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Natural Methods for Treatment of Waste Water

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***Abstract*—The aim of this study is to find various types of natural low cost materials which can be used in purification of water. This paper emphasize on study of natural herbs which are effective in treating wastewater like neem (Azadirachta indica), tulsi (ocimum sanctum), amla (phyllanthus Emblica) and detail study on sustainable filtration with aquatic plants like hyacinth and duckweed plants for treatment of water and also suggests the basic design parameters for implementing of hyacinth and duckweed treatment plants.**

***Index Terms*—Natural low cost materials, natural herbs, sustainable filtration, hyacinth plants, duckweed plants, purification**

I. Introduction

About 70 percent of this planet that we call home is covered with water. Without water, we would not be able to exist, and neither would the earth exist. Water is important as it is irreplaceable and in present scenario a large number of people do not have access to safe drinking water sources. Many of these people reside in developing countries with very few resources available to them due to which simple and low cost natural materials and methods have been developed to provide ways to treat water.

Water treatment is the process of removing contaminants from wastewater and domestic water. It is helpful in eliminating undesirable chemicals, biological contaminants, suspended solids and gases from water. It includes physical, chemical, and biological processes to remove pollutants from wastewater before discharging it into a water body.

Water treatment has two main purposes first is to make water safe to drink which is potable water and second making water aesthetically acceptable for drinking which is also called palatable water. We mainly treat water to protect public health, provide safe drinking water to large number of people.

Water treatment plant through natural filters means treating of water through natural materials like herbs, aquatic plants, sand, charcoal, pebbles, gravel, seashells, oysters, coconut etc. Its main purpose is to produce water fit for a specific purpose. It is cheap method and can be used in rural areas as well. Poor communities cannot afford the costs of the advanced and specialized systems, which require a trained and qualified staff as well due to which the development of simple and cost effective natural wastewater treatment systems are introduced. These treatments are called extensive, since they require long times and wide surface areas to become effective.

Waste water characteristics: Domestic wastewater contains organic and inorganic matter in suspended, colloidal and dissolved forms. The concentration in the wastewater depends on the original concentration in the water supply, and the uses to which the water has been put. The climate, and the wealth and habits of the people have a marked effect on the wastewater characteristics. Concentrations of wastewater are also affected by the amount of water used per person since in many communities the amount of solids added per person varies within relatively narrow limits. Thus, wastewater characteristics vary not only from city to city but also from season to season and even hour to hour depending on the water supply within a given city.

Features of natural wastewater treatments:
The main features of natural wastewater treatments are:

Efficiency: Natural waste water treatment plants are efficient in removal of most of the harmful chemicals from water like lead, chromium, mercury etc. The efficiency majorly depends upon climatic conditions; it is high with higher temperatures and low with lower temperatures.

Reliability: Natural ways of treatments of water are reliable even in adverse conditions. It has better performance and they are ecofriendly due to which it does not have any adverse effect on the environment.

Cost effective: Natural waste water treatment involves low labor and maintenance costs. They are more suitable than the chemical wastewater plants because in this energy consumption is low. In natural waste water treatment mechanical devices are not used and hence it reduces the maintenance costs making it cost effective. The only restriction in this treatment is the attainability and the cost of land to design the treatment plants.

Simplicity: The design and construction technique of these plants are very simple. It is also applicable in rural areas as design is very simple and it is cost effective and methods and techniques are so simple that it does not require any skilled

II. Objective

- To study about the low cost natural materials used for treatment of water

- Detail study on sustainable filtration with duckweed and hyacinth aquatic plants.
- To study design parameters involved in implementation of duckweed and hyacinth treatment plants.

III. Scope of Work

The scope of the research is to study the various types of low cost natural materials and techniques used in treatment of water .People living in rural areas cannot afford advanced and specialized systems of water treatment. So study of this research will be a boon for those people who live in rural areas or don't have good financial conditions as these natural materials and methods are cost effective.

