ROLE OF AlGAE IN WASTE WATER MANAGEMENT

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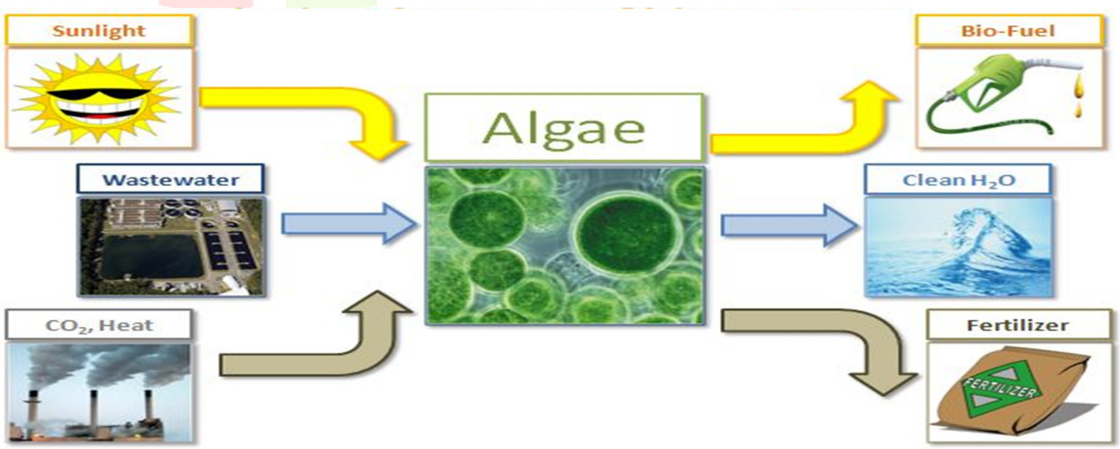
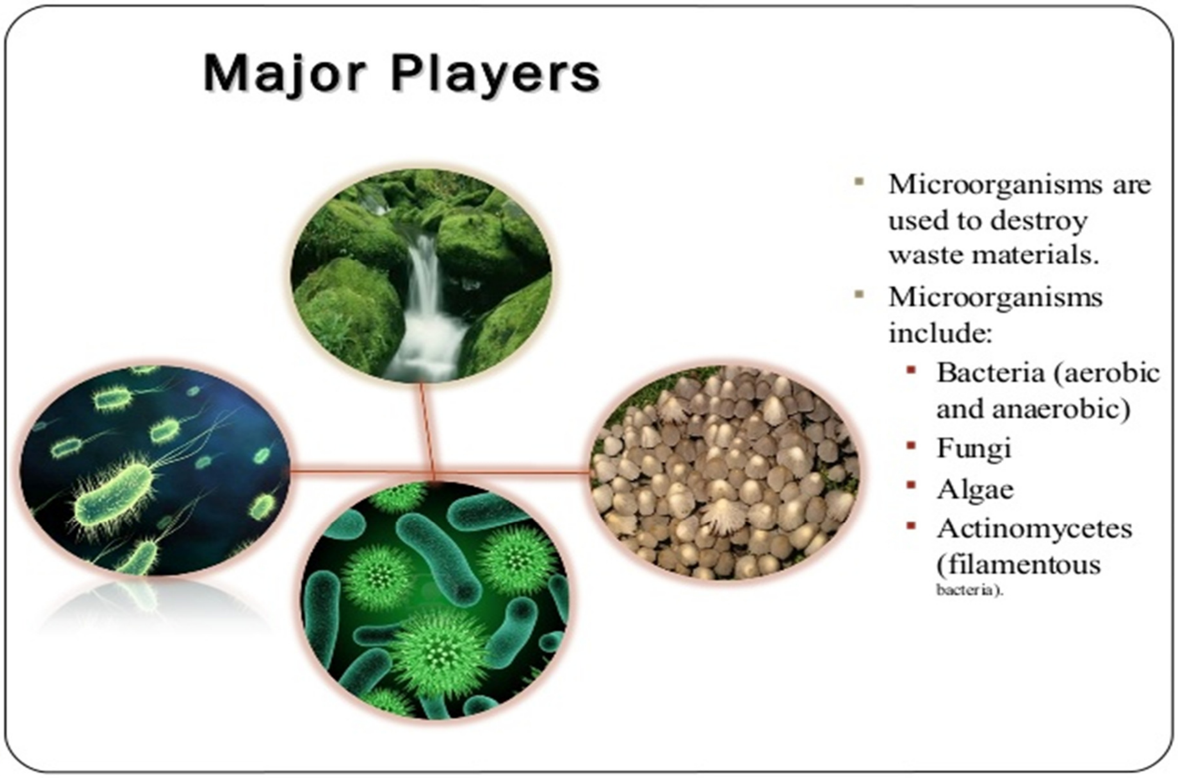
Abstract -Organic and inorganic substances which were released into the environment as a result of domestic, agricultural and industrial water activities lead to pollution. The normal primary and secondary treatment processes of these wastewaters have been introduced in a growing number of places, in order to eliminate the easily settled materials and to degrade the organic material present in wastewater. Clean effluent which is discharged into natural water bodies. This secondary effluent is, however, loaded with inorganic nitrogen and phosphorus and causes eutrophication and long-term problems because of refractory organics and heavy metals that are being discharged. Microalgae culture offers an interesting step for wastewater treatments, because they provide a tertiary biotreatment coupled with the production of potentially valuable biomass, which can be used for biofuel production. Treatment of wastewater with Microalgae based system have the ability to remove nutrients (Nitrogen, Phosphorus and other nutrients), heavy metals, toxic substances (both organic and inorganic), BOD, COD and other impurities present in the wastewater by using the sunlight, CO2, and impurities like nutrients present in the wastewater.

