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Algal Bioreactors for Gray Water Remediation

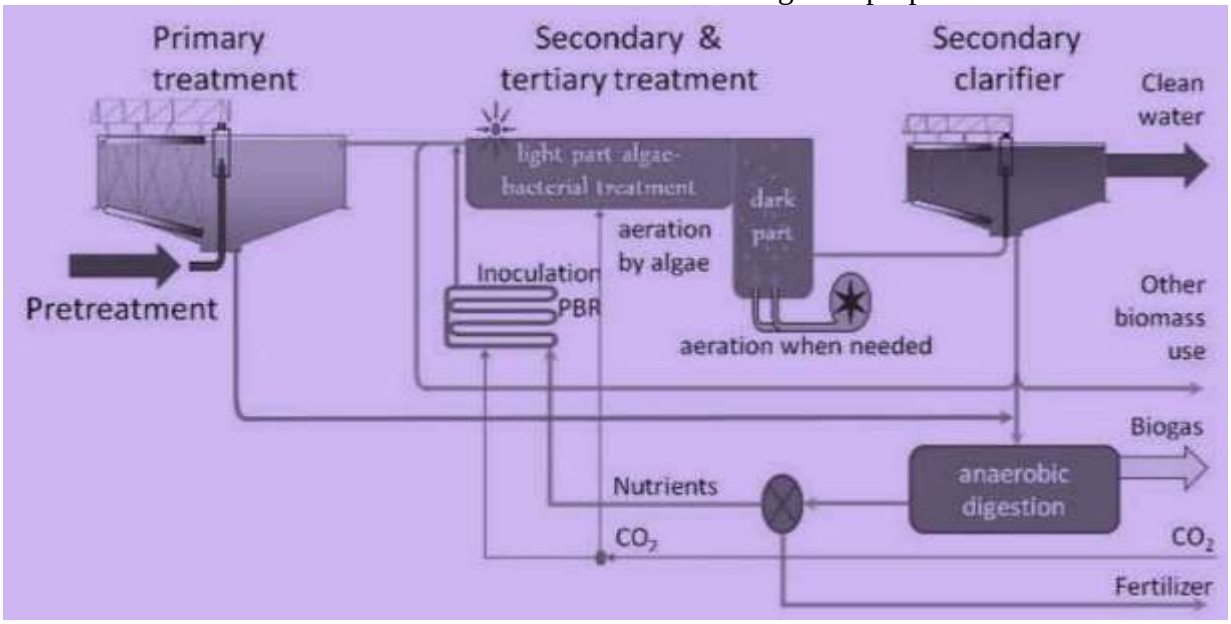
A.Senthilkumar[1] , B. Bhakiyathu Saliha[2], R. Balamurugan[3], Geethu Jacob[1] and J. Vinoth Raj[1]
[1]Department of Soils Science, The Indian Agriculture College, Radhapuram
[2]Professor (SS&AC), Krishi Vigyan Kendra, Madurai
[3]Department of Agronomy, The Indian Agriculture College, Radhapuram

SUMMARY

The main reasons for declining water availability are rapid population growth, depleting water storage facilities and contamination of the existing water resources due to the discharge of untreated industrial and sewerage effluents into streams and rivers. The use of freshwater for irrigation is causing the unavailability of freshwater for drinking in many areas of the world. Due to improper or expensive wastewater treatment systems and the unavailability of fresh water, agricultural lands are irrigated using untreated wastewater. This practice results in many health problems for the farmers and the end users of the produce.

