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BIOACCUMULATION OF POLLUTANTS FROM TEXTILE WASTE WATER BY *HYDROCOTYLE UMBELLATA* L.

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ABSTRACT

Textile industry has posed serious environmental problems causing adverse health effects, thus making it a social obligation for industries to minimize water pollution. During the present study, sample was collected from textile industry of Faisalabad and their analysis showed that the discharge of textile waste water was violating PEPA, (1997) as most of their results was found above their permissible limits of NEQS (1997) including pH, EC,TDS, BOD, COD, SO_4^{-2}, Cu and Cr. Among the treatment technologies, Phytoremediation is feasible and environmental friendly method for the removal of pollutants from the industrial effluents. A study was carried out to investigate the phytoremediation of pollutants from textile wastewater by *Hydrocotyle umbellata* L. Reduction in the pollutants load was achieved from 11.37 to 7.03 (pH), 2138 to 1202 (TDS), 18.02 to 15.87 (EC), 900 to 500 (Cl^-), 4833.3 to 2535.1 (SO_4^{-2}), 3.26 to 2.01 (NO_3^-), 7000 to 2500 to (CO_3^-), 7500 to 4030 (HCO_3^-), 533 to192 (COD), 246.45 to 86.5 (BOD), 0.138 to 0.13 (Cu), 1.012 to 0.13 (Cr), 0.46 to 0.026 (Zn) by *Hydrocotyle umbellata* . Phytoremediation using aquatic plants provide a potential opportunity to remove contaminants from the waste water. Aquatic plant *Hydrocotyle umbellata accumulated* the contaminants when introduced in textile waste water. *Hydrocotyle umbellata* has the potential to be used in phytoremediation to remove metal pollutants from contaminated textile wastewaters.

Keywords: *Hydrocotyle umbellata*, Textile industry, water pollution, Phytoremediation.

INTRODUCTION

Environmental pollution is the result of rapid industrialization that occurred in the middle of the eighteenth century. Due to the revolution of urbanization and industrialization, chemicals, dyes, fertilizers and pesticides have been used in large amount that has resulted in the major pollution problems in both terrestrial as well as in aquatic environment (Schnoor, 1997). The rapid economic growth achieved by most of the developing countries after globalization has adversely affected the quality of the environment, imposed considerable social costs and livelihood impacts, and has become a major threat to sustainable development (Azeez, 2001). Pollution of the biosphere due to different sectors of our society like industries, agriculture and domestic activities has created serious problems for the safe use of soil and water (Legwe *et al*., 2005; Srivastava *et al.*, 2005). Industries are found in most of the countries and their number is increasing day by day. In Pakistan, 670 textile units are discharging their wastes into water bodies without any effective waste water treatment (Easton, 1995, McMullan *et al.*, 2001). In Pakistan, very few industries are equipped with satisfactory operating treatment facility set up, so there is common trend that industries dispose off untreated effluents *via* open and covered routes into the water ways which degrade water quality (Farid, 2003). The domestic, agricultural and industrial sector generates wastes, but among these the industrial sector are the most potential source of water and soil pollution. Industrial effluents contain heavy metals as well as chemicals, which affect plant and soil in variety of ways (Dhevagi and Oblisami, 2002). Textile industries use synthetic complex organic dyes as the coloring material (Zollinger, 1987) which causes serious environmental problems. Color is the first containment to be recognized in waste water and has to be removed before discharge in water bodies or on land. The presence of very small amount (less then 1ppm for some dyes) of dyes in water is highly visible and effect the aesthetic merit, transparency and gas solubility in rivers, lakes and other water bodies (McCrudy *et al.,* 1992). The treatment of textile waste water is still a major environmental concern, because of synthetic dyes, which are difficult to be removed by conventional treatment systems (Zhang *et al*., 2004). As the characteristic of dyes waste water are very variable, many physical, chemical and biological treatment methods have been employed for its treatment (Karcher *et al.*, 2002). Currently the biological removal processes including phytoremediation strategies has recently proved to be the most efficient treatment system. Phytoremediation is the use of plants to extract, sequester, and/or detoxify various kinds of environmental pollutant. It is a newly evolving field of biotechnology that uses plants to clean-up polluted soil, water, and air (Salt *et al*., 1998). Due to the recent advancement in the genetic modification, scientists are trying to bring plants for the protection of environment. So plants should have such qualities that allow them to be used in an effort to relieve environmental stresses. This field has generated great excitement because it may offer a reasonable cost effective means to restore the hundreds of thousands of square miles of land and water that have been polluted by human activities (Salt *et al*., 1995; Cunnigham *et al*., 1996; Salt *et al*., 1999). Among many aquatic plants found in tropical and subtropical fresh water ecosystem, *Hydrocotyle umbellata* , which can propagate easily with stem and can grow well not only in aquatic condition but also in dry condition (Siriporn, 1997). *Hydrocotyle umbellata has* the ability to remove heavy metals from the water (Dierberg *et al.,* 1987).

