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The Capability of Water Spinach (*Ipomoea aquatica*) as Phytoremediator of Heavy Metal Chromium (Cr)

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Abstract
In the current era of globalization, humans are involved in various industrial and household activities with high intensity, which leads to water pollution in rivers. This water pollution is caused by the discharge of waste from industries and household waste containing chromium (Cr). To prevent the harmful effects of chromium, it can be addressed through phytoremediation methods. Consequently, the purpose of this investigation is to illustrate the potential of water spinach (*Ipomoea aquatica*) as a phytoremediation species capable of lowering chromium (Cr) concentrations in the cultivation medium. This trial was arranged under a randomized block design (RBD) involving a single treatment variable, namely the chromium (Cr) concentration within the medium at 0 ppm, 5 ppm, 10 ppm, and 15 ppm. Evaluation of chromium content, foliar chlorophyll levels, and fresh biomass was carried out through a one-way ANOVA followed by Duncan's multiple range test. The treatment with 15 ppm chromium demonstrated a decrease of 11.853 ppm in the medium, yet it yielded the lowest chlorophyll value and the greatest reduction in biomass compared to the other treatments, reaching 10.167 mg/l and 142 grams, respectively, from an initial mass of 200 grams. A correlation coefficient of 0.796 was also identified, signifying a strong association between leaf chlorophyll concentration and the final fresh biomass of water spinach (*Ipomoea aquatica*). These outcomes confirm that *Ipomoea aquatica* possesses the capacity to uptake chromium (Cr)

Keywords: ANOVA; Growth Medium; Metal Absorption; Water Pollution

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INTRODUCTION

In the current era of globalization, humans are involved in various industrial and household activities with high intensity, leading to the clear impact of increased industrial activity, one of which is water pollution in rivers. The water pollution is caused by the discharge of waste materials from industries and household waste containing chromium (Cr) (Putri *et al.,* 2022). Chromium (Cr) is a type of heavy metal that cannot be degraded. Its characteristic properties, which are toxic even in small amounts, make heavy metals have the potential to cause negative impacts on the environment over a sustained period (Darmono, 2008). These heavy metals can cause damage to the lungs, liver, nervous system, and kidneys in humans if exposed to levels exceeding the established threshold (Alvarez *et al.,* 2021).

Chromium (Cr) is a toxic heavy metal often found in industrial effluents such as electroplating solutions, textile processes, pigments, dyes, and leather-curing activities. Elevated concentrations of chromium can suppress enzymatic functions, harm root tissues, and trigger alterations in chloroplast structures as well as cellular membranes. Decreased chlorophyll levels due to harmful absorption caused by these contaminants (Izzah *et al.,* 2018). In order to withstand the impact of chromium, polluted air will be treated by applying phytomediation techniques (Panda *et al.,* 2005). Phytoremediation is a process that requires plants to clean up pollution from contaminated soil and water (Ali *et al.,* 2013). Stability occurs through vegetation activity, which also extracts and degrades organic and inorganic substances in the environment. Aquatic plants play a crucial role in remediation, filtration, and reproduction in various ecosystems (Reddy *et al.,* 2013). These pollutants include heavy metals, industrial waste residues, household waste, heavy metals, and even agricultural waste (Rosyidah and Rachmadiarti, 2023). Furthermore, aquatic plants tend to be effective in reducing chromium (Cr) levels. For example, water spinach (*Ipomoea aquatica*) (Rahmadiah, 2020) is capable of absorbing toxic metals from its surroundings and adapts well to tropical conditions. Its rapid growth makes this species an effective and efficient phytoremediator. They are often found in rivers contaminated with heavy metals (Juhri, 2017).

Various previous studies have always discussed and discussed the role of water spinach in phytoremediation. Leading researchers include Agustyadevy (2013), Weerasinghe *et al.* (2007), and Sulastri *et al.* (2022). Agustyadevy's (2013) study later found that 100 grams of water spinach biomass was able to reduce chromium (Cr) levels by up to 84%. In another case, Weerasinghe *et al.* (2007) found and reported that the use of water spinach (*Ipomoea aquatica*) for phytoremediation had an average chromium absorption rate exceeding 60%, with the highest absorption results reaching 92%. Furthermore, Sulastri *et al*. (2022) showed that water spinach (*Ipomoea aquatica*) was able to play a role in reducing chromium concentrations with a very high efficiency of 97.26%, reducing the value from 1.388 mg/L to 0.038 mg/L.