INTRODUCTION

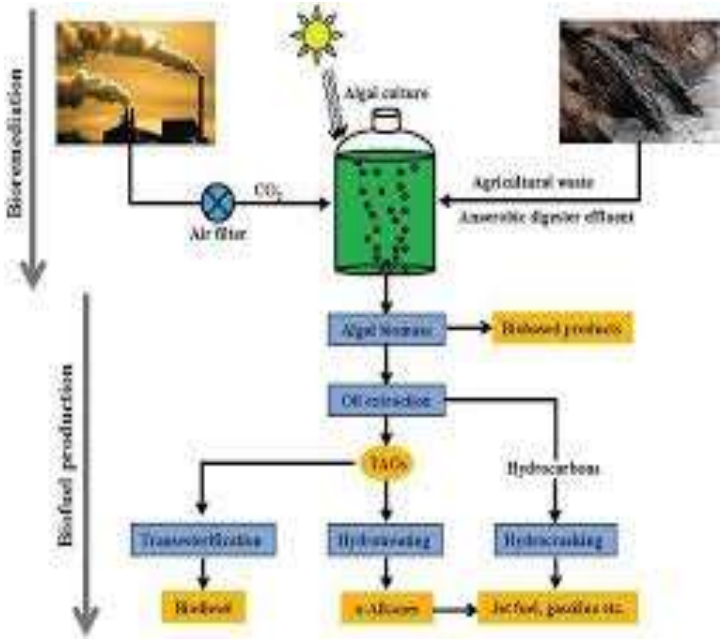
The role of algae in treating sewage water in oxidation ponds is an economical and efficient way of treating wastewater. Algae grow well in waste water and use their nutrients for photosynthesis thus reducing the nutrient load on it. Instead of fresh water, this treated water can then safely be used for the irrigation of crops and lawns. It will not only reduce the pollution load on Rivers into which Industrial effluents are released by reusing this water after treatment but also reduce the use of freshwater for irrigation purposes.



The health and environmental aspects are particularly sensitive before replacing fresh water with wastewater. Wastewater cannot be safely used unless it is efficiently treated and all the harmful pathogens and excessive nutrients are fully removed from it. Organic matter, nitrogen and phosphorous, suspended (SS) or dissolved solids (DS) and microbes are the main components of municipal wastewater (Bohan *et al.*, 2016). There are many conventional aerobic and anaerobic treatment facilities available worldwide. Aerobic treatments mostly occurred in the upper layer of the system whereas anaerobic in the lower one.

Algae for wastewater

Wastewaters are excellent algal growth media, with CO_2 addition combining algae for wastewater remediation with biofuel production is an economically feasible process. The waste water treatment plants are an invaluable source of algal biomass which serves as a bright prospect for many industries and companies that use algae as a feedstock for a variety of purposes. Oxidation ponds grown with algae are suitable for tropical countries where the temperature is warmer and sunlight is optimum. Oxidation ponds treat wastewater naturally without adding any substance i.e., chemicals. These ponds have large and shallow basins involving both algae and bacteria as a natural source of treatment in suspension.



Main goal for algae

The main goal of these ponds is to increase the production of oxygen and algae so that aerobic conditions prevail throughout the depths of the pond. Algae plays a remarkable role in the treatment of municipal wastewater at small and medium scale (Henze *et al.*, 2020). The algal biomass produced from the treatment can be harvested and then could be converted through various methods to bio-fuels, for example, anaerobic digestion to biogas, trans-esterification of lipids to biodiesel, fermentation of carbohydrate to bioethanol and high-temperature conversion to bio-crude oil (Cheremisinoff, 2020).

- The objective of this feasibility study was to investigate the ability of aquatic fern, *Azolla microphylla* to treat the wastewater from a piggery farm.
- The wastewater was about 103,250 L/day. The results showed that changes in water quality by using *A. microphylla* in the wastewater treatment were significantly different ($P<0.05$) from control and *A. microphylla* can reduce BOD, TN, NO_{3-} and PO_{4-}^{3} within three weeks in wastewater from 6% to 98%. It was also found that nitrogen and phosphorus increased in *A. microphylla* and it would be useful as a biofertilizer.
- This study suggested that using *A. microphylla* for piggery wastewater may be suitable for the developing country's wastewater treatment.

Mechanism

It does not require any external source of oxygen rather it produces its oxygen by utilizing CO_2 produced by bacteria, thus reducing the carbon load on the environment. During the treatment process, carbon dioxide uptake by algae was measured, and concluded that the process is a net carbon dioxide fixer. (Rose *et al.*, 2021).