This work was done by keeping in view the collection of the textile effluent and estimation of the pollution load in the collected sample, acclimatization of test plant in the waste water for experimentation and reduction of pollution level in textile waste water through *Hydrocotyle umbellata.*

MATERIAL AND METHODS

Experimental Area: Sample was collected from Arshad Textile Dying Mills Ltd located in the vicinity of Faisalabad. This is a textile manufacturing company that uses synthetic complex organic dyes as coloring material. The analytical work was carried out at the National Agricultural Research Center (NARC) Islamabad Pakistan and Federal Environmental Protection Agency (FEPA), also known as CLEAN Laboratory, located at H-8/2 Islamabad. Both the National Institute of Bioremediation Department of NARC and FEPA comprise of standardized laboratories, where chemical analysis was conducted during April 2012.

Sampling Strategy: The sample was collected during the month of April 2012. The textile effluent was collected by grab method. Polyethylene containers were used for the purpose. Before collection, the containers were properly cleaned with non ionic detergents, followed by thorough washing with tap water and then rinsing with de-ionized water. The sample was stored at $4^{o}C$ in the Bioremediation Department of NARC.

Sampling Design and Plant Selection: *Hydrocotyle umbellata* L. plant was selected for the study. Nearly equal weight of the plant (i.e. 100g fresh weight) was taken for experimental design. The plants were thoroughly washed with distilled water to remove soil particles attached with the leaves and other parts of the plant. An average length and width of plant parts were generally taken for each experiment. The sample was taken in triplicate and the plants were placed in three circular tubs, each having five liters of textile waste water. The fourth tub was kept for control purpose .The experimental and control tubs were kept in the natural condition (outdoor) of NARC, and the plants were introduced in the tubs for 15 days.

Analytical Procedure : Detailed physico-chemical tests were carried out on the textile waste at the beginning of the experiment to determine the pH, electrical conductivity, dissolved oxygen, total dissolved solids, chlorides, sulphates, carbonates, bicarbonates, COD and BOD, copper, chromium and zinc etc. The physico-chemical tests were in conformity with the American Public Health 1998 (APH 1998) method, where as the Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and metals tests were conducted with EPA method.

Physico-Chemical Analysis

pH: The pH of textile effluent was measured with the help of pH meter (model WA. 2015). For measurement each time the pH meter was adjusted to neutral, using the buffers of pH 4.0, 9.0, and 10.0 respectively.

Electrical Conductivity: The Electrical Conductivity of textile effluent was measured with the help of EC meter (model WA. 2015) and reading was recorded in micro Simon (μS). The EC meter was calibrated with 0.01M potassium chloride (KCL) solution (Method 2510B APHA, 1998).

Total Dissolved Solids: Total Dissolve Solids' were measured with the help of TDS meter (model WA. 2015). TDS meter was calibrated with 0.01M potassium chloride (KCL) solution (Method 2510 BAPHA, 1998).