IV. Methodology

The following methodology has been adopted in the present study:

- Study of various types of low cost natural materials which are used in treatment of water.
- By analyzing data through literature study.
- Study of researches done before on the same topic.
- Comparison between treatment of water through normal techniques and treatment of water through natural ways.
- Drafting inferences and conclusion.

Low cost natural materials:

Neem (Azadirachta indica): Neem is a magical tree with over 140 biologically active compounds present in its various parts, which makes it effective against a wide host of bacteria, fungi, viruses and parasites. From root to leaves every part of the tree has incredible benefits. Adsorption is one of the established unit operations used for the treatment of polluted water. Activated carbon is the most popular adsorbent but it I expensive so to replace activated carbon we can use neem leaves powder as a low cost adsorbent.

Tulsi (ocimum sanctum): This herb is used to remove fluoride from water. Leaves and stem of the tulsi plant can detoxify water with high fluoride content and make it safe for human consumption. Tulsi or ocimum sanctum has natural bio absorbent properties, that is the leaves and stem of this Indian herb serve as a natural magnet to adsorb fluoride molecules in the water. All one has to do is dip the leaves or stem of the tulsi in a glass of water for 20 min and then remove the plant pieces and drink the water

Amla (phyllanthus Emblica): When magnesium and calcium in high amount are dissolved in water, then that water is considered as hard water. Hard water comprises of heavy metals such as chromium, lead, iron, and mercury etc. Methods that have been used for treating hard water are reverse osmosis, ion exchange method, UV radiation, chlorination. But these chemicals are harmful. Phyllantus emblica (wood) has primary coagulant. The wood has shown a high coagulation activity for high- turbidity water and however the coagulation activity has been found to be low for low turbidity water. Firstly, the phyllantus emblica wood are cleaned and dried then the outer covering from wood is removed and at last fine powder is obtained from these dried woods by using mortar and then this powder is stored in air tight container and is used for removing the hardness of water. Hard water is directly treated with the prepared powder from amla at a concentration of 50 g/L. It has been found that before treatment the taste of water was too salty but after treatment with phyllanthus emblica the taste became bearable.

Sustainable filtration with Aquatic Plants like hyacinth and duckweed plants:

Hyacinth plants: These plants are the aquatic plants which are free floating growths. Free floating growths are harnessed in the form of built up units for waste treatment such as the hyacinth and duckweed ponds while reeds are cultivated in constructed wetlands. Aquatic plants ponds consisting of aquatic plants, free floating macrophytes, such as water hyacinths, alligator weeds, duckweeds, hydrilla, mart, solms etc. have been cultured in ponds either for their ability to remove heavy metals, phenols, pesticides, nutrients, etc. from waste waters or to assist in giving further treatment to pre – treated wastewaters to meet stringent discharge standards while at the same time producing new plant growths (biomass) for their biogas or food value

Hyacinth ponds: Aquatic macrophytes can be used to purify municipal and industrial wastewaters in secondary ponds located after algal waste stabilization ponds. Hyacinth (Eichornia Crassipes) flourishes in tropical areas and are known for their beautiful blue flowers. Hyacinths are known for their rapid growth rate in warm temperatures and while growing, they pick up nutrients and other dissolved substances from the wastewater thus giving good removal of BOD, etc. in the treated wastewater. Their function is to provide the surface and oxygen for growth of organisms thus improving treatment capability and reliability.

Fig. 1. Hyacinth plants used in water purification

Fig. 2. Eco friendly waste water treatment by using hyacinth plants

Growth characteristics:

The growth characteristics of hyacinths, summarized from O'Brien, are:

TABLE I
GROWTH CHARACTERISTICS

Natural availability	Over a wide region from 33ºN to 33ºS of the equator
Growth rate	Optimum rate 220 kg/ha/day(India) at 28-30ºC (upto 600 kg/ha/day seasonally (100-200 tons dry weight/ha/year)
Area doubling time	About six days(Florida, USA)
Density in pond	Varies from 224-412 tons/ha
harvesting	About ten times per year

Removal of pollutants:

The capability of hyacinths for removing various substances is shown below:

