Management of Hattar Industrial Estate's Effluent by Phytoremediation Technology

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Abstract

Presently Pakistan is facing a scarcity of freshwater resources and per capita water availability which was 5300 m3 in 1951 had reduced to 1105 m3. However, Agriculture is the single largest user of fresh water in the world, in Pakistan nearly 88% of fresh water used for irrigation. The main reasons for declining water availability are rapid growth, depleting water storage facilities, and pollution/contaminants of existing water resources due to discharge of untreated industrial and sewage effluents into streams/rivers. Deterioration of water quality of lakes, rivers and groundwater aquifers has resulted in increased waterborne diseases and other health impacts. The reuse of treated wastewater for agricultural irrigation has expanded, especially in arid and semi-arid regions, helping to relieve water scarcity and improving the means for local food production. Hattar Industrial Estate discharges their untreated effluent in Jhar, Noro and Dojal drains. It has been estimated that 20,000 gallons of wastewater is discharged into these drains every day. The industrial waste then passes through more than 100 villages of Haripur and Attock. The estimated cost given by Ministry of Environment for Combined Effluent Treatment Plant was 345 million but due to this project the estimated cost decrease from 345 million to 35 million.

Keyword: *Hydrocotyle umbellata, Pistia stratiotes, Eichhorina crassipess, Phragmites australis, Scirpus acutus, Typha latifolia, contaminants,* industrial, wastewater, Hattar, Haripur, phytoremediation.

1. Total Cost (PAK):

(Rs. millions) **31.62**

2. Location:

HATTAR INDUSTRIAL ESTATE,
HATTAR, HARIPUR, KHYBER
PAKHTOONKHWA, PAKISTAN

3. Duration:

3 years

4. Aim of the Project:

Aims of the project are Safe water, Safe Soil- Healthy Pakistan.

5. Goals of the Project:

- Development of effective Bio-remediation macrophytes and treatment of Hattar industrial effluent.
- To develop economic viable bio-remediation ways, to treat used-water for irrigation and to rehabilitate contaminated soil for reuse, to incorporate bio-remediate used-water.
- To unearth eco-toxicological issues and providing biological solutions.
- To establish research and demonstration facilities at national, provincial and villages level.

- To sensitize concerned stakeholders about the dangers of water and soil contamination.
- To build capacity at all levels.

6. Situation Analysis:

Currently, industries in Hattar Industrial Estate are discharging effluents with high concentration and load of pollutants varying in comparison from toxic metals, metal salts, bacteria, acids and alkalis. Equally important producers of chemical pollution are other small scale and medium scale industrial units at Hattar Industrial Estate, which involve handling of toxic chemicals in a massive scale.

The present status of environmental issues related to Hattar Industrial Estate (HIE) is quite grave as no extensive factual field study has hitherto been carried out to characterize and quantify the waste water being generated and discharged from various industrial outlets and their impact on relevant soils in the area. As per requirement of the international standards and practices the industries in Hattar Industrial Estate are not even categorized on the basis of the nature of their effluent discharge. In fact, no viable work has been done in this regard to assess the assimilative capacity of the natural water bodies and the level of pollution, perhaps partly due to financial and technical constraints. However, in the view of increased industrial discharges there is an immediate need to deal with this vital issue. The Hattar Industrial Estate is involved in production activities that generate extensive amounts of liquid effluents. The Hattar Industrial Estate houses a large number of chemical units, paper/pulp manufacturing units, heavy electrical engineering plants, textile mills, food processing units, vegetable oil processing units each one with its specific pollution problems. The situation calls for specific knowledge and expertise in the treatment of the effluents. With the increase of the number of technologies commercially available and put in operation at Hattar Industrial Estate overall environmental degradation is on the increase day by day demanding a stern pollution abatement policy for the future. According to a study carried out by Rural Development Project, a local non-governmental organization (NGO), unchecked industrial waste has reduced the agricultural produce by 30 to 40 per cent, while over 20 per cent of people living near HIE are suffering from skin allergies and kidney, respiratory and eye diseases (The Express Tribune, August 26th, 2011).

HIE Industrialists' Association Vice President Malik Ashiq Awan said that the industrialists are ready to contribute their share for the construction of Combined Effluent Treatment Plant (CETP). However, he said that the entrepreneurs are paying billions of rupees to the government and it should do its bit to protect the environment (The Express Tribune, August 26th, 2011).

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7. Hattar Industrial Estate, Haripur:

The Hattar industrial estate is located at Kot Najeebullah Haripur a district in Khyber Pakhtunkhwa (KPK) Province of Pakistan. It is located between 33 51 IN, 72 51 8E, at an average altitude of 527 m, and is 65km from federal capital Islamabad, and 145km, from provincial capital Peshawar. Back in 1965, the government of KPK (formerly known as NWFP) approved a five phase plan for the HIE to install 142 industries established over an area of 10363 acres with the capital cost of Rs. 180 millions for providing the basic infrastructure facilities such as roads, gas, electricity, telephone, water and community centers. The industrial estate today house a large number of chemical units, heavy electrical plants, textile mills, food processing units, paper manufacturing, textile, steel mills, vegetable oil processing units, lather industry and many more.

