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A Review on "Bioremediation of Polluted Water by using Different Herbs"

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ABSTRACT- In the developing technologies and growing environment, the usage of the water source plays a vital role and its been needed and used in large amount. Insufficient management of municipal and wastewater in immense environmental problems and increasing hygienic risks for the growing urban population thereby hampering poverty alleviation and a sustainable development of Indian society. But now days, the waste water is converted into a source for various purposes in different aspects by the use of phytorid technology. phytorid technology is a patented technology and being very effective in water pollution treatment it leads one step forward to sustainable treatment of wastewater in safe manner. In view of rising concern about pollution of water bodies due to discharge of waste in them, it is necessary to initiate alternative thinking as conventional methods through STPs (Sewage treatment Plants) have had limited success. In recent years the application of specifically designed Phytorid technology (popularly known as wetland based technology) for treatment of wastewater- municipal, urban and agricultural, is becoming widely acceptable. Phytorid technology is a type of constructive wetland system developed by, National Environmental Engineering Research Institute (NEERI), CSIR In 2005. This technology used the type of decentralized waste water treatment approach for the treatment of wastewater. It can be used for the treatment of domestic, agricultural, slaughter house, fish pond water etc. If sufficient land area is available it is preferable for pre-treated sewage. The technology utilizes wetlands plants, gravel/ porous stone and their associated microorganisms to mimic natural wetland ecosystem processes for the treatment of wastewater.

KEYWORDS- Phytorid Technology, Wastewater, Natural Wetlands, Wetlands Plants, NEERI

I. INTRODUCTION

Currently, water pollution is a major environmental issue worldwide. This occurs when harmful substances such as chemicals, heavy metals, microorganism as well as nutrient pollution contaminate water recipients such as streams, lakes and groundwater. According to Rockström et al. (2009) there are currently three times as much available nitrogen in circulation in the environment than it naturally should. This could then lead to eutrophication which causes algal bloom and dead zones (Backlund, 2011). The result is a degrading water quality which could become toxic to both the environment and humans (Denchak, 2018). This highlights the importance of fresh water preservation and remediation of wastewater since the global demand for fresh water is expected to increase by one-third by 2050 (WWAP, 2018). The Earth is called the blue planet, since freshwater is a scarce resource available in earth. Only 2.5% of all water resources are freshwater, of the 2.5% which are freshwater, nearly 70% is not accessible, because it is bound in snow and ice, thus only 0.5% of the total water on earth is accessible for drinking and other freshwater uses. Primary water source is polluted to a great extent through the discharge of harmful substances. It is estimated that every 1m3 of contaminated water once discharged into water bodies will contaminate further 8 to 10 m3 of pure water. In addition to this, the effects of the globe warming has increase the water source in one side and scarcity in the other part in major uses such as agriculture. The Earth is called the blue planet, since freshwater is a scarce resource available in earth. Only 2.5% of all water resources are freshwater, of the 2.5% which are freshwater, nearly 70% is not accessible, because it is bound in snow and ice, thus only 0.5% of the total water on earth is accessible for drinking and other freshwater uses. Primary water source is polluted to a great extent through the discharge of harmful substances. It is

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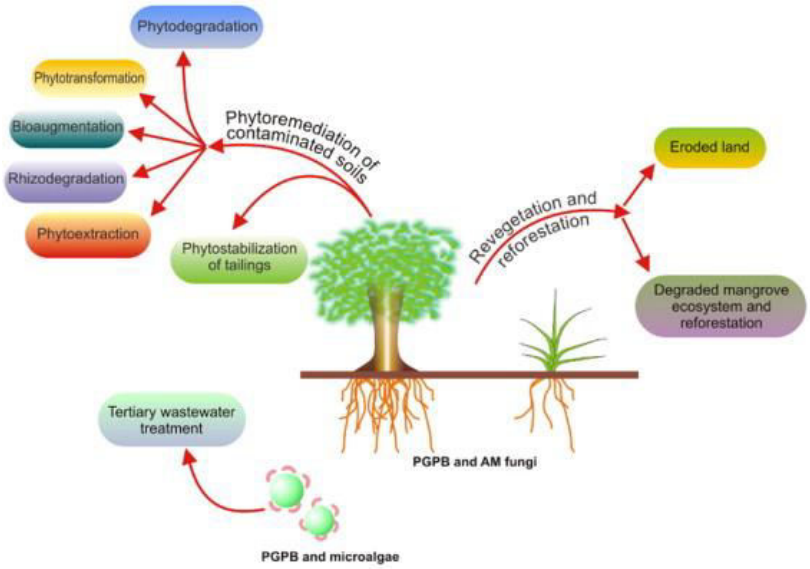
1.1 BIOREMEDIATION

