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Research article

PROCESSING OF WASTEWATER FOR AGRICULTURAL IRRIGATION, USING EXPEDITIOUS DICOTS

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ABSTRACT: Disposal of effluent or wastewater into lakes, ponds etc. can pollute the water causing eutrophication, biomagnification etc. By incorporating the properties of water purification by soil and rhizosphere we have devised a method for processing wastewater and effluents for agricultural irrigation by utilizing the fast growing dicots from the plant family *Fabaceae* namely, *Pisum sativum* (Pea plant) and *Arachis hypogea*(Ground nut) along with sand and pebbles. The rapid growing root network of these plants provides rhizofiltration of particulates and complex organic matter of wastewater. Our observations indicated that this method is useful for plant growth and simultaneously treating the wastewater with an efficiency of 65-75 %, thus ruling this method as environmental friendly and cost effective.
Keywords: Rhizofiltration, Water pollution, Chemical Oxygen Demand (C.O.D), Biological Oxygen Demand (B.O.D), Sedimentation

INTRODUCTION

Increased production of effluents and wastewater, in many areas in recent years has lead to problems like eutrophication, biomagnification etc. in water bodies resulting in imbalanced aquatic ecosystems. Rhizofiltration is a form of remediation that involves filtering water through a network of roots to remove toxic substances and excess nutrients. It utilizes both physical and chemical properties of roots and soil in order to filter out suspended particles and complex organic matter in wastewater.

Many scientific investigations have proved that wetlands are an efficient media for water treatment. The soil in wetlands act as sinks for nutrients and suspended waste particles [1], [2]. Soil porosity acts as an important physical element for the filtration of effluent aiding in direct removal of suspended solids by acting as a support for growth of microbes. They help in removal of bacteria and viruses by filtration and sorption [6, 7]. Soils which are more clayey contain higher capacity of ion exchange than soils with greater grain size. Ion exchange helps in exchange of PO^{-3}, NH^{4+} and K^{+} ions [2, 8]. The nutrients get bound to soil physically by sorption process, some metals such as Aluminum and Iron get precipitated in soil, this phenomenon is better for the removal of heavy metals than sorption [10].

Rhizofiltration is similar to the Root-zone method of water treatment. In the latter, the water is passed horizontally through the roots and stagnated for a period of few days to weeks and the microorganisms in the rhizosphere degrades the suspended wastes and provide nutrients for the plants to grow. However in rhizofiltration, the water is filtered out within few hours and the retained organic matter is broken down by plants for growth.

During wastewater treatment, the plant roots form a rhizosphere, containing nitrogen fixing microbes, oxidation and anoxic zone. The organic matter in wastewater enables plants to grow and extend their roots deep into the soil thus acting as en efficient filter for the wastewater. As the roots grow and penetrate the soil, they create porosity in the soil and increase the wastewater penetration into the soil. The nutrients for the growth of the microbes in rhizosphere are provided by decaying roots and rhizomes themselves [3].

The complex organic content in the wastewater is broken down into simple organic substances and further into carbon dioxide and the nitrifying bacteria oxidize ammonia to nitrate. The oxidizing zone is provided by the water which is present around the roots, the oxygen in the water acts as terminal electron acceptor thus providing microbes to carry out oxidation reactions.

Further away from oxidizing zone is anoxic zone; where the degradation of organic matter takes place by denitrifying bacteria. In reducing areas, the organic matter is decomposed by anaerobic microbes. The interactions of microorganisms within these three zones help in the decomposition of persistent compounds such as chlorinated hydrocarbons [4, 5].

We utilized plants belonging to family *Fabaceae* namely *Arachis hypogea* (Ground nut) and *Pisum sativum* (Pea plant), which are known for harboring nitrogen fixing bacteria and prompt growth.

MATERIALS AND METHODS

Garden soil (red soil with manure), sand and pebbles were utilized in different ratios for getting optimal ratio for effective filtration. To maintain consecutive increase in pore size and to mimic the natural soil profile, the garden soil, sand and pebbles were used in succession. About ten plastic containers (85 centimeter in height) were taken, in which different ratios of garden soil, sand and pebbles were filled.