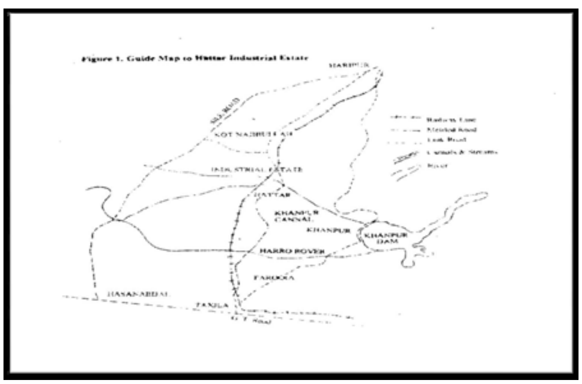

Figure 1. Guide Map to Hattar Industrial Estate

According to Sarhad Development Authority, currently only 184 units of the HIE are functional, 91 units are closed, 69 are under construction and 15 are vacant plots. Many different size factories exist on the Hatar Industrial Estate. Because of these industries, the district plays an important role in national economic development. Since Haripur has developed medium and large scale industries.

8. Environmental problems of Hattar Industrial Estate:

Waste from the Hattar Industrial Estate (HIE) is taxing the nearby ecosystem and putting people at risk of various diseases. Spread over an area of 1,063 acres, the HIE houses 215 operational, 378 closed, 162 under construction and 98 sick industrial units; it houses chemical, vegetable oil manufacturing, steel, paper, cement, marble, pharmaceutical, textile, poultry feed and beverages industries, which are the key source of pollution in the area. Apart from hazardous emissions by marble, fiberglass, cement, poultry feed and steel manufacturing units, most of the units do not have waste treatment facilities. The firms discharge their untreated effluent in Jhar, Noro and Dojal drains. It has been estimated that 20,000 gallons of wastewater is discharged into these drains every day. The industrial waste then passes through more than 100 villages of Haripur and Attock; a part of the waste is absorbed by the cultivated land, while the rest ends up in ditches and ponds.

Due to the absorption of water by the land, the villagers are at a greater risk of harmful diseases such as brain tumor, bronchitis, kidney, lung and skin diseases and bone deformation, according to doctors. Residents also complain of bad smell coming from the water, due to decomposition of solid waste and volatile organic compounds. Unchecked industrial waste has reduced the agricultural produce by 30 to 40 per cent, while over 20 per cent of people living near HIE are suffering from skin allergies and kidney, respiratory and eye diseases. The Hattar industrial estate is mainly affected by air pollution; some of the industries burn coals and it burns in the open environmental and realize the pollutant to the environment directly to the air and the places near by .and it effect directly the human being living their or in the other case workers of the industry, and all of the industries are build in not proper arrangement food industries are built near to steal mills that also effect the products of the other industry (Ghaffar, 2012).

9. Sustainability:

After three year project, the whole project is hand over to the SDA.

10. Introduction:

In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it (United Nations, 1992). In last decade, as the environmental pollution is increased the importance of monitoring and determination of some heavy metals become more important for the analytical scientists. Heavy metal contents in the environmental samples such as soils, natural waters, plants etc. have been determined continuously in the various areas. The heavy metal loads of sediments and river water are important factors for determination of contaminants. Heavy metal discharges are of great importance for water and living things. Both toxic (i.e. lead, nickel, etc.) and essential (i.e. iron, zinc, etc.) metals are toxic for living organisms if they have concentrations above the maximum allowable limits set by several authorities such as WHO (WHO, 2005). Studies showed that (Barlas, 1999; Pekey *et al.*, 2004) heavy metals accumulate in the sediment samples (Ak¸cay *et al.*, 2003). The toxicity of many substances is modified by water quality (Barlas, 1999).

Pakistan's population was 32.5 million at the time of independence which increased up to 153 million in 2006. Addition of 120.5 million people in the last six decades with a projected population of 263 million by the year 2025 pose a serious threat to limited resources (Pak-SCEA, 2006). High population growth rate coupled with urban migrations have changed demographic features (Water Aid in Pakistan, 2010). Pakistan, once having surplus water is currently a water deficit country. Per capita water availability at the time of 1951 was 5300 m3 but now reduced to 1105 m3, just touching the water scarcity level of 1000 m3 (SOER, 2005). The main reasons for declining fresh water availability were the rapid growth, depleting water storage facilities, and pollution/contaminants of existing water resources due to discharge of untreated industrial and sewage effluents into streams/rivers (PCRWR, 2006). Domestic waste containing household effluent and human waste is either discharged directly to sewer system, natural drain, water body, a nearby field or an internal septic tank (Rasheed *et al.,* 2013). Untreated discharge of pollutants to a water resource system from domestic sewers, storm water discharges, industrial wastewaters, agricultural runoff and other sources, all can have short term and long term significant effects on the quality of a river system (Singh, 2007). It is a common practice for people living along the river catchments to discharge their domestic waste as well as human excreta into rivers in Pakistan. Wild and Domestic animals using same drinking water can also contaminate the water through direct defecation and urination (Best *et al.*, 1997; Jain, 2009).

