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Pre and post treatment toxicity of chrome plating industry effluent to *Poecilia reticulata* Peter 1859

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Abstract
Chromium is one of environmental pollutant that produces high toxicity even at very low concentrations. Domestic and industrial discharges are probably the two most important sources for chromium in the water environment. The toxic heavy metals are entering the food chain through drinking water, agriculture and fisheries activities and therefore endangering human life. The general objective of this study is to investigate the physico-chemical parameter of Chrome Plating Industrial Effluent and to assess the toxicity of pre and post treated Chrome Plating Industrial Effluent to *Poecilia reticulata* Peter 1859. The 96 hr LC_{50} of untreated chrome plating industry effluent is 2.24 and treated effluent with *Wolffia Columbiana* Karst is 18.07 ml/l. Metal accumulation in duckweed, *W. columbiana* growing in these chromium contaminated sites were also determined. Therefore, duckweed may be used as a bioassay for bio monitoring and control of Cr pollution in the environment.

Keywords: Toxicity, Chrome plating, *Wolffia Columbiana*, *Poecilia reticulata*

1. Introduction
Chromium and its compounds are widely used in various industries such as metal finishing, petroleum refining, iron and steel industries, pulp and paper industry, electroplating, leather tanning, textile and wood preservation [8, 15, 22]. Chromium can contaminate soil, sediment, groundwater and surface water [9, 19]. It occurs in several oxidation states ranging from Cr^{2+}, Cr^{3+} to Cr^{6+} in which Cr^{3+} and Cr^{6+} exist in stable states. Trivalent chromium occurs naturally in the environment as an essential nutrient [5]. Hexavalent chromium (Cr (VI)) is the most toxic form and a well-known carcinogenic, and mutagenic to living organisms [3, 17, 26] because of its high solubility, ability to penetrate the cell membrane and strong oxidizing ability [28]. It has been reported by various authors that hexavalent chromium causes lung cancer, ulcer, Severe damage to the liver and kidneys, perforation of nasal septum, leukocytosis, and skin rashes in humans [21, 22].

Presently there are several options for treating contaminated water [16]. The most common technique is the coagulation/filtration method that involves removing pollutants by chemically conditioning particles to agglomerate into larger particles that can be separated and settled. Recently, a promising alternative remediation technique, called phytoremediation that can be utilized in certain situ to replace other costly methods has been explored [14, 16]. Phytoremediation is the use of plants to absorb certain contaminates from soil or water through the plant's root system into the body of the plant where they are stored and ultimately disposed [14]. Heavy metals convert into less harmful substances within the plant or gaseous form and are released into the air through transpiration activities [1]. *Ipomea aquatica* F. The plant removes chromium metal upto 0.05 mg/l after 40 days of contact time from initial chromium concentration 2.04 mg/l [7].

Duckweed (*Lemna minor* L.) is used in water quality studies to monitor heavy metals and other aquatic pollutants, because duckweed like other water plants may selectively accumulate certain chemicals. Duckweed has been identified as a tiny aquatic plant with enormous potential for agriculture and the environment. In recent years this commonly occurring aquatic plant "duckweed" *Wolffia* sp. has become prominent, because of its ability to concentrate minerals on heavily polluted water such as that arising from sewage treatment facilities, intensive animal or crop processing or production industries.

However, it has also attracted the attention of scientists because of its apparent high potential as a feed resource for aquaculture and livestock. Duck weed grows on water with relatively high levels of N, P and K concentrates the minerals and synthesizes portion and therefore, duckweed can clearly supply the portion needs of aquaculture. The present study was conducted to estimate physico-chemical analysis of Chrome Plating Industrial Effluent (CPIE) and phytoremediation of CPI effluent using duckweed, *W. columbiana.*

2. Materials and Methods

2.1 Test plant

The floating macrophyte, *W. columbiana* was collected from the pond maintained in the Department of Zoology, Scott Christian College (Autonomous), Nagercoil. The collected plants were acclimatized for 7 days in freshwater taken in large cement tanks. Only mature and healthy plants were used for metal absorption studies.

2.2 Collection of Chrome Plating Industrial Effluent

Chrome Plating Industrial Effluent (CPIE) was carefully collected from a small scale industry in a private working area, Ozhuhinasery (8.184'' and 77.433''), Kanyakumari district, Tamil Nadu, India and characterized. The physicochemical characteristics were estimated following methods suggested by APHA [2].