Dissolved Oxygen : Dissolve Oxygen was measured with the help of DO meter (model WA. 2015). DO meter was calibrated with 0.01M potassium chloride (KCL) solution (Method 2510B APHA, 1998).

Chlorides: The concentration of chlorides was determined by Argentometric method (Method 4500-Cl- BAPHA, 1998). 20 ml sample was taken and potassium chromate K_2CrO_4 (2-3 drops) was added as an indicator. The solution was titrated against standard silver nitrate solution ($AgNO_3$) till the achievement of end point (i.e. change of color from greenish yellow to reddish brown).

Carbonates: The concentration of carbonates was determined by Argentometric method (Method 4500-Cl-BAPHA, 1998). 10 ml sample was taken and 2-3 drops of phenolphthalein was added as an indicator. The solution was titrated against standard 0.02 normal HCL till the achievement of end point (i.e. change of color from purple to colorless).

Bicarbonates: The concentration of Bicarbonates was determined by the same method as for carbonates. 10 ml of the sample was taken and methyl orange was used as indicator. The sample was titrated against standard 0.02 normal HCL till the achievement of end point (i.e. change of color from orange to pink).

Sulphates: The concentration of sulphates was determined by turbidimetric method (Method 4500- SO_4^{-2} BAPHA 1998). A standard solution with SO_4^{-2} concentration was prepared in the range of 0 to 50mg/L. Solid 0.3 mg Barium Chloride ($BaCl_2$) was added while stirring. According to the reaction: $BaCl_2$+ $(SO4)^{2-}$= $BaSO_4$+2Cl^-, where $BaSO_4$ is white precipitate, and normally this reaction is used as a qualitative test for the presence of sulphate ion in the sample. Afterwards the solution was transferred to a cuvette and the absorption reading at 420 nm (UV-VIS Spectrophotometer) was noted repeatedly over a period of two minutes. The highest measured value was noted.

Nitrates: The concentration of nitrates was checked by turbidimetric method as cited above. A standard solution with NO_3^- concentration was prepared in the range of 0 to 10mg/L. 0.2 ml of Standard 0.1 Normal HCL was added to it while stirring. Afterwards the solution was transferred to a cuvette and the absorption reading at 220 nm (UV-VIS Spectrophotometer) was taken repeatedly over a period of two minutes. The highest measured value was noted.

Chemical Oxygen Demand: COD for the sample was determined by closed reflux method (EPA Method).The textile effluent (30ml) sample and concentrated potassium dichromate ($K_2Cr_2O_7$) (10ml) were placed in the flask with anti bump granules. We added to it (15 ml) of sulphuric acid containing silver AgH_2SO_4 carefully. 1g of mercuric sulphate was added to the flask. The mixture was then carefully boiled in draft chamber for three hours. The mixture was cooled down and 20 ml of distilled water was added to the mixture to stabilize the temperature. Ferrion was added as an indicator and the mixture was titrated with Ferrous Aluminum sulphate till the end point (i.e. till the color is muddy brown indicating very high COD concentration).

Biological Oxygen Demand: BOD for the sample was determined by taking 2 ml sample and 5 ml each of the following four reagents: Calcium Chloride, Phosphate buffer, Ferrous Chlorate and Magnesium Sulphate in 2 sets of BOD bottles. One set is analyzed on the spot to measure the dissolved oxygen. The second bottle was kept in the incubator for five days (Method EPA). The result of BOD is obtained by subtracting the Final value of BOD from the initial value.

Detection of Metals: Digestion of sample for metals detection was done by taking 100 ml sample with 10 ml of nitric acid (HNO_3) added and then the mixture was boiled on hot plates till the volume reduced to 10 ml. The sample was then transferred into volumetric flask and made up to 100ml with 2% nitric acid.