Wastewater generates additional benefits including greater income from cultivation and marketing of high-value crops such as vegetables, which create year-round employment opportunities (Lazarova and Bahri, 2005). A case study conducted by Hoek *et al.,* (2002) which proved that consumption of contaminants drinking water, crops, vegetables and fish etc, ultimately affect human health. Farmers who were irrigating their lands with untreated wastewater had a significantly highly occurrences of diarrhea diseases than those who irrigated their land with canal or tube well water. Untreated wastewater irrigation encourages higher prevalence of hookworm and degrades the soil quality. Wastewater management is increasingly becoming a problem in developing countries due to rapid industrialization and urbanization which are not matched by expansion and upgrading of wastewater treatment facilities (Chino et al., 1991). When effluents are disposed of in rivers, most metals they contain attach to suspended particulates and ultimately accumulate in sediments at the bottom of the water bodies. At high pH, characteristic of most water bodies, most metals precipitate in the form of oxides and hydroxides (Alloway, 1990).

Increasing industrialization and urbanization leads to ever increasing pollution of rivers in developing countries (Jan et al., 2010). The discharge of effluents and associated toxic compounds enter the surface water and subsurface aquifers resulting in pollution of irrigation and drinking water (Rehman et al., 2008).

The problems of environmental pollution from toxic metals from anthropogenic sources have begun to cause concern in the metropolitan cities. In this regard, industrial and agricultural practices in particular are responsible for widespread contamination of the environment in many places. Thus, the impacts of this pollution on the relationships between animals and/human health, and exposure to such elements through air, water and food, are an important area of environmental research (Fifield & Haines 1995). Arora et al. (2008) investigated heavy metal concentrations in vegetables which were irrigated by different kinds of water sources. Concentration of heavy metals varies with the different species of vegetable. Vegetable irrigated with the wastewater showed the highest concentration of heavy metals. However, the concentrations of heavy metals were found below the maximum tolerable limit established by FAO/WHO. However, they suggested the regularly monitoring of the levels of heavy metals in vegetables to avoid the excessive increase of these metals in food chain.

Li et al. (2009) reported in the heavy metals sources in the coastal soils of Shanghai, China. They used multivariate statistical methods (PCA, CA, and correlation analysis). Cu, Ni, Pb, and Cd had anthropogenic sources (e.g., overuse of chemical fertilizers and pesticides, industrial and municipal discharges, animal wastes, sewage irrigation, etc.). Zn and Cr were associated with parent materials and, therefore, had natural sources (e.g., the weathering process of parent materials and subsequent pedogenesis due to the alluvial deposits). The effect of heavy metals in the soils was greatly affected by soil formation, atmospheric deposition, and human activities. Khan et al. (2010) reported high concentrations of heavy metals in soils and vegetables of the northern areas of Pakistan. These metals were contributed from parent rocks and the extent of enrichment was in the order of Cd>Pb>Zn>Cu>Ni. The leafy vegetables were highly enriched with heavy metals because of their greater capability to accumulate heavy metals from soil but also there were potential health risks for the local residents that regularly consume heavy metals enriched vegetables. The mean concentrations of heavy metals in various vegetable species collected from the study area were also compared with the standards set by China, India and FAO/WHO for vegetables and fruits.

The disposal of sewage and industrial effluent into the rivers has been blamed for the deteriorating water quality in the Manyame catchment, which includes Mukuvisi River and Lake Chivero (Marshall, 1994).

- **pH and TDS:**

Rapidly growing algae or submerged aquatic vegetation remove CO_2 from the water during photosynthesis, significantly increasing pH levels. Water with high or low pH is not suitable for irrigation. At low pH most of the metals become soluble and become available and therefore could be hazardous in the environment. At high pH most of the metals become insoluble and accumulate in the sludge and sediments (USGS, 1970). Metals such as potassium, sodium, chloride, carbonate, sulfate, calcium, and magnesium all contribute to the dissolved solids in the water. Measuring total dissolved solids is a way to estimate the suitability of water for irrigation.

High concentrations of TDS may also reduce water clarity, contribute to a decrease in photosynthesis, combine with toxic compounds and heavy metals, and lead to an increase in water temperature. Water with high TDS often has a bad taste and/or high water hardness (Taylor *et al.*, 1997).

The organic materials that may cause turbidity can also serve as breeding grounds for pathogenic bacteria. The relatively high levels of turbidity could be attributed to the presence of decaying organic matter and the dredging activities; turbidity diffuses sunlight and slows photosynthesis. Plants begin to die/reducing. Turbidity raises water temperature because the suspended particles absorb the sun's heat. Highly turbid water can clog the gills of fish, stunt their growth, and decrease their resistance to diseases. Suspended particles near the water surface can absorb extra heat from sunlight, raising surface water temperatures (DWAF, 1996).

- **Electric Conductivity:**

Any electrical conductivity observable in water is the result of ions of mineral salts and carbon dioxide dissolved in it. The water with more salt contents conducts more current when a potential is applied through it. Distilled or de-ionized water has very few dissolved ions and so there is almost no current flow across the gap (low EC) (Morrison *et al.*, 2001).