TABLE II
REMOVAL OF POLLUTANTS

Substance	Removal rate
Trace metals	120-670mg/day/kg dry plant matter
Phenols	About 12 mg/day/kg dry plant matter
Nitrogen	About 1 g/day/m^2pond area
Phosphorus	About 0.25g/day/m^2 pond area

Design Criteria Recommended for India:

Suggested design criteria for water hyacinth treatment systems

TABLE III
DESIGN CRITERIA

Parameter	For secondary treatment
Detention times, days	>6
Pond depth, m	0.91
Length to width ratio	>3:1
Mosquito control	essential
Plant harvesting	Monthly/weekly

Kumar (1986), who worked on hyacinth ponds at Roorkee University in north India, recommends a detention time of ten days. Kumar and Garde (1999) found that lab scale hyacinth ponds of ten days detention time performed well and gave an average density of 20g/m²of hyacinth with an average root length of 200-300 mm at the end of the run. They also observed that the dense growth tended to reduce the radiation reaching the pond water by over 90 percent. Thus the effluent was relatively free of algae and devoid of oxygen. Interestingly, the absence of oxygen did not affect the purification process and the final BOD was always<10mg/L and phosphorus, 1.5mg/L.

Duckweed ponds:

Duckweed ponds can be used effectively in wastewater treatment because they grow profusely under favorable conditions and can be harvested easily and used as fish feed to give a marketable end product, namely fish, while at the same time providing a high degree of treatment to wastewater.

Duckweed based wastewater treatment systems can be used:

- To give further treatment to effluents from algal waste stabilization ponds and mechanically aerated lagoons to meet more stringent BOD and Total suspended solids(TSS) regulations, especially where TSS are due to algal growth.
- To provide enhanced denitrification before discharge of effluent to a river or a lake.
- To develop a treatment system which can generate some financial returns from duckweed fish cultivation that can pay for the operation and maintenance costs of treatment, and thus attract local community involvement in ensuring maintenance of the treatment plant.

Characteristics of Duckweed Species:

Duckweed are small, floating aquatic plants that grow in many parts of the world. They belong to the botanical family Lemnaceae and are classified as macrophytes though they are sometimes mistaken for algae. Individual duckweed 'frond' has no leaf, stem or specialized structure; it has only an ovoid frond suited for floating free. Hence, it needs little fibre in contrast to terrestrial plants, which need much more fibre for supporting their stems and leaves. At 27°C, they double every four days in laboratory studies. Their dry weight is 252 kg/ha. Heavy metals can also be removed by duckweed plants. A floating homogeneous single layer of duckweeds tends to form a continuous mat on the water surface which inhibits light penetration and oxygen transfer at the surface. Thus, the water column below the mat tends to be devoid of both oxygen and algae.

Fig. 3. Duckweed plants floating in water

Fig. 4. Duckweed plants

Design Criteria:

Pre-treatment: Some form of pre-treatment is generally recommended and can be given either by using an anaerobic process such as the Up flow anaerobic sludge blanket (UASB) or by using an anaerobic/facultative process such as an aerated lagoon or an algal waste stabilization pond. In either case, it is recommended that the inflow coming to the duckweed pond be

kept within the following parameters

TABLE IV
DUCKWEED POND PARAMETERS

Biochemical oxygen demand(BOD)	≤ 80 mg/l
Ammonia(NH3)	≤ 50 mg/l
Hydrogen ion concentration(PH)	≤ 9.0
Total suspended solids(TSS)	≤ 100 mg/l
Total dissolve solids(TDS)	≤ 4000 mg/l

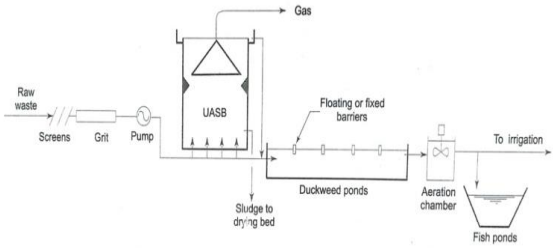

Fig. 5. Sectional view of a UASB + duckweed + fish pond system

Pre –treatment should be designed accordingly which is relatively easy to attain with UASBs, algal ponds and aerated lagoons. The limiting values shown above are only approximate and indicative, and would need to be updated as more experience is gained.

