialdehyde (MDA) accumulation a marker of lipid peroxidation and oxidative damage (Kara, 2017). Protein content decreases with increasing Cd concentration and exposure time (Jin, *et al.,* 2017). At moderate Cd levels, antioxidant enzymes (like superoxide dismutase, catalase, peroxidase) may be activated, but these defenses can be overwhelmed at higher concentrations, leading to cellular damage (Qassim, *et al.,* 2024a and Qassim, *et al.,* 2025b). Higher Cd reduces fresh and dry weight, indicating inhibited growth (Zheng, et al., 2022). Cd likely interferes with metabolic pathways by binding to proteins and enzymes, displacing essential metal cofactors and disrupting electron transport in chloroplasts (Chen, *et al.,* 2015).

Even very low Cd can affect photosynthesis before other physiological symptoms appear (Ashraf, *et al.,* 2012). Wheal Lead exposure reduces cause accumulates Pb in a concentration-dependent manner (Mohammed, *et al.,* 2024).

Pb can build up to high levels in tissues, Lead exposure reduces chlorophyll content, similar to Cd, impairing photosynthesis (Akmukhanova, *et al.,* 2018). Protein levels respond to Pb stress, typically decreasing as concentrations rise (Abdallah, 2012). Increased MDA levels show enhanced lipid peroxidation and oxidative damage under Pb stress (Li, *et al.,* 2019).

Enzymes like superoxide dismutase (SOD) and catalase (CAT) are initially stimulated at low Pb doses but may decline with prolonged or high exposure. Peroxidase (POD) activity can continue rising, reflecting ongoing stress response, Some antioxidant and defense-related enzymes (like phenylalanine ammonialyase and polyphenol oxidase) may be induced under Pb stress, indicating biochemical adaptation attempts (Qassim, *et al*., 2024 c and Qassim, *et al*., 2025 a). The current study aims to investigate the effects of cadmium chloride and lead chloride on the physiological status of *Ceratophyllum submersum* and *Ceratophyllum demersum*.

Materials and Methods

This study used *Ceratophyllum submersum* and *Ceratophyllum demersum*. 250grams of plant material were weighed for each specimen and grown separately in ten 12-liter plastic containers. Ten liters of chlorine-free water were added to each container, and three different concentrations of the element under investigation (10, 20, and 30 mg/L) were used during the experiment (Qassim, *et al.,* 2024 b and Qassim, *et al.,* 2024 e). Plant samples were collected for protein and chlorophyll levels and heavy metal concentrations. Growth monitoring and data collection continued for 30 days. The protein content in plant tissues was estimated using the Bradford method, while the total chlorophyll content in aquatic plant tissues was measured using a chlorophyll meter (Qassim, *et al*., 2024 d and Qassim, *et al*., 2025 c).

Results and Discussion

The results of the study showed the effect of different heavy metal concentrations on the physiological state of the studied aquatic plants, *C. submersum and C. demersum.* At the end of the experiment, Figure (1 and 2) shows an increase in heavy metal concentrations in the tissues of the aquatic plants used, *C. submersum and C. demersum,* compared to the control group. Figure (1) shows the highest lead concentration in C. demersum (5.278), while the lead concentration was lower in C. submersum (5.011) compared to the control group. Figure (2) shows the lowest cadmium concentration in C. demersum (1.515), while the highest cadmium concentration was in C. submersum (2.018) compared to the control group. These results indicate the ability of the studied aquatic plants to accumulate these elements within their tissues, or to possess a specific mechanism for tolerating high concentrations of these elements, or to absorb them at high concentrations, where they are converted into inactive forms in the vacuoles (Qassim, *et al*., 2024 b and Qassim, *et al*., 2025 b). The differences in the concentration of accumulated elements in the plants can be attributed to differences in plant species, their physiological state, and their response to the element (Wang, *et al*., 2020). The study results also showed a decrease in the total chlorophyll concentration in the studied aquatic plants at the end of the experiment.

