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Original Article

Eichhornia crassipes (Mart.) Solm: A biotic resource for waste water treatment

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ABSTRACT

The present study was conducted on effectiveness of *E. crasssipes* (water hyacinth) on physico- chemical parameters along with heavy metal removal from the waste water bodies present naturally in the trans-Yamuna regions of Allahabad, India during two seasons i.e., winter (November to February, 2011) and rainy (July to October, 2012). Results reveals that water hyacinth can be biotic resource which are useful in waste water treatment by altering the physico-chemical environment(DO increases with decrease in BOD and COD) of the water along with the reduction in the concentration of toxic heavy metals(Fe^{2+},Zn^{2+} and Cr^{6+})showing its highest pollution reducing capacity.The water hyacinth hold promise as a natural water purification system, which could be established at a fraction of the cost of a conventional wastewater treatment facility.

Key words: *Eichhornia crassipes,* Physico-chemical parameter; trans-Yamuna regions; biotic resource; conventional wastewater treatment facility.

INTRODUCTION

Water quality, which is influenced by various natural processes and anthropogenic activities, is worldwide current environmental issue in research [**1-2**]. Yamuna water is one of the most polluted river water in the world and 85% of this pollution contributes by industrial and domestic sewage. This water is unfit for drinking, swimming and fisheries [**3**]. The utility of river water for various purposes is governed by physico-chemical and biological quality of the water. Allahabad river water is polluted by various kinds of natural wastes, domestic wastes and agricultural wastes and other factors creating water pollution problem particularly in fresh water system [**4**]. Heavy metal contamination in water is recognized as a severe environmental problem and therefore the study related to water contamination has become important. The contamination of water by hazardous and toxic metals is harmful for the human consumption. These metals may enter into the water system through cesspits and flowing water through streams [**5**]. Due to the anthropogenic activities soil and water quality gets contaminated. Heavy metals are stable and persistent environmental contaminants since they cannot be degraded or destroyed. Therefore, they tend to accumulate in soils and sediments [**6**]. Elevated concentrations of heavy metals in soils may cause phytotoxicity, direct hazard to human health, indirect effects due to transmission through the food chain or contamination of ground or surface waters [**7**]. Water hyacinth (*E. crasssipes*) is one of the aquatic plant species successfully used for wastewater treatment. Water hyacinth belongs to the family *Pontederiaceae* and genus *Eichhornia* and species *crassipes.* Water hyacinth grows throughout the tropics and sub-tropics as a free-floating perennial. In temporary water bodies, the plants survive in moist mud and remain anchored to the soil [**8**]. The mature water hyacinth plant consists of roots, rhizomes, stolons, leaves, inflorescences and fruit clusters. It grows equally well in natural water and in artificially produced water bodies [**9**]. It is very efficient in removing pollutants like suspended solids, BOD, organic matter, heavy metals and pathogens [**10**]. Water hyacinth treatment system can be promising in Nepal for domestic wastewater treatment. It grows equally well in natural waters and in artificially produced water bodies [**11**]. The growth is adversely affected by low temperature and completely ceases in freezing cold. For that reason, water hyacinth behaves like a seasonal plant where growth is halted by winter temperatures but enhanced during rainy seasons [**12**]. The treated wastewater can be reused as drinking water, in

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industry and in the rehabilitation of natural ecosystems as well as improving the quality of irrigation water resulting in improvement in to the production of crops [**13**]. Water hyacinth can improve the effluent quality from oxidation ponds and as a main component of one integrated advanced system for treatment of municipal, agricultural and industrial wastewaters [**14**].The present study was conducted to determine the upgrading the existing sewage lagoons/facultative ponds with naturally grown water hyacinth system showing its pollutant reduction capacity in relation to physiochemical parameters and heavy metals present in the *trans*-Yamuna regions of Allahabad, India during winter and rainy seasons.

MATERIALS AND METHOD

Sample area and Sampling Points: Allahabad is situated at 25.45°N 81.84°E in the southern part of Uttar Pradesh at an elevation of 98 metres (322 ft) and stands at the confluence of two rivers, the Ganges and Yamuna. The region was known in antiquity as the Vats country. To its south and southeast is the Bundelkh and regions, to its east is the mid Ganges valley of North India, or Purvanchal, to its southwest is the Bundelkh and region, to its north and northeast is the Awadh region and to its west along with Kaushambi it forms the lower doab region. The water samples were collected for the physiochemical parameter and heavy metal analysis inhabited by *E. crassipes* from the four nearby *trans*-Yamuna regions *viz.* Cheonki, Maheva, Naini Gaon, Vinobha Nagar and designated as sampling stations 1, 2, 3 and 4 and all the samples collected were compared with local waste water bodies without *E. crassipes* (control=C) in Allahabad region (Fig.1). The sample collection and analysis was done during the months of during the rainy season (July–October, 2011) and winter season (November, 2011–February, 2012).

