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Performance Assessment of Macrophyte Stabilization Pond- A case Study of Eight Parameters

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Abstract- Now-a-days safe and pure water is a major issue all over the world. A research reveals that one third of the world's people are in water stressed region, and this proportion will be increased to two-thirds in 2025. 80% to 90% of the per capita consumption of water becomes wastewater [1]. Now-a-days wastewater treatment is common in practice to fulfill the water consumption demand. The aim of this project is to determine the feasibility and efficiency of water hyacinth (Eicchornia crassipes) in treating wastewater by construction of wetland. This treated wastewater can be reused for irrigation purposes and in order to improve the groundwater water recharge.

Index Terms- Macrophytes, Water Hyacinth (*Eicchornia crassipes),* Wastewater Stabilization Pond.

I. Introduction

Macrophytes play important roles in balancing aquatic ecosystem. They have capacity to improve the water quality by absorbing nutrients with their effective root system. Macrophytes are advantageous to lakes because they provide cover for fish and substrate for aquatic invertebrates [2].They also produce oxygen, which assists with overall lake functioning, and provide food for some fish and other wildlife. Crowder and Painter (1991) indicate that a lack of macrophytes in a system where they are expected to occur may suggest a reduced population of forage fish and waterfowl [2, 3]. In addition, the absence of macrophytes may also indicate water quality problems as a result of excessive turbidity, herbicides, or salinization [3, 4, 5].

This project objective is to evaluate the usefulness of macrophytes (Biofilters) in reducing the nutrient content of the water i.e. to reduce the pollution level of water, and check the efficiency of stabilization pond. In this project, one Macrophyteic Species *Eicchornia crassipes* commonly known as water hyacinth is taken to improve water quality by reducing nutrient concentration. This floating perennial has been used in aquatic systems for wastewater purification for many years worldwide. In this project, a frame structure made by steel and covered with high strength tempered glasses consisting three tanks (inlet, main and outlet tank) is used as Macrophytes Stabilization Pond. The municipal wastewater sample for the examination and study is taken from main outlet chamber of UET, Taxila. Six trials is performed with detention period of each trial is 10 days. Throughout the project 72 samples are taken on. 1^{st}, 3^{rd}, 5^{th}, 7^{th} and 10^{th} day of each trial and perform laboratory test to check the improved water quality and the efficiency of the treatment plant. Treated wastewater quality is than compared with the NEQS (NATIONAL ENVIRONMENTAL QUALITY STANDARDS OF PAKISTAN) and WHO values that give an effective result. Purification of water through macrophytes is a good example of purification of water with natural means.

II. IMPORTANT MUNICIPAL WASTEWATER PARAMETER

In this project, Eight (08) parameters of municipal wastewater are chosen for lab test that are given below:

1) Total Suspended Solids (TSS)
2) Total Dissolved Solids (TDS)
3) Chemical oxygen demand (COD)
4) Zinc
5) Floride
6) Chloride
7) Sulphate
8) Iron

Total Suspended Solids (TSS) is an important characteristic of sewage. The volume of sludge produced in a treatment plant is directly related to the total suspended solids present in the sewage. Industrial and storm sewage may contain higher concentrations of suspended solids than domestic sewage.

Total Dissolved Solids (often abbreviated TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in: molecular, ionized or micro-granular (colloidal sol) suspended form. Generally the operational definition is that the solids must be small enough to survive filtration through a sieve the size of two micrometer. TDS is not generally considered a primary pollutant (e.g. it is not deemed to be associated with health effects) it is 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 [6, 7, 8]. There is no reliable data available on the health effects of the TDS in drinking water (*WHO, Guidelines for Drinking Water Quality, third edition, 2004).*[9, 10]

The chemical oxygen demand (COD) is commonly used to indirectly measure the amount of organic-compound in water. Most applications of COD determine the amount of organic pollutants found in surface water (e.g. lakes and rivers), making COD a useful measure of water quality. It is expressed in milligrams per liter (mg/L), which indicates the mass of oxygen consumed per liter of solution. Older references may express the units as parts per million (ppm). [9, 10]