- **Nitrate and Sulfate:**

Nitrate was an important constituent of chlorophyll, protoplasm, protein, amino acids, nucleic acid and growth hormones. Above 30 ppm limit, it shows the adverse effects for human body like the blue-baby syndrome, convert the hemoglobin (Hb) to meta-hemoglobin which reduces the transformation of oxygen in body. High concentrations of nitrate cause methemoglobinemia in infants and could cause cancer (Overcash, 1986). An excess of nitrate leads to more vegetative growth and cause lodging. Excessive nitrate contents, higher than 100 mg/liter, may affect transplants and sensitive crops at the initial growth stage (WHO, 2004). Serious public health problems rose due to the use of wastewater. Wastewater carries a wide range of pathogenic organisms posing a risk to agriculture workers, crop handlers and consumers. High level of nitrogen in wastewater results in nitrate pollution of groundwater, which could lead to adverse effects on human health (Blumenthal *et al.*, 2001). Sulfate is used for protein synthesis, enzyme reaction and energy transfer. A plant injured by excessive sulfate first displays mottled leaves or yellowed tissue between the veins of leaves. This is followed by leaves that are dead at their tips, at their margins, and in areas between their veins. Excessive sulfate concentration may lead to laxative effect and it affects the alimentary canal (Purushotham *et al.*, 2011). High concentrations of nitrate cause methemoglobinemia in infants and could cause cancer. In the blood, nitrate convert hemoglobin to methemoglobin, where it does not carry oxygen to the body cells, which may lead to death from asphyxiation (Purushotham et al., 2011).

- **Chloride:**

Chloride helps plants to metabolize. The accumulated chloride concentration in leaves exceeds the crop's tolerance, injury symptoms develop in the form of leaf burn. This starts at the tips of leaves and progresses from the tip back, along the edges, as the severity increases. In extreme cases chloride toxicity manifests itself in early leaf drop. Crop quality is affected by chloride-induced leaf injury in plants whose leaves are the marketed product, or where fruit size and appearance are affected by chloride-induced yield decreases (Imran, 2005).

The impact to human health is the utmost important criteria to look into apart from the effect to surface water and groundwater on the living organism and sediments. Metals, as described in the above case studies showed the potential for health risk. However, the organic matter also will bring adverse health impact to human. The health hazard to human is further described in the following.

- **Aluminium:**

High concentrations of Aluminium can cause hazard to brain function such as memory damage and convulsions. In addition, there are studies suggested that Al is linked to the Alzheimer disease (Jordao et al., 2002). Toxicity of aluminium to plants has been reported for both acid and alkaline conditions. It is, however, mostly associated with low pH values (less than 5.5) in natural soils. In nutrient solutions toxicities have been reported for a number of plants at a concentration range of 0.1 - 1.0 mg/R. Aluminium toxicity has been observed at concentrations range of 0.1 - 0.5 mg/R in soil solution. These values cannot be extrapolated directly to irrigation waters, because soil chemical interactions modify the aluminium concentration and species found in soil solution (PRATT and Suarez 1990). High concentrations of Al can cause hazard to brain function such as memory damage and convulsions. In addition, there are studies suggested that Al is linked to the Alzheimer disease (Jordao et al., 2002).

- **Potassium:**

High potassium concentration may cause nervous and digestive disorders (Purushotham *et al.*, 2011), kidney heart disease, coronary artery disease, hypertension, diabetes, adrenal insufficiency, pre-existing hyperkalaemia. Infants may also experience renal reserve and immature kidney function (WHO, 2009). Excessive sulphate concentration may lead to laxative effect (Purushotham *et al.*, 2011) and it affects the alimentary canal (WHO, 2004).

- **Cadmium:**

Cd is harmful to both human health and aquatic ecosystems. Cd is carcinogenic, embryotoxic, teratogenic, and mutagenic and may cause hyperglycemia, reduced immunopotency, and anemia, as it interferences with iron metabolism (Rehman & Sohail Anjum, 2010). Furthermore, Cd in the body has been shown to result in kidney and liver damages and deformation of bone structures (Abbas et al., 2008).

- **Chromium:**

Cr (III) is essential nutrient for animal and essential to ensure human and animal lipids' effective metabolism but Cr(VI) is carcinogenic. Cr(VI) is the most toxic form of chromium and having equivalent toxicity to cyanides. It can cause skin ulcer, convulsions, kidney and liver damage. Moreover, it can generate all types of genetic effects in the intact cells and in the mammals in vivo (Khe´rici-Bousnoubra et al., 2009). It has also been reported that intensive exposure to Cr compounds may lead to lung cancer in man (Jordao et al., 2002).

- **Iron and Lead:**

Iron is an essential element in several biochemical and enzymatic processes. It involved the transport of oxygen to cells. However, at high concentration, it can increase the free radicals production, which is responsible for degenerative diseases and ageing (Jordao et al., 2002). Lead could accumulate in kidney, liver, bone, and brain. Chronic intoxication can lead to encephalopathy mainly in children (Jordao et al., 2002).