Index Term – environment, materials, normal primary, wastewaters, Treatment

Introduction:

During the last 50 years Biological wastewater treatment systems with microalgae have gained importance and now it is widely accepted that microalgal based wastewater treatment systems are as effective as conventional wastewater treatment systems. Bio-treatment with microalgae is particularly attractive because of their photosynthetic capabilities, converting solar energy into useful biomasses and incorporating nutrients such as nitrogen and phosphorus causing eutrophication. Microalgae have the ability to remove nutrients, heavy metals, organic and inorganic toxic substances and other impurities present in the wastewater by using the sunlight, CO2, and various nutrients.After primary and secondary treatment of wastewater, effluent is discharged to the nearby water bodies. However, the effluent still contains considerable nitrogen, phosphorus and pathogens. Especially, in anaerobic wastewater treatment, nitrogen, and phosphorus are not removed much, and raised concern in several places in India. These nutrients leads to eutrophication in lakes and causes harmful microalgal blooms and have considered P and N to be the key elements behind the eutrophication. In this regard polishing of anaerobically treated wastewater using algae can absorb nitrogen and phosphorus from wastewater, increases the dissolved oxygen content and helps to reduce pathogens present in the treated wastewater.





Objective-In developing country like India, due to the increasing population and rapid industrialization, the amount of wastewater generated every day is very huge. Due to this, water pollution is one of the most critical environmental problems. So, in terms of health, environment and economy, the fight against pollution has become a major issue. For wastewater treatment various conventional methods are used in India but they are very costly and not economical. Cultivation of Microalgae in wastewater for wastewater treatment is practiced to control pollution and produce energy from microbial biomass. Microalgae have become significant organisms for biological treatment of wastewater. Microalgae based treatment system is one of good solutions to solving the environmental problems such as global warming, the increase of ozone hole and climate changed due to its ability to consume high quantity of carbon dioxide in Photosynthesis process to produce oxygen and glucose.

The main advantage of using algal system is that it absorbs solar radiation in the form of energy in its chloroplast cell and takes CO2 along with nutrients from wastewater to synthesis their biomass and produce oxygen. The released oxygen from microalgae is enough to meet the most aerobic bacterial requirements while metabolizing the residual organics in the treated wastewater. Algae also release a large amount of simpler organic compounds that can be assimilated in aqueous system.

WHY ALGAE???

- because algae consume nitrates and phosphates and reduce bacteria and toxins in the water. The end result: clean wastewater and stock for a promising biofuel.

- The purified wastewater can be channeled back into receiving bodies of water at treatment plants, while the biodiesel can fuel buses, construction vehicles and farm equipment. Algae could replace diesel's telltale black puffs of exhaust with cleaner emissions low in the sulfur and particulates that accompany fossil fuels.

