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Treatment of Urban Runoff Using Agglomerated Floating Weeds - A Review

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Abstract - Pollutants from an urban area are transported to receiving streams during a rainfall event, causing quality impairment of the waters. They play a critical role in degrading receiving water bodies and ecosystems. The pollutants can pose risks to humans, animals, and plants. In high concentrations, they cause technical and aesthetic problems. The most frequently reported metals in stormwater are cadmium (Cd), lead (Pb) and zinc (Zn), and concentrations of these ions in stormwater commonly exceed surface water quality guidelines by 10 times or more [3].
Keywords – Lakewater; urban runoff; Floating weeds; Depolluting

I. Introduction

The use of aquatic macrophytes, such as water hyacinth, duckweed, water lettuce etc., in wastewater treatment has attracted global attention in recent years. Aquatic ecosystems are used directly or indirectly as recipients of potentially toxic liquids and solids from domestic, agricultural and industrial wastes. Pollutants may accumulate in surface waters, groundwater, substrates and plants and can be divided into four classes: nutrients (P, N), organic contaminants (e.g. polycyclic aromatic hydrocarbons, polychlorinated biphenyls and pesticides), xenobiotics derived from the pharmaceutical industry (personal care products, hormones, etc.) and metals and metalloids (e.g. Cu, Zn, Fe, Cd, Ni, Pb, Hg, Cr, Sr, Al, Ba, Se, and As) [2].

The pollutants found in the urban runoff are - Eroded Soil (inert particulate), Lawn Chemicals (Fertilizers and Pesticides), Housing Products (paints, thinners, solvents, cleaning agents etc.), oil and grease, Dust (atmospheric deposition and Automobiles), and Septic system discharges. These pollutants are diffuse or nonpoint source in nature In high concentrations, they cause technical and aesthetic problems. Within receiving waters, the exposure of aquatic macro‐organisms to metals depends not only on the concentrations of contaminants in the water but also on their bioaccumulation throughout the food chain [5].

Reed canarygrass biomass grown on contaminated land shows limited contaminant uptake when compared to MC or SRC, especially for the uptake of Zn and Cd. Although the biomass is rich in K and low in Ca, additional Si and ash content offset this, improving fuel quality for combustion. The biomass is suitable for use for commercial and industrial scale combustion, with the added advantage of alternative energy uses, such as conversion via anaerobic digestion to biogas or to bioethanol for transport fuels.

Keeping all these above facts in view present study is focused towards floating plant clusters to treat the urban runoff in a lab scale. The specific objectives are

- To study the Removal Efficiency of pollutants using Marshsmart Weed in a single channel
- To study the Removal Efficiency of pollutants using Reed plant in a single channel
- To investigate the Removal Efficiency of pollutants using Marshsmart Weed and Reed plant in Dual channel
- To investigate the effect of Flow rate in Single and Dual channel Configuration
- To investigate the effect of Flow rate by Intermittent flow and Continuous flow

II. Methodology

The rectangular duals channels were employed and charged with the lake water then peristaltic pump is used to regulate the required flow rate. The plants were kept floating by the help of polyurethane foam. The plant is placed in the openings provided in foam such a way that root system is in contact with water and shoots system is in contact with atmosphere. The outflow water were collected and analyzed for the considered parameters–lead, zinc, cadmium, nitrate, phosphorous, to determine the efficiency of the aquatic plants. The outflow water was collected and analyzed for the considered parameters (lead, Zinc, Cadmium, Nitrate and Phosphorus) to determine the efficiency of the agglomerated floating weeds.

In order to maintain the uniformity (to certain extent) with respect to the phragmites australis and persicaria plants having same weight were used in each channel. The weight of each aquatic plant chosen was 0.25+/-0.05kg. Each plant was weighed after washing with clear water and draining out water completely. Initially, the channel was fed with tap water and the weeds were placed in there for two days.

The initial characterization of the lake water is made and the parameters analyzed are pH, Turbidity, Total dissolved solids, total Nitrates, Total Phosphates and Total suspended solids.

The effects of total ammonia concentration, pH and type of growth medium on duckweed growth were studied under various experimental conditions (Table 1). These experiments were conducted in 250 ml plastic containers with a water depth of 5 cm that were operated as renewal fed batch reactors. At the beginning of each experiment ten healthy duckweed fronds from a stock culture were put in each of the containers. An experiment lasted for 14 days, during which the fronds were counted every 3 days. The total dry weight of the duckweed biomass was determined at the start and at the end of the experiments. The medium was replaced every 4 days to compensate for nutrient losses and to reduce algae growth. In addition, the ammonium nitrogen levels were restored to the initial concentration every other day by adding NH4Cl. The pH was measured every day and subsequently adjusted to the initial conditions with NaOH or HCL solutions. The average pH during a particular day was assumed to be the average of the pH measured just before the pH adjustment, and the pH that was set. The average pH for the total incubation period was calculated by taking the average of the daily average pH values, for the three duplicates. Average pH calculations were based on average

H^+-concentrations. The pH range was defined as the range between the maximum and minimum daily average value. Containers were placed randomly under fluorescent lamps at a light intensity of 85±100 mE/(m2s) (16-h light, 8-h dark). The average water temperature was 258C. Evaporation losses were compensated for every day with tap water. Each treatment had three replicates.