2.3 Experimental design

Acclimatized plants were transferred into a plastic bucket containing different concentrations of CPI effluent (ranges from 25 to 150 ml) and their growth was followed. In 75 ml concentration the plant survival was high. Therefore that concentration (75 ml) was selected for absorption studies.

From the stock tank equal amount of plant biomass were transferred into buckets containing 75 ml/lit of Chrome Plating Industrial Effluent and small amount of vermicompost. All the buckets were exposed of enough sunlight for a detention period of 20 days. Level of water in the holding buckets was maintained by adding tap water once a week.

2.4 Bioaccumulation test

After 20 days exposure whole plant body was collected for absorption studies. Samples were thoroughly washed in distilled water to remove trace soil. Fresh samples were weighted and dried in a hot air oven at 110 ^{0}C for 24 hours. Dried samples were powdered using a glass mortar and pestle. The total chromium in the sample was estimated using Atomic Absorption Spectrophotometer in SITRA, Coimbatore.

2.5 Toxicity test

The freshwater fish, *P. reticulata* with same size were collected from the pond and acclimatized for about 7 days. The acclimated fish were exposed to different concentration of treated (ranges from 5 to 60ml/l) and untreated CPI (ranges from 1.0 to 6.5ml/l) effluent. This is done to check whether the effluent is remediated or not.

3. Results

Table 1.

Sl. No.	Parameter	Quantity	Permissible Limits (CPCB) 2013-2014
1	pH	1.75	5.5-9.0
2	Total Dissolved Solids (mg/l)	39860	2100
3	Total Suspended Solids (mg/l)	2100	600
4	Electrical Conductivity (µScm^{-1})	78	2100
5	Turbidity (NTU)	150	30
6	Dissolved Oxygen (mg/l)	6.49	4-6
7	Biochemical Oxygen Demand (mg/l)	ND5	-
8	Chemical Oxygen Demand (mg/l)	2228	-
9	Total Hardness (mg/l)	2000	-
10	Oil and Grease (mg/l)	59	20
11	Potassium (mg/l)	129	-
12	Sodium (mg/l)	750	60
13	Calcium (mg/l)	500	-
14	Chlorides (mg/l)	1600	1000
15	Sulphates (mg/l)	1765	1000
16	Magnesium (mg/l)	1500	-
17	Total Chromium (mg/l)	15147.50	2.0
18	Copper (mg/l)	287.6	3
19	Zinc (mg/l)	84.5	15
20	Cadmium (mg/l)	ND1	-
21	Nickel (mg/l)	798.6	3
22	Cobalt (mg/l)	ND1	-
23	Iron (mg/l)	232	-
24	Lead (mg/l)	ND2	-
25	Selenium (mg/l)	ND3	-
26	Tin (mg/l)	ND4	-
27	Boron (mg/l)	ND1	-
28	Arsenic (mg/l)	ND3	-

CPCB – Central Pollution Control Board

ND5- Not Detected upto 20ppm, ND- 2ppm, ND3-0.0005 ppm ND4- 0.02 ppm, ND5- 5 ppm

Table 2: LC_{50} values and their fiducial limits of raw and treated chrome plating industrial effluent to *P. reticulate*

Sl. No	Hours Exposure	Raw Effluent			Treated Effluent		
		LCL	LC_{50}	UCL	LCL	LC_{50}	UCL
1	12	5.14	6.01	6.67	46.45	52.01	58.14
2	24	4.91	5.24	5.91	41.47	45.26	49.32
3	36	4.36	4.69	5.03	37.41	40.83	44.49
4	48	3.90	4.24	4.59	33.36	36.70	40.31
5	60	3.28	3.62	3.98	27.62	31.22	35.22
6	72	2.75	3.07	3.40	23.09	25.84	28.88
7	84	2.34	2.63	2.95	19.50	21.88	24.51
8	96	1.98	2.23	2.51	15.57	18.07	20.93

The physico-chemical characterization of Chrome Plating Industrial Effluent is presented in table 1. All the parameters except Electrical Conductivity were above the permissible limit (CPCB, 2013-2014). Within 24 hr of exposure 20 percent mortality was recorded in the concentration of 4.5 ml/ lit and all the exposed fish were died at 6.5 ml/ lit. At 1.5 ml/ lit 10 percent mortality was recorded in 96 hr exposure and all the exposed animals were died in 3.5 ml/ lit at 96 hr exposure.

