Available online at http://www.ijims.com
ISSN: 2348 – 0343

Phytoremediation of Textile Waste Water Using Potential Wetland Plant: Eco Sustainable Approach

Mesania Rizwana[1], Marjadi Darshan[1] and Desai Nilesh[2]
1Department of Biotechnology, Shree Ramkrishna Institute of Computer Education and Applied Sciences, Surat, Gujarat, India,
2 Palsana Enviro Protection Ltd Company (PEPL), Umbhel, Kamrej, Surat, Gujarat, India
Corresponding Author: Marjadi Darshan

Abstract

One of the major problems encountered in the textile industry is the production of large volumes of highly coloured wastewater. The textile industries daily discharge million litres of untreated effluents in the form of wastewater into public drains that eventually empty into rivers. They cause serious health hazard. Textile wastewater also contains substantial pollution loads which increase the Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Suspended solids (TSS), Total Dissolved Solids (TDS) and heavy metals. So pre-treatment is needed prior to discharge of these effluents. Among all method investigated presently, Phytoremediation by AMATS (Aquatic Macrophytes Treatment Systems) is a well established environmental protective technique. The most common aquatic Macrophytes being employed in wastewater treatment are water hyacinth, penny wort, water lettuce, water ferns and duck weeds, because they are cheaper to construct and a little skill is required to operate them. This review paper discusses comparative study and efficiency of plants and proposed mechanism of various plant contributed for remediation of textile waste water.

Keywords: Aquatic macrophytes treatment system, Chemical Oxygen Demand, Eichhornia crassipes, Heavy metals, Lemna minor, Pistia stratiotes.

Introduction

Water pollution is a major global problem and it is leading worldwide cause of deaths and diseases. Pollution of the biosphere with toxic metals has accelerated dramatically since the beginning of the Industrial Revolution [1, 2].The concentrations of pollutants in textile wastewaters vary according to the wastewater management practices and their dilution after production. Textile dyes are one of the most prevalent types of chemicals in use today. Around 10 000 different dyes with an annual production of more than 7×10^5 metric tons worldwide are commercially available. Heavy metals are the most dangerous type of chemical pollutants since they cause serious health hazard. In India, about 2000-32000 tons of elemental Metal (Cr) annually escapes into the environment[3]. Neober and Richardson[4] show that "heavy metals" are associated with toxicity of biota, although some metals such as manganese and uranium are not known to be toxic to life form, include such as water hyacinth and Duck weed, water lilies etc.

Impact of textile waste water on ecosystem

According to Thilakar et. al.,[3] improper disposal of waste causes direct contamination of ground water and surface water both. This wastewater has serious negative impact not only on land area but also on the aquatic ecological system. Due to usage of dyes and chemicals textile effluents are dark in colour, thus increasing the turbidity of the receiving water body.

This is cause alteration in the habitat. Table-1 summarized the characteristics of typical textile waste water. Metal pollution has harmful effect on biological systems and does not undergo biodegradation. Ions of Heavy metals (Cd and Cr), which are frequently present in the wastewaters can cause renal dysfunction as well as chronicle alterations in nervous system and gastrointestinal tract [5].

Phytoremediation by wetland plant

Several conventional methods are already being used to clean up the environment from these kinds of contaminants, which include chemical precipitation, lime coagulation, ion exchange, reverse osmosis solvent extraction, aeration, chemical oxidation, electrolysis, ultra filtration, and chlorination. But most of them are costly and far away from their optimum performance[7]. The chemical technologies generate large volumetric sludge and increase the costs [8]. Chemical and thermal methods are both technically difficult and expensive. All of these methods can also degrade the valuable component [7].Therefore among all these methods; Phytoremediation by AMATS (Aquatic Macrophytes Treatment Systems) is a well-established environmental protective technique for removing heavy metals and other pollutants. FVP (Fresh water Vascular Plant) when combined with the macroscopic algae are known as 'Macrophytes'. According to Hutchison [9] macrophytes have ability to concentrate element from aquatic environment. AMATS for waste water treatment are the need of developing countries, because they are cheaper to operate and environmental friendly. The most common aquatic macrophytes involved in AMATS are mention in figure 1 and; table 2 summarizes the uptake of trace elements by aquatic plants reported so far by Rahman et al. [10].