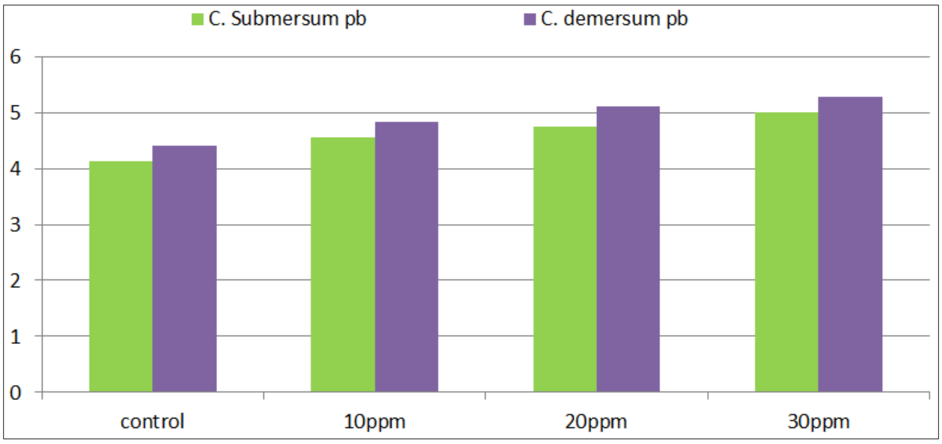

Figure 1: Three different concentrations of Pb in *C. submersum and C. demersum* tissue

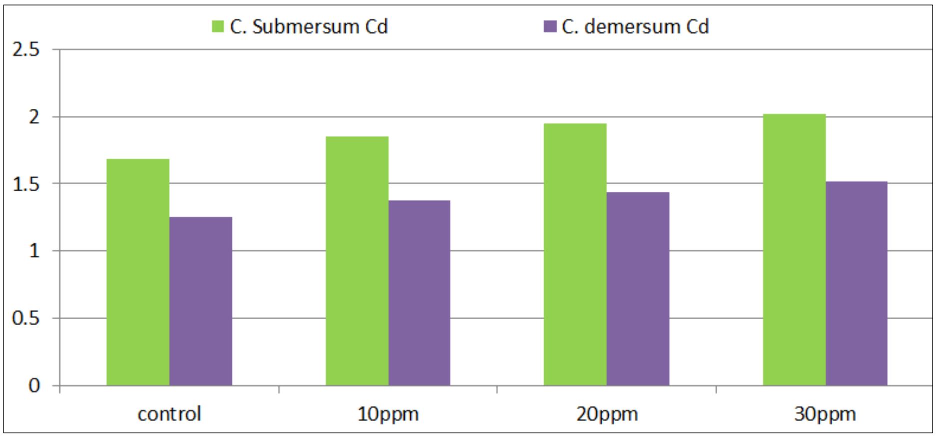

Figure 2: Three different concentrations of Cd in *C. submersum and C. demersum* tissue

Figure (3 and 4) illustrates the decrease in chlorophyll concentration in the aquatic plants compared to the control group exposed to heavy metal concentrations. Figure (3) shows that the chlorophyll concentration in C. demersum (4.282) was lower than in C. submersum (4.378) when exposed to lead, while Figure (4) shows that the chlorophyll concentration in C. submersum (3.586) was lower than in C. demersum (3.699) when exposed to cadmium. The low chlorophyll concentration in experimental plants is attributed to the presence of these highly toxic substances, which can accumulate in plant tissues (Qassim, *et al*., 2024 b and Qassim, *et al*., 2025 b). These substances inhibit chlorophyll synthesis by inhibiting the enzymes responsible for its production, such as aminolevulinic acid dehydratase and porphobilinogen deaminase, which are responsible for porphyrin formation. This can be explained by the fact that increased concentrations of heavy metals in plant tissues lead to a decrease in chlorophyll content due to their inhibitory effect on the enzymes involved in chlorophyll and carotene synthesis. Nasser points out that some enzymes contribute to chlorophyll synthesis (Soheil, 2019).