- **Mercury and Fluoride:**

Mercury can cause brain damage, heart, and kidney and lung disease in human. At very low concentration, Hg can permanently damage to the human central nervous system (Rai & Tripathi, 2009a). Inorganic and mercury through biological processes, can converted into MeHg. MeHg is organic, toxic, and persistent (Wang et al., 2004; Rai

& Tripathi, 2007). Furthermore, MeHg can cross the placental barriers and lead to foetal brain damage (Rai & Tripathi, 2009a). High concentration of fluoride can cause dental and skeletal fluorosis such as mottling of teeth, deformation of ligaments and bending of spinal cord (Janardhana Raju et al., 2009).

- **Zinc and Nickel:**

Zinc is an essential element to human and plant (Jordao et al., 2002). Recent studies indicated that Zn is also involved in bone formation. However, elevated intake of Zn can cause muscular pain and intestinal haemorrhage (Honda et al., 1997; Jordao et al., 2002). Nickel is an essential element to both plant and human, but high exposure to this metal can lead to cancer in organs of the breathing system, cardiovascular and kidney diseases (Jordao et al., 2002).

11. Specific Project Objectives:

1. To analyze all the contaminants in the Hattar's effluent.

2. To analyzed the soil quality before and after irrigation.

3. To construct the phytoremediation ponds and determine the biological potential of selected macrophytes in phytoremediation process.

4. To compare the wastewater with treated water after phytoremediation process.

5. To find out the impacts of contaminated water, normal water and treated water on the crop yield.

6. To decrease the contamination level up to 70 percent in three years.

7. Treatment of 20,000 gallon contaminated water every day.

12. Scope:

This project provides bioremediation facilities for the farmers and aware the importance of identifying plant nutrient deficiencies and excesses and of determining the amounts and types of nutrient additions needed. It is also important that farmers be aware of how nutrients in excessive amounts can be harmful not only to the crop to which they are applied but to the environment and its interdependent web of organisms, including humans. Awareness rising in the field of used water treatment through bioremediation. Capacity building in bio-remediation of wastewater to the concerned/ stakeholders. Irrigation with treated water often causes less expenditure while irrigated with another source like tube well. Studies show that irrigated with treated water have good effects on the crop yield, this also increase the crop yield. This project helps the policy makers to think about this bioremediation and take some effective measures for the industrial and domestic waste water. It gives mitigation measures for the control of waste water contamination in fresh water.

13. Justification:

Bioremediation is a "natural process". It usually does not produce toxic by-products and destroys the target contaminants. It is usually less expensive than other technologies and can be used where the problem is located. The Pakistani nation has to pay the price of daily discharging of 2000 million gallons of untreated municipal and industrial used water to freshwater streams. It affects both human health and life in water. And the nation bears Rs. 114 billions health cost on water born diseases. It does not include worker's productivity loss due to illness. Through this project introduction of local aquatic plants, microbial strains and biological engineering tools for treating used water, research on bioremediation process to make used water fit for irrigation. Through various biological natural ways the water is made pathogenically free.

14. Material and Methods:

14.1 Primary data collection

a. Field Test

Analyze of the composition of Hattar industrial effluent and soil quality from where this water passed. Then remediate the wastewater through selected aquatic plants.

b. Wastewater sampling and physio-chemical analysis:

For sample collection the bottles were washed with hot water followed by distilled water. During collection bottles were filled, rinsed with the sample water 2-3 times, tightly capped and properly labeled (APHA, 2005). Physical parameters of collected water samples were studied immediately, which were collected in replicates from river Siran and all the bio-treatment ponds. In physical parameters analysis pH, EC, Turbidity and TDS were studied. While Carbonates, Bicarbonates, Total Hardness, Calcium, Magnesium, Chloride, Sulfate and Nitrate were the chemical parameters which were studied. Biological parameters include BOD, COD and E.coli. Analytical procedure given by APHA (2005) used for water analysis. The pH of the waste water determined by pH meter (WA-2015). Electric conductivity determined by conductivity meter (WA-2015). Total Dissolved Solids determined by TDS Meter (WA-2015). Turbidity determined by Turbidity meter (HANNA, HI-93703-11). Carbonates, Bicarbonates, Total Hardness, Calcium, Magnesium and Chloride, determined by titration method. The UV-visible method used for the rough estimate of Nitrate. It determined the absorption of nitrate ion at 220 nm. UV/VIS spectrophotometer (Lambda 3B) used for analysis. The UV-visible method used for the rough estimate of Sulfate. It determined the absorption of nitrate ion at 420 nm. UV/VIS spectrophotometer (Lambda 3B) used for analysis.

d. Soil sampling and physio-chemical analysis:

The primary methods used for laboratory analyses are those of the USDA-NRCS (2004), however, soil texture was determined using the modified hydrometer method (Shahid, 2006) supplemented with wet sieving. Laboratory analyses of soil samples include heavy metals, pH of the soil saturated paste (pHs) with , electrical conductivity of the soil saturation extract (ECe) and water-soluble calcium (Ca2+), sodium (Na+) and potassium (K+) using flame photometer and Mg2+ by Atomic Absorption Spectrophotometer (AAS), and bicarbonates (HCO3 -) ions using acid titration, chlorides by silver nitrate titration, and sulfate by difference between total cations and HCO3 - and Cl- ions. Sodium Adsorption Ratio (SAR) was calculated from water extractable elemental data using the formula [SAR = Na/[(Ca + Mg)/2]0.5 with results recorded as (mmoles/l)0.5. Calcium carbonate equivalent was determined using standard Calcimeter and the presence/absence of gypsum was tested by acetone precipitation test.