Mechanism of Phytoremediation of potential wetland plant

There are two main approach available which proposed the utilization of wet land plants for remediation of polluted water [15]. There are two natural division (Figure-2) of aquatic phytoremediation system that involved, Purely aquatic plants such as water hyacinth and submersion of rhizosphere of terrestrial plants to remove metal pollutants (rhizofiltration) [15].

A. Water hyacinth (<u>Eichhornia</u> <u>crassipes</u>)

Many proposals have been put forward to explain the possible mechanism involved in the water hyacinth-based treatment systems [43-46]. The presence of aquatic macrophytes in water body alters the physio-chemical environment of the water body [44]. The presence of other aquatic photosynthetic autotrophs can deplete dissolved CO_2 in water during the period of high photosynthetic activity. This increases dissolved oxygen in the wastewater thus resulting in increased water pH [43].In terms of bacterial reduction by water hyacinth-based systems, two theories exist which summarized in Figure-3.

Aquatic macrophytes like water hyacinth uptake contaminants and stores in its biomass. These plants are called bio accumulators as they accumulate the contaminants in their tissues [47].They have high tolerance against contaminants like heavy metals and are able to absorb large quantities. This method of extracting heavy metal from polluted water bodies is called phytoextraction. The uptake of contaminants is by three methods[48]

a. Root absorption- The roots absorb water together with the contaminants in water. 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. In sewage systems, the root structures of water hyacinth (and other aquatic plants) provide a suitable environment for aerobic bacteria to function. Aerobic bacteria feed on nutrients and produce inorganic compounds which in turn provide food for the plants. The plants grow quickly and can be harvested to provide rich and valuable compost. Water hyacinth has also been used for the removal or reduction of nutrients, heavy metals, organic compounds and pathogens from water

b. Foliar absorption- In addition to root absorption, plants could also derive low amounts of some contaminants through foliar absorption. They are passively absorbed through stoma cells and cracks in cuticle.

c. Adsorption- The fibrous and feathery roots not only\trap suspended solids and bacteria, but provide attachment sites for bacterial and fungal growth. The contaminants get adsorbed to the root surface by the bacteria present there. It is also due to ionic imbalance across the cell membrane.

B. Water lettuce (Pistia stratiotes)

Pollutant (Heavy metals) removal by Pistia stratiotes from solution involved two stages: First stage involved process like adsorption, chelation, and ion exchange, in which heavy metal uptake is different for each species of Pistia .Second stage involve heavy metal(Cr) precipitation induced by root of Pistia, in which heavy metal uptake is different for each species and metals of Pistia [49]. Pistia do phytoremediation also by a process called 'Rhizofiltration'. They are natural hyper accumulators of many heavy and toxic metals [3].

C. Duck weed (Lemna minor)

Duck weed has the capability to purify wastewater in collaboration with both aerobic and anaerobic bacteria. The duck weed mat, which fully covers the water surface, result in three zones. These are the aerobic zone, the anoxic zone and aerobic zone[50]. In aerobic zone, organic materials are oxidised by duck weed roots [51]. Nitrification and denitrification take place in the anoxic bacteria into ammonium and ortho-phosphate, which are intermediate products used as nutrient by the duck weed [52].

