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"AN EXPERIMENTAL STUDY OF ALGAE WALL FOR THE TREATMENT OF WASTE WATER"

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ABSTRACT

Water pollution is one of the most critical environmental problems of today's world. In India, as much as 80% of the surface water is polluted resulting mostly from untreated wastewater sludge. In this project, proposes cultivation of algae in urban wastewaters as a sustainable approach for removing the nutrients from the wastewaters and make it useful for other purpose. This study assesses the feasibility of microalgal wastewater treatment, and the utilization of the resulting microalgal biomass, as a renewable energy source. A 'soft path' for wastewater management is presented as a sustainable alternative. We have developed a leaf-shaped tile made of clay and algae infused hydrogel called LEAFED INDUS that is capable of cleaning heavy metals from wastewater sludge. The wastewater sludge would be collected in a tank which would then be funnelled down by gravity through the channels in the tiles which are laden with algae .We created ' LEAFED INDUS', a tile-based, modular bioreactor wall system that can filter toxic chemical dyes and heavy metals out of water. The tiles made of ceramic can be mounted on the walls of factories or other buildings, and the water tank at the top of the building would direct water through vein-shaped channels. It is eco-friendly, It reduces cost of filtration of wastewater. The process of filtration of water is easy such as, it could be understand by any common person. We are using microalgae for the filtration of wastewater , the use of microalgae is showing great application in filtration of wastewater. Use of Microalgae will ensure the sustainable development of society with saving in natural resources.

Keyword: *Microalgae, INDUS Leafed shaped tiles, waste water filtration.*

1.INTRODUCTION

A comprehensive review of the past and present urban wastewater management is presented in this chapter, including shortcomings of our conventional centralised management systems. A 'soft path' for wastewater management is presented as a sustainable alternative. Such an approach emphasises on small-scale management systems, incorporates fit-for-purpose water reuse and recommends the use of diverse, locally appropriate and commonly decentralised infrastructures. Instead of depositing wastewater from textile dying and jewelry -making

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into sand pits or rivers, wastewater tanks would funnel the water onto a wall of these tiles. As the water passes over the tiles, heavy metals get caught in the algae membrane, creating cleaner water for reuse.

In India, as much as 80% of the surface water is polluted resulting mostly from untreated wastewater sludge. Another culprit is industrial waste which comes in the form of dyes and other chemicals that are disposed of during textile production. Because textile production is widespread across India, finding a remedy for the pollution is a very challenging one. Compounding the problem is the fact that communities rely on river water for bathing and drinking which makes this a significant health hazard that needs a sustainable solution.

We have developed a leaf-shaped tile made of clay and algae infused hydrogel called Indus that is capable of cleaning heavy metals from wastewater sludge. Their hope is that they could manufacture these tiles for use in factory walls or buildings. The wastewater sludge would be collected in a tank which would then be funnelled down by gravity through the channels in the tiles which are laden with algae.

Conventional wastewater treatment

Untreated wastewater generally contains high levels of organic material, numerous pathogenic microorganisms, as well as inorganic nutrients and toxic compounds. Unreleased of these waste water in water bodies causes eutrophication and disposal of solid wastes in sanitary landfills is usually associated with soil, surface water and groundwater contamination, thus entails environmental and health hazards. Wastewater treatment is a process, where contaminants are removed from waste water to produce waste stream or solid waste suitable for discharge or reuse. Physical, chemical and biological methods are used to remove contaminants from wastewater. In order to achieve different levels of contaminant removal, individual wastewater treatment procedures are combined into a variety of systems, classified as primary, secondary, and tertiary wastewater treatment (Maier 2000). Conventional waste water treatmentis simple and commonly used method.It consist set of chambers in a series such that influentcan pass from one to other successively to upgrade the quality of water. It follows-Primary treatment, Secondary treatment and Tertiary treatment, shown in figure 1