After crop harvest, soil samples will be collected from 0-15, 15-30 and 30-50 cm depth. The samples so collected will be air dried under shade, ground, passed through a 2 mm sieve, will be stored and analyzed for N, P, K and organic matter contents (Ryan *et al.,* 2001). The hydrometer method (Bouyoucos, 1962) will be used for determination of particle size. The textural class will be then determined following the International System Textural Triangle. Bulk density will be determined by Blake and Hartge (1986). Soil cores from the required depths will be collected and soil samples will be oven dried for the calculation of bulk density. Organic carbon (OC) content of soil will be estimated by the modified Walkley-Black method (Walkley and Black, 1934). The soil samples will be collected (0-15, 15-30 and 30-50 cm) for OC analysis that will be used for the calculation of C-sequestration. The total porosity (*f*) of the soil will be obtained from its bulk density (ρb) and particle density (ρp) by the following formula described by Lowery *et al.* (1996). $f = 1 – (\rho b / \rho p)$

14.2 Secondary data collection

a. Literature Review

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Relevant research reports, magazines, brochures, pamphlets, posters, published and unpublished research reports shall be review to gain needful information. Moreover, web survey shall be carried out to analyze similar trends being happened in other countries having similar problems of deforestation.

b. Aquatic Plants for Wastewater Treatment:

Aquatic plants are chosen for absorb particular nutrient and to remove pathogens, metals and other contaminants from wastewater (NIB, NARC).

Common Name	**Botanical Name**	**Family**	**Life Form**	**Bioremediation Potential**
Water hyacinth	*Eichhornia crassipess*	Pontederiaceae	Aquatic free-floating plant.	Water hyacinth uptake of heavy metal e.g., Pb, Cu, Cd, Hg from contaminated water.
Common duckweed	*Lemna minor*	Lemenaceae	Free- floating Aquatic Plant	COD (73-84%), nitrogen (83-87%), phosphorus (70-85%) ortho-phosphate (83-95%).
Water lettuce	*Pistia stratiotes*	Araceae	Aquatic Free- floating Plant	Turbidity, phosphates, total iron, sulfates, colour, COD, BOD5, Suspended solids, dissolved oxygen and nitrates.
Cattail	*Typha latifolia*	Typhaceae	Emergent rooted plant	Removal of organics from tannery wastewater, up to 88% of (BOD5), and 92% (COD), and of other contaminants, such as nitrogen, operating at hydraulic retention times of 2 and 5days.
Water cress	*Nosturtium officinale*	Brassicaceae	Submerged aquatic rooted plant	It was elevated and observed that it is able to accumulate Cu, Zn and Ni at high level.
Hard Stem Bulrush	*Scirpus acutus*	Cyperaceae	Emergent aquatic rooted plant	Nitrogen removal.

Common Reed	*Phragmites australis*	Poaceae	Emergent aquatic rooted grass	The concentration of metals such as Cd, Cu, Pb, Zn, As, Al and Fe is higher in roots than in shoots of the common reed, while Ni, Cr and Mn concentrations were higher in leaves of the plant.
Water Pennywort	*Hydrocotyle umbellatta*	Apiaceae	Aquatic Free Floating Plant	Removal of nitrogen and phosphorus
Water Fern	*Salvinia minima*	Salviniaceae	Aquatic Floated plant	High-strength organic pollutants, ammonium-nitrogen, Cd and Pb

Activities:

Following are the different activities design for the project.

Activities	**Planned Accomplishment**	**Performance Measures**
Objective 1. To analyze the contaminants in the Hattar effluent.	Take sample of Hattar effluent before entering the lagoons.	Water samples analyzed in the lab of NARC, and some of parameters analyzed in EPA (Islamabad) and Qarshai Industry Hattar.
Objective 2. To analyzed the soil quality before and after irrigation.	Take sample from all three plots i.e.: A, B and C plot before and after irrigation. Stratify random sampling technique used for sampling.	Soil sample analyzed in the lab of NARC.
Objective 3. To determine the biological potential of selected	Taking samples from treatment lagoon 1, treatment lagoon 2, treatment	Treated water analyzed at every level in the labs of NARC, Qarshai Industry Hattar and EPA (Islamabad).

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macrophytes in phytoremediation process.	lagoon 3, treatment lagoon 4 and treatment lagoon 5, water quality analyzed and compare the treatment level of different macrophytes.	
Objective 4. To compare the wastewater with treated water after phytoremediation process.	Take samples before treatment and then taking samples after treatment lagoons.	Compare water quality and analyzed in the labs of NARC and EPA (Islamabad).
Objective 5. To find out the impacts of contaminated water, normal water and treated water on the yield.	Weight all the yield of tea in the plots (A, B and C) and compare the yield obtained.	All the work done under supervision of NTRI experts.

