Environment friendly alternative for conventional method of water purification in still water bodies

Phytoremediation and Mycoremediation

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Abstract : anthropogenic activities on static water bodies deteriorate the water quality and leads to the accumulation of toxic chemicals and sediments and also to the shrinkage of catchment area. Pollution includes point sources such as emission, effluence and solid discharge and non-point sources such as soluble salt (natural and artificial), use of insecticides pesticides and municipal waste in agriculture. Phytoremediation is an efficient, environment friendly and low cost technology which uses plants or trees to clean up soil and water, contaminated with heavy metals or organic contaminants such as solvents, crude oil and other toxic compounds from contaminated environments. This technology is useful for soil and water remediation. It has gained increasing attention since last decade as emerging cheaper technology. This natural ability of phytoplants can be exploited as the alternative for the conventional chemical methods of purification. It is attractive due to its low cost and versatility. This technology uses special type of plants to decontaminate soil or water by inactivating metals in the rhizosphere or translocating them in the aerial plants.

Water samples from different static bodies which shows variation in degree of pollution are initially tested in laboratory for the analysis of physical chemical and biological contaminants .Few varieties of phytoplants are grown in buoyant tubes placed on the water surface so that they act as sponges to clean , desalinate and mitigate the chemicals .After a certain period of time again the water samples are taken and tested .The result shows effective declination in the degree of contamination.

Finally, issues with the disposal of the toxic material inside the plant still remain. To start with some of the absorbed waste will naturally decompose with the plants. However chemicals, radioactive isotopes and heavy metals will require special treatment when the plants die. A new method of handling this plant waste is to use mushroom spores. Mushrooms produce a thin thread like network of roots called mycelium which produces enzymes which breakdown a great many contaminants. So in essence we use a plant to clean a plant.

Researches have been conducted on phytoremediation property of plants one of which is by Muhammad Aqeel Ashraf etal(2011) deals with the removal of heavy metals and contaminants from soil and water. We thought this to be the suitable alternative for present purification methods of still water

IndexTerms **- Pollution, Anthropogenic, Phytoremediation, Phytoplants**

I. INTRODUCTION

One of the world's greatest concerns is the increasing rate of pollution of our aquatic ecosystem. According to the latest Indian infrastructure report, the socio-economic costs of water pollution are extremely high. 1.5 million Children under 5 years die each year due to water related diseases, 200 million person days of work are lost each year, and the country loses about Rs 366 billion each year due to water related diseases.

To start with, Water pollution is the addition of undesirable biological, physical, chemical substances to natural water bodies. These substances reach the water bodies either by point sources (a specific source of pollution) or by non-point sources (various other means of pollutant discharge).Point sources of pollution probably indicate a pipe which directly discharges pollutants (which can be from industries) to the water body or a drain. On-point sources usually indicate the runoff through which the pollutants enter the water body. Lots of toxins are added to still water bodies by the anthropogenic activities like disposal of waste water (which contains detergents) after washing clothes. If any water body is no longer suitable for aquatic life and if it has lost its ecological balance then it is deemed as "Highly polluted".

In rural India, local Stillwater bodies like ponds, lakes etc. are the common property of villages which play vital roles not only in social and environmental development but also in cultural and economic development too. These water bodies which once were the source of drinking water for the people is now in the brim of complete degeneration due to agricultural runoff, pesticides, insecticides, anthropogenic activities, laundry activities, lack of maintenance and neglect. Now talking about the case of urban India, the degeneration of Stillwater bodies mainly happens as the result of dumping of garbage, draining untreated sewage water, industrial waste disposal etc.

The major pollutants that are likely to be present in still water bodies are chemical nutrients, organic matter, acids slits, inorganic substances, dissolved solids, suspended solids, biocides, heavy metals like Cadmium, Lead, Mercury etc.(the case is so if the water body is located near industries), bacteria, oils, pathogens etc. The various substances that we use for keeping our houses

clean add to water pollution because they contain harmful chemicals. Most detergents and washing powders contain chemicals like phosphates.

These pollutants can cause great harm to human beings. Pathogens are very harmful as they can cause diseases like typhoid, dysentery etc. It can cause skin diseases and also minor respiratory problems. The polluted water from the water bodies can migrate through the soil structure and enter the nearby drinking water sources thereby contaminating that too and in turn lead to the spread of water borne diseases like malaria, cholera, diarrhea, Trachoma etc. Interference with the polluted water causes skin infections, itching etc. The toxins present in detergents can even lead to death of hypersensitive people.