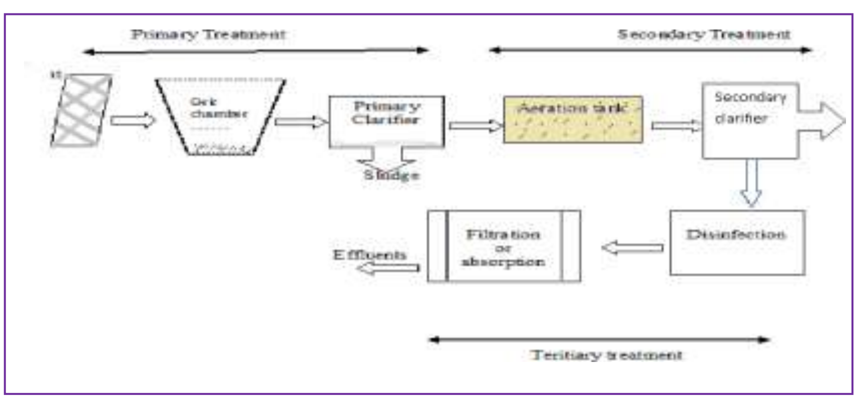

Fig 1- Conventional waste water treatment plant (Shelef& Sukenik 1984)

Objective of the Project is given as:-

- The objective of this phase was to evaluate the efficiency of microalgae for tertiary treatment to remove nutrients (N and P), remaining COD, and pathogens from secondary wastewater effluent as well as side stream.
- The objective of this phase was to evaluate the efficiency of microalgae when it was used in combination with the activated sludge process for the enhanced removal of COD and nutrients during biological treatment.
- Reuse of wastewater for different purpose.
- Reuse of organic wastage.
- Presenting the future of water.
- To use the Algae for treatment of water.
- To make the environment Eco-Friendly.

2.MATERIALS AND METHOD

2.1 Materials

- **Algae**

Algae consist of a wide mix of photosynthesizing organisms. Depending on morphology and size, algae are divided into micro- and macroalgae. Macro-algae are multiple cell organisms that resemble plants, while microalgae are a diverse range of single celled primary producers. Microalgae are found practically everywhere where there is light and humidity at least at some time of the year. Microalgae are found in marine and fresh waters, deserts, hot springs and on snow and ice.The number of species of microalgae is greatest in the seas and lakes . Micro-algal cultures assimilate huge amounts of nutrients as well as reduce biological and chemical oxygen demand (BOD and COD). The increase in pH caused by photosynthesis can further accelerate the removal of nutrients by ammonia stripping or phosphorous precipitation.

Microalgae have been proven to effectively remove nitrogen, phosphorous and chemical oxygen demand and even pathogens from wastewater. The use of microalgae is more cost efficient than activated sludge processes and other secondary treatment processes

Algal based wastewater treatment	Conventional Method
Low operating cost	Expensive method
Very low biological and chemical sludge formed	Large amount of toxic sludge is formed that may cause other types of pollution
Possible to recover valuable metals	Not possible to recover metals
Microbial biomasses have various industrial applications.	Could not be used for any other purposes
More efficient method especially to remove heavy metals.	Less efficient to remove heavy metals
Reduces the release of green house gases	Releases green house gases like CO_2

Table 1: Advantages of algae based waste water treatment over conventional method

Hydrogel

A hydrogel is a crosslinked hydrophilic polymer that does not dissolve in water. They are highly absorbent yet maintain well defined structures. These properties underpin several applications, especially in the biomedical area. Many hydrogels are synthetic, but some are derived from nature.

Fig2.1(a) Hydrogel

- **Tiles**
  - The tiles is shaped like a leaf veins that’s reason we named it Indus
  - Tiles could be cast by any normal person after teaching it to process of casting.
  - A local clay artist fabricating the Indus Tiles through press moulding with clay .

- The tiles designed with small containers which can hold the algae laden hydrogel CNC milling is used to fabricate the initial mood which is then used to cast a plaster mould.

