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Industrial wastewater treatment using *Spirodela polyrhiza*

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Abstract
Industrial wastewater treatment can be done by using *Spirodela polyrhiza* in different retention time. This study investigates the use of *Spirodela polyrhiza* improves the quality of industrial wastewater parameters like negative log of hydrogen ion concentration (P^H), Electrical Conductivity (EC), Chemical oxygen demand (COD), Total hardness, sulphates, Total dissolve solids (T.D.S.). This study also signifies the *Spirodela polyrhiza* can be used for accumulation of toxic metals. It was found that after 60 days retention time the reduced level of pH was 7. At initial, maximum chloride content was 214.93 mg/l however the minimum Chloride content after treatment was 173.70 mg/l. Value of total hardness present in water before treatment was 1603 mg/l however the minimum hardness after treatment was 968mg/l. Maximum COD at initial time was 202.66 mg/l however the minimum COD after retention time was found as 64mg/l. Amount of Chromium (VI) before introducing macrophyte was 0.0401 mg/l however the minimum Chromium (VI) after introducing macrophyte was 0.0233mg/l. Minimum chromium (VI) content in plant was 4.92 mg/l however the maximum chromium (VI) content in plant at after 60 days was 7.05 mg/l due to absorption of toxic metals. Minimum copper (II) content in plant was 24.22 mg/l however after absorption of copper by macrophyte the maximum copper (II) content in plant was found as 27.81 mg/l.

Keywords: Industrial wastewater; physicochemical properties; toxic metals and accumulation

1. Introduction
Water is a prerequisite resource for organizations across the globe. Water is a resource that is becoming increasingly scarce and needs to be sustained, globally and locally. One of the most serious problems faced by billions of people today is the availability of fresh water [1]. Water pollution is one of the major environmental problems. These problems primarily occur due to generation of wastewater from metropolitan cities and industries having most of the organic and inorganic pollutants, nutrients & heavy metal, which are legally or illegally discharged into environment. The industrial, municipal and agricultural wastes which are legally or illegally discharged into the environment are responsible for the environmental pollution. In general, industrial wastewaters may contain suspended, colloidal and dissolved (Mineral and Organic) solids. Several industries discharge heavy metals, it can be seen that of all of the heavy metals, chromium is the most widely used and discharged to the environment from different sources. Metal ions are released from electroplating and manufacturing industry includes chromium (Cr), copper (Cu), lead (Pb), cadmium (Cd), mercury (Hg), zinc (Zn) etc. The increased environmental burden of Cr (VI) may come from various industrial sources like those from electroplating, leather tanning, textiles and metal finishing industries [2]. Physicochemical methods of wastewater treatment are cost intensive. Biosorption is a physical-chemical process, simply defined as the removal of substances from solution by biological material.

Phytoremediation is an emerging technology that utilizes plants and then the associated rhizosphere microorganisms to remove, transform, or contain toxic chemicals located in soils, sediments, ground water, surface water, and even the atmosphere. Duckweeds are aquatic plants which often form dense floating mats in eutrophic ditches and ponds [3].

The objective of this paper is to study the impact of *Spirodela polyrhiza* on physicochemical properties of Industrial wastewater.

2. Methodology
2.1 Selection of water sample collection area
The selected area for present study was Naini, Allahabad, and District of Uttar Pradesh as shown in Figure1.

Fig 1: Geographical location of Sample Collection Area

Allahabad has a humid subtropical climate common to cities in plains of North India. Industrial waste water sample were collected from Naini Industrial Area, near Bharat Pump and Compressors Limited Naini, Allahabad Uttar Pradesh.