Copper: Analysis of copper in textile waste water was observed by Atomic absorption spectrophotometer (Model No. Analyst 800- Perkin Elmer). Standard stock Solution of 0.2, 0.4 and 0.8 ppm was prepared for copper analysis. In 1ml copper add 2%nitric acid and make it to 100ml it became 10 ppm. Multiply and divide 0.2 by 10 to get 0.2ppm standard solution of copper. Pour 0.2 ml of 10ppm solution of copper by digital pipette in 10ml flask and fill it with 2% nitric acid and put a lid on it. For 0.4 ppm standard solution multiplies and divides 0.4 by 10. Pour 0.4 ml of 10ppm solution of copper by digital pipette in 10ml flask and fill it with 2% nitric acid and put a lid on it. For 0.8 ppm standard multiply and divide 0.8 by 10. Pour 0.8 ml of 10ppm solution of copper by digital pipette in 10ml flask and fill it with 2% nitric acid and put a lid on it. Put the nebulizer of the Atomic absorption spectrophotometer in the flask. It will show a curve on the computer get the reading from there.

Zinc: Atomic absorption spectrophotometer (Model No. Analyst 800- Perkin Elmer) was used for the detection of Zinc. Standard stock Solution of 0.2, 0.4 and 0.8 ppm was prepared for zinc analysis. In 1ml zinc add 2%nitric acid and makes it to 100ml it became 10 ppm. Multiply and divide 0.2 by 10 to get 0.2ppm standard solution of zinc. Pour 0.2 ml of 10ppm solution of zinc by digital pipette in 10ml flask and fill it with 2% nitric acid and put a lid on it. For 0.4 ppm standard solution, multiply and divide 0.4 by 10. Pour 0.4 ml of 10ppm solution of copper by digital pipette in 10ml flask and fill it with 2% nitric acid and put a lid on it. For 0.8 ppm standard, multiply and divide 0.8 by 10. Pour 0.8 ml of 10ppm solution of zinc by digital pipette in 10ml flask and fill it with 2% nitric acid and put a lid on it. Put the nebulizer of the Atomic absorption spectrophotometer in the flask. It will show a curve on the computer get the reading from there.

Chromium: Atomic absorption spectrometer (Model No. Analyst 800- PerkinElmer) was used for the chromium. Standard stock Solution of 0.2, 0.4 and 0.8 ppm was prepared for chromium analysis. In 1ml chromium add 2% nitric acid and make it to 100ml it became 10 ppm. Multiply and divide 0.2 by 10 to get 0.2ppm standard solution of chromium. Pour 0.2 ml of 10ppm solution of chromium by digital pipette in 10ml flask and fill it with 2% nitric acid and put a lid on it. For 0.4 ppm standard solution, multiply and divide 0.4 by 10. Pour 0.4 ml of 10ppm solution of Chromium by digital pipette in 10ml flask and fill it with 2% nitric acid and put a lid on it. For 0.8 ppm standard, multiply and divide 0.8 by 10. Pour 0.8 ml of 10ppm solution of chromium by digital pipette in 10ml flask and fill it with 2% nitric acid and put a lid on it. Put the nebulizer of the Atomic absorption spectrophotometer in the flask. It will show a curve on the computer get the reading from there.

RESULTS

In this study, the sample of textile effluents was obtained from Faisalabad according to the standard procedure. The physico-chemical analysis of the effluent were pH, EC, TDS, DO, COD, BOD, Cl^-, SO_4^{-2}, NO_3^-, CO_3^-, HCO_3^- and metal contents Zn, Cr, Cu. Results showed that the values of these parameters were found to be very high during the present research work as compared to the permissible values for the discharge of waste water given in National Environment Quality Standards (NEQS, 1997).