The LC_{50} values and their fiducial limits of treated and untreated CPI effluent to *P. reticulata* was presented in table 2. The 24 hr LC_{50} value recorded for the raw effluent was 5.24 with the LCL and UCL value of 4.91 and 5.91 ml/ lit respectively. The corresponding value recorded for the treated effluent is 45.26, 41.47 and 49.32 ml/ lit respectively. The 48 hr LCL and UCL value recorded for the raw effluent was 3.90 and 4.59 with LC_{50} value of 4.24 ml/lit respectively. The corresponding value recorded for the treated effluent is 33.36, 40.31 and 36.70 ml/ lit respectively. The 72 hr LC_{50} value recorded for the raw effluent was 3.07 with the LCL and UCL value of 2.75 and 3.40 ml/ lit respectively. The corresponding value recorded for the treated effluent is 25.84, 23.09 and 28.88 ml/ lit respectively. The 96 hr LC_{50} value recorded for the raw effluent is 2.23 ml/ lit and the corresponding value recorded for the treated effluent was 18.07 ml/ lit.

4. Discussion

Most of the industrial effluents are subjected to selected treatment to convert them into less toxic compounds. Even though, chemical treatments are highly effective, biological and non-chemical treatments are greatly preferred as they are eco-friendly, cost effective, biocompatible and do not leave any toxic compounds to the environment. In the present study the physico-chemical characterization was done for the Chrome Plating Industrial Effluent and also the remediation of CPI effluent with *Wolffia* sp. was assessed.

The results indicated that the *Wolffia* sp. tolerate in the chromium effluent upto 75 ml/ lit as no toxicity was recorded at this concentration. This is in agreement with the reports of earlier workers who reported that aquatic plants tend to adapt themselves to cope-up with chromium toxicity [12,13,31] and lower concentration (1 µm) facilitates the chromium accumulation and maximum removal of chromium was exhibited at this level. This conforms to the earlier reports with *Nymphaea alba* L. which suggested the suitability of this plant for bioremediation of effluent having low level of chromium [32].

Reduction in the LC_{50} value may be due to absorption of Cr from the effluent by *Wolffia* sp. These plants can tolerate metals through chelation with appropriate high affinity ligands, biotransformation with reductants, and compartmentalization in the cytoplasm or in the vacuoles. Thus, Cr immobilization in vacuoles in plant root cells may represent an important mechanism of Cr detoxification by the plant [24,29].

Duck weeds are fast-growing species adapt easily to various aquatic conditions and play an important role in the extraction and accumulation of metals from water. They bioconcentrate heavy metals such as Fe and Cu up to 78 times in waste water so it is the potential candidate for phytoremediation [4]. It has been shown that exposure of plants to toxic metal concentrations generally causes the fast inhibition of cell elongation and expansion [23,30]. Although the duckweed *Lemna* sp. attained higher chromium concentrations in its tissue compared with other aquatic macrophytes its bioconcentration factor (BCR) value much lower than those reported in other aquatic species [33].

Rafati *et al*. [25] evaluated the ability to uptake Cr from the soil by different organs of *Populus alba* L. and *Morus alba* L. and found that leaves accumulated higher levels of Cr than stems or roots. However, neither *P. Alba* nor *M. alba* showed potential of Cr phytostabilization, since presented TF > 1 and root BCF < 1; also these plants are not suitable for phytoextraction as they presented a BCF < 1. In another study, Ghafoori *et al*. [10] evaluated the potential accumulation of heavy metals, including Cr in *Dyera costulata* Hook. f. This species presented high potential to retain amounts of Cr in leaves, suggesting that this species has high phytoremediation potential, as they presented high translocation factor and low BCF factor. *Pluchea indica* also shown a good potential of phytoremediation as it presented high levels of Cr accumulation and translocation to the leaves [27]. Mellem *et al*. [20] found that *Amaranthus dubius* L. tolerate high Cr (VI) concentrations as indicated by the BCF value > 2, showing good potential for phytoremediation. Furthermore, Gardea-Torresdey *et al*. [11] found that *Convolvulus arvensis* L. exposed to 20 mg L of Cr (VI) demonstrated capability to accumulate more than 3800 mg of Cr kg^{-1} dw tissue, showing that this species can used in phytoremediation of Cr (VI) contaminated soils. Also, the concentration of Cr in leaf tissue indicates that this plant species could be considered as a potential Cr hyperaccumulator.