Parameters

Water Quality	Ph	TDS	Hardness	BOD	Chloride	Heavy Metals
	EC	Carbonates	Calcium	COD	Sulfate	
	Turbidity	Bicarbonates	Magnesium	E.coli	Nitrate	
Soil Quality	pH	Bicarbonates	Calcium	Chloride	Sulfate	Heavy Metals
	EC	Potassium	Magnesium	Sodium	Soil texture	

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Year Wise Schedule:

Year	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Year 1st												
1. Field visit of Hattar industrial estate.												
2. Enlist all the industry of Hattar.												
3. Estimate and classify all the type of industrial effluent.												
4. Analysis of contaminated water of Hattar (physical, chemical and biological).												
5. Construction of 5 ponds for phytoremediation.												
6. Population of aquatic macrophytes.												

7. Introduction of aquatic macrophytes.				▬						▬		
8. Selection and analysis of soil quality of different plots.	▬											▬
9. Water analysis of treated water.					▬	▬	▬	▬	▬	▬	▬	▬
10. Removal of aquatic plants.			▬						▬			
10. Soil analysis after irrigation with treated water.								▬				▬

Year	**Months**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Year 2nd												
1. Analysis of contaminated water of Hattar (physical, chemical and biological).	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬

2. Water analysis of treated water.												
3. Introduction of aquatic macrophytes.												
4. Removal of aquatic plants.												
5. Analysis of soil quality of different plots.												

Year	**Months**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Year 3rd												
1. Analysis of contaminated water of Hattar (physical, chemical and biological).												
2. Water analysis of treated water.												

3. Introduction of aquatic macrophytes.				▬						▬		
4. Removal of aquatic plants			▬						▬			
5. Analysis of soil quality of different plots.	▬											▬
6. Data analysis and report writing.								▬	▬	▬		
7. Publication of project reports.											▬	▬

Dimension of Ponds & Capacity

Pond	Length (ft)	Width (ft)	Depth (ft)	Storage Capacity (gallon)
P1	120	100	5	50,000
P2	120	100	5	50,000
P3	120	100	5	50,000
	Total			**150,000**

15. Significance of the project:

Bioremediation is a "natural process". It usually does not produce toxic by-products and destroys the target contaminants. It is usually less expensive than other technologies and can be used where the problem is located. The Pakistani nation has to pay the price of daily discharging of 2000 million gallons of untreated municipal and industrial used water to freshwater streams. It affects both human health and life in water. And the nation bears Rs. 114 billions health cost on water born diseases. It does not include worker's productivity loss due to illness. Through this project introduction of local aquatic plants, microbial strains and biological engineering tools for treating used water, research on bioremediation process to make used water fit for irrigation. Through various biological natural ways the water is made pathogenically free.

16. Outcome of the project:

This project provides bioremediation facilities for the farmers and aware the importance of identifying plant nutrient deficiencies and excesses and of determining the amounts and types of nutrient additions needed.

It is also important that farmers be aware of how nutrients in excessive amounts can be harmful not only to the crop to which they are applied but to the environment and its interdependent web of organisms, including humans.

Awareness rising in the field of used water treatment through bioremediation. Capacity building in bio-remediation of wastewater to the concerned/ stakeholders.

Irrigation with treated water often causes less expenditure while irrigated with another source like tube well.

Studies show that irrigated with treated water have good effects on the crop yield, this also increase the crop yield.

This project helps the policy makers to think about this bioremediation and take some effective measures for the industrial and domestic waste water. It gives mitigation measures for the control of waste water contamination in fresh water.

17. Recommendations:

The capacity of the regulatory authority in Pakistan (i.e. Environmental Management Agency) responsible for the enforcement of proper disposal of domestic and industrial effluent in the country is increased.

Heavy fines should be charged for any organizations found dumping toxic effluent into rivers.

Awareness programs should be lounged nationwide by the regulatory authority on the dangers of illegal disposal of toxic effluent into river systems to aquatic life and the food chain.

Research to develop river water quality standards based on metal concentration in river sediments should be conducted.

Treated water has some of organic compounds and also micronutrients which are required for better crop yield, it is good for soil.

Water treatment is possible by using aquatic macrophytes for both domestic and industrial effluents. Government should take effective measures for water treatment with low cost and better efficiency (phytoremediation).

Wastewater should be deposited off after suitable treatment. Any violation in this regards must be dealt strictly.

Each and every industry must treat their wastewater before discharging; phytoremediation is also very effective in case of heavy metals contamination done by industry.

18. Proposed Budget:

TABLE-I
Estimated Cost of the Project in Rupees

Year:	Recurring (Salary/honorarium and allowances)	Non-Recurring (Equipment and Res. Materials)	Travelling within country	Total
1st Year:	2,196,000	22,565,500	165,000	25,091,500
2nd Year:	2,196,000	900,500	165,000	3,261,500
3rd Year:	2,196,000	900,500	165,000	3,261,500
Total:	**6,588,000**	**24,531,500**	**495,000**	**31,614,500**

19. Comparison of cost between Combined Effluent Treatment Plant (CETP) and Bioremediation Plant for Effluent Treatment (BPET) in Hattar Industrial Estate (HIE):

COST FOR 3 YEARS	CETP	BPET	CETP - BPET
Installation Cost	225 Million	25 Million	200
Operational and Maintenance Cost	120 Million	6.5 Million	113.5

