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Original Research Article

Phytoremediation of Chromium and Iron by *Ceratophyllum submersum* and *Ceratophyllum demersum*

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Abstract: Heavy metals, such as chromium and Iron, can be bioaccumulated by aquatic plants. The different physiological impacts, however, have not been thoroughly investigated. Thus, the purpose of this study is to look into how iron and chromium chloride affect the physiological state of *Ceratophyllum submersum* and *Ceratophyllum demersum*. The study's findings showed physiological reactions such lower protein content and a drop in chlorophyll concentration, which affects photosynthesis. According to the study's findings, heavy metals have an impact on plants' evolutionary condition through enzyme alterations, oxidative stress reactions, and pigmentation loss.

Keywords: Phytoremediation, Aquatic Plants, Chromium and Iron.

INTRODUCTION

The aquatic plants exhibit high Bioconcentration factors for metals including Cr and Fe, meaning it can accumulate them from water even at low ambient levels, making it a good indicator of contamination and a candidate for phytoremediation [1]. The plants show a combination of Biosorption (surface binding) and bioaccumulation (internal uptake) mechanisms when exposed to metals, which can sequester Cr and Fe but might also alter physiological status when internal concentrations rise [2]. *Ceratophyllum submersum* is closely related to *C. demersum* and also noted for its potential in metal uptake based on bio factor analysis, but direct research on physiological effects under varying Cr and Fe stress remains scarce. Research suggests similar uptake and tolerance traits, given their shared genus characteristics [3].

Cr uptake often Irons to metal accumulation in tissues which may impair key physiological functions at high concentrations common in polluted waters. Aquatic plants including *C. demersum* often show reduced chlorophyll and protein content under increased Cr exposure, suggesting stress on photosynthesis and metabolism [4].

Ceratophyllum demersum can accumulate chromium from water, with significant chromium bio-concentration observed in plant tissues during exposure experiments, showing that the plant can act as a bio-accumulator for Cr [5]. Cr uptake often Irons to metal accumulation in tissues which may impair key physiological functions at high concentrations common in polluted waters. Aquatic plants including *C. demersum* often show reduced chlorophyll and protein content under increased Cr exposure, suggesting stress on photosynthesis and metabolism [6]. As an essential micronutrient, Fe is taken up by aquatic macrophytes and can be removed from water by Ceratophyllum, with significant reductions in Fe concentration in water during plant incubation [7].

At moderate levels Fe is generally tolerated, but excessive Fe can Iron to interference with physiological processes and oxidative stress (in other aquatic organisms, Fe can promote the formation of reactive oxygen species). Increased Cr is associated with reduced chlorophyll levels in *Ceratophyllum demersum* and other submerged aquatic species, indicating impairment of photosynthesis and lower energy production, in other aquatic plants, Cr stress correlates with decreased growth rates and metabolic inhibition, often via oxidative stress mechanisms that damage cellular structures [8]. For Fe, being a necessary cofactor in photosynthesis and electron transport, mild Fe levels support normal function. At high concentrations, excess Fe can precipitate and cause shading or oxidative effects that disrupt chloroplast structure and function, although specific plant studies are fewer [9]. Cr exposure in *Ceratophyllum demersum* and other aquatic vascular plants has been shown to reduce protein levels and disturb chloroplast ultrastructure, including disorganization of thylakoids. Oxidative stress from Cr uptake can Iron to increases in reactive oxygen species and stress-related metabolites (e.g., proline), while photosynthetic efficiency declines. Fe can affect redox balance in plant tissues [10]. While necessary for enzymes and electron transport, overabundance can generate free radicals that damage lipids, proteins, and DNA when antioxidant defenses are overwhelmed. Bioaccumulation and Biosorption are Both Cr and Fe are taken up and/or adsorbed by Ceratophyllum tissues, changing tissue metal composition and cellular processes [11]. Heavy metals disturb chloroplast structure and pigment content, lowering photosynthetic efficiency. Excess Fe/Cr can enhance reactive oxygen species that damage cellular components unless buffered by plant antioxidant systems.

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 [12, 13].

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 [14, 15].