The consequences of water pollution not only affect human beings but also the flora and fauna associated with the water body. The increased availability of chemical nutrients which are essentially the limiting growth factor for the water plants and algae causes the excessive bloom of these species(for example Potamogen species, cyanobacteria etc).These excessive blooms of algae causes harm to the life of other organisms. This process of enrichment of aquatic ecosystem is termed as Eutrophication. Even though this can happen naturally over time, Human activities can trigger its growth by a very sharp rate. When the algae die a large amount of dissolved oxygen in the water body gets used up in their decomposition leading to a reduced level of Dissolved Oxygen (DO) content in water. If DO content is less than 5mg/l, then the living organisms like fishes are affected and they die off. Eutrophication leads to higher rate of photosynthesis of phytoplankton and thereby depletes the inorganic carbon leading to the raise in pH level during day, due to which the aquatic organisms can turn blind. It also leads to dense coloration of water and reduces water clarity. The chemicals present are also found to be a major threat to aquatic life. Oils may contain toxic chemicals which may coat the living species leading to injury or even mortality. The toxins present in detergents can lead to gender swaps in fishes.

The use of contaminated water for irrigation in the production of food crops increases the risk of food borne illness. The contaminated water leads to the spread of bacteria like E.coli, Salmonella, cryptosporidium etc and microbes like cyclospora through food crops..

II. PURIFICATION OF WATERBODIES

In the current situation of increasing water pollution, the need for purification of water bodies becomes viable. The conventional purification method involves chemical treatment, treatment in plants etc, which is costly and some of the chemicals when in excess can have carcinogenic effects.

An eco-friendly plant based technology for water and soil called phytoremediation is currently gaining large attention due to its low cost and effectiveness. Various studies have shown that certain green plants have the capability of purifying various contaminants present both in soil and water. These contaminants include nutrients, chemicals, heavy metals, explosives etc.

We have been experimenting about the capability of certain terrestrial plants to purify the pollutants present in still water body which mainly consist of nutrients, chemicals, acid content etc. by in situ treatment.

III. PHYTOREMEDIATION

Phytoremediation can be precisely defined as the method of purification of soil and water using plants which enables removal, degradation or containment of contaminants. The implementation of this technology needs a Plants offer a permanent and in situ method pollution removal .During the growth of the plant it consumes the excess nutrient which is present in the water body as the result of pollution and reduces algae growth and thereby reducing Eutrophication. Various contaminants are removed in by different techniques by different varieties of plants which possess the genetic potential to remove, degrade, metabolize or immobilize these contaminants. So plants for remediation must be chosen in accordance with the contaminants present in the soil. Floating iris is used for remediation of common organic pollutants. Duckweed and sweet flag is used for the removal of nitrate. Pond weed is the fastest TNT remover. The plants like Azolla, Indian mustard, and morning glory are heavy metal accumulators. Contaminants can be removed easily after the process by harvesting the plants itself.

IV. TYPES OF PHYTOREMEDIATION

Phytoremediation can be of various types based on the mode of accumulation, uptake or degradation of contaminants. The various types of Phytoremediation are:

Phytoextraction, which is the ability of some plant species by which it accumulates the pollutants in a nonreactive form. These plants absorb pollutants in their roots where the pollutants gets chemically bonded to organic compound thus becomes inactive so that the plant growth is not affected by the pollutant.. Then this is transported to different body parts and stored there in inactive state. This process is extensively useful in heavy metal removal. Chelating agents can also be used to accelerate the uptake of metals.

Phytostimulation/Rhizodegradation is shown by plants which have specific niches in their root for the microorganisms to live, which help in the degradation of organic pollutants present in the water. The degradation occurs due to the enzymic activity of some microorganisms in the rhizosphere which transforms organic compounds to much simpler harmless substances. These microorganisms are aided by the phytoplants which provides it with essential nutrients.

Phytostabilization is the process by which some of the Phytoplants immobilize the pollutants by adsorbing or accumulating these on their roots so that pollutant becomes less available. This process is helpful if rapid immobilization is necessary.

Phytotransformation/Phytodegradation is the process by which the organic pollutants are absorbed and degraded by various metabolic processes inside the plant. The product of these reactions integrated into plant tissues can foster the plant growth. This process is helpful in remediation of organic contaminants such as chlorinated solvents.

Rhizofilteration is the ability of some plants because of which they take up contaminants by absorbing them through roots and converts them to biomass till they are harvested. Contaminants are stored in roots. This process is effective in remediation of toxic substances and excessive minerals

Phytovolatilization is the property by the virtue of which plants take up volatile compounds through their roots and convert them into less harmful form for further transpiring the same into the atmosphere. This works on remediation of organic compounds, heavy metals and TCE.