Five different ratios were made and were distributed amongst five pairs of containers such that same ratio of garden soil, sand and pebbles was maintained for each pair. One drum from each pair was utilized as a control and the other was utilized for filtration of effluents and wastewater. The control drums were also subjected to effluent filtration, without any plants in them.

The *Arachis* and *Pisum* plants were grown for about 3 weeks in these drums until they grew more than 10 centimeters and less than 25 centimeters in height. This height was considered optimal, because the plants in growth phase can easily acclimatize to the soil containing effluent; this stage of growth enabled us to calculate the minimum time required for the utilization of these plants for proficient filtering process.

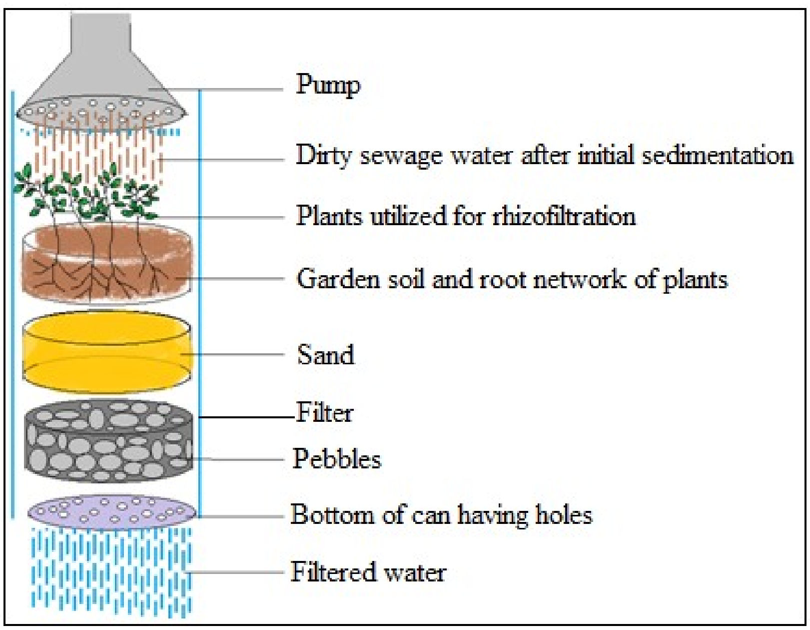

Figure 1: Rhizofiltration apparatus used for water treatment

Five liters of wastewater was poured into each of these filters, and the time was calculated until the approximately 4 liters of wastewater filtrate was retained. This method was utilized to calculate the filtration rate of each of the five filters.

We used the protocol devised by Young et al. for measuring Biological Oxygen Demand (BOD) of effluent and the filtered water. BOD depicts rate of oxygen uptake by microorganisms in a sample of water at 20°C for 5 days in the dark [11]. We used Potassium dichromate reflux method for determining Chemical Oxygen Demand (COD) of the effluent and filtrate.

RESULTS AND DISCUSSION

After conclusively repeating the procedure in triplicates we computed the mean inlet and outlet concentrations of the sample by calculating the Biological Oxygen Demand (B. O. D) and Chemical Oxygen Demand (C. O. D).The waste removal efficiency was observed more in samples containing more percentage of garden soil. Our findings indicate that this could be due to the smaller pore size and also greater root penetration into the soil which enabled better filtration.