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 Chromium concentration in *C. demersum* (3.357), while the lowest highest Chromium concentration was in *C. submersum* (2.842) compared to the control group. Figure (2) shows the highest Iron concentration in *C. demersum* (3.765), while the Iron concentration was lower in *C. submersum* (3.581) 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 [16, 17].

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, the study results also showed a decrease in the total chlorophyll concentration in the studied aquatic plants at the end of the experiment [18, 19].

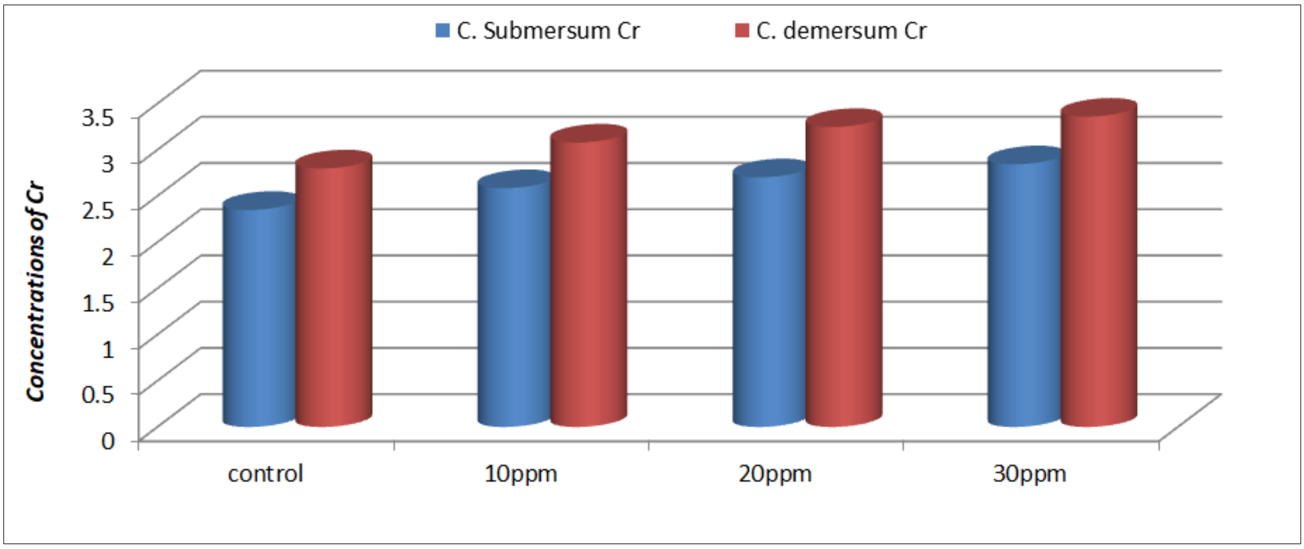

Figure 1: Three different concentrations of Cr in *C. submersum and C. demersum* tissue

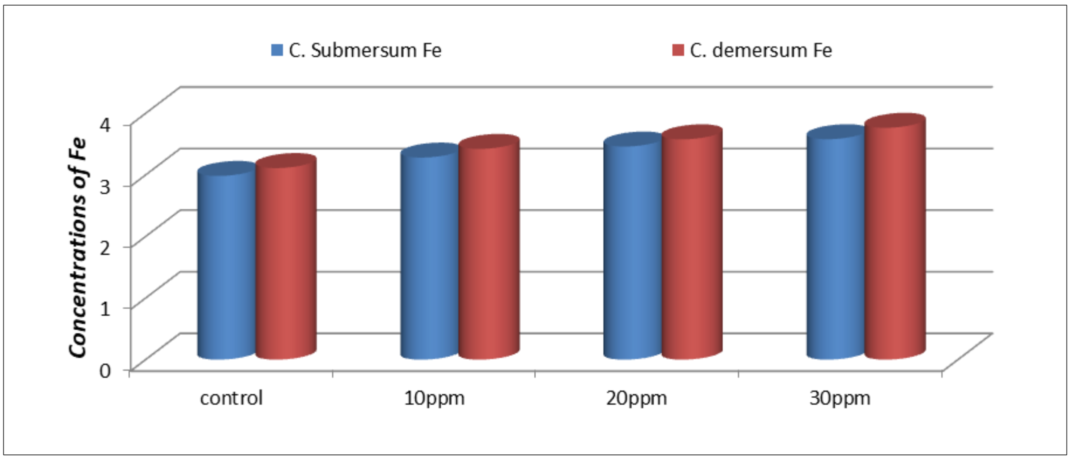

Figure 2: Three different concentrations of Fe in *C. submersum and C. demersum* tissue