I. aquatica is a chromium hyperaccumulator that shows no toxicity symptoms when exposed to high levels of Cr (VI). up to 28 mg L^{-1} Cr (VI), *I. aquatica* exhibits uniform absorption characteristics showing over 75% removal of added Cr (VI) over 90% Cr (VI) is accumulated in stems and leaves, that is aerial region [32]. Furthermore, Mant *et al*. [18] found that *Pennisetum purpureum* Schumach and *Brachiaria decumbens* Stapt when exposed to 20 mg L^{-1} of Cr (III) showed a metal removal efficiency of 78% and 66%. Barbosa *et al*. [6] found that *Genipa americana* L. has potential for Cr (III) phytoremediation in contaminated watersheds, since its seedlings uptake elevated amounts of Cr (III) from the solution and it presented high capacity of immobilizing and storing the metal on their roots.

Plants could be considered a superior accumulator because of its ability to remove large concentrations of metals and remain vigorous and healthy. These studies have shown that certain plants can have remediatory effects on metals in aqueous environments. More research is needed to better understand the symbiotic or antagonistic relationship between plants and metals.

5. References

1. Ahalya N, Ramachandra TV, Kanamadi RD. Research

Journal of Chemistry and Environment 2003; 7:4.
2. APHA. Standard methods for the examination of water and waste water. APHA, Washington D.C, 1985.
3. Ashwini CP, Seeta LR. Studies on biological reduction of chromate by *Streptomyces griseus*. Journal of Hazardous Materials 2009; 169:539–545.
4. Axtell NR, Sternberg SPK, Claussen K. Lead and nickel removal using *microspora* and *Lemna minor*. Bioresource Technol 2003; 89:41-48.
5. Bahijri SMA, Mufti AMB. Beneficial effects of chromium in people with type 2 diabetes and urinary chromium response to glucose load as a possible indicator of status. Boil. Tr. Elem 2002; 85:97-110.
6. Barbosa RMT, Aimeida AAF, Mielke MS, Loguercio LL, Mangabeira PAO, Gomes FP. A physiological analysis of *Genipa Americana* L. a potential phytoremediator tree for chromium polluted watersheds. Environmental and Experimental Botany 2007; 61(3):264-271.
7. Bhat SV, Goswami HA, Ghosh TK. Journal of environmental science and engineering 2005; 47:316-321.
8. Das AP, Mishra, S. Biodegradation of metallic carcinogen hexavalent chromium Cr(VI) by an indigenously isolated bacterial strain. Journal of Carcinogenesis 2010, 9:6.
9. Desjardin V, Bayard R, Lejeune P, Gourdon R. Utilisation of supernatants of pure cultures of *Streptomyces thermocarboxydus* NH50 to reduce chromium toxicity and mobility in contaminated soils. Water, Air and Soil Pollution 2003; 3:153-160.
10. Gafoori M, Majid NM, Islam MM, Luhat S. Bioaccumulation of heavy metals of *Dyera costulata* cultivated is sewage sludge contaminated soil. African Journal of Biotechnology 2011; 10(52):10674-10682.
11. Gardea-Torresdey JL, Peralta-Videa JR, Montes M, Rosa, G, Corral-Diaz B. Bioaccumulation of cadmium, chromium and copper by *Convolvulus arvcensis* L. impact on plant growth and uptake of nutritional elements. *Bioresource Technology* 2004; 92(3):229-235.
12. Garg P, Chandra P. The duck weed *Wolffia globosa* as an indicator of heavy metal pollution sensitivity to chromium and cadmium. *Environment Monit, Assess* 1994; 29:89-95.
13. Gupta K, Mehta R, Kumar N, Dahiya DS. Effect of chromium (VI) on phosphorous fractions in developing sunflower seeds. Crop Research 2000; 20:46-51.