It is defined as the use of plants to immobilize the contaminants in the soil and groundwater through absorption and accumulation in plant tissues, adsorption onto roots or precipitation within the root zone preventing their migration in soil. Several aquatic plants have been used in water purification and wastewater treatment. Among die most widely used are cattails, totora, water hyacinth, and duckweed.

Water is a resource that supports life and contamination of water resulting from anthropogenic activities, is a matter of concern worldwide. Water defects and contamination of existing water supplies threaten to be critical environmental issues today for agricultural, domestic and industrial uses. Discharge of municipal sewage and industrial activities deteriorate water quality in urban areas. Synthetic fertilizers, herbicides, insecticides and plant residues released from agricultural activities change the water quality in rural areas. Aquatic plants grow profusely in lakes and waterways all over the world and in recent decades their negative effects have been magnified by man's intensive use of water bodies. Eradication of the weeds has proved almost impossible and even reasonable control is difficult. Turning these weeds to productive use would be desirable if it would partly offset the costs involved in mechanical removal. Among other uses, there has been considerable interest in using aquatic plants for pollution control. Aquatic macrophyteshave been reported to be very efficient in accumulation of heavy metal ions from the water in which they are growing. Bioremediation is a waste management technique that involves the use of organisms to remove or neutralize pollutants from a contaminated site. Bioremediation exploits the natural capability ofliving organisms to clean environment. It aids in transformation and degradation of contaminants into non-hazardous or less hazardous substances. Bioremediation is defined as any process that uses microorganisms or their enzymes to destroy or reduce the concentrations of hazardous wastes from contaminated sites without further disruption to the local environment. It is a relatively slow process, requiring weeks to months to effect clean up. If done properly, it can be very cost-effective. It uses naturally occurring bacteria and fungi or plants to degrade or detoxify substances hazardous to human health and the environment. This is an attractive process due to its cost effectiveness and the benefit of pollutant mineralization to CO2 and H2O (Mills et al., 2004). The microorganisms may be endogenous to a contaminated area or they may be isolated from elsewhere and brought to the contaminated site. Contaminant compounds are transformed by living organisms through reactions that take place as a part of their metabolic processes (Margesin and Schinner, 2001).



[Fig.1.1: Bioremediation of contaminants by plants]

Bioremediation can be effective only where environmental conditions permit microbial growth and activity, its application often involves the manipulation of environmental parameters to allow microbial growth and degradation to proceed at a faster rate. So, bioremediation methods have focused on the addition of microorganisms or nutrients

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concentration and the temperature dependant condition of the process environment. The main requirements for degradation of oil by microorganism are energy sources and carbon sources. Biostimulation is the addition of substrates, vitamins, oxygen and other compounds that stimulate microorganism activity, so that they can degrade the waste faster. The addition of materials to encourage microbiological biodegradation of oil which has received the most attention, notably after the "Exxon Valdez" incident (Swannel et al., 1996), however, such as low water temperature are not favorable for bioremediation.