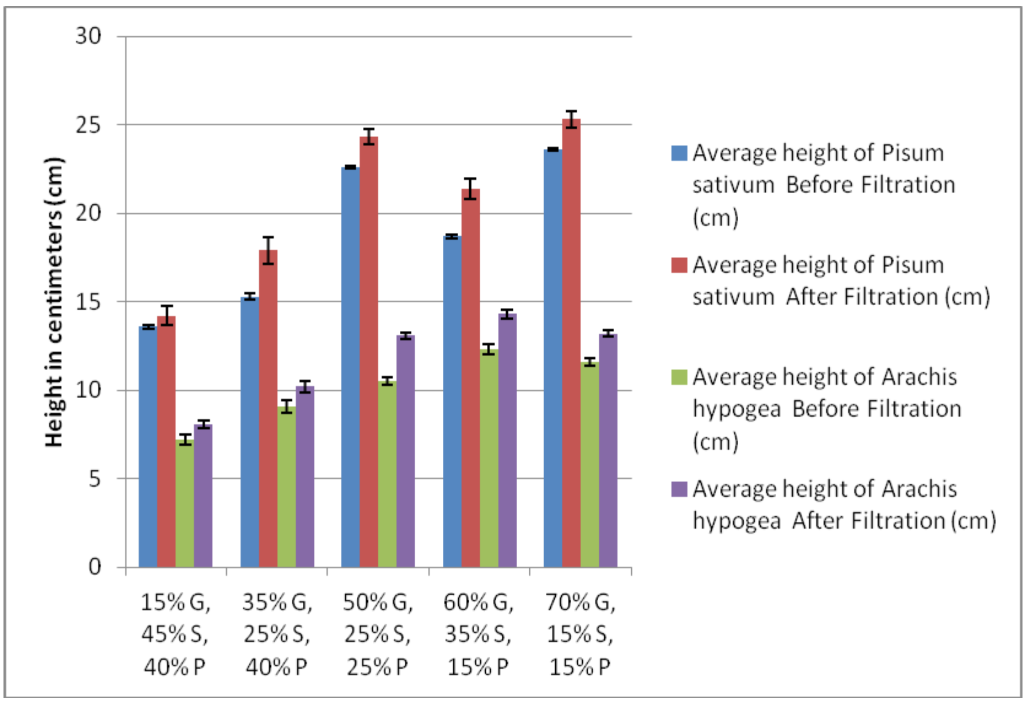

Figure2: Growth of the plants *Arachis hypogea* and *Pisum sativum* utilized as a control (i.e. without subjecting the plants to wastewater) in plain soil. (G= Garden soil, S= Sand and P= Pebbles)

We also determined that the optimum ratio for quicker but efficient filtration of effluent was 50:25:25 (Garden soil: Sand: Pebbles) which was about 4:45 hours (approximately 5 hours).

We also observed that the *Pisum sativum* plants grew about 1.74 cm more and *Arachis hypogea* plants grew about 0.78 cm more when utilized for filtering the effluent, we concluded by these findings that the organic matter in the effluent was being utilized by the plants and hence supported faster growth of the plants.