Fig2.1(b) Tiles

2.2 Method

2.2.1 Fabrication of Tiles

To tackle this problem, we created 'INDUS', a tile-based, modular bioreactor wall system that can filter toxic chemical dyes and heavy metals out of water.A plaster mould is fabricated from a CNC Milled component allowing for easy replicability of the Indus tiles.The tiles' surfaces are inspired by the grooves and veins of leaves, as one of nature's most efficient, water-dispensing systems.

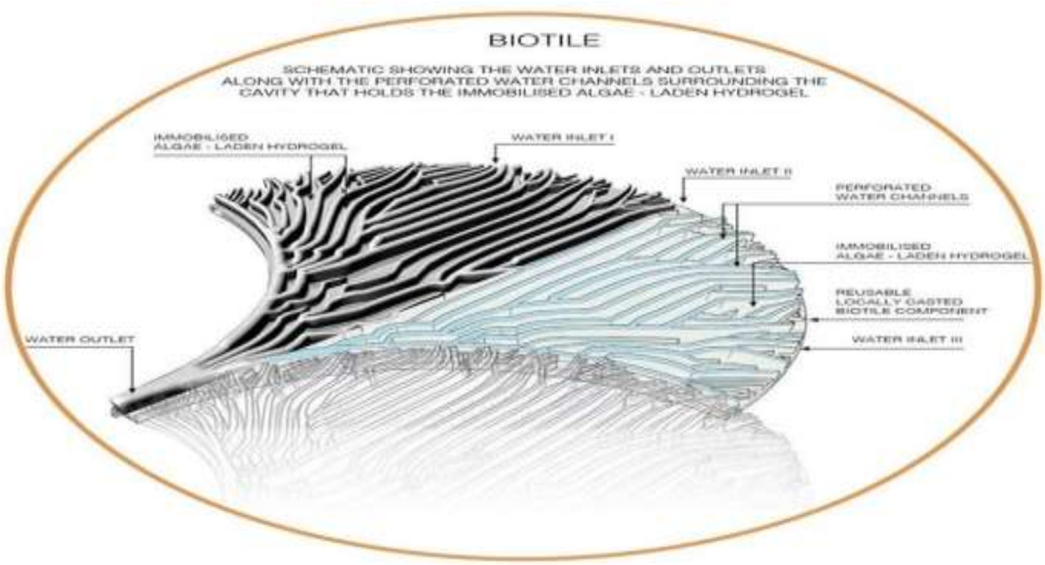

Fig 2.2.1 Fabrication of Tiles

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2.2.1.1 Using Clay

- A local clay artist fabricating the Indus Tiles through press moulding with clay.
- The tiles designed with small containers which can hold the algae laden hydrogel CNC milling is used to fabricate the initial mood which is then used to cast a plaster mould.
- It Could be cast easily in India

Fig 2.2.1.1 Clay Tiles

2.2.1.2 Using Cement

- We use thermacoal sheets for the moulding and casting of the tiles.
- We use 1:3 Cement and sand for the Casting of tiles and check there durability ,which is quiet effective than clay , and give shaped of vanes with a stick.

Fig 2.2.2.2 Cemented Tiles

2.2.2 Preparation of Microalgae

Sodium alginate is the most commonly used polymer matrix for microalgae immobilization . The immobilized microalgae have been exploited for removing nutrient in wastewater and have great potential to be used in marine aquaculture wastewater treatment. Effluents from aquaculture are rich in solids and dissolved nutrients, mainly in the form of inorganic nitrogen and phosphorus . However, the major limitation for the use of alginate gel entrapment for microalgae in marine system is the instability of calcium alginate gel upon contact with cation chelating agents and antigelling cations. For this, different concentrations of alginate and hardening cations calcium were used to formulate beads *Nannochloropsis* sp. is a unicellular marine algae to create a “green-water” in tanks.