Bioremediation exploits the natural capability ofliving organisms to clean environment. It aids in transformation and degradation of contaminants into non-hazardous or less hazardous substances. Effective in mitigating hydrocarbons, halogenated organic solvents, halogenated organic compounds, non-chlorinated pesticides and herbicides, nitrogen compounds, metals (lead, mercury, chromium) and radionuclides. In the era of bioremediation, vegetation or plants as a biological resource with immense capacity for removing variable contaminants from various components of ecosystem have been studied. Plants remove or degrade selected contaminants present in soil, sludge, sediment, groundwater, surface water and wastewater by utilizing their metabolic and hydraulic processes, thereby improving the environment quality that is termed as 'Phytoremediation'. Bioremediation methods by using plants have proven to be useful for contaminant removal in soils. But the main concern that arises from phytoremediation is that because phytoremediation is still a new technology, the actual processes of contaminant removal by plants is still not fully understood. Other concerns in using phytoremediation with plants is that there are not very plants capable of taking up PCBs, and thus more research needs to be. Plants that are in symbiotic associations with mycorrhizal fungi need to also be taken into consideration when it comes to phytoremediation (Kumar, Vankayalapati Vijaya, 2017). While plants can take up contaminants, there are certain pollutants that cannot be degraded such as heavy metals and they will keep on accumulating in the plant tissue.

1.2 PHYTORID TECHNOLOGY

The phytorid technology was developed by NEERI (National Environmental Engineering Research Institute) and patented in Indian, European and Australian countries. The advantages of this technology is compensate and offset the rate of existing wetland loss, improve wetland quality provide flood control. The phytorid technology is a subsurface flow type wherein water is applied to the cells/beds filled with porous media such as gravel and stones. The hydraulics is maintained in such a manner that water does not rise to the surface retaining a free board at the top of the filled media. These systems may include a wide variety of foliage in the form of aquatic, marsh, ornamental, herbs, grasses and also terrestrial plants known to grow in water logged condition. Phytorid Technology is a recycling technology of wastewater to reduce the water scarcity in the earth presently and for the rest of the decades. This technology holds the sustainability of water for the next generations. People have to save water. Somehow, still, they are wasting the humungous amount of water, be it intentionally or by mistake. Along with that, people are making the natural water bodies polluted through different activities; as a result, they will suffer from a lack of water in future. To deal with this situation, CSIR-NEERI produced an eco-friendly, economic, wetland technology called Phytorid Technology to make the water purified, decontaminated and likely to be reused.

The system is based on use of specific plants normally found in natural reed with filtration and treatment capability. This system can be utilized for a wide variety of applications. It can be used for secondary and tertiary treatment of municipal wastewater, sludge management, treatment of industrial or agricultural effluent as well as for the treatment of landfill leachates. The phytorid technology is a effective and safe method of treating wastewater using the plants based on principle of natural wetlands. The 'Phytorid Technology' is a combination of the physical, chemical and biological processes which resulted into ultimate treatment for the waste water. This particular technology works without electricity, minimum maintenance, less manpower and importantly self sustainable.'Phytorid Technology' is being very, effective in water pollution control as it functions as "pollutant" sinks for sediment, nutrients, and metals. There are different mechanisms plays an important role in treating waste water in the wetland, principal measures are sedimentation,bacterial action, filtration, decomposition, nutrient uptake and vegetative system. The system comprises of a sequence of two independent cells.Advanced Filter Cell (AFC), that supports a permutation of different sizes of stones and gravel wherein anaerobic digestion occurs Phytorid Treatment Cell (PTC) made up of different layers of life supporting media (Gravel) as in AFC, planted with wetland plants. 'Phytorid Technology' can treat the wastewaters by naturally without the addition of chemicals. It has been accomplished with the use of aquatic or semi aquatic plants along with their associated biota. 'Phytorid Technology' is an improved wetland ecosystem for treatment of wastewater. It involves proper utilization of biological treatment capacity with optimized engineering parameters. The filterable wetland will be sown with aquatic and/or semiaquatic plants where wastewater will flow in through vertical and horizontal specially designed units for better hydraulics and adequate retention period. These units will be designed and evaluated for its efficiencies with regard to removal of BOD/COD, suspended solids, phosphorous, nitrogen and