2.2 Collection of plant sample and Experimental set-up

Duckweed *Spirodela polyrhiza* were obtained from a natural pond near, Dhanuha, Allahabad, India. It is a floating aquatic macrophyte belonging to the family Lemnaceae. The plant stocks were cleaned by tap water to eliminate remains of pond sediments and were placed in eight plastic tubes in laboratory condition in the treatment system with growing duckweed in eight tubes of 10-12 L was constructed in laboratory set up. Approximately 60g of fresh wet *Spirodela polyrhiza* plants were stocked into each of the eight tubes. Each of the eight tubes was filled with 5 L same industrial wastewater. Retention time of duckweed was 15 days in the first two reactors, 30 days in the second and 45 days in the third and 60 days in fourth. Experimentation under laboratory condition is shown in Figure 2.

Fig 2: Experimentation under Laboratory condition

2.3. Selection of Physicochemical Parameters and method of investigation

The parameters selected for study were Colour, Odour, pH, EC, COD, Total Hardness, Sulphates, TDS, Chloride, Copper and Chromium. Analysis was carried out according to standard method of examination of water and wastewater (American Public Health Association, 1998) [3].

Collected water samples was digested at first in lab by taking 10 ml of water sample, then heated it up to 100 ^{0}C by addition of 3 ml concentrated sulphuric acid followed by perchloric acid in 3:1.

Plant material was wrapped in paper towels and dried in an oven at 70 ±2 °C to a Constant weight. Dried plant was digested with concentrated nitric acid followed by perchloric acid in 3:1. Trace metal chromium and Copper concentrations level were carried out with Perkin-Elmer model 2380 atomic absorption spectrophotometer. The industrial wastewater with macrophyte *Spirodela polyrhiza* at different day interval is shown below:

D_0-Industrial wastewater without *Spirodela polyrhiza* at the time of sampling

D_{15}- Industrial wastewater with *Spirodela polyrhiza* after 15 days.

D_{30}- Industrial wastewater with *Spirodela polyrhiza* 30 days.

D_{45}- Industrial wastewater with *Spirodela polyrhiza* after 45 days.

3 Results and Discussion

Industrial wastewater treatment was carried out at different time interval by use of macrophyte *Spirodela polyrhiza*. The results obtained are presented and discussed with respect to data are given below: Given Table 1 represents the results obtained of physicochemical properties after collection of wastewater and content of heavy metal chromium and copper present in plant sample [4].

From above table it has been observed that the reduced level of pH at D_{60} was recorded as 7.85. Minimum EC at D_0 was 1.13 mmhos/cm however the maximum EC at D_{60} was 3.2 mmhos/cm. Minimum TDS at D_0 was 510 ppm however the maximum TDS at D_{60} was 1259 ppm. Minimum Chloride content at D_{60} was found as 173.70 mg/l. The minimum Chloride content at D_{60} was found as 173.70 mg/l. Maximum hardness at D_{60} was 1603 mg/l however the minimum hardness at D_{60} was 968mg/l. Maximum COD at D_0 was 202.66 mg/l however the minimum COD at D_{60} was found as 64mg/l. Maximum Chromium (VI) at D0 was 0.0401 mg/l however the minimum Chromium (VI) at D60 was 0.0233mg/l. The maximum Copper (II) at D0 was 0.05406 mg/l however the minimum Copper (II) at D60 was 0.0098 mg/l. Minimum chromium (VI) content in plant at D_0 was 4.92 mg/l however the maximum chromium (VI) content in plant at D60 was 7.05 mg/l. Minimum copper (II) content in plant at D_0 was 24.22 mg/l however the maximum copper (II) content in plant at D_{60} was 27.81 mg/l.