Zinc is naturally present in water. Zinc imparts an undesirable astringent taste to water. The levels of zinc in surface and ground water normally do not exceed 0.01mg/litre and0.05mg/litre, respectively. Concentration in tap water may increase due to dissolution from the pipes. The daily requirement for an adult man is 15-20mg/day. A value 5 mg/l may be appropriate for Pakistan although up to 3 mg/l is usually acceptable for consumption for consumers (WHO, Guidelines for Drinking Water Quality, third edition, 2004) [9, 10]

Fluoride compounds are salts that form when the element, fluorine, combines with minerals in soil or rocks. Exposure to excessive consumption of fluoride over a lifetime may lead to increased likelihood of bone fractures in adults, and may result in effects on bone leading to pain and tenderness. Epidemiological evidence shows that fluoride primarily affects the skeletal tissue (*WHO, Guidelines for Drinking Water Quality, third edition, 2004*).Children aged 8 years and younger exposed to excessive amounts of fluoride have an increased chance of developing pits in the tooth enamel, along with a range of cosmetic effects to teeth. [9, 11]

Chlorides are widely distributed in nature as salts of sodium (NaCl), potassium (KCl), and calcium ($CaCl_2$). Chlorine is used to combat microbial contamination, but it can react with organic matter in the water and form dangerous, carcinogenic Trihalomethanes. According to Dr. Joseph M. Price, MD, in Moseby's Medical Dictionary, "Chlorine is the greatest crippler and killer of modern times. It is an insidious poison". Chloride in drinking water comes from natural sources, sewage and industrial effluents, urban runoff containing de-icing salt and saline intrusion. The main source for humans comes from the edible salt. The high dose of chloride may result in detectable taste at 250mg/l but no health-based guideline value is proposed (*WHO, Guidelines for Drinking Water Quality, third edition, 2004).* However, less that 250 mg/l would suffice as a Pakistani standard for Chloride. [9]

Sulfate is a constituent of TDS and may form salts with sodium, potassium, magnesium, and other cations. Almost all natural waters contain sulfate ions. Their concentrations vary considerably according to the mineral content of the earth in any given area. In large concentrations they present problems. Sulfates can be more troublesome because they generally occur in greater concentrations. Low to moderate concentrations of sulfate ions add palatability to water [9, 12].

Iron is normally found in spent pickle and etch baths from plating shops, steel mills, foundries, chemical milling, and wire drawing operations. It is also found in ground water. Iron in water is normally found in the ferrous state or iron 2. The ferric state or iron 3 is very insoluble at neutral PH's. Both the iron 2, ferrous, and iron 3, ferric, can be precipitated to low concentrations by pH adjustment, carbonate, and phosphate and sulfide precipitation. Iron 2 can easily be converted to iron 3 by aerating the water allowing the precipitation to take place at a neutral pH [13, 14, 15].

III. WASTEWATER STABILIZATION POND

Waste water stabilization pond technology is one of the most important natural methods for wastewater treatment. Waste stabilization ponds are mainly shallow man-made basins comprising a single or several series of anaerobic, facultative or maturation ponds the primary treatment takes place in the anaerobic pond, which is mainly designed for removing suspended solids, and some of the soluble element of organic matter (BOD5). During the secondary stage in the facultative pond most of the remaining BOD5 is removed through the coordinated activity of algae and heterotrophic bacteria. The main function of the tertiary treatment in the maturation pond is the removal of pathogens and nutrients (especially nitrogen). Waste stabilization pond technology is the most cost-effective wastewater treatment technology for the removal of pathogenic micro-organisms. The treatment is achieved through natural disinfection mechanisms. It is particularly well suited for tropical and subtropical countries because the intensity of the sunlight and temperature are key factors for the efficiency of the removal processes. [16, 17, 18, 19]