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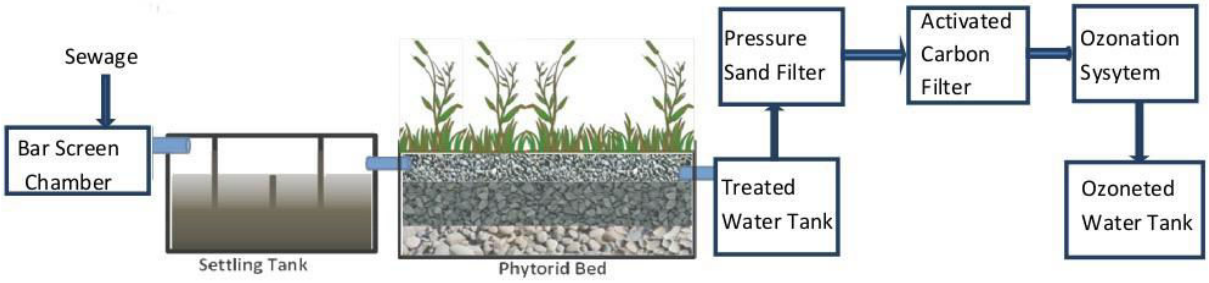
fecal coliforms. It is useful for secondary and tertiary treatment of municipal wastewater, management of sludge, treatment of industrial or agricultural effluent as well as for the treatment of landfill leachates.



[Fig.1.2: Phytorid Water Treatment Technology]

Phytorid Technology for Sewage Treatment:
In rural and urban areas, sewage is generated in a huge quantity. A huge portion of this sewage remains untreated and is left in water bodies with a limited installed treatment capacity in centralised manners. The impact of sewage contamination on rivers and lakes is currently a threat.

II. LITERATURE REVIEW

[1] Bioremediation of Polluted Waters Using Nanoparticles (2022)

- Water pollution is an issue of great concern worldwide, contamination by organic compounds, inorganic compounds and microorganisms. Bioremediation using microorganisms helps in the removal of toxic metals from the environment. The focus is on the heavy metals associated with environmental contamination, lead (Pb), cadmium (Cd), and chromium (Cr) which are potentially hazardous to ecosystems. In the present study textile effluent was collected, and subjected to Physicochemical treatment methods , Herbal-Metal nanocomposite was prepared and used to treat textile effluents. As a bioremediation study, the plant growth potential of treated effluents was evaluated using pot studies of an aquatic plant.
- It was very interesting to note that the turbidity which averaged 425 NTU at the beginning of the tests, decreased dramatically during the first 15 days by the addition of Herbal-Metal Nanocomposite and then increased again to reach double of the initial value.
- The BOD was reduced from 875 to 320 mg/l. The COD was decreased from 945 to 335 mg/l. In the present research, the developed nanocomposite were found to be very efficient in removing the color from 60% to 95% during the period of studies. For untreated control samples, colour reduction was not evident; in contrast the nanocomposite treated effluents showed colour removal significantly from 0th day to 25th day with reduction of 95%. As a bioremediation study, the plant growth potential of treated effluents was evaluated using pot studies of an aquatic plant called Ludwigia repens.

[2] Bioremediation of Contaminated Water-Based on Various Technologies (2014)

- This paper presents a brief outline of the development of bioremediation technologies (Microorganism remediation, phytoremediation, animal remediation and other methods applied in bioremediation.) applied at heavy metals, eutrophication, petroleum spills, pesticide contamination and other organic pollutions in water. Ecological relationships of microorganisms and contaminates were clearly expressed here. And mechanisms and types (Phytoextraction, phytodegradation, rhizofiltration, phytostabilization, phytovolatilization) of phytoremediation were fully discussed followed by animal remediation, which was not a popular way of bioremediation for contamination.
- If used properly, bioremediation has minimal adverse effects since it can be applied with little or no disruption to contaminated sites.
- In short, Bioremediation should be improved by us through biotechnology tools to enhance its exploitation for managing environmental pollution in a sustainable pattern.

[3] Microalgae Based Sustainable Bioremediation of Water Contaminated by Pesticides (2022)

- The use of pesticides in agriculture reduces the loss of crops and increases crop productivity. Agricultural discharge into water bodies increases pesticide toxicity in water.