Effect of Phytoremediation on plant growth

The plant growth was not affected to any great extent but some yellowish and necrotic spots appeared on the leaves. The anatomy of plants showed some significant ($p < 0.05$) reduction in different cell sizes in various parts of plant [6].While studying the uptake of some heavy metals by water hyacinth, Ingole[53] indicated that at lower concentrations (5 mg/l) of heavy metals, the plant growth was normal and removal efficiency was greater. At higher concentrations, greater than 10 mg/l, the plant started wilting and removal efficiency was reduced. The effect of lead (Pb), copper (Cu), and cadmium (Cd), on metal uptake and growth of the water hyacinth was studied. Although, lead had no effect on plant growth**.** They found that cadmium and copper were toxic to this plant and that thresholds were respectively 0.5 and 1-2 µg/ml in the ambient water. Beyond this they effect were chlorosis, suppressed development of new root and greatly reduced growth rate [15].

Analysis of various components inside the plants can be done by using different parameter with different approaches based on purpose of the research. Some researcher Analyses parameter like pH, COD, Conductivity, Total solids(TS), BOD [6],total nitrogen(TN), total phosphorous(TP), ortho phosphate(PO4-P)[54] ,various Heavy metals like Cr , Zn by AAS (atomic absorption spectroscopy) [5] and color reductions in terms of optical density etc. are determined at different time intervals and some determine whether adding light and heat to the plant environment would improve their heavy metal uptake and plant health by looking at both the plants visual health and their weight [55]. Before and after heavy metal exposure, Phytochemical component [56] in plant was also analyzed. In spite of these other parameter like the effectiveness of using Plant powder as coagulant with powder of different dosages and their effect on pH and conductivity was also analyzed [57]. The result obtained after experiment is summarized in table 3.

Discussion and Conclusion

The reduction in pH by wetland plant is favoured microbial action to degrade BOD and COD in the wastewater. According to Reddy [44] the presence of plants in wastewater can deplete dissolved CO_2 during the period of high photosynthetic activity. This photo-synthetic activity increases the dissolved oxygen of water, thus creating aerobic conditions in wastewater which favor the aerobic bacterial activity to reduce the BOD and COD. Weber concluded that nitrification followed by de nitrification was the principal nitrogen removal mechanism. The water hyacinths store most of the heavy metal (arsenic) in their bladders, followed by their stems and leaves, followed by their roots. This shows that the water hyacinths are transporting the arsenic up through their roots to the stems and then out to the bladders, which are not an actively photosynthesizing part of the plant. As per the study the promising attributes of Water hyacinth includes that its tolerance to dye and dye absorption along with good root development, low maintenance and ready availability in contaminated regions. These characteristics prove the suitability of water hyacinth in dyeing industry effluent treatment ponds. Many aquatic plants have been used to remove nutrients from eutrophic waters but water lettuce proved superior to most other plants in nutrient removal efficiency, owing to its rapid growth and high biomass yield potential. However, the growth and nutrient removal potential are affected by many factors such as temperature, water salinity, and physiological limitations of the plant. Low temperature, high concentration of salts, and low concentration of nutrients may reduce the performance of this plant in removing nutrients.

The water hyacinth was found to be efficient in reducing the concentrations of total solids, pH, conductivity, heavy metals etc., within 96 hours of treatment. Water hyacinth was found to be effective in reduction of BOD and COD. At this time of water, energy and environmental purity crisis, water hyacinth can be a very effective tool in polishing the wastewater after primary and secondary treatments. Water lettuce has a great potential in removing N and P from eutrophic storm waters and improving other water quality properties**.** Lemna minor has a high capacity of adaptation as it plays a substantial role in nutrient removal. Eicchornia crassipes and Lemna trisulca L, Oenathe javanica, Lepironia articulate have good potential for the practical remediation of Cd ,Hg and Pb contaminated water respectively.

In future, Eicchornia crassipes can be used in both secondary and tertiary treatment systems, for the removal of nutrients and in integrated secondary and tertiary treatment systems, where both BOD and nutrient removal is the goal [59, 60]. Recent discovery have given first insight into molecular basis of metal hyper accumulation and metal hyper tolerance in some plants. The recent Progress of molecular techniques has helped to improve the performance of phytoremediation technology as well as plant adaptation to extreme metallic environments. Molecular technique help to understand the gene regulation system and plant metal homeostasis [61].