2.2.2.1 Procedure

- We use Sodium alginate and 1% of $CaCl_2$ as base solution. Firstly, alginate solution was prepared by slow stirring of sodium alginate (Fisher Scientific) in warmed distilled water and then autoclaved at 121°C and 15 psi pressure for 20 minutes.
- The sterile alginate solution was added dropwise into $CaCl_2$ solution from a height of 2.5 cm above by using a peristaltic pump (MASTERFLEX) at a rate of one drop per second.
- The 4 mm beads formed were kept stirred in the $CaCl_2$ solution for 30 min to allow complete hardening of the alginate.
- The beads were washed several times to eliminate the remaining CaCl2. A known volume of alginate beads was counted to determine the number of beads formulated. Approximately 3000 beads were produced from 100 ml of alginate solution. Different concentrations of alginate and hardening cation calcium were used to formulate beads.

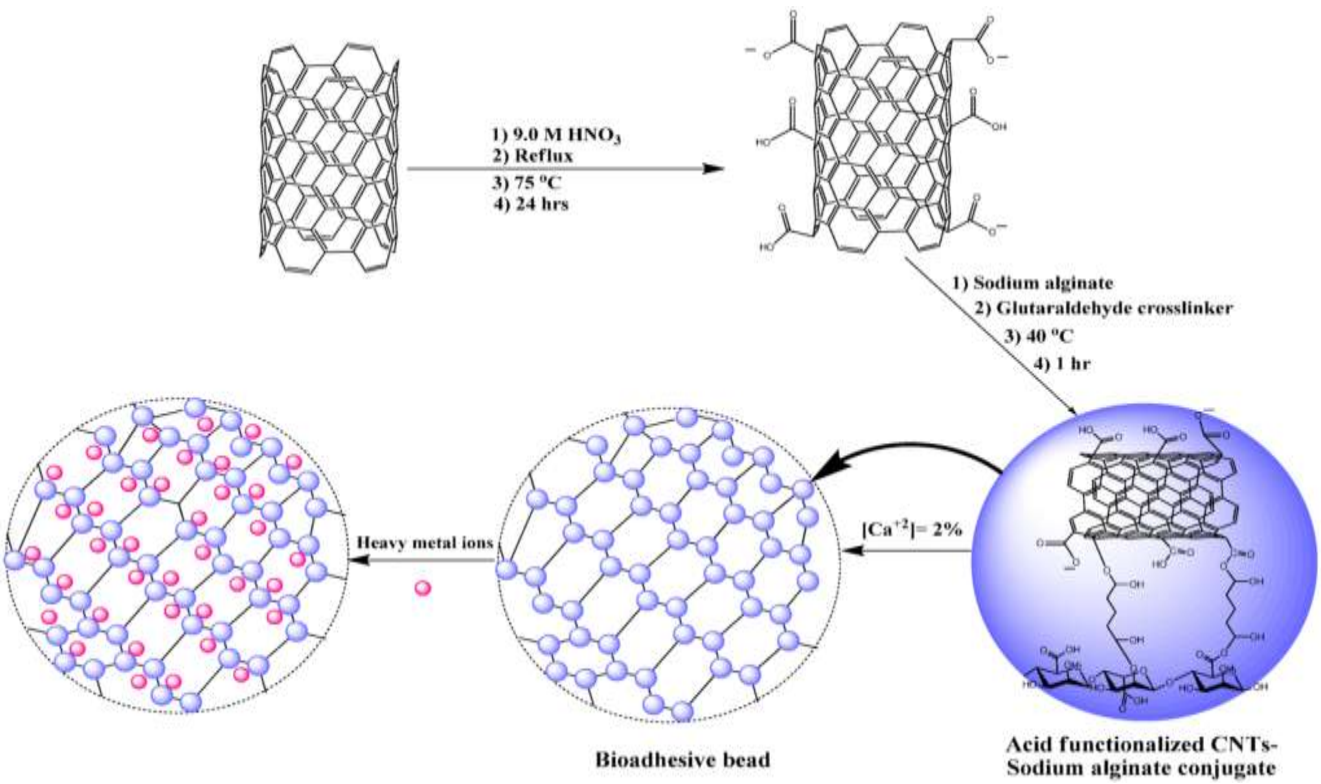

Fig 2.2.1 Preparation of microalgae

2.2.2.2 Experimental Studies

- To study the effect of alginate concentration on beads stability, four concentrations of alginate solution which are 10 g L^{-1}, 30 g L^{-1}, 40 g L^{-1}, and 60 g L^{-1} were used to prepare beads as described above by using a 10 g L^{-1} $CaCl_2$ solution as hardening cation. For alginate hardening, five concentrations of $CaCl_2$ solution which are 3 g L^{-1}, 10 g L^{-1}, 20 g L^{-1}, 30 g L^{-1}, and 40 g L^{-1} were used to study the effect of $CaCl_2$ concentration on beads stability.
- At each sampling time, ten beads of each treatment were taken to test the stability of beads. The diameter of the beads was measured by using a digital caliper (GERE), to monitor bead swelling or shrinkage, which were considered as signs of alginate instability.

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2.2.3 Mechanism

- After preparation of microalgae we fill up the microalgae in our tiles INDUS with Hydrogel.

Microalgae + Hydrogel

Fig 2.3 (a) Microalgae with hydrogel

- Then We Assembled from the Leaf Tiles onto An Existing wall. Tiles adjustment through wall, and recirculate it according to the contamination level of water

Fig 2.2.3(b) Inclined wall

In the pipe the water flows continuously in the pipes which passes through the tiles veins and according to the contamination of the water recirculate it.