Table 1: Experimental variables for the growth experiments with Spirodela polyrrhiza

Growth medium	Initial pH	Initial total ammonia concentration
10% Huttner medium	5,7,8,9	30, 20,50,100
UASB effluent	5,7,8,9	20,50,100
Raw domestic wastewater	5,7,8,9	20,50,100

In contrast to emergent rooting plants, floating plants do not actively promote metal adsorption to the substrate, but store them into their biomass. Eichhornia crassipes doubles its biomass in six days under favorable conditions which, in conjunction with its strong absorption capacity, makes it a suitable species in combination with surface flow systems. Moreover, E.

crassipes takes up high amounts of P and N in the roots. These support micro organisms that degrade organic matter and release oxygen into the water and allows an important P removal rate in a short time after harvesting. Duckweed has the capability to purify wastewater in collaboration with both aerobic and anaerobic bacteria. The duckweed mat, which fully covers the water surface, results in three zones. These are the aerobic zone, the anoxic zone and the aerobic zone. In the aerobic zone, organic materials are oxidised by aerobic bacteria using atmospheric oxygen transferred by duckweed roots. Nitrification and denitrification takes place in anoxic zones, where organic nitrogen is decomposed by anoxic bacteria into ammonium and ortho-phosphate, which are intermediate products used as nutrients by the duckweed.

The system consists of two tanks in which Lemna minor L. has been grown. Tanks are formed in dimension with 40x20x15 cm. The surface area of each tank is 800 cm2. The water depth of the reactors is 8 cm. The effective volume of the tank is 6.4 litres. Tanks are put into pond with a dimension of 80x50x16 cm to regulate environment temperature. Water temperature in the pond was around 21±0.5oC which was measured using special thermometer (JAGER). Light has been supplied by a special lamp during day times. During night, the lamp was switched off by a timer. The wastewater was supplied from the effluent water of Bursa west side municipal wastewater treatment system and Bursa organized industrial estate wastewater treatment system.(nihan)

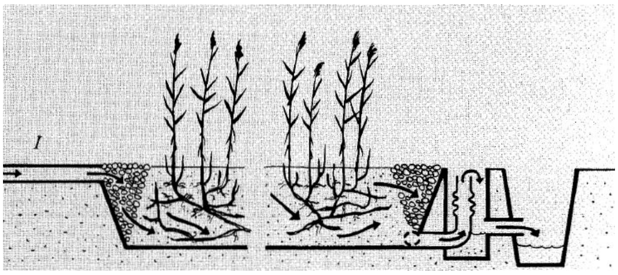

Figure 1: Constructed wetland with sub surface horizontal water flow. Consists typically of a bed planted with Phragmites australis and underlain by an impermeable membrane to prevent seepage. The medium in the bed may be soil or gravel.

III. Conclusion

The effect of parameters such as total ammonia concentration and pH on duckweed growth should preferably be assessed by measuring the RGR based on dry biomass production, rather than the RGR based on frond number counting. The maximum RGR was observed at low concentrations of ammonium (3.5±20 mg/l N). In the pH range where no direct effects of pH are expected (5±8), it was found that both increasing total ammonia concentration and increasing pH values caused increasing growth inhibition. The inhibition of duckweed growth by total ammonia nitrogen is probably the result of a \ combined effect of two inhibition mechanisms, due to ammonium and ammonia, respectively. The relative importance of each mechanism is determined by the pH.(J. R. CAICEDO)

The average removal efficiency of colloidal particles from the synthetic runoff by the coated sand was 88.7%. The performance of the column to remove turbidity was improved over time. The removal efficiency of lead and zinc were 64% and 81%, respectively. Previous studies reported an average removal efficiency of 54% and 29% for lead and zinc, respectively. It is evidence that sand coated with manganese oxide has improved the adsorption of heavy metals. Metal oxides increases the numbers of adsorption sites and with the presence of water, oxide surfaces such as Mn and Fe are covered with surface hydroxyl groups, protons, and coordinated water molecules. Results of this study indicated that MOCS has a significant efficiency in improving urban runoff quality. Furthermore, magnetic field increased removal efficiencies of pollutant from runoff [2]

The root zone provided in the UROPAS was sufficient enough to remove >80% of both nitrate and phosphorous even at maximum flow rate considered in the present study. In continuous flow phytoremediation the efficiency of the system is affected by flow rate i.e. as the flow rate increases efficiency decreases. The heavy metal uptake was effective in the present simple urban runoff pollution abatement system. The average removal of heavy metals (zinc, cadmium and lead) is found to be >85%, which is a significant value in phytoremediation. The designed reactor channel performance is found to be promising for depolluting urban runoff. Therefore, providing FPC to storm water channels/detention ponds can be recommended to reduce the pollution load on receiving water body. Further study is recommended to understand the effect of shock load on the performance of the FPCUROPAS [5].

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