Sample Collection**:** Wastewater samples were collected from sampling points in polyethylene bottles previously cleaned in non-ionic detergent, rinsed with tap water and later soaked in 10% HNO_3 for 24 hours and finally rinsed with deionised water prior to usage.

Physico-chemical analysis: pH were analyzed by using digital pH meter (Hach EC 20), biochemical oxygen demand (BOD), Chemical Oxygen Demand (C.O.D.), Dissolved Oxygen (D.O), alkalinity and acidity in mg/l of water sample were analyzed through titrimetric method and were determined according to standard procedure [**15-16**]. The samples were analyzed for Iron (Fe^{2+}), Zinc (Zn^{2+}) and Chromium (Cr^{6+}) using double-beam Perkin-Elmer AAnalyst 300 atomic absorption spectrophotometer (AAS) as per standard method of the water quality **[17].**

Statistical Analysis: Each treatment was analyzed with a minimum of 3 replicates and the Standard Deviation (SD) was calculated. All the data reported as MEAN ± SD (Minimum of 3 replicates.

RESULTS AND DISCUSSION

Physical and Chemical Parameters: From the period July 2011 to February, 2012, the physical and chemical properties of the study stations in the *trans*-Yamuna regions of Allahabad are presented in the fig.2 with the following inferences during winter and rainy season. The physico-chemical parameters shows a maximum reduction from 7.7 to7.3and 7.9 to7.4 in pH along with the DO value increase varying from 4.7 to 6.7mg/l and 3.9 to 6 mg/l, the BOD were decreased maximum from 175mg/l to 82mg/l and 259mg/lto175 mg/l whereas the maximum reduction in COD value were from 405 to192 mg/l and 526 to 261 mg/l during rainy season and winter season, respectively. The acidity reports maximum decrease from 64-14 mg/l and 88 to 40mg/l while total alkalinity between 183 to 58 mg/l and242 to 135mg/l during rainy season and winter season, respectively. Water samples taken from station 3 show a maximum decrease of 5.2% in wet season and 6.3% winters in pH and maximum increase in DO of 43% in station 4 and 50% in station 4 during rainy season and winter season, respectivelyover the control. Station 2 exhibited maximum decrease in BOD level of 53 % whereas 13% in station 1 and the lowest value of COD exhibited the range of 53% and 51% in station 4, during the rainy season and winters, respectively over the control.

The study by **[18]** reported that when facultative ponds fed by secondary effluent with similar conditions were compared (one with water hyacinth and another without water hyacinth), significant reduction of COD (75%) from water hyacinth treated secondary effluent. The study by **[19]** reported that upon treatment of domestic wastewater with E. crassipes a reduction of 81% in Chemical Oxygen Demand (COD), 91% Biochemical Oxygen Demand (BOD) levels.The study done by **[20]** results revealed that for the treatment of wastewater samples collected from Shelginala (Pune naka) located in Solapur city using water hyacinth as a biotic resource through phytoremediation technology. The results revealed that DO level increased after treatment with water hyacinth from 1.3 mg/L to 3.2 whereas the BOD and COD are reduced by 48.69% and

54.38%respectively, along with the reduction in heavy metals.

Heavy metal: The results of heavy metal (Zn^{2+}, Fe^{2+}, Cr^{6+}) reduction levels due to water hyacinth were analyzed during the month of rainy season (July–October, 2011) and winter season (November, 2011– February, 2012) are given in table 1 and presented in fig.2 present in sampling stations. In the study, Fe^{2+} level ranges from 4.10 to 2.56 mg/l with reduction of 38% in station 3 in the rainy season and from 3.10 to 1.026 mg/l with a maximum reduction of 67% in station 2 in winter season; the maximum decrease of Cr^{6+} level ranges from 2.48 to 0.868 mg/l (65% decrease) in station 2 during rainy season and from 1.29 to 0.218 mg/l (83% decrease) in station 3 during winters. The average decrease of 57.6% were analyzed varying from Zn^{2+} from 1.85 to 0.889 mg/l in rainy season and of 68.5% maximum reduction from 0.873 to 0.443 mg/l in station 3 in winters. The higher concentration values were detected for zinc, chromium and iron in the winter season whereas the lowest values were recorded in rainy season by the reduction of heavy metal of waste water using the plant 'water hyacinth'. The study done by **[21]**found that water hyacinth effect on heavy metal from the month of January to June 2007 in Ekpan creek in southern Nigeria founded the respective range of values include iron (0.43-2.6mg/l), zinc (0.16-0.87mg/l) and chromium (0.002-0.02mg/l).