Table 1: Experimental Analysis

S. No	Parameters	Methods	Result at D_0	D_{15}	D_{30}	D_{45}	D_{60}
1.	Colour	Self-Appearance	Brownish	Brownish	Brownish	Light brownish	Light brownish
2.	Odour	Self-Appearance	Unpleasant				
3.	P^H	Digital pH meter (Jackson 1958)	8.29	8.20	8.12	8.61	7.87
4.	Electrical conductivity	EC meter (Wilcox 1950)	1.13 (mmhos/cm)	1.17	1.77	2.77	3.20
5.	Chloride	Titration method (Mohr 1938)	214.93 (mg/l)	209.93	195.04	175.35	173.70
6.	Total Dissolved Solids	Digital TDS meter	510 (ppm)	510.33	555.67	720.67	1066.00
7.	Total Hardness	EDTA Titrimetric method	1603 (mg/l)	1321	1046	1021	968
8.	Chemical Oxygen Demand	Titrimetric method	202.66 (mg/l)	170.67	85.33	74.67	64.00
9.	Sulphates	Spectrophotometer	17.92 (mg/l)	16.00	14.96	13.68	12.69
10.	Chromium (VI) (Water sample)	AAS (Perkin-Elmer model 2380)	0.0401 (mg/l)	0.038	0.031	0.027	0.023
11.	Copper (II) (Water sample)	AAS (Perkin-Elmer model 2380)	0.054 (mg/l)	0.038	0.018	0.014	0.010
12	Chromium (VI) (Plant sample)	AAS (Perkin-Elmer model 2380)	4.92 (mg/l)	5.79	5.94	6.20	7.05
13	Copper (II (Plant sample)	AAS (Perkin-Elmer model 2380)	24.22 (mg/l)	24.61	25.23	26.00	27.81

Decreasing value shows that the plant species under investigation try to grow and maintain the pH towards the neutral due to their root secretion and addition of organic acids in water sample. Same results was reported [5]. After introducing *Spirodela* in wastewater it may also results to root loss in wastewater results to high electrolyte content which may cause to increase in value of EC from increasing the time interval. TDS of sample increased highly in different retention time within the contact of *Spirodela polyrhiza*. This may be cause due to the secretions from roots of plants and addition plant content and residues of roots dissolve in water after retention time. The ion associated with the roots of S*pirodela* help in absorption of chloride from wastewater by exchange takes place between anions of chloride also cations present in water. Therefore the reduction of chloride in water sample takes place by increasing the time interval. Total Hardness of sample decreased in different retention time within the contact of *Spirodela polyrhiza*.

In industrial wastewater sample the content of calcium and magnesium salts was found be high which can govern the total hardness. Decline in COD was due to the consumption of organic substances by the plant which have capability to purify the sample, thus reducing its COD, related studies was given [6]. The cause of reduction may be due to plant ability to absorb different types of pollutants and accumulated in their tissues [7]**.** The presence of carboxyl groups at the roots system induces a significant cation exchange through cell membrane and this might be the mechanism of moving heavy metal in the roots system where active absorption takes place. A similar reason was also suggested by [8]. The metal ions removal rates from aqueous solution by biosorption are generally faster.

Concentration of copper present in sample decreased in different retention due to absorption of heavy metal Cu (II) by *S. polyrhiza*, because the roots absorb water together with the contaminants in water.

It results that the chromium content of *spirodela* increased in different retention time due to accumulation of heavy metal chromium present in wastewater. Plant showed the capacity to reduce the concentration of copper in wastewater and accumulation of Cr in their tissues in 60 days interval. Same results were also observed by others who studied the phytoextraction capacity of copper by *Spirodela* [9].

4. Conclusion

From experimental findings it has been concluded that the changes have been occurred in physicochemical properties of industrial wastewater by introduction of spyrodela thereby reducing pH by 5.3%, Chloride by 19%, Total hardness 39.6%, COD 68%, and level of heavy metal like chromium by 64.6% and Copper by 81%. Overall EC and TDS of sample was increased by 64% and 59.4% respectively. Thus *Spirodela* has been successfully used for treatment of industrial wastewater and removal of toxic metal. Reduction in most of water parameters were observed after treating with this macrophyte. This study has been clearly show that this plant is appropriate for treatment of wastewater and can be used for absorption of heavy metals like copper and chromium as well as removal of toxic metal. After the treatment the plant biomass and residue can be used for biogas production and as raw material.

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