References

[1] Nriagu JO., Global inventory of natural and anthropogenic emission of trace metals to the atmosphere. Nature,1979, 279: 409-411.

[2] Sayyed MRG, Sayadi MH., Variations in the heavy metal accumulations within the surface soils from the Chitgar industrial area of Tehran. Proceedings of the International Academy of Ecology and Environmental Sciences, 2011,1(1): 36-46.

[3] Ranjana Julias Thilakar, Jeya Rathi. J and Prabha M. Pillai, Phytoaccumulation of Chromium and Copper by Pistia stratiotes L. and Salvinia natans (L.) J. Nat. Prod. Plant Resour., 2012, 2 (6),725-730.

[4] Nieboer, E and Richardson, D.H.S ,The replacement of the non-descript term “Heavy metals” by a biologically and chemically significant classification of metal ions. Environmental Pollution B, 1980, 1, 3-26.

[5] Santosh Kumar Prajapati, Neelima Meravi, Shivangee Singh, Phytoremediation of Chromium and Cobalt using Pistia stratiotes: A sustainable approach, International Academy of Ecology and Environmental Sciences, 2012, 2(2),136-138.

[6] Q. Mahmood, P. Zheng , E. Islam, Y. Hayat, M. J. Hassan, G. Jilani , R.C. Jin , Lab Scale Studies on Water Hyacinth (Eichhornia crassipes Marts Solms) for Biotreatment of Textile Wastewater ,Caspian Journal of Environmental Science, 2005, 3, 83-88.

[7] Bieby Voijant Tangahu, Siti Rozaimah Sheikh Abdullah,Hassan Basri, Mushrifah Idris, Nurina Anuar, and Muhammad Mukhlisin, A Review on HeavyMetals (As, Pb, and Hg) Uptake by Plants through Phytoremediation, International Journal of Chemical Engineering.,2011, 2011, 31.

[8] R. Rakhshaee, M. Giahi, and A. Pourahmad, Studying effect of cell wall’s carboxyl carboxylate ratio change of Lemna minor to remove heavy metals from aqueous solution, Journal of Hazardous Materials, 2009, 163, 165–173.

[9] Hutchinson,G.E,A Treatise on Limnology, 1975, 3,264-348.

[10] M. A. Rahman, H. Hasegawa, K. Ueda, T. Maki, and M. M. Rahman ,Arsenic uptake by aquatic macrophyte Spirodela polyrhiza L.: interactions with phosphate and iron,” Journal of Hazardous Materials, 2008,160, 356–361.

[11] Fritioff, A., Greger, M., Aquatic and terrestrial plant species with potential to remove heavy metals from stormwater. Int. J. Phytorem., 2008, 5, 211–224.

[12] Mkandawire, M., Lyubun, Y.V., Kosterin, P.V., Dudel, E.G., Toxicity of arsenic species to Lemna gibba L. and the influence of phosphate on arsenic bioavailability. Environ. Toxicol., 2004, 19, 26–35.

[13] Mkandawire, M., Dudel, E.G., Accumulation of arsenic in Lemna gibba L.(ducweed) in tailing waters of two abandoned uranium mining sites in Saxony,Germany. Sci. Total Environ.,2005, 336, 81–89.

[14] Miretzky, P., Saralegui, A., Cirelli, A.F., Aquatic macrophytes potential for the simultaneous removal of heavy metals (Buenos Aires, Argentina). Chemosphere, 2004, 57, 997–1005.

[15] Robinson, B., Marchetti, M., Moni, C., Schroeter, L., van den Dijssel, C., Milne, G., Bolan, N., Mahimairaja, S., Arsenic accumulation by aquatic and terrestrial plants. In: Naidu, R., Smith, E., Owens, G., Bhattacharya, P., Nadebaum, P. (Eds.),Managing Arsenic in the Environment: From Soil to Human Health. CSIRO,Collingwood, Victoria, 2005, pp. 235–247.