CONCLUSION

The present study demonstrated that E. *crassipes* is suitable for wastewater treatment. It can be used commercially for cleaning wastewater. This luxuriant plant has the tremendous capacity for absorbing toxic heavy metals and other pollutants from wastewater showing its phyto-remediation potential. The treated wastewater can be used for domestic, agricultural and industrial applications.

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Fig.1. Location map of the Allahabad nearby study area

TABLE 1: The heavy metal concentration of the water sample (mg/l) (Fe^{2+}, Zn^{2+} and Cr^{6+}) from the *trans*-Yamuna sampling sites during the winter season and rainy seasons

(JULY,2011-FEBRUARY, 2012)	**WINTER SEASON**	**RAINY SEASON**	**WINTER SEASON**	**RAINY SEASON**	**WINTER SEASON**	**RAINY SEASON**
STATIONS/HEAVY METALS(mg/L)	**Fe^{2+} (248.33nm)**	**Fe^{2+} (248.33nm)**	**Zn^{2+} (213.86nm)**	**Zn^{2+} (213.86nm)**	**Cr^{6+} (357.87nm)**	**Cr^{6+} (357.87nm)**
Control	3.10±0.0.098	4.101±0.05	0.873±0.095	1.85 ±0.099	1.29±0.058	2.48 ± 0.058
Station 1	1.544±0.093	3.38±0.077	0.556±0.014	0.997 ±0.014	0.538±0.027	1.18 ±0.062
Station 2	1.026±0.098	2.78± 0.099	0.604±0.058	1.04 ±0.058	0.311±0.0021	0.868± 0.048
Station 3	1.908±0.083	2.56±0.082	0.443±0.43	0.889 ±0.043	0.218±0.045	0.914±0.0275
Station 4	2.48±0.064	3.43±0.080	0.548±0.083	1.08±0.089	0.255±0.0433	0.948±0.0335

The results are shown as mean±SD of the three replicates.