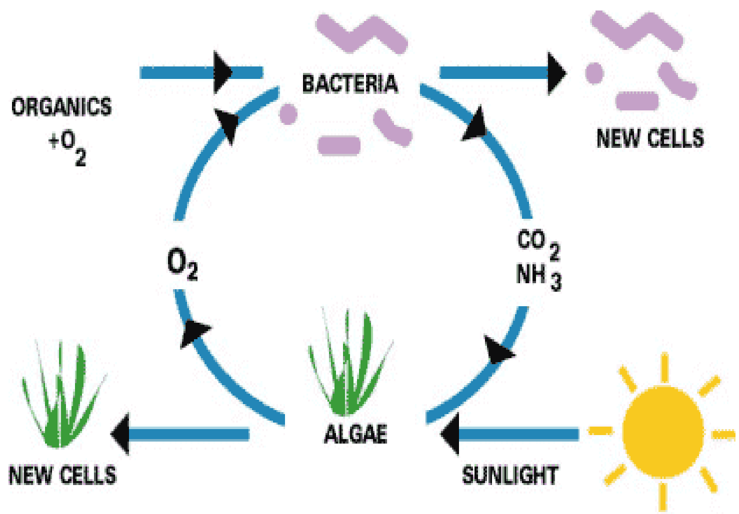

Fig 1: Algae-Bacteria-Simbiosis [Courtesy: *United Nations Environment Programme]*

IV. WATER HYACINTH

Water hyacinth (*Eichornia crassipes)* is a member of the pickerelweed family (*Pontederiaceae*). The plants vary in size from a few centimeters to over a meter in height. The glossy green, leathery leaf blades are up to 20 cm long and 5-15 cm wide and are attached to petioles that are often spongy-inflated. Numerous dark, branched, fibrous roots dangle in the water from the underside of the plant. The inflorescence is a loose terminal spike with showy light-blue to violet flowers (flowers occasionally white). Each flower has 6 bluish-purple petals joined at the base to form a short tube. One petal bears a yellow spot. The fruit is a three-celled capsule containing many minute, ribbed seeds. [10,12,20]

Water hyacinths grow over a wide variety of wetland types from lakes, streams, ponds, waterways, ditches, and backwater areas. Water hyacinths obtain their nutrients directly from the water and have been used in wastewater treatment facilities. They prefer and grow most prolifically in nutrient-enriched waters. New plant populations often form from rooted parent plants and wind movements and currents help contribute to their wide distribution. Linked plants form dense rafts in the water and mud.[10]

In the Pacific Northwest, water hyacinth is planted outdoors in ponds and in aquaria, but it is not considered winter hardy, except under special conditions. The fibrous root system of water hyacinth provides nesting habitat for invertebrates and insects. Leaf blades and petioles are occasionally used by coots. However, whatever benefits this plant provides to wildlife are greatly overshadowed by the environmental invasiveness of this noxious species. [12]

Water hyacinth reproduces sexually by seeds and vegetatively by budding and stolen production. Daughter plants sprout from the stolons and doubling times have been reported of 6-18 days. The seeds can germinate in a few days or remain dormant for 15-20 years. They usually sink and remain dormant until periods of stress (droughts). Upon reflooding, the seeds often germinate and renew the growth cycle.[2]

V. MODEL CONSTRUCTION AND SAMPLING

For studying the efficiency of the macrophytes regarding the treatment of municipal wastewater, a bench scale model has been design and constructed at the hydraulic laboratory of UET Taxila. The municipal wastewater sample for the examination and study has been taken from the Gate # 02 of UET, Taxila. Water hyacinth has been used for treating wastewater. The model has been constructed with the tempered glass with wall thickness of 25mm. the outer surface of the model has been protected with the steel frame. Silicone sealant has been used to attach the tempered glasses with the frame structure. The detail of the model has been shown in the following figure.