[16] Huebert, D.B., Shay, J.M., Zinc toxicity and its interaction with cadmium in the submerged aquatic macrophyte Lemna trisulca L. Environ. Toxicol. Chem., 1992,11, 715–720.

[17] Odjegba, V.J., Fasidi, I.O.,Phytoremediation of heavy metals by Eichhornia crassipes. Environmentalist, 2007, 27, 349–355.

[18] Alvarado, S., Guédez, M., Lué-Merú, M.P.,Nelson,G.,Alvaro, A., Jesús, A.C.,Gyula, Z, Arsenic removal from waters by bioremediation with the aquatic plants water hyacinth (Eichhornia crassipes) and lesser duckweed (Lemna minor). Bioresour. Technol., 2008, 99, 8436–8440.

[19] Espinoza-Quinones, F.R., Zacarkim, C.E., Palacio, S.M., Obregon, C.L., Zenatti, D.C.,Galante, R.M., Rossi, N., Rossi, F.L., Pereira, I.R.A., Welter, R.A., Rizzutto, M.A, Removal of heavy metal from polluted river water using aquatic macrophytes Salvinia sp. Braz. J. Phys., 2005, 35,744–746.

[20] Junior, A.C.G., Lindino, C.A., da Rosa, M.F., Bariccatti, R., Gomes, G.D., Removal of toxic heavy metals cadmium, lead and chromium from swine biofertilizer, using an aquatic macrophyte (Eichornia crassipes) as a bioindicator. Acta Sci.,2008.

[21] Mishra, V., Upadhyay, A., Pathak, V., Tripathi, B., Phytoremediation of mercury and arsenic from tropical opencast coalmine effluent through naturally occurring aquatic macrophytes. Water Air Soil Pollut., 2008, 192, 303–314.

[22] Dixit, S., Dhote, S., Evaluation of uptake rate of heavy metals by Eichhornia crassipes and Hydrilla verticillata. Environ. Monit. Assess., 2010, 169, 367–374.

[23] Banerjee, G., Sarker, S.,The role of Salvinia rotundifolia in scavenging aquatic Pb(II) pollution: a case study. Bioprocess Biosyst. Eng.,1997, 17, 295–300.

[24] Dhir, B., Salvinia: an aquatic fern with potential use in Phytoremediation. Environ. Int. J. Sci. and Techno., 2009, 4, 23–27.

[25] Sen, A.K., Mondal, N.G., Removal and uptake of copper(II) by Salvinia natans from wastewater. Water Air Soil Pollut., 1990, 49, 1–6.

[26] Sen, A.K., Bhattacharyya, M., Studies on uptake and toxic effects of lead on Salvinia natans. Indian J. Environ. Health, 1993, 35, 308–320.

[27] Olguin, E., Rodriguez, D., Sanchez, G., Hernandez, E., Ramirez, M., Productivity, protein content and nutrient removal from anaerobic effluents of coffee wastewater in Salvinia minima ponds, under subtropical conditions. Acta Biotechnol., 2003, 23, 259–270.

[28] Hoffmann, T., Kutter, C., Santamaria, J., Capacity of Salvinia minima Baker to tolerate and accumulate As and Pb. Eng. Life Sci, 2004, 4, 61–65..

[29] Vardanyan, L.G., Ingole, B.S., (2006) Studies on heavy metal accumulation in aquatic macrophytes from Sevan (Armenia) and Carambolim (India) lake systems.Environ. Int., 2007, 32, 208–218.

[30] Lee, C.K., Low, K.S., Hew, N.S., Accumulation of arsenic by aquatic plants. Sci.Total Environ., 1991,103, 215–227.