Physico-chemical Characterization of waste water and their treatment: The color of the sample (textile waste-water) was found turbid or slightly yellowish. This may be due to the presence of total dissolved solids. We followed the phyto-remediation strategy in order to reduce the pollution load from the textile effluents. The plant *Hydrocotyle umbellata* L. was introduced in the sample for 15 days and its bioaccumulation potential was observed. Before introducing the plant in the sample, the average length and width of plants were measured. The largest plants had an average stem length of 22cm, leaf length of 3cm, leaf width of 4.2cm; whereas the smallest plants on the average were 6 cm long, with leaf size of 1 x 1.4cm. During the initial adjustment phase, the plants showed some wilting but later on, they flourished and developed new leaves and branches. After introducing the plants to the effluents, the observations were taken with an interval of five days. All the characteristics were monitored during the study period. The details are given below.

pH: pH is the Hydrogen ion concentration. It is an important indicator because highly basic or highly acidic water is neither suitable for animals nor plant consumption (Pagga and Teager, 1994). At low pH, most of the metals remain persistent in the environment while at high pH, most of the metals get insoluble and accumulate in the sludge or settle down as sediments (WHO, 1993). The pH of the sample was measured with pH meter (model WA. 2015). The readings were taken after one hour of introducing the plants into the sample. The initial pH reading observed was 11.37. Obviously, it was not according to the permissible limits of NEQS (1997), i.e. 6-9. After 15 days treatment, a significant reduction in pH was observed (from 11.37 highly basic to 7.03 nearly neutral) as shown in (Table1).

Temperature: Temperature is also an important parameter for both natural and waste water. It is an important factor for phyto-remediation process. Very high or very low temperatures are not suitable for the survival of plants and aquatic life. Variation in temperature depends on season and humidity in the atmosphere. We observed only slight variations in the temperature as shown in (Table 1). The observed temperature of the waste water was low / or within the range of NEQS (1997) i.e.40 ^oC for industrial effluent. Similar observations have been reported by Ogunlaja and Aemere (2009) while evaluating the efficiency of textile wastewater.

Electric Conductivity (EC): Electrical conductivity (EC) is an indicator of the total concentration of dissolved salts in water. A lower EC values indicates the presence of low contents of dissolved salts and the high EC values indicate high contents (Abdullah and Mustafa, 1999). The recommended permissible limit for EC is 300 $\mu S\ cm^{-1}$ (Jafari *et al.,* 2008). In the present research study EC of the sample was found to be high. The maximum and minimum values were 18 and 15.75 milli Simon respectively as shown in (Table 1).

Dissolved Oxygen: Dissolved Oxygen is an important component of fresh water. Obviously the low value of dissolved oxygen leads to a serious threat to aquatic life. We observed value of dissolved oxygen (DO) in the textile effluent as 37mg/l. After introducing *Hydrocotyle umbellata* the DO value increased. The minimum and maximum values were in the range of 37 to 45 mg/l respectively. Similar results were observed Ogunlaja and Aemere (2009) for dissolved oxygen in textile wastewater. Increase in DO is shown in (Table 1).

Table 1. Mean values showing physicochemical characterization of textile waste water treatment during Phytoremediation.

Parameters	Zero time	5th day	10th day	15th day
Temperature (°C)	39.5 ± 0.20	22.4 ± 0.23	23.4 ± 0.15	23.7 ± 0.15
pH	11.3±0.01	7.665±0.015	7.595±0.005	7.015±0.015
Ec (mS)	18.01±0.01	17.9± 0.1	16.125 ± 0.125	15.435 ± 0.435
DO (mg/L)	37.25±0.25	39.1 ± 0.1	43.5 ± 0.5	49 ± 1
TDS (mg/L)	2138 ± 0.1	2054 ± 4	1267.5 ± 2.5	1201 ± 1
Carbonates (mg/L)	7000 ± 0.5	6752.5 ± 2.5	4061 ± 1	2501 ± 1
HCO_3 (mg/L)	7501 ± 1	6294 ± 0.6	5994 ± 0.8	4027.5 ± 2.5
sulphate (mg/L)	4833.3 ± 0.1	3986.5 ± 0.5	3333.15 ± 0.15	2532.5 ± 2.5
Cl (mg/L)	900.5 ± 0.5	747.5 ± 2.5	701 ± 1	501 ± 1
Nitrates (mg/L)	3.23 ± 0.03	3.015 ± 0.015	2.025 ± 0.025	1.755 ± 0.255
COD (mg/L)	533 ± 0.1	401 ± 1	331.5 ± 1.5	191 ± 1
BOD (mg/L)	251.45 ± 0.5	198.31 ± 0.31	183.48 ± 1.4	86.85 ± 1.85
Cu (mg/L)	0.285 ± 0.0049	0.155 ± 0.005	0.145± 0.0049	0.125 ± 0.005
Zn (mg/L)	0.46 ±0.1	0.3185 ± 0.0015	0.2085 ± 0.0085	0.113 ± 0.013
Cr (mg/L)	0.827 ± 0.001	0.467 ± 0.017	0.368 ± 0.008	0.305 ± 0.005