14. Huang JW, Poynton CY, Kochian LV, Elless MP. Phytofiltration of arsenic from drinking water using hyper-accumulating ferns. Environmental Science and Technology 2004; 38:3412-3417.
15. Huaxiao S, Yunguo L, Weihua X, Guangming Z, Nuzaaiti A, Xu L, Beibei C. Simultaneous Cr(VI) reduction and phenol degradation in pure cultures of *Pseudomonas aeruginosa* CCTCC AB91095. Bioresource Technology 2009; 100:5079–5084.
16. Kakitani T, Hata T, Kajimoto T, Imamura Y. Designing a purification process for chromium, copper and arsenic contaminated wood. Waste Management 2006; 26:453-458.
17. Kotas J, Stasicka Z. Chromium occurrence in the environment and methods of its speciation. Environ Pollut 2000; 107(3):263-283.
18. Mant C, Costa S, Williams J, Tambourgi E. Phytoremediation of chromium by model constructed wetland. Bioresourse Technology 2005; 97(15):1767-1772.
19. Mei B, Puryear JD, Newton RJ. Assesment of Cr tolerance and accumulation in selected plant species. *Plant and Soil* 2002; 247:223-231.
20. Mellem JJ, Baijanth H, Odhav B. Bioaccumulation of Cr, Hg, As, Pb, Cu and Ni with the ability for hyperaccumulation by Amaranthus dubius. African Journal of Agriculture Research 2012; 7(4):591-596.
21. Pechova A, Pavlata L. Chromium as an essential nutrient: a review. Veterinarni Medicina 2007; 52(1):1–18.
22. Poornima K, karthik L, Swadhini SP, Mythili S, Sathiavelu A. Degradation of chromium by using a novel strains of *pseudomonas* species. Journal of Microbial. Biochem Technol 2010; 2(4):95-99.
23. Poschenrieder C, Barcelo J. Water relations in heavy metal stressed plants. In: Prasad MNV (ed) Heavy metal stress in plants: from biomolecules to ecosystems, 2nd edn. Springer, Berlin 2004; 249–270.
24. Pulford ID, Watson C, McGregor SD. Uptake of chromium by trees: prospects for phytoremediation. Environmental Geochemistry and Health 2011; 23(3):307-311.
25. Rafati M, Khorasani N, Moattar F, Shirvany A, Moraghebi F, Hosseinzadeh S. Phytoremediation potential of *Populus alba* and *Morus alba* for cadmium, chromium and nickel absorption from polluted soil. International Journal of Environmental Research 2011; 5(4):961-970.
26. Ramakrishna K, Ligy P. Bioremediation of Cr(VI) in contaminated soils. Journal of Hazardous Materials, B, 2005; 121:109–117.
27. Sampanpanish P, Pongsapich W, Khaodhiar S, Khan E. Chromium removal from soil by phytoremediation with weed plant species in Thailand. Water Air and Soil Pollution 2006; 6(1-2):191-206.
28. Shanker AK, Pathmanabhan G. Speciation dependent antioxidative response in roots and leaves of sorghum (*Sorghum bicolor* (L) Moench cv CO 27) under Cr (III) and Cr (VI) stress. Plant Soil 2004; 265:141-151.
29. Shanker AK, Cervantes C, Loza-Tavera H, Avudainayagam S. Chromium toxicity in plants. Environmental International 2005; 31(5):739-753.
30. Srivastava S, Mishra S, Tripathi RD, Dwivedi S, Gupta DK. Copper-induced oxidative stress and responses of antioxidants and phytochelatins in *Hydrilla verticillata* (L.f.) Royle. Aquat Toxicol 2006; 80:405–415.
31. Vajpayee P, Tripathi RD, Raj UN, Ali MP, Singh SN. Chromium (VI) accumulation reduces chlorophyll biosynthesis nitrate reductase activity and protein content in *Numphaea alba* L. Chemosphere 2000; 41:1075-1082.
32. Weerasinghe A, Ariyawnasa S. Weerasooriya R. Phytoremediation potential of *Ipomea aquatica* for Cr (VI) miligation. Chemosphere 70(3):521-524.
33. Zayed A, Lytle CM, Qian JH, Terry N. Chromium accumulation, translocation and chemical speciation in vegetable crops. Planta 1998, 2008; 206:293-299.