[31] Gothberg, A., Greger, M., Bengtsson, B.E., Accumulation of heavy metals in wate spinach (Ipomoea aquatica) cultivated in the Bangkok region, Thailand.Environ. Toxicol. Chem., 2002, 21, 1934–1939.

[32] Hu, M.H., Ao, Y.S., Yang, X.E., Li, T.Q., Treating eutrophic water for nutrient reduction using an aquatic macrophyte (Ipomoea aquatica Forsskal) in a deep flow technique system. Agric. Water Manage., 2008, 95, 607–615.

[33] Wang, K.S., Huang, L.C., Lee, H.S., Chen, P.Y., Chang, S.H., Phytoextraction of cadmium by Ipomoea aquatica (water spinach) in hydroponic solution: effects of cadmium speciation. Chemosphere , 2008,72, 666–672.

[34] Zhang, X., Lin, A.-J., Zhao, F.-J., Xu, G.-Z., Duan, G.-L., Zhu, Y.-G., Arsenic accumulation by the aquatic fern Azolla: Comparison of arsenate uptake, speciation and efflux by Azolla caroliniana and Azolla filiculoides. Environ. Pollut., 2008,156, 1149–1155.

[35] Rai, P.K., Phytoremediation of Hg and Cd from industrial effluents using an aquatic free floating macrophyte Azolla pinnata. Int. J. Phytorem., 2008, 10, 430–439.

[36] Rai, P.K., Tripathi, B.D., Comparative assessment of Azolla pinnata and Vallisneria spiralis in Hg removal from G.B. Pant Sagar of Singrauli industrial region, India. Environ. Monit. Assess.,2009,148, 75–84.

[37] Cardwell, A.J., Hawker, D.W., Greenway, M., Metal accumulation in aquatic macrophytes from southeast Queensland, Australia. Chemosphere, 2002, 48, 653–663.

[38] Mayes, R.A., MacIntosh, A.W., Anderson, V.L.,Uptake of cadmium and lead by a rooted aquatic macrophyte (Elodea canadensis). Ecology, 1977, 58, 1176–1180.

[39] Mal, T.K., Adorjan, P., Corbett, A.L., Effect of copper on growth of an aquatic macrophyte, Elodea canadensis. Environ. Pollut., 2002, 120, 307–311.Technol. 30, 9–14.

[40] Chandra, P., Kulshreshtha, K.,Chromium accumulation and toxicity in aquatic vascular plants. Bot. Rev., 2004, 70, 313–327.

[41] Dogan, M., Saygideger, S., Colak, U., Effect of lead toxicity on aquatic macrophyte Elodea canadensis Michx. Bull. Environ. Contam. Toxicol., 2009, 83, 249–254.

[42] Maine, M.A., Suñé, N.L., Lagger, S.C., Chromium bioaccumulation:comparison of the capacity of two floating aquatic macrophytes. Water Res., 2004,38, 1494–1501.

[43] Reddy, K.R. Doil variations in physio-chemical parameters of water in selected aquatic systems. Hydrobiologia, 1981, 85**,** 201-207.

[44] Reddy, K.R. Fate of nitrogen and phosphorus in wastewater retention reservoir containing aquatic macrophytes. J. Environ. Qual., 1983, 12**,** 137- 141.

[45] Mandi, L. Marrakesh wastewater purification experiment using vascular aquatic plants Eichhornia crassipes and Lemna gibba. Water, Science & Technology, 1994, 29, 283- 287.

[46] Zhenbim, W., Yicheng, X., Jiaqi, D., Qijun, Z and Xitao, C. Studies on wastewater treatment by means of integrated biologi-cal pond system: design and function of macrophytes. Water Science and Technology, 1993, 27, 97- 105.

[47] Boyd, C. E. ,Vascular aquatic plants for mineral nutrient removal from polluted waters. Economic Botany, 1993, 24, 95–103.