Based on previous research, this question aims to describe the potential role *of Ipomoea aquatica* in reducing chromium (Cr) concentration and to examine how variations in Cr levels affect the proportion of leaf chlorophyll and plant fresh mass.

MATERIALS AND METHODS

This research was conducted from November to December 2023, at the C10 Greenhouse, Department of Biology, Faculty of Mathematics and Natural Sciences, Surabaya State University. Chlorophyll levels in plants were measured at the C10 Physiology Laboratory, Faculty of Mathematics and Natural Sciences, Surabaya State University. Chromium (Cr) concentrations were determined at the Environmental Laboratory, East Java Provincial Environmental Service.

The investigation commenced by acclimating *Ipomoea aquatica* in containers filled with purified water for a duration of one week. The cultivation medium was then arranged by dissolving potassium dichromate ($K_2Cr_2O_7$), a dense chromium compound, at varying concentrations into vessels holding five liters of distilled water. The chromium dosages consisted of 5 ppm, 10 ppm, 15 ppm, along with a control group maintained at 0 ppm. In the treatment phase, 200 grams of *Ipomoea aquatica* were weighed and introduced into the prepared medium containing the chromium solution, simulating wastewater with different levels of contamination. This procedure lasted seven days, during which physicochemical indicators such as temperature and pH were monitored both prior to and following the exposure period.

The chromium (Cr) concentration in the treated medium will be analyzed with an Atomic Absorption Spectrophotometer (AAS) at 324.7 nm. For chlorophyll assessment, 1 g of leaf tissue will be weighed, cut, ground, mixed with 100 ml of 96% ethanol, and filtered before spectrophotometric reading at 649 nm and 665 nm. The fresh biomass of *Ipomoea aquatica* (initial and final) will be measured using a digital balance, while pH and temperature will be monitored with a pH meter and thermometer.

In this research, the dataset will be processed through the SPSS application, employing a single-factor ANOVA approach along with Duncan's multiple range test. The one-way ANOVA will serve to examine how plant species influence chromium levels, chlorophyll concentration, and fresh biomass yield, whereas Duncan's method will determine the specific variations among the different treatments. At the same time, measurements of temperature and pH will be interpreted through a quantitative descriptive technique.

RESULTS

The application of differing Cr dosages influenced the decline of chromium content in the solution, as illustrated in Table 1. From the experimental outcomes, it was revealed that water spinach possesses the ability to diminish chromium accumulation in its environment, with its uptake of the metal escalating proportionally to the elevated concentrations within the substrate. The Cr treatment with a concentration of 15 ppm showed a higher reduction compared to the treatments with Cu concentrations of 10 ppm and 5 ppm (Table 1).

The amount of chlorophyll found in *Ipomoea aquatica* foliage following exposure to different levels of chromium is presented in Table 2. The pigment concentration within the leaves was shaped by the variation in Cr doses applied. A noticeable decline in chlorophyll levels occurred as the chromium concentration in the cultivation medium rose. The control group at 0 ppm recorded the highest chlorophyll level of 16.498 ppm, whereas the least level of 10.167 ppm, appeared in plants subjected to 15 ppm of Cr (Table 2).

Table 1. The results of chromium (Cr) concentration reduction

Initial Cr Concentration (ppm)	Final Cr Concentration in the Growth Medium (ppm)	Reduction in Cr Concentration in the Growth Medium (ppm)
0	0±0.000	0±0.000[a]
5	0.777±0.465	4.223±0.465[b]
10	2.442±0.901	7.558±0.901[c]
15	3.147±1.534	11.853±1.534[d]

Note: Numbers followed by different alphabetic notations in rows and columns indicate that the data are significantly different according to the Duncan's test at a 0.05 significance level.

Table 2. Final Chlorophyll Content of Leaves

Cr Concentration (ppm)	Concentration a (mg/l)	Concentration b (mg/l)	Total Concentration (mg/l)
0	7.309±2.085	9.189±2.450	16.498±0.656[b]
5	4.953±1.865	5.729±0.999	10.682±2.360[a]
10	4.814±0.975	5.757±0.695	10.571±1.603[a]
15	4.609±1.311	5.558±1.001	10.167±2.278[a]

Note: Numbers followed by different alphabetic notations in rows and columns indicate that the data are significantly different according to the Duncan's test at a 0.05 significance level.

The final wet biomass of *Ipomoea aquatica* decreased after treatment with various concentrations of Cr as shown in Table 3. The treatment with Cr concentrations affected the wet biomass. The higher the Cr concentration in the growth medium, the greater the impact on the reduction of wet biomass. The greatest reduction in wet biomass occurred in the 15 ppm concentration treatment, while the 0 ppm concentration treatment showed an increase in wet biomass (Table 3).