Fig 2.2.3 (c) flow through veins

3. RESULTS AND DISCUSSION

Microalgae is an unicellular photosynthetic organism, utilizes inorganic nutrients such as N, P and CO_2 from the environment to synthesize organic compound for the biomass growth and produce O_2 as a byproduct according to the following overall stoichiometric formula for photosynthesis:

$$6\ H_2O + 6\ CO_2 + light \longrightarrow C_6\ H_{12}O_6 + 6\ O_2$$

Secondary effluents are rich inorganic nutrients (nitrogen, phosphorus) that can result to eutrophication and formation of dead zones in water bodies. Microalgae assimilate different forms of inorganic nitrogen (such as nitrites, nitrates, ammonia) from waste water and convert them into organic nitrogen sources required for protein, DNA,RNA and cell synthesis (Conley 2009). Microalgae prefer ammonia and after depletion of ammonia it assimilates nitrate than nitrite depending on their availability in wastewater.

All forms of inorganic nitrogen species are reduced to ammonium inside the cell by their enzymatic systemas ammonium easily gets converted into glutamine without any redox reaction and thus utilizes less cellular energy (Flynn et al 1997). Phosphorus (P) is the second essential nutrient for microalgae, which isutilizedfor the synthesis of various compounds such as ADP, ATP, nucleic acids, phospholipids and protein (Conley et al 2009). Different forms of phosphorus mainly orthophosphate are accumulated in wastewater due to different human activities particularly through phosphorus containing fertilizers. Microalgae have a ability to absorb excess phosphorus and stores it as granules of polyphosphate in the cell for future utilization.

Waste water	**Microalgae strain**	**P**	**N**	**References**
Domestic wastewater	Mixed algae growth	99%	90%	Metcalf et al 2003
Domestic wastewater	*Botryococcusbraunii*	100%	79%	Nurdogan & Oswald 1996
Wastewater From textile industry	*Chlorela vulgaris*	33%	45%	Sydney et al 2011
Synthetic wastewater	*Chlorela vulgaris*	96%	97%	Peng et al 2010
Primary wastewater	*Haematococcus pluvialis*	100%	100%	Kang et al 2006
Soybean processing wastewater	*Chlorella pyrenoidosa*	70%	89%	Kang et al 2006
Primary and secondary wastewater	*Desmodesmus communis*	99%	99%	Hongyang et al2011
Urban waste water	*Chlorella*sp.and*Chlamydomonas* sp.	100%	84%	Samorì et al2014