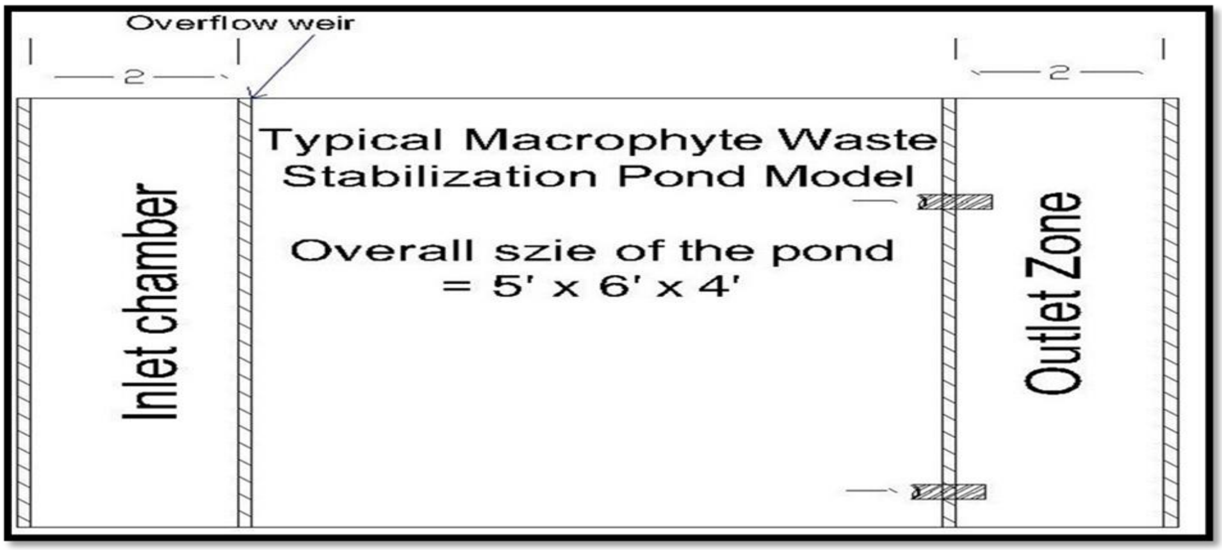

Fig-2: Macrophytes Stabilization Pond (Plan)

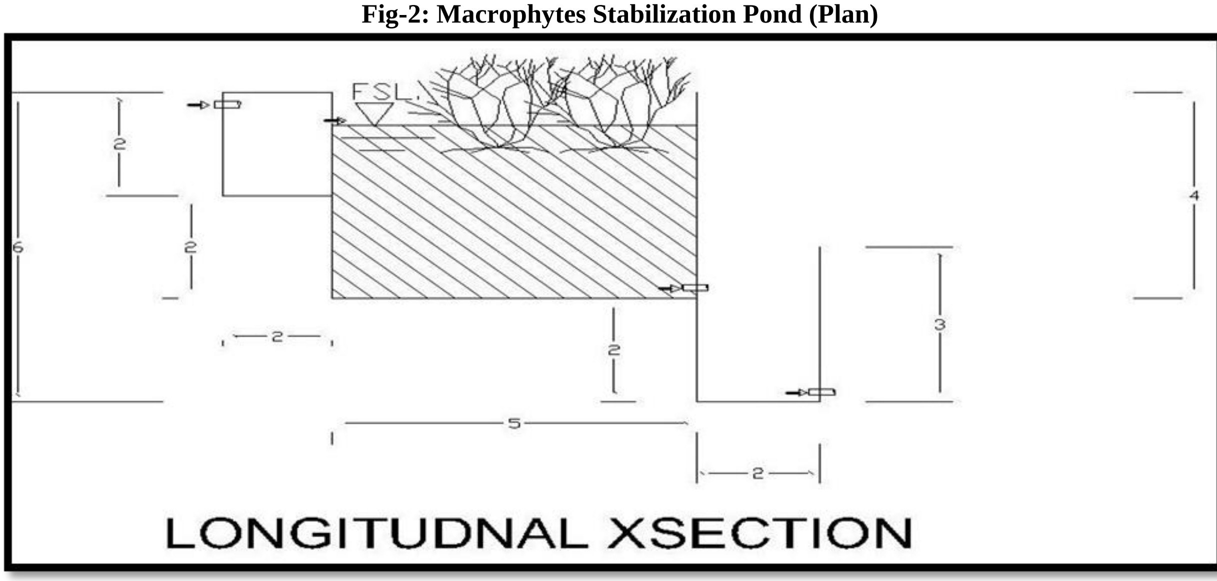

Fig-3: Macrophytes Stabilization Pond (Section)