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. submersum* (2.333) was lower than in *C. demersum* (2.709) when exposed to Chromium, while Figure (4) shows that the chlorophyll concentration in *C. demersum* (3.682) was lower than in *C. submersum* (3.811) when exposed to Iron. The low chlorophyll concentration in experimental plants is attributed to the presence of these highly toxic substances, which can accumulate in plant tissues [16, 17]. 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 Iron 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).

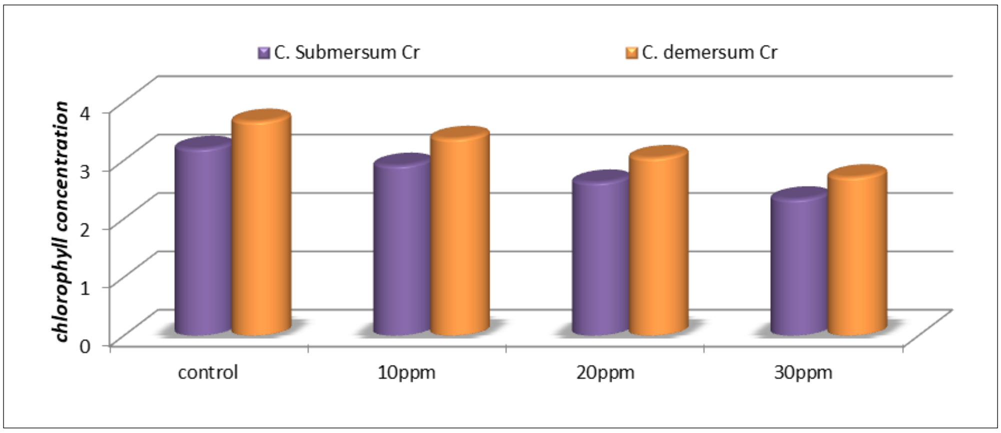

Figure 3: Effect concentrations of Cr on chlorophyll in *C. submersum and C. demersum.*

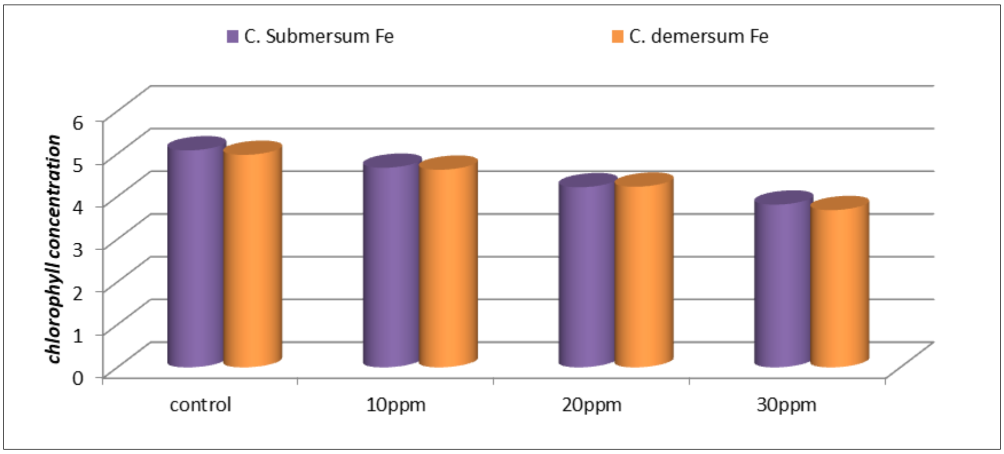

Figure 4: Effect concentrations of Fe on chlorophyll in *C. submersum and C. demersum.*

Figure (5 and 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* (2.831) was more than in *C. submersum* (2.544) when exposed to Chromium, while Figure (6) shows that the protein content in *C. submersum* (3.223) was more than in *C. demersum* (2. 931) when exposed to Iron. 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 [16, 17].