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- A pesticide, when entered into water bodies, attacks non-targeting species, which disturbs the aquatic life. Because of low-cost taking, high material removal efficiency, low sludgy amount, and generated biomass for economic benefit, biological bioremediation methods are mostly preferred. Algae are used to remove pollutants from the environment or to convert them into harmless forms. Bioremediation by algae is highly preferred as biomass generated is used in biogas and biofuel production.
- Algae fix carbon dioxide (CO2) and release oxygen (O2) by photosynthesis and increase BOD (biological oxygen demand) in contaminated water. Therefore, it is necessary to reduce the use of pesticides or dispose of them in the best manner. To be on the safer side and make our water bodies less toxic, it is necessary to make efficient water treatment arrangements.

[4] Pollutant Removal in Wastewater by Vetiver Grass in Constructed Wetland System (2013)

- Constructed wetland technology is one of the emerging and acceptable technologies because it can effectively remove all most all types of pollutants from waste waters without harming the environment. The objective of the present study was to find out the effectiveness of vetiver grass (Vetiveria zizanioides L. Nash) in the pollutant removal from waste water in constructed wetlands. The vetiver plants (Vetiveria zizanioides L.Nash) (ODV-3) were planted (Test group and control group) in the constructed wetland and after 90 days, the test group was divided into three (T1, T2, T3) and were treated with waste water (50% dilution) from automobile service station (W1), spray painting workshop (W2) and sewage (W3) respectively, and allowed to grow for further 15 days.
- At the end of the experiment (on the 15th day of waste water treatment), the treated water from the tanks was collected and analyzed for various chemical attributes. The plants were uprooted, and the plant biometric parameters and nutrient content were also determined. The chemical characteristics of the wastewaters analysed show that all the wastewaters were contaminated, and automobile service station effluent was heavily polluted. More than 50% percentage removal of pollutants especially nutrients after 15 days treatment of waste waters in constructed wetlands was observed, and it showed the efficiency of the vetiver variety for improving the water quality.

[5] Phytoremediation: A Promising Approach for Revegetation of Heavy Metal-Polluted Land (2020)

- Heavy metal accumulation in soil has been rapidly increased due to various natural processes and anthropogenic (industrial) activities. As heavy metals are non-biodegradable, they persist in the environment, have potential to enter the food chain through crop plants, and eventually may accumulate in the human body through biomagnification. Owing to their toxic nature, heavy metal contamination has posed a serious threat to human health and the ecosystem. Therefore, remediation of land contamination is of paramount importance. Phytoremediation is an eco-friendly approach that could be a successful mitigation measure to revegetate heavy metal-polluted soil in a cost-effective way.
- To improve the efficiency of phytoremediation, a better understanding of the mechanisms underlying heavy metal accumulation and tolerance in plant is indispensable.
- In this review, we describe the mechanisms of how heavy metals are taken up, translocated, and detoxified in plants.
- We focus on the strategies applied to improve the efficiency of phytostabilization and phytoextraction, including the application of genetic engineering, microbe-assisted and chelate-assisted approaches.

[6] Traditional plant and herbs used in rural area for prevention of disease caused by water pollution (2021)

- Water being the most vital requirement for the survival of the life in the planet becomes even more vital when its demand increases due to increase in population as well as due to scarcity of consumable water. This chapter explains about water pollution and the causes of it. It also elaborates about type of water pollution and water borne diseases like diarrhea, cancer, hepatitis and many more that affects the world immensely.
- Furthermore, it explains about different types of herbs and plants that is used by people of rural area to tackle the problem of water pollution and effectively manage the diseases caused by the same. Examples of herb or plant derived substances utilized for water borne diseases include malvaceae and amaranthaceae, to name a few.
- This present chapter elaborated about the effect of pollutants in causing water pollution. Human being plays a major role in degrading the quality of water and making it difficult for human consumption. Water pollution also gives rise to many water borne diseases which claims many lives around the globe. Water borne diseases are quite prevalent in rural areas due to lack of hygiene but rural population relies on herbal and plant products

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to cope of with various diseases that occurs due to water pollution. Plant and herbs can be potential target in future for dealing with the alarming issue of water pollution and the disease caused by it.