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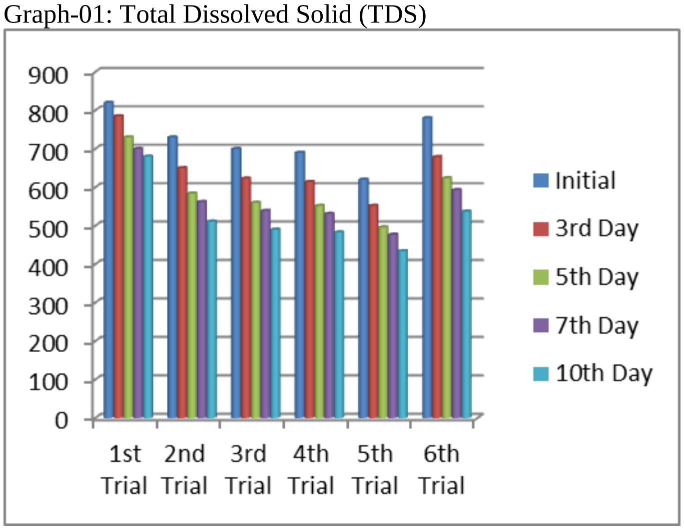
All the sampling and preservation procedures for water samples were performed according to Standard Methods for the Examination of Water and Wastewater, 1998 and Guidelines for drinking water quality (WHO). Sampling for bacteriological analysis was done aseptically with care, ensuring that there was no external contamination of the samples. For bacteriological analysis sampling, sterilized plastic Poly Ethylene (PET) bottles of 0.5 litre capacity were used, cleaned and rinsed carefully, given a final rinse with distilled water, and sterilized at 121°C for 15 minutes, as directed in section 9030 & 9040 of standard methods. For physicochemical analysis, samples were collected in Poly Ethylene (PET) bottles of 1.5 litre capacity, properly washed with the sampling water for three times. Sample bottles were marked with date and sample ID using indelible ink. During sample collection, ample air space was left in the bottle (at least 2.5 cm) to facilitate mixing by shaking, before examination. Sample bottles were kept closed until filled (without rinsing) and caps were replaced immediately. In case of water samples from distribution network, un-rusted taps supplying water from a service pipe, directly connected with the main and not served from a storage tank, were selected. Tap was opened fully, and water was let run to waste for 2 or 3 minutes, and then water flow was reduced to permit the filling of bottle without splashing

VI. RESULTS AND ANALYSIS

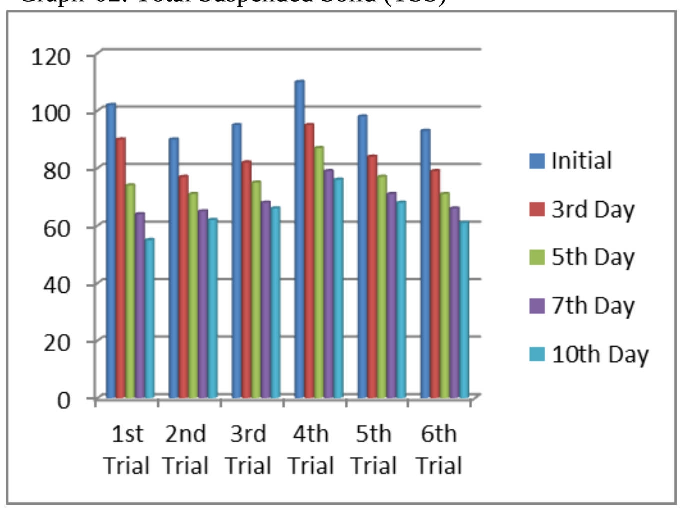
All parameters values reduced 60%-70% in 10th day from its initial values and also achieve WHO and NEQS (NATIONAL ENVIRONMENTAL QUALITY STANDARDS OF PAKISTAN). All result shown below in graph.