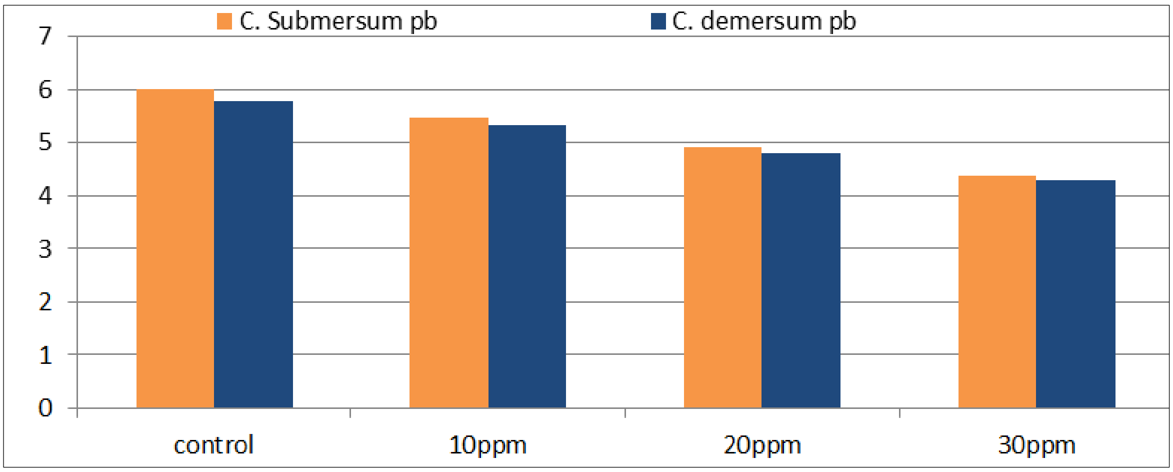

Figure 3: Effect concentrations of Pb chlorophyll in *C. submersum and C. demersum.*

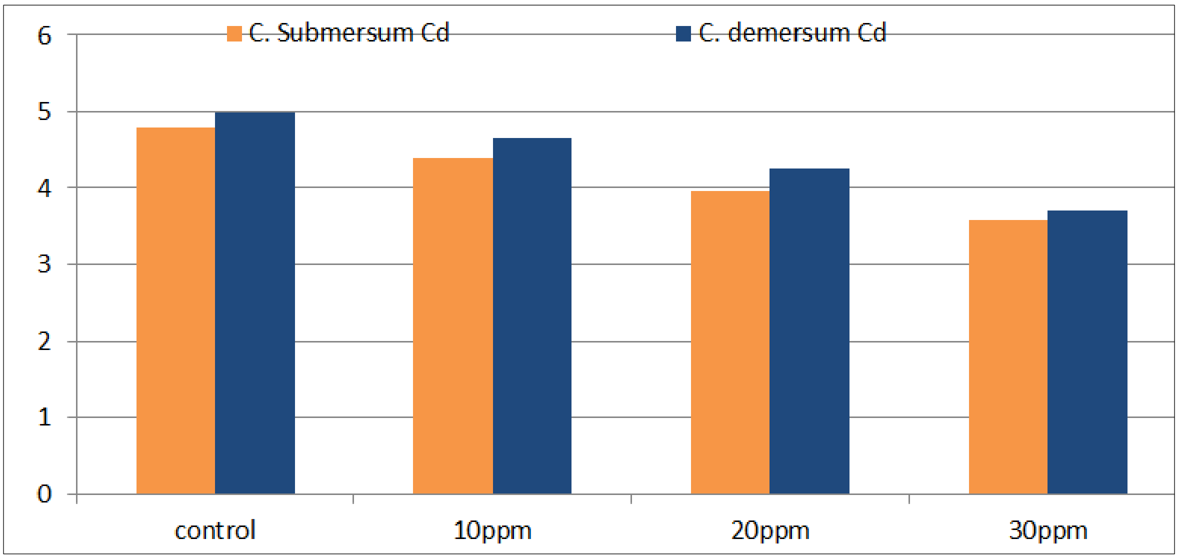

Figure 4: Effect concentrations of Cd on chlorophyll in *C. submersum and C. demersum.*

Figure (5&6) shows a decrease in protein concentration in aquatic plants compared to the control group exposed to heavy metal concentrations. Figure (5) shows that the protein content in C. demersum (2.409) was lower than in C. submersum (2.417) when exposed to lead, while Figure (6) shows that the protein content in C. submersum (1.698) was lower than in C. demersum (2.395) when exposed to cadmium. This is attributed to the consumption of protein in plant tissues to carry out vital activities or metabolic processes that occur within them to balance the concentration of these elements, thus reducing the percentage of protein in their tissues, This percentage decreases with the duration of exposure until the end of the experiment (Qassim, *et al*., 2024 b and Qassim, *et al.*, 2025 b).