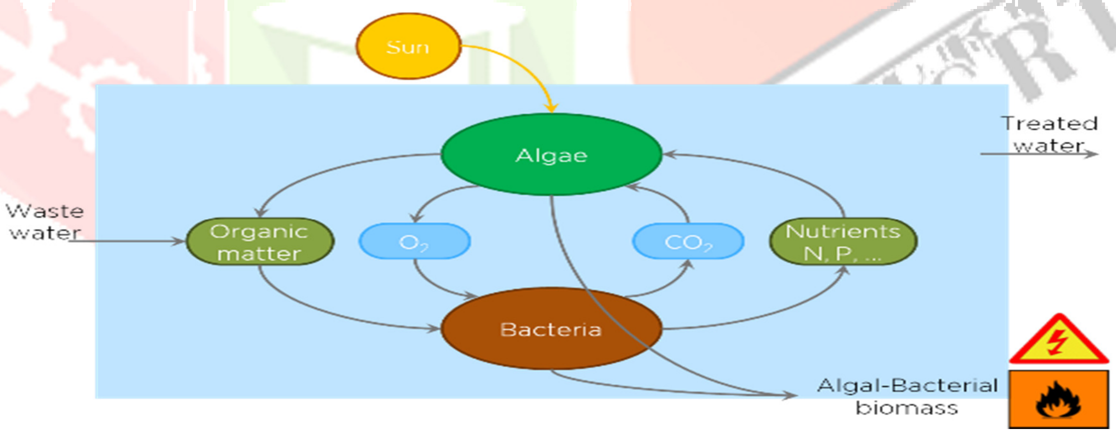
- Algae have a lot of advantages. They are cheaper and faster to grow than corn, which requires nutrient-rich soil, fertilizer and insecticide. Factor in the fuel used to harvest and transport corn and ethanol starts to look complicated.

- In contrast, algae are much simpler organisms. They use photosynthesis to convert sunlight into energy. They need only water—ponds or tanks to grow in—sunlight and carbon dioxide.
- “Algae—as a renewable feedstock—grow a lot quicker than crops of corn or soybeans
- We can start a new batch of algae about every seven days.
- Algae will take out all the ammonia—99 percent—88 percent of the nitrate and 99 percent of the phosphate from the wastewater — all those nutrients you worry about dumping into the receiving water. In three to five days, pathogens are gone.

Analysis-The main difference between macroalgae and microalgae is the size and cell binding formation. Normally, macroalgae called as “seaweed” and found in sea water it is a multicellular compound,whereas Microalgae are normally unicellular called as phytoplankton. We cannot see by naked eye due to microscopic in size. The most important common feature of all eukaryotic microalgae and cyanobacteria is that they have oxygen evolving photosynthesis and that they use inorganic nutrients and carbon as their source of nutrients. Research shows that wastewater that has been exposed with microalgae shows a rapid decrease in level of metals, nitrates and phosphate. This shows the possibility of microalgae to be commercialized for tertiary wastewater treatment solution. Normally, wastewater comes from activated sludge effluent or anaerobic wastewater treatment, can be effectively treated by means of microalgae. Before starting any kind of treatment by algae, primary treatment must be required. Wastewater that contains of carbon, nitrogen, phosphorous and other metals can be effectively used by microalgae. The microalgae system can treat various types of wastewater like, domestic sewage, industrial waste water etc and reduce the nutrients (Nitrogen, phosphate and other minerals) from the waste water. Removal of Nutrient is an important part of wastewater treatment because rich nutrient effluent discharged into water bodies can result in eutrophication in water bodies.

The Figure: I. shows the Basic operation principles for the microalgal production combination with wastewater treatment.

Figure:



1. FACTORS AFFECTING FOR THE GROWTH OF MICROALGAE

a) Sunlight

Microalgae are unicellular, photosynthetic microorganisms and they use sunlight in photosynthesis process. Photosynthesis is the process of converting light energy into organic molecules, which are mainly composed of carbohydrates, CH2O. Sunlight is important to the growth of microalgae and without sunlight microalgae growth has been reduces.

b) Carbon Dioxide (CO_2)

The increased atmospheric CO_2 level is now world-wide accepted to be a major contributor to global warming; its various potential effects are only beginning to be understood. Microalgae use Carbon dioxide and sunlight in photosynthesisactivity and release the Oxygen in the environment.

The photosynthesis reaction gives food to the algae. The reaction between sunlight and CO_2 shown below:

$$6\ H_2O + 6\ CO_2 \rightarrow C_6H_{12}O_6 + 6\ O_2$$

Microalgae can fix CO_2 from three different sources, viz. atmospheric CO_2, discharge gases and soluble carbonates.

c) Nutrients (Nitrogen, Phosphorus and other minerals)

The use of municipal and industrial wastewater effluent as a nutrient feedstock for the production of algal has environmental and economic benefits. Wastewater nutrients are fed microalgae by different nutrients like nitrogen, phosphor, ammonia, sulphur, iron, toxins and all the metals in wastewater to production of microalgae biomass. Phosphorus and Nitrogen are the most essential nutrients for the microalgae growth.