Total Dissolved Solids: Overall declining trend was observed for the total dissolved solids in textile effluent during the treatment period. Total dissolved solids **(**TDS) in the textile sample were 2460 mg/l, whereas the desirable limit of TDS prescribed in NEQS (1997) is 2000 mg/L. After introducing *Hydrocotyle umbellata* the TDS value reduce to 1202, i.e. 36.35 % reduction as shown in (Table 1).

Carbonates and Bicarbonates: Alkalinity of water is generally measured by the amounts of carbonate $(CO_3)^-$ and bicarbonate $(HCO_3)^-$ content. In the present study, the values of carbonates and bicarbonates were found to be high in the textile waste water as compared to the international standards. After introducing the plant *Hydrocotyle umbellata* , we observed significant decrease in the alkalinity of waste waters. The maximum and minimum range of carbonates was 7000 and 2500mg/l respectively i.e. 64.3 % reduction as shown in (Table 1). The maximum and minimum range of bicarbonates was 7500 and 4030 mg/l respectively i.e. 46.26 % reduction as shown in (Table 1). During the treatment of the sample, a reduction in pH value indicated a simultaneous reduction in the concentration of carbonates and bicarbonates.

Sulphates: The high values of sulphate contents are capable of causing ailments like catharsis, dehydration and gastrointestinal irritation (Bertram and Balance, 1996). In the present research work, the sulphate $(SO_4)^{-2}$ values were found to be greater than the permissible limit of NEQS i.e. 600 mg/l. The maximum and minimum range of sulphates in the textile effluent was 4833.3 and 2535.1 mg/l respectively i.e. 47% reduction. After introducing *Hydrocotyle umbellata* , a decreasing trend was observed in the concentration of sulphates, as shown in (Table 1), which might be due to the ability of plants to accumulate contaminants in their tissues. This reduction in the sulphate content was observed in the textile waste water on 15th day of the treatment. However the observed value after reduction was still above the reference range. If the retention period of the treatment is increased, then maximum reduction could be expected.

Chlorides*:* The chloride concentration of the textile waste water was found to lie within the permissible limits of NEQS (1997) i.e. 1000mg/l. The maximum and minimum range of chlorides in the textile waste water was 900 and 500 mg/l respectively. After introducing *Hydrocotyle umbellata* in the textile waste water the percentage reduction was 44% corresponding to an actual concentration of 900 mg/l as shown in (Table 1). Sources of chlorides in the textile effluents includes acids, sodium chlorite and sodium hyperchlorite. Significant reduction in chlorides in tannery sludge was observed by Khilji and Bareen (2008), using *Hydrocotyle umbellata.*

Nitrates: The concentration of nitrate contents $(NO_3)^{-1}$ in the textile waste water was high, i.e 3.26 mg/l as compared to the International standard. High nitrates concentration in the waste water is an indication of high nitrate pollution. After introducing *Hydrocotyle umbellata*, we observed a decreasing trend. The maximum and minimum values observed were 3.26 and 2.10 mg/l respectively i.e. 38.3% reduction in nitrate concentration as shown in (Table 1). High concentration of nitrates could cause cancer in human being and possibly in other aquatic animals (McCasland *et al*., 2007).