* All values are in mg/l

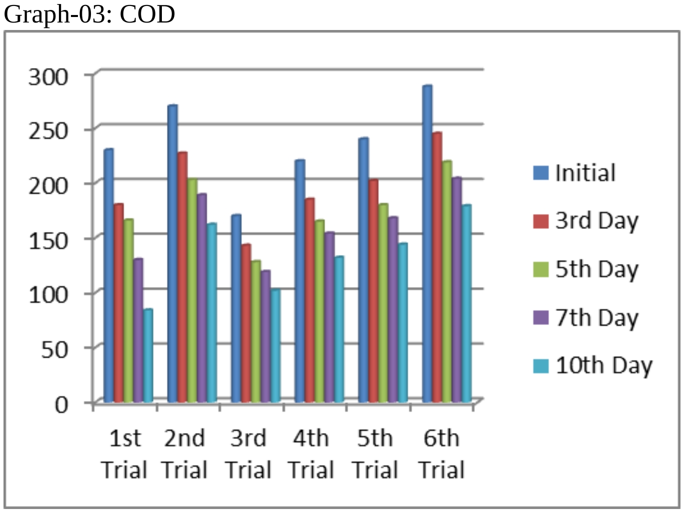
Graph-01: Total Dissolved Solid (TDS)



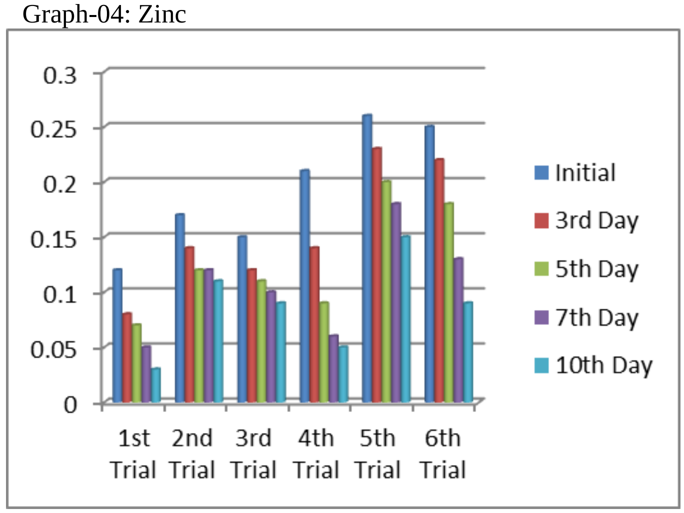
Graph-02: Total Suspended Solid (TSS)