Total Cost	345 Million	32 Million	313
Area	2 Hectares	1 Hectares	1 Hectares

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Project Budget

Project Title: Management of Hattar Industrial Estate's Effluent by Phytoremediation Technology

Submitted By:Haroon Ur Rasheed

Budget Code	Budget Line	Type of Unit	No. of Units	Quantity (column C)	Price Per Unit Rupees	Quarter 1	Quarter 2	Quarter 3	Total PKR
A	PERSONNEL					*2,196,000*	*2,196,000*	*2,196,000*	*6,588,000*
	Staff Salaries (Programme Support Unit)					*2,196,000*	*2,196,000*	*2,196,000*	*6,588,000*
A1	Project Director	Month	12	1	70,000	840,000	840,000	840,000	2,520,000
A2	Project Manager	Month	12	1	30,000	360,000	360,000	360,000	1,080,000
A3	Monitoring & Evaluation Officer	Month	12	1	20,000	240,000	240,000	240,000	720,000
A4	Finance Cum Data Entry Officer	Month	12	1	17,000	204,000	204,000	204,000	612,000
A5	Field Assisstant	Month	12	5	8,000	480,000	480,000	480,000	1,440,000
A6	Security Guards	Month	12	1	6,000	72,000	72,000	72,000	216,000
B	DIRECT PROJECT COSTS					*24,498,000*	*2,668,000*	*2,668,000*	*29,834,000*
BA	*Objective 1 - Budget*					*21,960,000*	*360,000*	*360,000*	*22,680,000*
BA1	Hiring of Project Staff	One time	1	1	50,000	50,000	0	0	50,000
BA2	Field visits for side selection	One time	1	1	50,000	50,000	0	0	50,000
BA3	Plot of 20 kanal	One time	1	1 acre	20,000,000	20,000,000	0	0	20,000,000
BA4	Construction of ponds	One time	1	5	300,000	1,500,000	0	0	1,500,000
BA5	Monitoring & lab analysis of water	Month	12	1	15,000	180,000	180,000	180,000	540,000
BA6	Monitoring & lab analysis of soil	Month	12	1	15,000	180,000	180,000	180,000	540,000
BB	*Objective 2 - Budget*					*22,010,000*	*410,000*	*410,000*	*22,830,000*
BB1	Chemicals, glass ware	Yearly	1	1	50,000	50,000	50,000	50,000	150,000
BC	*Objective 3 - Budget*					*22,302,000*	*472,000*	*472,000*	*23,246,000*
BC1	Aquatic plants (seeds)	Yearly	1	6	50,000	50,000	50,000	50,000	150,000
BC2	Soil Sampling Kit (augers, tubes etc.)	One time	1	1	100,000	100,000	0	0	100,000
BC3	Gloves	One time	500	1	5,000	5,000	0	0	5,000
BC4	Bottles	Yearly	200	1	2,000	2,000	2,000	2,000	6,000
BC5	Tamp Can	One time	5	1	5,000	5,000	0	0	5,000
BC6	Implement	One time	1	1	100,000	100,000	0	0	100,000
BC7	Literature	One time	1	1	10,000	10,000	0	0	10,000
BC8	Contingencies, Postage etc	One time	1	1	10,000	10,000	0	0	10,000
BC9	Report writing/Publications	Yearly	1	1	10,000	10,000	10,000	10,000	30,000
C	OPERATIONAL COSTS					*25,091,500*	*3,261,500*	*3,261,500*	*31,614,500*
CA	*Office Running Costs - Programme Support Unit)*					*178,500*	*178,500*	*178,500*	*535,500*
CA1	Office Rent	Month	12	1	10,000	120,000	120000	120000	360000
CA2	Office utilities	Month	12	1	5000	15000	15000	15000	45000
CA3	Landline / fax / phone / internet / Cable	Month	12	1	5000	15000	15000	15000	45000
CA4	Postal & Courier (DHL, FedEx, PTT, UPS etc.	Month	12	1	5000	15000	15000	15000	45000
CA5	Office Supplies (Consumables)	Month	12	1	2000	6000	6000	6000	18000
CA6	Stationery	Month	12	1	1000	3000	3000	3000	9000
CA7	IT/Technical Maintenance	Month	12	1	1000	3000	3000	3000	9000
CA8	Bank Charges	Month	12	1	500	1500	1500	1500	4500
CB	*Travel & Transportation Costs - Programme Support Unit*					*343,500*	*343,500*	*343,500*	*1,030,500*
CB1	Vehicle rental,driver,maintenance	Month	12	1	10000	120000	120000	120000	360000
CB2	Fuel	Month	12	1	15000	45000	45000	45000	135000
CC	*Specialized / External Services*					*593,500*	*593,500*	*593,500*	*1,780,500*
CC1	Annual Audit	Yearly	1	1	50,000	50,000	50,000	50,000	150,000
CC2	Annual Monitoring, Review	Activity	1	1	100,000	100,000	100,000	100,000	300,000
CC3	Project Completion-Evaluation	Activity	1	1	100,000	100,000	100,000	100,000	300,000
	Total Grand					***25,091,500***	***3,261,500***	***3,261,500***	***31,614,500***