COD: The chemical oxygen demand (COD) for the textile effluent was determined by closed reflux method. The present study observed a large amount of the average value of COD in the textile effluent as compared to the permissible limits of NEQS (1997) i.e. 150mg/l. Generally, a higher value of COD indicates higher pollution of water. A maximum COD removal was obtained on the 15 day of the observation. The percentage removal for COD was 63%, with actual value (533 mg/l) as shown in (Table 1).

BOD: The biological oxygen demand (BOD) of the textile waste water was higher than the permissible limits of the NEQS. The maximum and minimum range was observed to be 246.45 and 88.7mg/l respectively i.e. 63.9% reduction. The rate of BOD removal was found to be decreasing but only up to a certain limit. When the waste water was treated with *Hydrocotyle umbellata* , an increase in BOD removal rate was observed. The maximum BOD reduction was observed on the 15^{th} day of the treatment that reduce from 246.45mg to 88.7mg/l i.e. 63.9% reduction as shown in (Table 1).

Copper: Heavy metals have been associated with the textile effluents (Yusuff and Sonibare, 2004) because the industries concerned use synthetic complex organic dyes containing metals as the coloring material (Zollinger, 1987), which cause serious environmental problems. Sekhar *et al.*, (2003) linked the heavy metal contamination of an area to industrial effluent discharge. Analysis of copper in textile waste water was observed by Atomic absorption spectrometer. The value of copper metals in the sample was 0.28 mg/l. This value is within the permissible limit of NEQS (1997) i.e. 1 mg/l. After treatment of the textile waste water with *H. umbellata* , a maximum reduction of copper was observed i.e. 53.5% reduction as shown in (Table 1).

Zinc: Zinc metal present in textile effluent was observed by atomic absorption spectrometer. It was found that zinc in the textile waste water was analyzed under the permissible limits of NEQS (1997) i.e.5mg/l. 72.6% reduction was observed in zinc concentration in the textile waste water as shown in (Table 1).

Chromium: Atomic absorption spectrometer (Model No. Analyst 800- PerkinElmer) was used for the chromium analysis. It was observed to have the concentration of 0.828 mg/l in the textile waste water. This might be due to its use for oxidation purpose in cotton dyeing and for chemical fixation in wool dyeing. NEQS recommended discharge limit for chromium is 0.1 mg/l. In the present study, the reduction from 0.828 mg to 0.31 mg/l was achieved when the textile effluents were treated with *Hydrocotyle umbellata* . Chromium has the percentage removal of 62.5%, which is due to effective metal accumulation by the *Hydrocotyle umbellata* as shown in (Table 1).

DISCUSSION

The major pollutants in textile waste waters comprise significant amounts of total dissolved solids, heavy metals, chemical dyes, acids, bases and other soluble material (Dae-hee *et al*., 1999). Moreover, a significant amount of heat is also released along with the effluents (Allegre *et al.*, 2006). The high pH of the textile effluent may be due to the application of chemicals, such as caustic soda, for mercerizing cotton yarn and for dyeing. Processes such as de-sizing and scouring, done before bleaching, might also be responsible for the basic nature of the waste water. Chemicals like soda ash and hydrogen peroxide used for scouring tends to increase pH (Ogunlaja and Aemere, 2009). Khilji and Bareen (2008) have observed significant reduction in pH of tannery effluent using the same plant, *Hydrocotyle umbellata* . Likewise, Roy *et al*., (2010) observed significant reduction in pH of textile effluents using Bio-remediation technology by introducing aquatic macro-phytes and *Nostoc* and their combinations.

Results of this study showed high EC which can be correlates with the release of chemical and salts from the textile industry as well as the influx of lagoon water. One of the effects of EC is the impact on the taste of water was reported by Langeneggar (1990). High EC indicates that a large amount of ionic substances like sodium, potassium, iron etc., are present in textile effluent (Kabir *et al.*, 2002). Khilji and Bareen, (2008) noted that the results of EC indicated minor fluctuations but significant reduction in EC was observed by using *Hydrocotyle umbellata* in treatment of tannery waste water. The low value of DO might be linked directly to high value of nutrients like nitrates and phosphates in the effluents or to subsequent high coliform populations. This implies that the effluent discharge from the textile industry might have released high oxygen-demanding wastes. Environmental implication of low DO is nothing but the expiry of aquatic organisms (Chapelle and Petts, 2004).