V. MYCOREMEDIATION- METHOD OF DISPOSAL

Most of the pollutant material gets decomposed inside the plant itself but still pollutants like heavy metals and some others still remain nonbiodegraded, which if disposed carelessly can again be a cause for pollution. To solve this dilemma of disposal, a new technology termed as mycoremediation can be adopted. Mycoremediation involves the use of different kinds of mushrooms to degrade the harvested plant material. It is simpler and cheaper than conventional remediation options. Mushrooms develop a network of roots called mycelium which produces enzymes to degrade the rest of the pollutants. The mycelium secretes extracellular enzymes and acids that breakdown lignin and cellulose which are the main constituent of plant fiber which consist of the pollutants during this process, the contaminants are broken down into simpler compounds. The whole process of breakdown is done not only by the mushrooms but also bythe microbes which participate in this process and thereby breaking down the contaminants into carbon dioxide and water. Thus the whole process becomes environmental friendly. This process is claimed to have the potential to be cost competitive with existing remediation technologies.

Mycoremediation is useful in the degradation of petroleum hydrocarbons, industrial wastes and heavy metal contaminants accumulated by phytoplants.

Gliocladium roesum can even convert cellulose to diesel. In essence Mycoremediation can convert cellulose to diesel!

VI. MATERIALS AND METHODS

Our objective was to experiment and find out the effectiveness of implementing phytoremediation as a potent alternative of chemical purification methods of water bodies. Here we have concentrated on Stillwater bodies.

As a first step, water samples were collected from Vellayani Lake (Trivandrum)(sample 1), Puthukulam pond (Trivandrum) (sample 2) and Marthandam pond (Trivandrum) (sample 3)where taken for initial testing.

Figure 1. Vellayani Lake, Thiruvananthapuram, Kerala

Various parameters of samples were tested like pH, Hardness, Temperature, Dissolved oxygen, Chloride, BOD, Nitrite, Nitrate, Total solids and Total dissolved solids. The tests were conducted on 2th September 2015 at the chemistry laboratory in ACE College of engineering and following results were obtained.

Table 1 Initial test results

	Initial test reports			
Sl No	Parameters	Sample 1	Sample 2	Sample 3
1	pH	6.2	6.4	6.7
2	Hardness (mg/L)	64	58	56
3	Temperature (° C)	30	20	31
4	Dissolved Oxygen(mg/L)	6.1	5.6	6
5	Chloride (mg/L)	300	280	250

6	BOD (mg/L)	32	30	29
7	Nitrite (mg/L)	0.08	0.07	0.07
8	Nitrate (mg/L)	0.27	0.2	0.23
9	Total solids (mg/L)	120000	90000	60000
10	Total dissolved solids (mg/L)	100000	75000	54000

By considering the test reports, three types of phytoplants – Hibiscus canabinus, Agrostics capillaris (bent grass) and Clitoria were selected for remediation purpose.

Figure 2. Hibiscus canabinus

Hibiscus canabinus has the capability of removing pollutants from sources such as leftover materials from incineration of plastic containers, sludge sewage application [1].

Figure 3.. Agrostics capillaries

Figure 4. Coriandrum sativum

The system for study was set up on 5th September .Three containers were set up which holds water from the above mentioned places. Buoyant tubes were taken and the bottom is adhered to a wire mesh above which a layer of coconut fiber was placed. Above that layer, a layer of soil was placed. It was taken care that soil layer does not fully submerge in water.

Then the selected plants were planted in the soil. The whole apparatus was set to float in the container filled with different water samples.

Figure 5. One of the systems under study

The plants were allowed to grow in the system for 3 months and the samples were finally tested for the same parameters on 5th December 2015 at chemistry laboratory of ACE College of engineering and following results were obtained.

Table 2. Final test results

	Final test results			
Sl..No	Parameters	Sample1	Sample2	Sample3
1	pH	6.4	6.4	6.6
2	Hardness (mg/L)	54	50	52
3	Temperature (° C)	29	26	30
4	Dissolved oxygen (mg/L)	7	8	8.1
5	Chloride (mg/L)	280	270	235
6	BOD (mg/L)	28	25	23
7	Nitrite (mg/L)	0.05	0.04	0.02
8	Nitrate (mg/L)	0.27	0.2	0.23