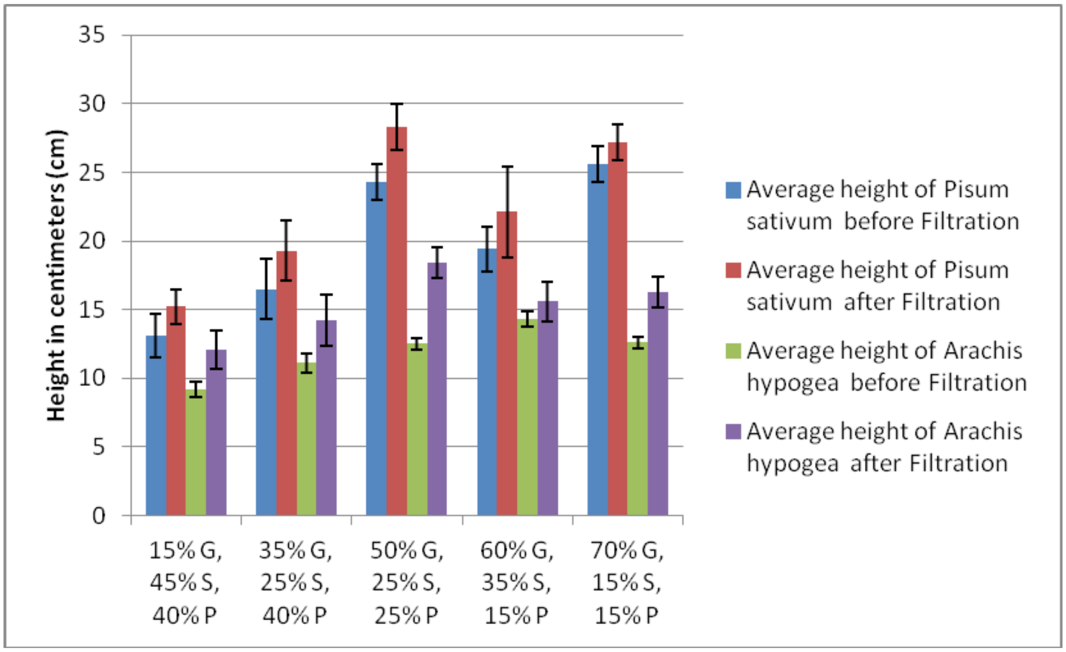

Figure 3: Growth of the plants *Arachis hypogea* and *Pisum sativum* utilized for filtration to observe the effects of the organic matter provided by effluents to the plants. (G= Garden soil, S= Sand and P= Pebbles)

The results shown in this paper conclusively prove that the effluent water can be effectively treated for gardening by utilizing the plants *Pisum sativum* and *Arachis hypogea*, which grow in very less time (about 15-25 days) and hence provide an excellent medium for filtering out effluents.

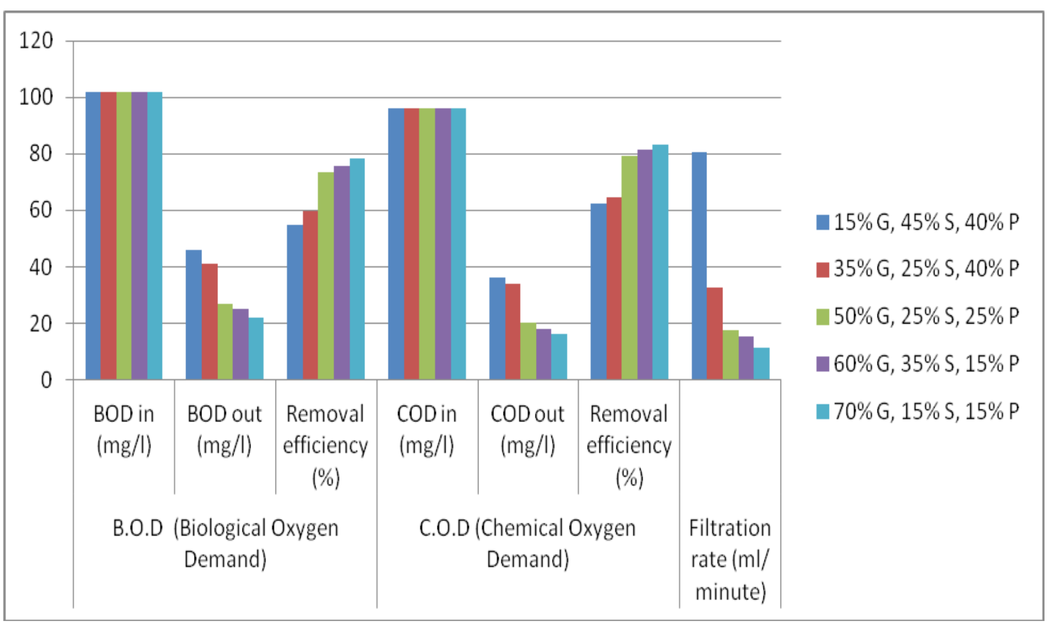

Figure 4: Biological oxygen demand (BOD) and Chemical Oxygen demand (COD) before and after filtration of the effluent. (G= Garden Soil S= Sand P =Pebbles)

Significant removal efficiencies of wastes by the roots and soil were observed though, the degradation of wastes by microbes is very less as the water stays in the filter for few hours. It also indicated that the effluent actually contributed organic matter which aided in the growth of the plants. This method hence, provides fertility to the soil and also helps in filtration of water.

CONCLUSION AND RECOMMENDATION:

In conclusion, rhizofiltration is an effective, economic and less time consuming process for the treatment of effluents. It is also environmental friendly as the plants themselves help in maintaining the oxygen cycle and can be present in close proximity with the garden where the water which they filter out can be utilized for irrigation.

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