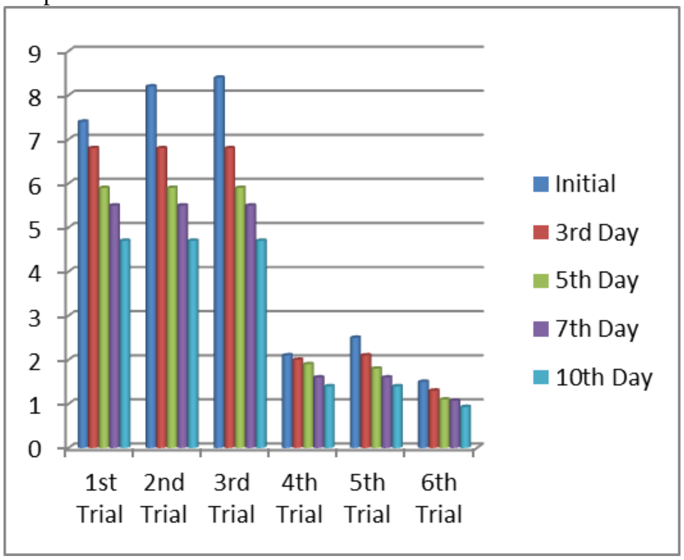
Graph-03: COD



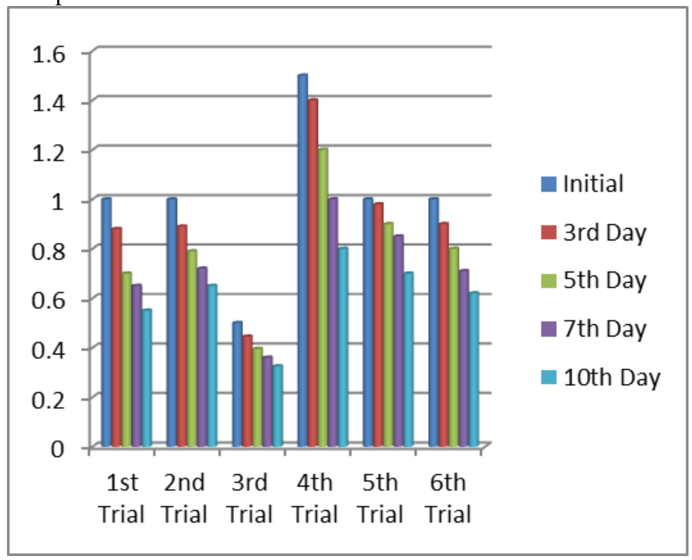
Graph-04: Zinc



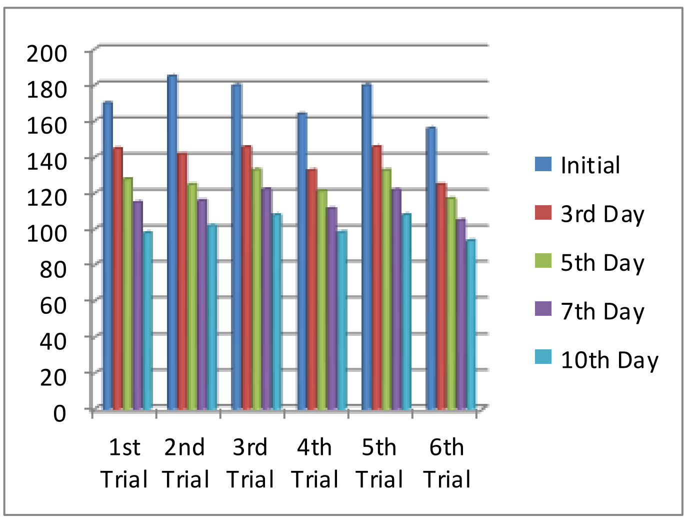
Graph-05: Iron



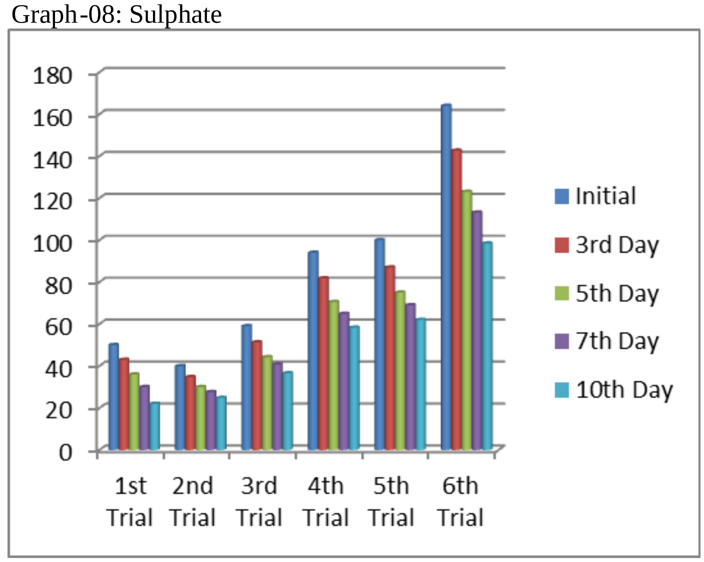
Graph-06: Floride



Graph-07: Chloride



Graph-08: Sulphate



VII. RECOMMENDATION

Wastewater treatment by water hyacinth is very much efficient to reduce water pollutant as this project result shows that pollutant concentration reduces 60%-70% of its initial and achieve WHO and NEQS standard. The result is satisfactory so it is recommended to be used in municipal wastewater treatment purposes. An important observation of this project, rate of growth of water hyacinth is very important. In the project trial session, it is noticed that temperature has a great influence on the growth of water hyacinth. Winter season at low temperature growth of water hyacinth is less as compare to summer season at high temperature. Extra water hyacinth should be removed to provide sufficient free space to penetrate sunlight. The technology is cost effective, maintenance free, self-sustained and Eco-friendly.

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