VII. COMPARITIVE STUDY

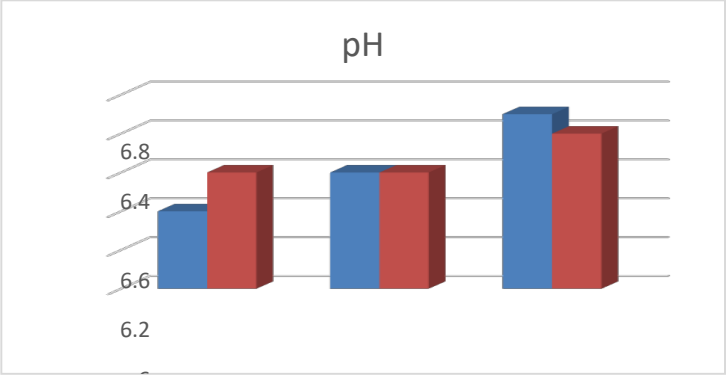

Figure 6. pH representation

pH is an important factor which controls the chemical changes, composition and metabolic activities of living organisms inhabiting the water body. Desirable pH level is 6.5 to 8.5.Water sample 3 is more or less neutral. Initial test shows that all the three samples were slightly acidic. The final result proves that there is a positive change in pH level due to the remediation process.

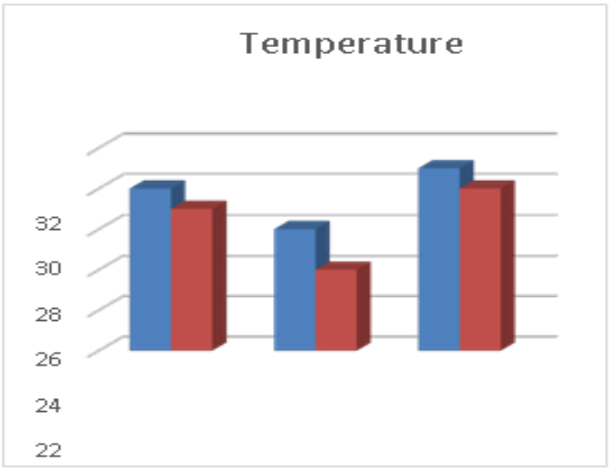

Figure 7. Temperature representation (oC)

The final result shows the decrease in temperature level as the result of remediation.

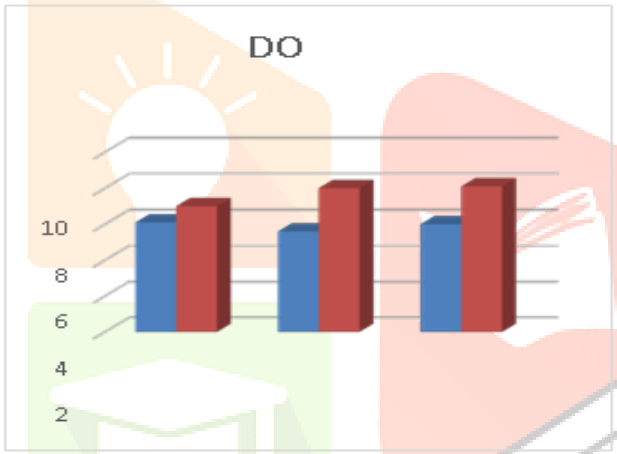

Figure 8. Dissolved oxygen representation

Dissolved Oxygen (DO) is an important parameter which affects chemical as well as biological reaction in the ecosystem. Variations in DO obtained are from 6 to 6.1mg/L. DO reduces with increase in chloride content. In addition to absorption of oxygen from atmosphere, the presence of tiny plants in water contributes O2. If the dissolved oxygen amount is zero the BOD will be high and whatever these is the demand of O2 for oxidation of waste in given volume of water.

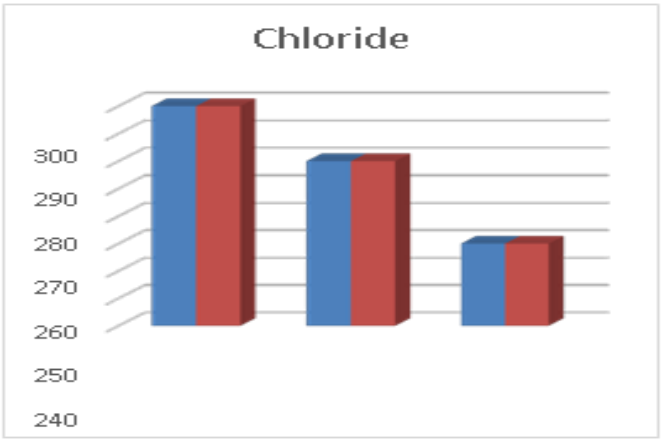

Figure 9. Chloride representation

The amount of chloride remained unchanged after remediation.