[48] A. Mary Lissy P N, B. Dr. G. Madhu, Removal of Heavy Metals from Waste Water Using Water Hyacinth, ACEEE Int. J. on Transportation and Urban Development, 2011, 01, No. 01.

[49] P.Tripathi, R.kumar,A.K.sharma,A.mishra,And R.gupta, Pistia stratiotes(jalkumbhi) pharmacogn rev.,2010,4,153-160.

[50] Skillicorn, P., W. Spira and W. Journey, Duckweed aquaculture: A new aquatic forming system for developing countries. The World Bank: Washington DC, USA.,1993.

[51] Tchobanoglous, G. and F.L. Burton, Wastewater engineering treatment, disposal and reuse. 3rd Edn. McGraw Hill, New York,1991

[52] Smith, M.D. and I. Moelyowati, Duckweed based wastewater treatment (DWWT): design guidelines for hot climates. Water Sci. Technol., 2001, 43, 290-299.

[53] Ingole, N. W.; Bhole, A. G. , Removal of Heavy Metals from Aqueous Solution by Water Hyacinth (Eichhornia crassipes). J. Water SRT-Aqua, 2001, 52**,** 119–128.

[54] Nihan Ozengin and Ayse Elmaci, Performance of Duckweed (Lemna minor L.) on different types of wastewater treatment , Journal of Environmental Biology, 2007, 28, 307-314.

[55] Kathryn VanderWeele Snyder, Removal of Arsenic from Drinking Water by Water Hyacinths
(Eichhornia crassipes),J. U.S. SJWP, 2006,vol. 1.

[56] Vasanthy Muthunarayanan, Santhiya. M, Swabna. V, Geetha. A, Phytodegradation of textile dyes by Water Hyacinth (Eichhornia Crassipes) from aqueous dye solutions, International Journal of Environmental Sciences , 2011,Vol.1,No.7.

[57] DR.T.Kannadasan, M.Thirumarimurugan, K.S.Sowmya, Sukanya karuppannan,M.Vijayashanthi, **"**Dye Industry Effluent Treatment Using Cactus (Opuntia) And Water Hyacinth (Eichhornia Crassipes)" Journal Of Environmental Science, Toxicology And Food Technology , 2013, 3, 41-43.

[58] Edaigbini Philip Izuangbe,Samuel Ogebeide,Dr.O.A.Olafuyi. A comparative study between water hycinth and water lettuce in the remediation of produced water,University of Benin,P.M.B.1126,Benin city,Nigeria.

[59] Brix, H. and Schierup, H. , The use of aquatic Macrophytes in water pollution control. Ambio**,** 1989, 18 **,** 100- 107.

[60] Middlebrooks, E. J. Upgrading pond effluents: An overview. Water, Science & Technology, 1995, 31, 353-368.

[61] Sarma and hemen, Metal hyperaccumulation in plants : A review Focusing on phytoremediation technology, Journal of environmental sciences & technology, 2011,4(2),118-138.

Tables and Figures

Table 1: Characteristics of typical textile waste water [6]

No.	Parameter	Range in Textile waste water(mg/l)
1	pH	5.5-10.5
2	COD	350-700
3	BOD	150-350
4	Total Dissolved Solids	1500-2200
5	Total Suspended Solids	200-1100
6	Sulphides	5-20
7	Chlorides	200-500
8	Chromium(Cr)	2-5
9	Zinc(Zn)	3-6
10	Copper (Cu)	2-6
11	Oil and grease	10-50
12	Sulphate	500-700
13	Sodium (Na)	400-600
14	Potassium (K)	30-50

Table 2 : A number of aquatic plants have been tested for the remediation of trace elements from water.