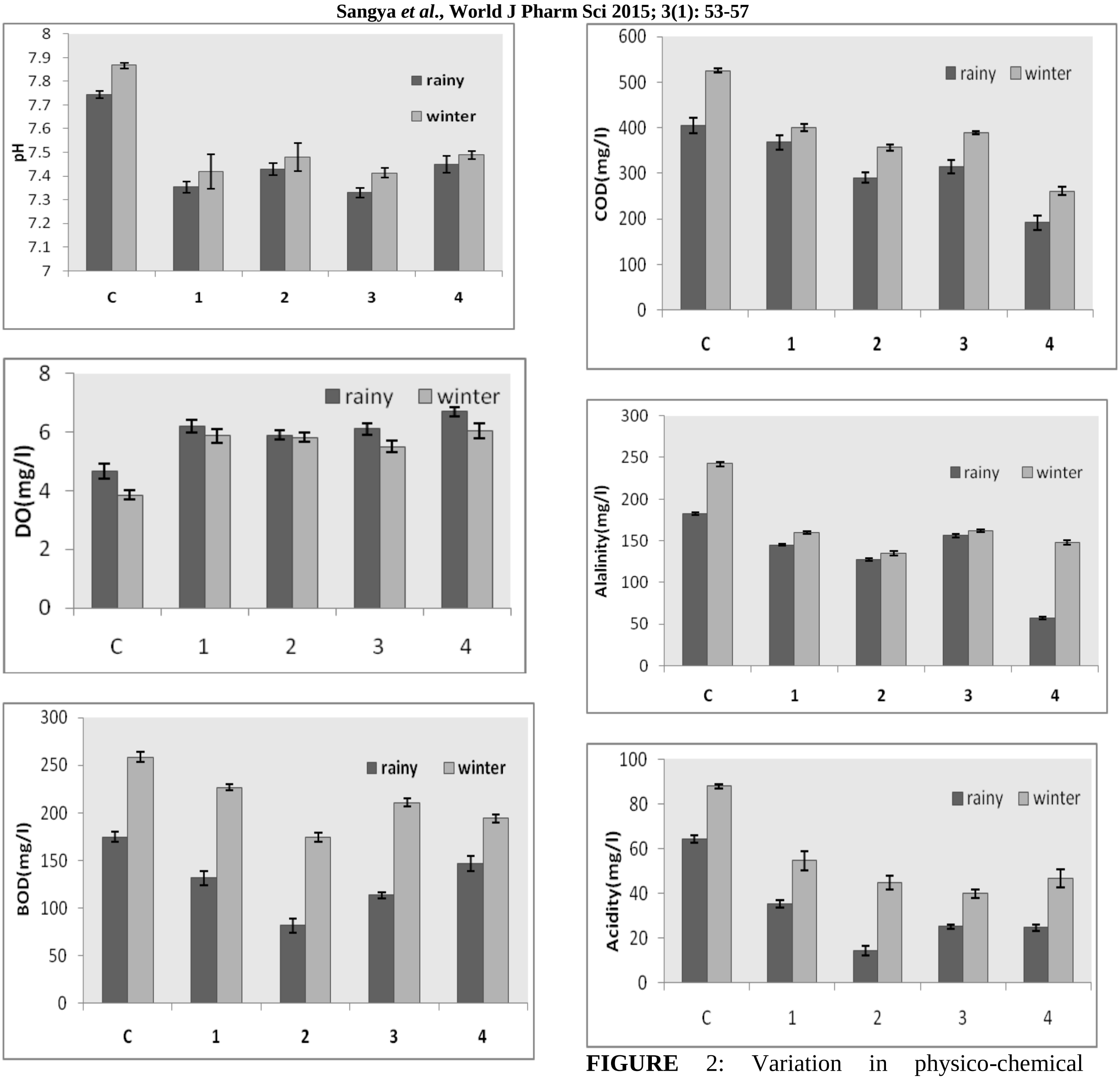

FIGURE 2: Variation in physico-chemical parameters of the water sample in the *trans*-Yamuna sampling sites of Allahabad. The results are shown as mean±SD of the three replicates.

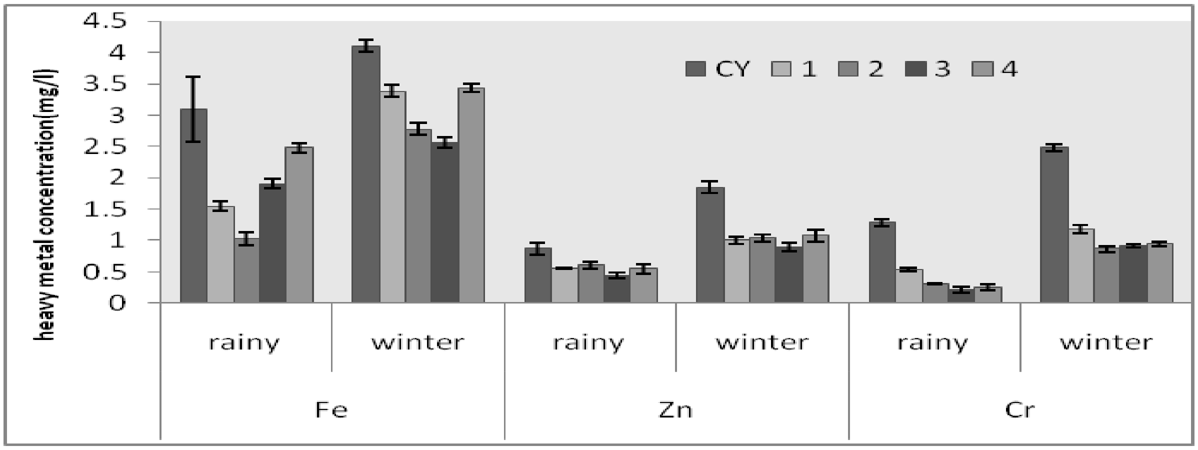

FIGURE 3: Variation in heavy metal reduction in water sample by water hyacinth in the *trans*-Yamuna sampling sites of Allahabad. The results are shown as mean±SD of the three replicates.

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