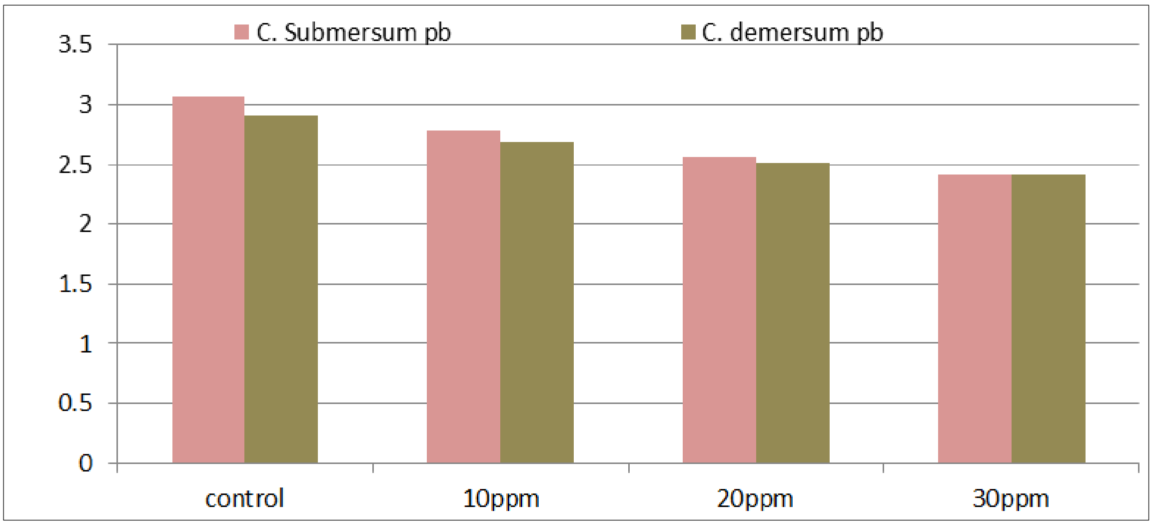

Figure 5: Effect concentrations of Pb on protein content in *C. submersum and C. demersum.*

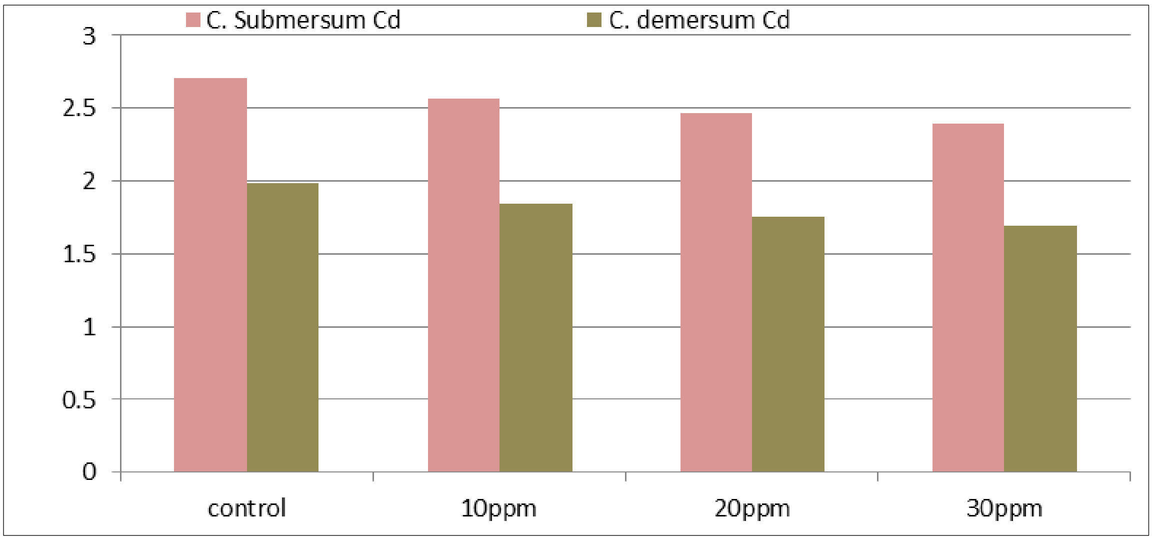

Figure 6: Effect concentrations of Cd on protein content in *C. submersum and C. demersum.*

Conclusion

C. submersum and C. demersum has been bioaccumulation potential for heavy metal, and physiological effects like pigment loss, oxidative stress responses, or enzyme alterations to Cd and Pb exposure such as reduced photosynthesis, oxidative stress, lowered protein content, and activation of antioxidant defenses although this needs confirmation by targeted experiments.

Acknowledgement: We thank to team of laboratory of Environmental pollution in Department of Environmental pollution /College of Environmental Science / Al-Qasim Green University, Babylon, Iraq for providing the appropriate facility to complete work.

Conflict of Interest: The authors have no conflict of interest.

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