[7] Microbial and Plant-Assisted Bioremediation of Heavy Metal Polluted Environments: A Review (2017)

- Environmental pollution from hazardous waste materials, organic pollutants and heavy metals, has adversely affected the natural ecosystem to the detriment of man. These pollutants arise from anthropogenic sources as well as natural disasters such as hurricanes and volcanic eruptions.
- Toxic metals could accumulate in agricultural soils and get into the food chain, thereby becoming a major threat to food security. Conventional and physical methods are expensive and not effective in areas with low metal toxicity.
- Bioremediation is therefore an eco-friendly and efficient method of reclaiming environments contaminated with heavy metals by making use of the inherent biological mechanisms of microorganisms and plants to eradicate hazardous contaminants.
- Microorganisms and plants possess inherent biological mechanisms that enable them to survive under heavy metal stress and remove the metals from the environment. These microbes use various processes such as precipitaton, biosorption, enzymatic transformation of metals, complexation and phytoremedation techniques of which phytoextraction and phytostabilization have been very effective.
- However, the environmental conditions need to be adequate for effective bioremediation. The use of hyperaccumulator plants to remediate contaminated sites depends on the quantity of metal at that site and the type of soil.

[8] Phytorid Bed Technology: A Sustainable Approach for Wastewater Treatment (2023)

- Phytorid Bed Technology is an environmentally friendly and sustainable method for treating wastewater using plants, soil, and microorganisms. It is a low-cost and low-energy alternative to traditional wastewater treatment technologies, making it particularly effective in regions with limited space, a lack of infrastructure, or high running expenses. The technology comprises a bed of gravel or sand with wetland plants that remove pollutants and nutrients from the water through physical, chemical, and biological methods.
- The treated wastewater is typically of high quality, with low levels of pollutants, and can be discharged into the environment or reused for non-potable purposes. Phytorid Bed Technology offers numerous advantages over traditional treatment methods, such as low cost, environmental friendliness, versatility, high-quality effluent, and aesthetic benefits.
- However, site-specific considerations and maintenance requirements must be considered when building and executing a system. Overall, Phytorid Bed Technology is a promising technology for sustainable wastewater treatment, with successful implementations worldwide.

[9] Domestic Wastewater Treatment using Phytorid Technology (2017)

- In the developing technologies and growing environment, the usage of the water source plays a vital role and its been needed and used in large amount. Insufficient management of municipal and wastewater in immense environmental problems and increasing hygienic risks for the growing urban population thereby hampering poverty alleviation and a sustainable development of Indian society. But now days, the waste water is converted into a source for various purposes in different aspects by the use of phytorid technology. phytorid technology is a patented technology and being very effective in water pollution treatment it leads one step forward to sustainable treatment of wastewater in safe manner using Iris Pseudacorus (Yellow Iris) plants and natural source for the treatment without affecting the ecosystem.
- The Chrysopogonzizanioides is to increase the pH value and to reduce the nitrogen, phosphorous content. The coagulation and flocculation process is done by alum to have a turbidity and to remove the suspended solids.
- This method is more advantageous of cost effective, negligible operation and maintenance with minimum electricity, smaller footprint. The main focus of the project is to avoid the scarcity of the irrigation water and to avoid the odor in the treated water and to enhance the quality of the water to prevent ground water pollution by analyzing the nominal water parameters that need to be satisfied for reusing the treated water with the references of IS 3025 code book.