Table 3. Final Biomass of Water Spinach Plants

Species	Cr Concentration (ppm)	Final Wet Biomass (gram)
Ipomoea aquatica	0	243±2.994[a]
	5	181±2.160[b]
	10	164±0.901[c]
	15	142±2.167[d]

Note: Numbers followed by different alphabetic notations in rows and columns indicate that the data are significantly different according to the Duncan's test at a 0.05 significance level.

The findings from the association analysis of chlorophyll concentration in water spinach (*Ipomoea aquatica*) foliage indicated a p-value of 0.000, indicating a relationship between the chlorophyll content of water spinach leaves and the final wet biomass of the plant. A correlation value of 0.796 was obtained, which, when considering the degree of relationship, indicates a strong correlation between the chlorophyll content of water spinach leaves and the final wet biomass.

The results of the physico-chemical environmental factor measurements obtained are presented in Table 4, which includes the average pH and temperature values of the growing media at various concentrations of Chromium (Cr) metal. The pH level showed an increasing trend during the duration of the experiment. The average pH readings at concentrations of 0 ppm, 5 ppm, 10 ppm, and 15 ppm were recorded at 7.17; 7.16; 7.21; and 7.31, respectively. Meanwhile, the average temperature value at the same concentration experienced an insignificant decrease, but remained stable within the standard interval, namely 26–27°C.

Table 4. Changes in the average physical and chemical parcels of the growth medium

Parameter	Treatment	Cr Concentration (ppm)			
		0	5	10	15
pH	Start	7.25±0.073	6.71±0.0296	6.72±0.035	6.79±0.028
	End	7.17±0.035	7.16±0.031	7.21±0.013	7.31±0.0378
Temperature (°C)	Start	29.7±0.367	29.9±0.270	29.9±0.122	29.9±0.423
	End	27.1±0.248	26.9±0.197	26.8±0.252	26.7±0.232

DISCUSSION

The administration of chromium (Cr) extract affected the Cr concentration in the culture medium, resulting in a significant decrease in heavy metal levels following the addition of chromium. This phenomenon is caused by Cr uptake by water spinach (*Ipomoea aquatica*). The absorption occurs for contaminants from polluted water, and plant roots play a crucial and significant role in this regard (Al-

Ajalin *et al.,* 2020). In addition to root function, microorganisms also contribute to the release of Cr in the rhizosphere. These microbes have the ability to rapidly reduce Cr levels in aquatic systems (Umar *et al.,* 2023). Plant roots work to reduce pollutants in diluted environments (Yuliasni *et al.,* 2023). Water spinach is capable of absorbing chromium ions from soil and water through its root system and accumulating them in plant tissues, particularly the roots and leaves (Weerasinghe *et al.,* 2008).

Chromium uptake occurs both actively—requiring energy for membrane transport—and passively through diffusion. This metal is generally present in the forms Cr^{6+} (hexavalent) and Cr^{3+} (trivalent), with the hexavalent form being more toxic (Sugihartono, 2016). Roots can internalize both forms through epidermal absorption, surface adsorption, or pore penetration (He *et al.,* 2023). Once inside the plant, chromium moves upward through the xylem vessels or diffuses via the phloem to reach other plant parts. Chromium can accumulate in the cytoplasm, vacuoles, or cell walls, which helps reduce its toxicity. Some plants, such as water spinach, can store significant amounts of chromium in their tissues. The overall absorption mechanism is complex and influenced by environmental factors, including chromium availability, soil pH, and plant growth conditions (Hidayati, 2013).

Oxidative imbalance triggered by the emergence of reactive radicals exerts a harmful influence on vegetation development; as radical levels rise, overall biomass is progressively diminished. This condition additionally provokes cellular impairment and manifests in outward signs such as drooping, yellowing, and tissue death of foliage. The accumulation of chromium within leaves may further suppress crucial enzymatic functions needed in the synthesis of chlorophyll. Interruption of this biosynthetic route consequently disrupts photosynthetic performance within the plant system. Chromium intrusion interferes with plastoquinone particles embedded in the thylakoid layer of the chloroplast, alongside deteriorating the organelle's structure and lessening the catalytic actions essential for chlorophyll production (Surakusumah *et al.,* 2020).