High TDS in textile waste water as indicated by results may be due to the contamination present in the waste water due to dyeing units. According to Shyamala *et al*., (2008), the TDS is not deemed to be associated with health effects, rather it can be used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants. According to Olayinka (2004), the effluents from textile industries are capable of increasing TDS of water body. Lee and Lin (1999) described the solids concentration as an important characteristic of wastewater. High COD values could be due to high organic load as evident from the results found by Osibanjo and Adie (2007). COD was strongly correlated to total dissolved solids and total suspended solids. This affirmed the linear relationship between total dissolved solids and COD (Ogunlaja and Aemere, 2009). As noted by Sawyer and McCarty (1978), the high COD in water indicates the presence of biologically resistant organic substances. Roy *et al.,* (2010) observed significant reduction in COD of textile waste water by using aquatic macrophytes and alga. The COD removal performance results proved that the chosen technology of phytoremediation was effective.

Scientifically, the higher BOD means that the water sample is most polluted. The more oxygen consumed by the microorganisms in decomposing organic compounds and pollutants may contribute towards unpleasant odor and taste of drinking water. Moorhead and Reddy (1990) studied the effectiveness of *Hydrocotyle umbellata* in the use of oxygen to reduce biological oxygen demand, ammonia and nitrogen concentrations in sewage and found it to be very effective in the conversion of organic carbon into carbon dioxide. Wolverton and McDonald (1976) observed that *E. crassipes* reduced the BOD of polluted waters.

The reduction of copper may be due to the specific properties of the plant. Phytochelatins are small glutathione derived metal binding peptides, which are a part of the plant metal detoxification system (Clemens, 2001), which may be responsible for phyto-removal of metals. Intoxication of copper salt results in vomiting, hyper tension comma and death (Rana, 2007). Khilji and Bareen (2008) observed the general trend in uptake of metals as Cr > Na > Zn > Cu by using *H. umbellata* in tannery effluent. Zinc is an important element, not only because it is essential for animals and plants (Brown *et al.,* 1993; Welch, 1993), but because it has a wide range of industrial uses (Cammarota, 1980). Despite its importance in our everyday lives, zinc is a heavy metal that occurs in the greatest concentration in the majority of wastes arising in modern industrialized communities (Boardman and McGuire, 1990). Zinc was determined as an essential element for plant growth by Sommer and Lipman (1926). Khilji and Bareen (2008) observed reduction of zinc in tannery effluent by using *Hydrocotyle umbellata* in tannery effluent. Chromium toxicity damages the liver, lungs and causes organ haemorrhages; although it is an essential trace nutrient and a vital component for glucose tolerance factor (WHO, 1988). Acute exposure to chromium causes death preceded by nausia, vomiting, shock and comma (Rana, 2007). Chromium merits a special reference for its extreme toxicity due to the interaction of its compounds with living cells (Costa, 1997).

Khilji and Bareen (2008) observed in their study of tannery waste water a higher amount of metal accumulation by *Hydrocotyle umbellata* typically in case of chromium treatment. They observed the general trend in uptake of metals i.e. Cr > Na > Zn > Cu. According to Lasat (2000), hyper accumulators are plants that have an innate capacity to absorb metal at levels 50 - 500 times greater than average plants. *Hydrocotyle umbellata* showed a good hyper-accumulation of almost all the metals used in textile processing. This plant can qualify as a hyper-accumulator according to the criterion given by Baker and Brooks (1989).

Conclusion and Recommendations

There is a need to explore more plants species for phytoremediation studies which are commonly cultivated /grown in our natural climatic conditions. Search out their mechanism of dehydration through HPLC, GCMS, NMR, Mass spectrometry etc. Explore and extract the proteins and enzymes from plant species that could be utilized for treating the waste water having diversified pollutants and recalcitrant compounds.

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