[10] Performance Assessment of Domestic Wastewater Treatment Plants Operating on Different Technologies (2020)

- The study reveals that the performance of Delhi Gate and Shahdara STPs based on BIOFOR and Phytorid technologies are more efficient for the treatment of the municipal wastewater which can be further be safely

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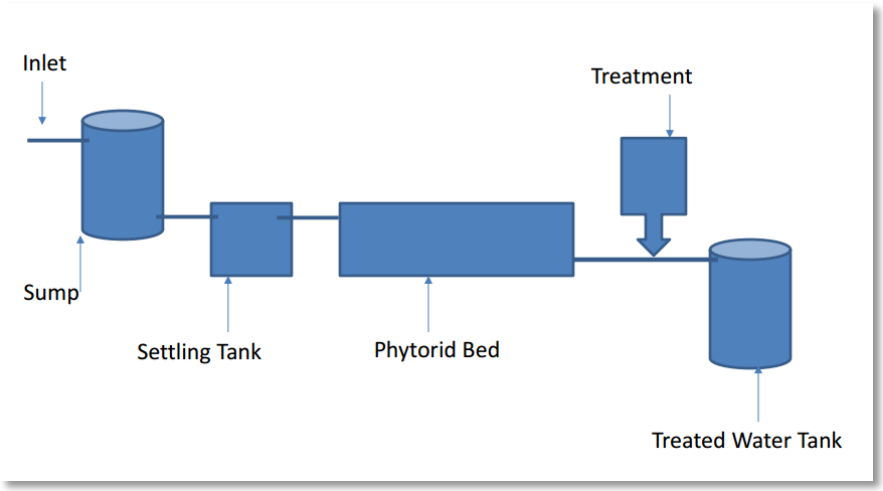
disposed off into surface water and can be used for non-domestic purposes like irrigation, agriculture, cleaning of parks and streets.

- The effluent quality of Najafgarh STP based on EA technology is found to be less efficient as compared to the BIOFOR and Phytorid technologies. Hence, it is required to be operated and maintained properly with close supervision so as to achieve effluent quality standards as prescribed by the Indian standards.
- In present study, it is found that the BOD removal efficiency is highest for Delhi Gate STP based on BIOFOR technology and COD removal efficiency is highest for Shahdara STP based on Phytorid technology. The total suspended solids removal rate is highest for Delhi Gate STP.
- The other parameters for BIOFOR and Phytorid based STPs are also within the permissible limit as per Indian standards with good removal efficiencies.

III. METHODOLOGY

The system includes intake well, settling chamber, treatment bed, and collection tank. If the water is to be treated with any dosing treatment then additional treatment dozing tank may be proposed. Wastewater from screening chamber flows into primary settling chamber by gravity. Solid waste has been separated in screening chamber by gravity and digested in anaerobic manner. Next bed is called Phytorid which is the heart of the system. Wastewater from primary settling chamber further flows into Phytorid bed by gravity. Phytorid bed is provided with different gradation of gravel/stone aggregate and hydrophytes type plants. The Phytorid bed is divided into compartments of baffle walls provided in such a way that the flow of wastewater is in sinusoidal manner. The unique design provides both the anaerobic and aerobic zones in the same Phytorid bed. Aerobic zone is near roots of plants, as plants transport oxygen from air to the roots and intern into water for biochemical oxidation. A specially design culture media helps in carrying biochemical oxidation in Phytorid bed. The flow of sewage is few inches below the gravel top layer and therefore no sewage is exposed leading to avoiding mosquito problems.

- After the Phyroid bed clears the water, it has been treated with chlorine or other dozing
- material to clear the bacterial or smell in water. This can be done by UV rays by natural
- ways without using any mechanical or electrical machineries at project.



[Fig.3.1: Steps involved in Phytorid Technology]

IV. CONCLUSION

It is concluded that phytorid technology is one of the efficient way of decentralized treatment of water, requiring negligible operational and maintenance cost. But more land area for higher volume of sewage. Hence, it can be adopted in local institutions and societies. Moreover institution should be further made to improve the quality and efficiency of the phytorid system. The studied wetland plants can reduce the level of Turbidity, COD, BOD, TS, TSS, Phosphate and Nitrate to different degree in waste water. Since the technology is low cost, environmentally friendly and simple, the use of constructed wetland in municipal wastewater treatment is a promising technology which could be adopted by the developing countries where limited resources are available for the installation of high tech treatment plants.

- Pollution load of raw sewage water varies with the location and season.

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- Use of raw sewage water for irrigation may cause soil and groundwater pollution problems.
- Treated sewage water through Phytorid Sewage treatment plant can safely utilized for the irrigation

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