Water spinach (*Ipomoea aquatica*) grown in growing media containing chromium (Cr) will experience a decrease in plant fresh weight This is because the accumulation of Cr causes the factory to be in a stressed-out condition, and the accumulation of essence in colorful corridor of the factory will reduce its functions, leading to a drop in wet weight (Paz-Alberto and Sigua., 2013). The reduction in factory weight can be caused by essence toxin, where chromium at high attention becomes poisonous to the factory. High chromium exposure can damage factory cells, dismembering metabolism and inhibiting overall factory growth. Also, the reduction in factory wet weight is also due to metabolic disturbances. Chromium can intrude with the factory's metabolic processes, including photosynthesis, respiration, and nutrient translocation. Nutrients similar as nitrogen, which are essential for factory growth, including water spinach, are affected. Nitrogen deficiency causes the leaves to turn yellow (chlorosis). Chlorosis can also lead to a decrease in plant biomass due to a lack of chlorophyll. When plants lack chlorophyll, their ability to produce energy is reduced, and chromium exposure can interfere with water and nutrient absorption. This disrupts critical physiological processes necessary for healthy plant growth and development.

Aquatic plants can absorb metals as they are influenced by both biotic and abiotic factors, including temperature, pH, and the ionic population of the water system (Irhamni, *et al.,* 2017). pH and temperature are physical-chemical factors used as supporting data during the treatment process. Generally, aquatic plants can grow optimally at temperatures of 20-30°C and with water pH ranging from 5 to 8. In the temperature measurements at the beginning and end of the study, values of 26.7-29.9°C and a water pH of 6.71-7.31 were obtained. These values are in accordance with the quality standards based on Government Regulation No. 22 of 2021, which states that the standard temperature deviation is 3, ranging from 25-30°C, and pH is around 6-9. pH values affect the results of phytoremediation tests because the pH of the growth medium influences the plant's growth and development process. If the pH of the growth medium does not approach neutral, the biological performance in the process of purifying water bodies from contaminants will be disrupted (Dewi and Faisal, 2015). The optimal pH for water spinach to remediate heavy metals is in the pH range of 7-8, so if the heavy metals in the waste have a high pH, water spinach cannot be used for remediation (Lestari, 2013).

CONCLUSION

The conclusion drawn from this research is that water spinach (*Ipomoea aquatica*) is capable of absorbing the heavy metal Cr in the growing medium. In the treatment with Cr at a concentration of 15 ppm, it was able to reduce the Cr level in the growing medium by 11.853 ppm, with a reduction percentage of 75.58%. As the Cr concentration in the growing medium increases, the absorption of Cr by *Ipomoea aquatica* also increases. Additionally, there is an effect of varying Cr concentrations on the chlorophyll content of *Ipomoea aquatica* leaves. As the Cr concentration in the growing medium increases, the chlorophyll content of *Ipomoea aquatica* leaves decreases. The growth (wet biomass) of *Ipomoea aquatica* is also affected; as the Cr concentration increases, the biomass of *Ipomoea aquatica* decreases.

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CONFLICT OF INTEREST

There is no conflict of interest

REFERENCES

Agusetyadevy I, Sumiyati S, and Sutrisno E, 2013. Fitoremediasi limbah yang mengandung Timbal (Pb) dan Kromium (Cr) dengan menggunakan kangkung air (*Ipomoea aquatica*). *Jurnal Teknik Lingkungan,* 2(2): 1-9.

Al-Ajalin FAH, Abdullah SRS, Idris M, Kurniawan SB, Ramli NN, and Imron MF, 2022. Removal of ammonium, phosphate, and COD by bacteria isolated from Lepironia articulata and Scirpus grossus root system. *International Journal of Environmental Science and Technology*, 19(12): 11893-11904.

Alvarez CC, Gómez MEB, and Zavala AH, 2021. Hexavalent chromium: Regulation and health effects. *Journal of trace elements in medicine and biology*, 65: 126729.

Ali H, Khan E, and Sajad MA, 2013. Phytoremediation of heavy metals concepts and applications. Chemosphere, 91(7) : 869-881.

Darmono, 2008. Lingkungan Hidup dan Pencemaran. Penerbit Universitas Indonesia, Jakarta. 69.

Dewi F and Faisal M, 2015. Efisiensi penyerapan phospat limbah laundry menggunakan kangkung air (*Ipomoea aquatic Forsk*) dan jeringau (*Acorus calamus*). *Jurnal Teknik Kimia USU,* 4(1) : 7-10. DOI: https://doi.org/10.32734/jtk.v4i1.1452.

He L, Wang S, Liu M, Chen Z, Xu J, and Dong Y, 2023. Transport and transformation of atmospheric metals in ecosystems: A review. *Journal of Hazardous Materials Advances*, 9: 100218.