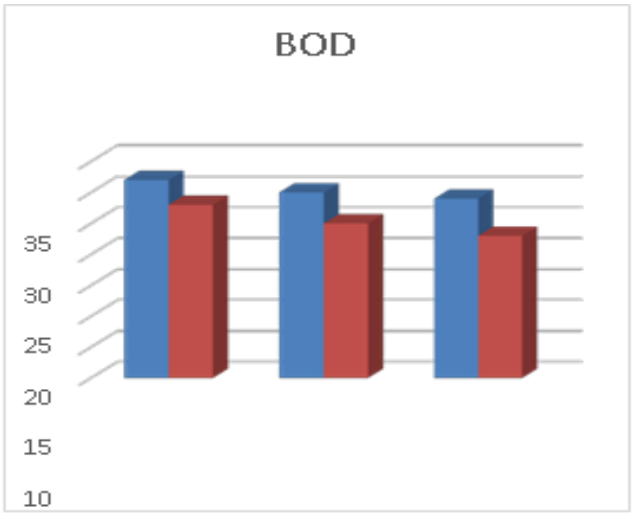

Figure 10. BOD representation

Since the dissolved oxygen content of the three samples increased after the remediation process, naturally BOD will decrease.

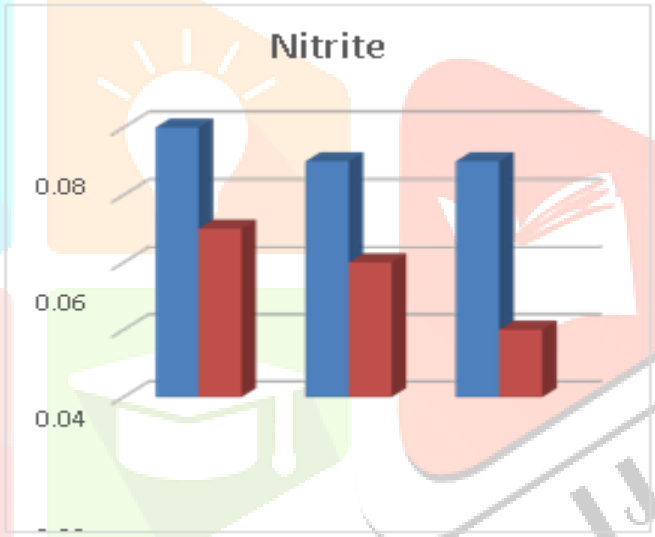

Figure 11. Nitrite representation

Nitrite is the partially reduced form of Nitrate and is usually present in very small quantities. Concentration of Nitrite in above samples varied from 0.02 to 0.05 mg/L. Low concentration of Nitrite depicts unpolluted nature of water.

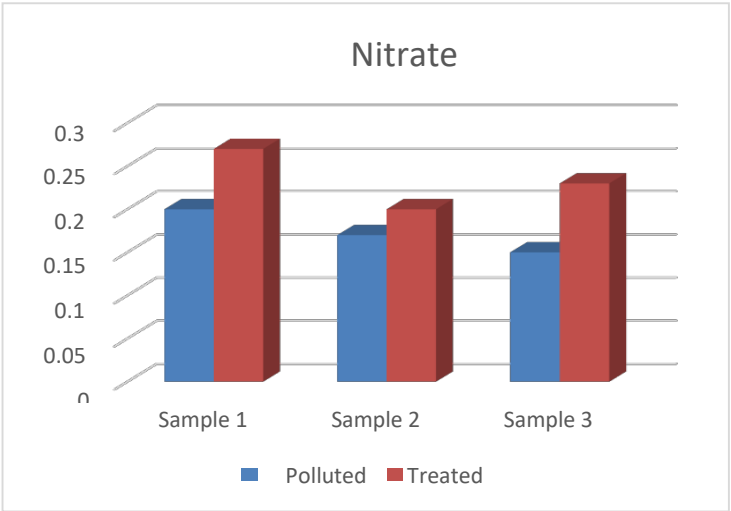

Figure 12. Nitrate representation

Nitrate is nontoxic in lakes and rivers up to 10mg/L and the concentration of Nitrate in the above samples is much below limiting levels.

CONCLUSION

As per the phytoremediation experiments conducted, it is clear that the phytoplants can effectively reduce the pollutants and nutrients present in polluted waters. The system of study can be practically applied in still water bodies. This will at a time contribute to two things one is the purification and second is it will increase the aesthetic appeal.

The water purified by this method can be used for domestic purposes except drinking purpose, irrigation purposes and other uses.

OUR FUTURE STUDY AREA

We are interested in studying and experimenting about the application of phytoremediation for the remediation of chemically detoxified industrial waste water and thereby making it suitable for other industrial purposes.
WE are also planning to study about the effectiveness of phytoremediation in purifying household waste water.

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