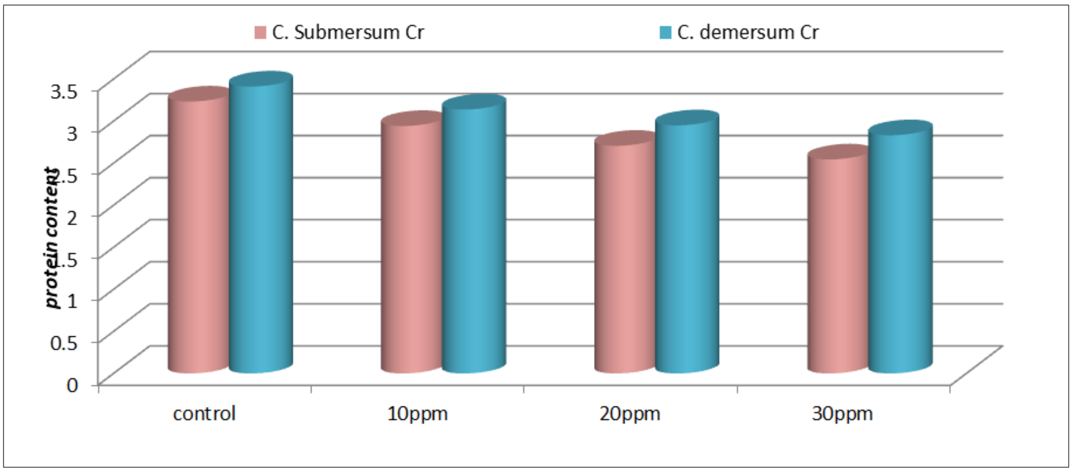

Figure 5: Effect concentrations of Cr on protein content in *C. submersum and C. demersum*

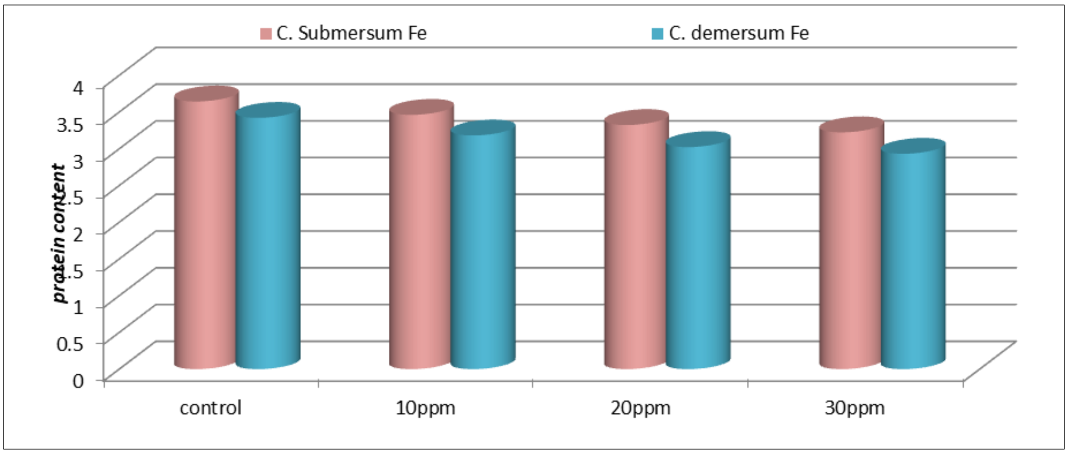

Figure 6: Effect concentrations of Fe on protein content in *C. submersum and C. demersum*

CONCLUSION

C. submersum and *C. demersum* exhibits high Bioconcentration factors for metals including Cr and Fe, meaning it can accumulate them from water even at low ambient levels, making it a good indicator of contamination and a candidate for phytoremediation. *Ceratophyllum submersum* is closely related to *C. demersum* and also noted for its potential in metal uptake based on bio factor analysis, but direct research on physiological effects under varying Cr and Fe stress remains scarce. Research suggests similar uptake and tolerance traits, given their shared genus characteristics.

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

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