Table 2: Microalgae in removing nutrients from different waste water sources

Microalgae emerged as an alternative technique over traditional methods (Aksu 2002). It is one of the most prominent eco-friendly method for removal of heavy metals from industrial effluents like mining, metals plating, paint industry. Metal removal capacities of microalgae have been recognized in previous studies as highlighted in Table 3. Both live and dead cells can be successfully used for the removal of heavy metals from waste water. Metals removal capacity of microalgae varies from species to species depending on its cell wall composition. The presence of various negatively charged functional groups such as carboxyl, carbonyl, amino, amido, hydroxyl, sulfhydryl, sulphonate and phosphorus, etc. on algal cell wall exhibits chemical affinity to positively charged metal ions and facilitate surface binding via chelation, adsorption, coordination, ion exchange and microprecipitation etc (Kajan 1992). Heavy metals are toxic in nature and causes serious threat to the human being and flora and fauna of receiving water bodies (Nageswara and Prabhakara, 2011).Once the metal releases into the water bodies, they persistthere and get accumulated in biological system over the time (Zahira, 2005). They are carcinogenic in nature and have detrimental effect on aquatic organisms and ultimately human being, as they get concentrated through food chain. Most of the heavy metal salts are soluble in water, form aqueous solutions (Zahira et al 2005). Therefore difficult to separate by ordinary physical means of separation. Conventional methods used for the removal of heavy metal ions include chemical precipitation, floatation, adsorption, ion exchange, membrane filtration, chemical oxidation/reduction and electrochemical processes

Algal species	Targeted Metals	References
Chlorella vulgaris	Copper, nickel	Fourest&Volesky 1997
Chlorella vulgaris; Scenedesmusacutus	Cadmium,chromium, zinc	Mehta et al 2001
Stichococcusbacillaris	Lead	Travieso et al 1999
Spirogyra hyaline	Cadmium,Mercury, Lead, Arsenic and Cobalt	Mahan et al 1992
Cladophorafracta	97-99% removal of copper,cadmium, mercury	Kumar &Oammen 2012
Chlamydomonusreinhar tii; Selenestrumcapricornut um	Chromium, copper, silver	Deng et al2007
Spirogyra hyline	Cadmium, lead, zinc, copper, nickel	Elmahadi& Greenway, 1991
Spirogyra condensates and Rchizocloniumhieroglyp hicum	Chromium	Gupta &Rastogi, 1992
Chlorella emersonii	Mercury	Onyancha et al2008
Chlorella sorokiniana	Cadmium , Chromium, lead, nickel	Wilkinson et al 1990
Chlamydomonasreinhar dtii	Cadmium, lead, mercury	Akhtar et al 2003

Table 3: Biosorption of heavy metals by microalgae

4.Conclusion

Algal based wastewater treatment is a viable alternate technology for treating wastewater in an economical and sustainable way over conventional treatment processes. Using microalgae in wastewater treatment can greatly improve the treatment process through reducing the pollutant concentrations, pathogenic organism,biological oxygen demand(BOD), CO_2, emission, and reducing aeration requirement. Furthermore, microalgae have the potential touse wastewaterfor the growth of its biomass having numerous benefits such as animal feed, fertilizer, production of biofuels and nutraceuticals. Integration of wastewater treatment with generation of microalgal biomass reduces the production cost. Therefore, further investigationsare needed forlarge scale cultivation of microalgae in wastewater, assessment ofenvironmental and safety risk and to explore the use of these microalgae in valuable products.Harvesting is a major hurdle to integrated microalgal wastewater treatment since it is the most costly process in microalgae treatment. Many harvesting methods have been practiced; however, further research is required to develop more economical harvesting methods.With the advantages of low cost raw material and no secondary pollution, algae could be promising for purification of waste water.

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