Hidayati N, 2013. Mekanisme fisiologis tumbuhan hiperakumulator logam berat. Jurnal Teknik Lingkungan, 14(2) : 75-82

Irhamni I, Pandia S, Purba E, and Hasan W, 2017. Kajian akumulator beberapa tumbuhan air dalam menyerap logam berat secara fitoremediasi. *Jurnal Serambi Engineering,* 1(2): 75-84.

Izzah I, Supriatno S, and Wardiah W, 2018. Kiambang (*Pistia stratiotes*) sebagai agen fitoremediasi logam krom (Cr). In Prosiding Seminar Nasional Biotik, 5(1): 324-330.

Juhri DA, 2017. Pengaruh Logam Berat (Kadmium, Kromium, dan Timbal) terhadap Penurunan Berat Basah Kangkung Air (*Ipomoea aquatica Forsk*) sebagai Bahan Penyuluhan Bagi Petani Sayur. *Jurnal Lentera Pendidikan Pusat Penelitian LPPM UM Metro,* 2(2): 219-229.

Kasmiyati S, 2014. Deteksi Cekaman Oksidatif Akibat Tokksisitas Krom Pada *Sonchus Oleraceus L.* Melalui Penentuan Spesies Oksigen Reaktif Secara Spektrofotometri dan Histokimia. *Agric*, 26(1): 85-98.

Lestari A, Anita S, and Hanifah TA, 2015. Potensi Tanaman Genjer (*Limnocharis flava*) Sebagai Fitoremediator Ion Kadmium (II), Kromium (IV) dan Timbal (II). *JOM FMIPA Universitas Riau.* 2(2): 1-7

Panda S, Sahoo L, and Mohapatra PK, 2005. Chromium-induced changes in enzyme activities and structural alterations in chloroplasts and cell membranes of plants. *Journal of Environmental Science and Health, Part A,* 40(5): 789-802

Paz-Alberto AM and Sigua GC, 2013. Phytoremediation: a green technology to remove environmental pollutants. *American journal of climate change,* 2(1): 71-86.

Putri LRID, Moelyaningrum AD, and Ningrum PTR, 2022. Kondisi Fisik Air Sungai Dan Kandungan Logam Kromium Pada Ikan Nila (*Oreochromis niloticus*)(Studi Di Sungai Kreongan Sekitar Industri Batik X, Kecamatan Patrang, Kabupaten Jember*). Jurnal Kesehatan Lingkungan Indonesia*, 21(3): 293-300.

Rahmadiah and Rachmaniyah, 2020. Fitoremediasi Tanaman Kangkung Air (*Ipomea aquatica*) dalam Menurunkan Kadar Timbal (Pb) pada Air Sumur. Poltekkes Kemenkes. Surabaya.

Reddy MV, Subrahmanyam D, and Singh AK, 2013. Phytoremediation: An overview. *Critical Reviews in Environmental Science and Technology,* 43(13): 1311- 1355

Rosyidah NF and Rachmadiarti F, 2023. Salvinia molesta sebagai Agen Fitoremediasi Logam Berat Zink (Zn) di Perairan. *LenteraBio: Berkala Ilmiah Biologi,* 12(3): 430- 438.

Sugihartono S, 2016. Pemisahan krom pada limbah cair industri penyamakan kulit menggunakan gelatin dan flokulan anorganik. *Journal of Leather, Rubber, and Plastics*, *32*(1): 21-30.

Surakusumah W, Nilawati T, and Khairunisa R, 2020. Potensi *Alocasia macrorhiza* Sebagai Fitoremediator Logam Kromium. *Jurnal Ilmu Alam dan Lingkungan,* 11(2): 8-14.

Umar YP, Anugroho F, and Tahir U, 2023. Perbandingan Kangkung Air (*Ipomoea Aquatica Forck*) dan Mikroorganisme Dalam Upaya Menurunkan Logam Kromium hexavalent (Cr (VI)) pada Air Sungai. *Jurnal Sumberdaya Alam dan Lingkungan,* 10(1): 42-48.

Weerasinghe A, Ariyawnasa S, and Weerasooriya R, 2008. Phyto-remediation potential of *Ipomoea aquatica* for Cr (VI) mitigation. *Chemosphere,* 70(3): 521-524.

Yuliasni R, Kurniawan SB, Marlena B, Hidayat MR, Kadier A, and Ma PC, 2023. Recent progress of phytoremediation-based technologies for industrial wastewater treatment. *Phycoremediation Processes in Industrial Wastewater Treatment,* 21-41.