Common name	Scientific name	Trace elements	References
Duckweed	Lemna gibba L.	As, U, Zn	11 -13
Lesser duckweed.	Lemna minor L	As, Zn, Cu, Hg	11 ,14, 15
Star duckweed	Lemna trisulca L	Zn	16
Water hyacinth	Eichhornia crassipes	As, Fe, Cu, Zn, Pb, Cd, Cr, Ni, Hg	17,18 ,19 ,20 ,21 ,22
Butterfly fern	Salvinia rotundifolia Salvinia natans Salvinia minima	Pb(II) As, Ni, Cu, Hg(II) As, Pb, Cd, Cr	23,24,25,26,27,28,10
Indian/sacred lotus	Nelymbium speciosum Ludwigia perennis L	Cr, Cu, Ba, Ti, Co, Pb	29
Water spinach	Ipomoea aquatic	As, Cd, Pb, Hg, Cu, Zn	30 ,31,32,33
Esthwaite water weed	Hydrilla verticillata	As, Pb, Zn, Cr	30,22
Mosquito fern	Azolla caroliniana	As	34
Water fern	Azolla filiculoides Azolla pinnata	As, Hg, Cd	10,34-36
Water lily	Nymphaea violacea	Cd, Cu, Pb, Zn	37
Waterweed/pondweed	Elodea Canadensis	As, Pb, Cr, Zn, Cu, Cd	11,15, 38-41
Water lettuce	Pistia stratiotes	As, Cr, Pb, Ag, Cd, Cu, Hg, Ni, Zn	14,19,30,42
Water cress	Lepidium sativum L.	As	15

Table 3: Reduction potential of different plant with respect to different pollutant

Aquatic plant	BOD Reduction	COD Reduction	Heavy metal reduction	References
Eichhornia crassipes	40-70%	40-70%	8.30-94.78%(Cr), 79.34-96.88%(Zn) 78.30-94.44% (Cu)	6
Pistia stratiotes	16.91%	15.15 %	14-31 %(TP) 100%(Cr)	3 , 58
Lemna minor	-	73-84 %	83-87 %(TN) 70-85%(TP) 83-95% (ortho phosphate)	54

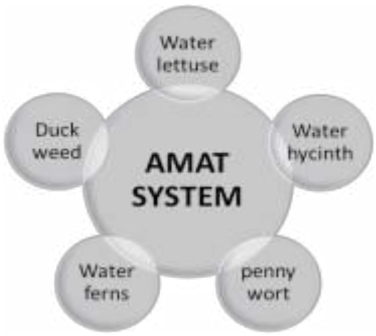

Figure 1: AMAT-Aquatic macrophyte system

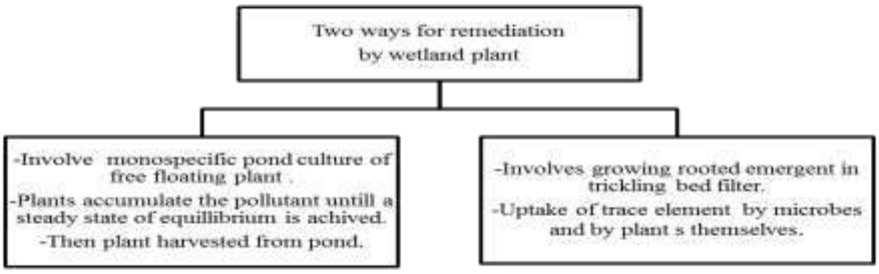

Figure-2 Remediation by wetland plant

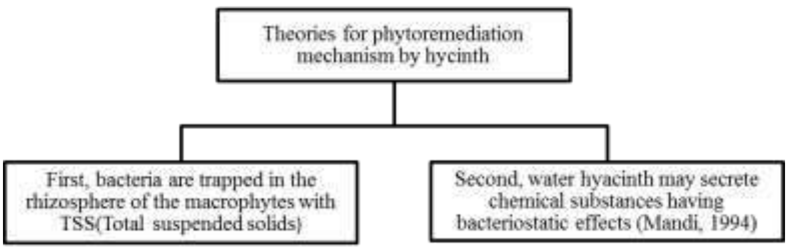

Figure- 3 Phytoremidiation by water hycinth