Thus it is helpful in greenhouse gas reduction in the atmosphere. It also removes heavy metals and pathogens from the wastewater. A pH of 9.2 for 24 hours provides a 100% kill of E. coli and most pathogenic bacteria and viruses (Rose *et al.*, 2021). Different studies have shown that different types of algae have different tendencies for the removal of nutrients from wastewater. Three microalgae, *Chlorella vulgaris* (Lau *et al.*, 2022) *Scenedesmus rubescens* and *Stigeoclonium stagnatile* helped to remove about >90% phosphorous from the sewage in oxidation ponds in the time of about 6-12 hours (. Amahmid *et al.*, 2022). Gracilaria birdie, macroalgae, reduced the amount of the nutrients e.g., PO_4^{3-} by 93.5%, NH_4^{+} by 34% and NO_3^{-} by 100% from aquaculture wastewater over about 4 weeks.

Comparative Benefits

Wastewater can be considered as a resource that can be used in a more beneficial way rather than being wasted. Reusing wastewater for agricultural and landscape irrigation is an opportunity that can potentially reduce the use of canal water for irrigation and help save the remaining freshwater resources (Tillett, 2023). Algae-based wastewater treatment system in oxidation ponds is a cost-effective way of treatment. It has a low

energy cost and lower operation costs and in the end, algae biomass can be used for the production of biofuels (Ogbonna *et al.*, 2020).

High operation costs make wastewater treatment conventionally unviable in many countries. The cost, use of renewable and nonrenewable energy sources, environmental load and energy yield of conventional wastewater treatment systems and algae-based treatment systems were compared and it was concluded that algal-based treatment systems can significantly reduce the ecological footprint (Groenlund *et al.*, 2022). Reusing wastewater for agricultural and landscape irrigation is an opportunity that can potentially reduce the use of canal water for irrigation and help to save the remaining freshwater resources (Haglund and Lindstrom, 2020).

Industries where algae can be used to treat wastewater

• Bio-fertilizer production units • Chemicals • Dairy • Distillery & Breweries • Dyes and pigments, • Foods • Leather • Meat processing plants	• Municipal Waste Waters • Metalworking • Mining • Oil Refineries • Petrochemicals • Pharmaceuticals • Poultry • Pulp and Paper • Textiles

Algae for Wastewater Treatment

Pros	Cons
• Produce oxygen with low-energy input • Remove soluble N and P • CO2 fixed, Biomass produced	• Rarely settle well • Failure to meet suspended solids limits (45 r • Interfere with disinfection • Biomass produced

Add CO_2 to Balance C: N: P

Algae: C : N : P = 50 : 8 : 1

Wastewater: C : N : P = 20 : 8 : 1

Salient features

❖ Improved and accelerated treatment
❖ Biomass fuel provides greenhouse gas abatement
❖ WWT savings: Rs100 per L oil produced
❖ Marginal oil cost is only extraction/processing
• Energy used in WW treatment decreases: 4 kWh saved per L oil produced
• Fuel production residue becomes fertilizer
❖ Suggested method and level of application
- 1 ml/ 10 KL Water medium/day

Treated Water can be used in the following Sites:

- Agricultural irrigation: crop irrigation, commercial nurseries
- Aquaculture
- Industrial: Cooling, boiler feed, process water
- Environment: Groundwater recharge
- Landscape irrigation: parks, gardens, green belts, golf courses, football fields and highway
- landscaping, school yards, cemeteries
- Non-potable urban uses: fire protection, air conditioning, toilet flushing.
- Recreational uses: Lakes and ponds, snowmaking

Advantages

Advantages of wastewater reuse for agriculture include the following:

- Reduced prevalence of diseases which are caused by the use of untreated wastewater for irrigation where water is unavailable for the cultivation of crops.
- It will help to conserve freshwater resources and their wise use, particularly in areas under water stress.

- It will avoid surface water pollution caused by the release of untreated wastewater in rivers and lakes.
- Contribution to better nutrition and food security for many households.

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