Duckweed pond sizing:

Duckweed pond sizing depends on whether one or both of the following major objectives have to be met:

- Detention time to give desired effluent quality, and
- Yield of duckweed biomass to give the desired fish production for marketing

Where both the above objectives have to be met, the duckweed pond size has to be calculated separately for both the purposes.

Layout and Construction of Duckweed ponds:

As duckweeds are free floating plants, the mats formed by them on a pond surface are easily blown by the wind and it is essential to design duckweed ponds with proper arrangements to confine them by using floating or fixed 'wind barriers' so as to keep the entire water surface uniformly covered at all times. The choice of the type of barrier depends on its cost, the permanency of any extra land required.

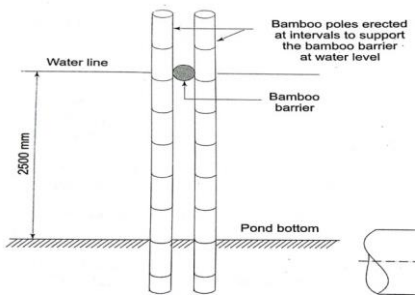

Fig. 6. A simple barrier made from bamboos

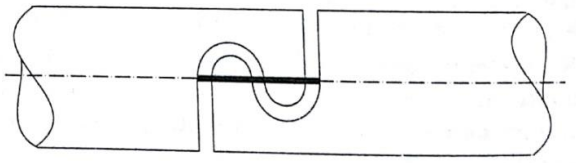

Fig. 7. Prefabricated HDPE barriers

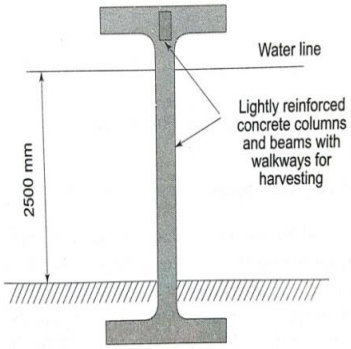

Fig. 8. Concrete column and beam arrangement

TABLE V
HARVESTING OF DUCKWEEDS

S. No.	Type of Barrier	Remarks	Increase in pond area needed to keep net water surface same	Relative costs
1.	Floating bamboos	Need frequent replacement	Negligible	Cheapest
2	Plastic HDPE floating barriers	Long life. Harvesting done by use of boats	5-10%	More expensive
3	Fixed barriers made from reinforced concrete columns, beams and walkways	Long life. Harvesting can be done from the walkways	10-15%	Medium

Overall Land Requirement:

The overall land requirements for duckweed –based wastewater treatment systems include the sum of requirements for

- Preliminary treatment(screening and degritting)
- Pre- treatment UASB
- Duckweed ponds
- Fish ponds, including nursery ponds
- Miscellaneous items(sludge drying in case of UASB, holding platforms for wet duckweed and tanks for harvested fish, administration building, etc)

The overall requirement may, thus be of the order of 2.0-2.5 m^2/person for a 7 day detention in duckweed pond to about 6m^2/person for a 20 day detention to get a high quality effluent.

V. Conclusion

From this paper, it can be concluded that natural ways to treat waste water are cost effective.

- It does not pollute the environment and it is ecofriendly.
- All the possible design and construction techniques are simple and can be operated easily.
- I also concluded the comparison between treatment of wastewater by mechanical ways and treatment of wastewater by natural ways which is listed below:

TABLE VI
Comparison

Through Mechanical Ways	Through Natural Ways
(i) Rapid treatment	Slow but effective treatment
(ii) Expensive	Cost effective
(iii) Adverse effect on environment	Eco- friendly
(iv) Requires large area	Can be implemented in smaller areas as well

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