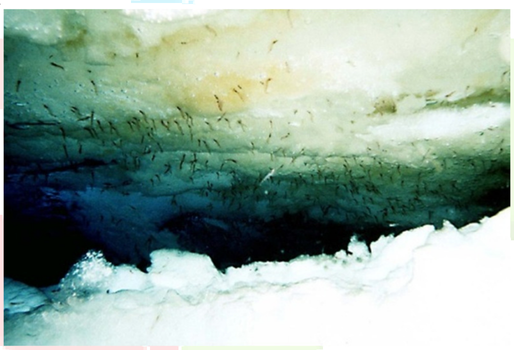
Table: I. shows the major nutrient removal efficiencies by microalgae cultivation.

Algae species	Wastewater characteristics	N (%)	P (%)	Carbon	Retention time
Algal–bacterial symbiosis (Chlorella + Nitzchia)	Settled domestic sewage	92	74	97% BOD, 87%COD	10 h
Chlorella pyrenoidosa	Settled domestic sewage	93.9	80	NA	13 days
Cyanobacteria	Secondarily treated domestic effluent + settled swine wastewater	95	62	NA	1 day
Chlorella vulgaris	Diluted pig slurry (suspended solids content to 0.2%)	54-98	42-89	BOD_5 98%	4.5 days
Chlorella pyrenoidosa	Domestic sewage and industrial wastewaters from a pig farm and a palm oil mill	60-70	50-60	80-88 % of BOD, 70-82 % COD	15 days
Mixed culture of Chlorella and diatom species	Wood-based pulp and paper industry wastewater			58%	42 days`

d) pH -Microalgal growth rate and treatment of waste water may also be affected by pH of the waste water.In microalgae cultivation, pH value usually increases because of the photosynthetic CO2 assimilation. pH value will affect the availability of inorganic carbon. Absorption of nitrogen by microalgae also increases the pH value of the medium, the highest growth rate of microalgae when the medium at a constant pH value of 7.0. The pH range for most cultured algal species is between 7 and 9, with the optimum range being 8.2-8.7. Complete culture collapse due to the disruption of many cellular processes can result from a failure to maintain an acceptable pH. The latter is accomplished by aerating or mixing the culture. In the case of high-density algal culture, the addition of carbon dioxide allows to correct for increased pH, which may reach limiting values of up to pH 9 during algal growth.

e) Light -Microalgae are phototrophes, which mean that they obtain energy from light. However, some algae are able to grow in the dark using simple organic compounds as energy and carbon source.The easiest way to prevent algal cultures from light limitation is to decrease the depth of the culture vessel. The productivity in light limited ponds is inversely correlated to the depth .Generally, depths of between 15 and 50 cm are recommended. However, during winter shallower depths are recommended due to the lower light conditions, and depths greater than 20 cm markedly decreases production .Light conditions affect directly the growth and photosynthesis of microalgae. However, it is foremost important to reach light for algae in mass culture production like raceway pond and algal pond. However, even though light is most often limiting the growth of microalgae, intense light may also cause lowered photosynthetic efficiency, which is known as photo inhibition.

f) Temperature -Temperature is also one of the crucial parameter for the growth of algae in countries where fluctuation of the temperature is high. Increased temperature is good for the growth of algae up to certain range, after that critical temperature growth is ceased (Monique and Jean,2013).The temperature at which culture are maintained should ideally be close as possible to the temperature at which the organism were collected. Most commonly cultured species of microalgae tolerate temperature between 16 and 27 degree Celsius. Overheating of the algae can reduce growth rate especially in the humid country where evaporation is inhibited.




Algae in cold environment algae in hot environment

2. CULTIVATION METHODS

There are three main groups of system for cultivation of microalgae. They are open system, closed system and immobilized system. Open is simpler to conduct and cheaper. However, open system is expose to the environmental factors such as temperature and light intensity. Closed system cultivation is more complex to conduct but it allows condition control for cultivation. The third is immobilized system where algae are trapped in a solid medium.

1. Open pond culture

Open system cultivation is the more preferable due to its low cost and can be done in large scale cultivation and it is easier to manage. Moreover it is more durable than large closed reactors. Open system cultivation can be carried out in natural or artificial lake and ponds. Although the open system is cost effective, it has some disadvantages. Among the disadvantages are it requires large land areas for a considerable biomass yield. Moreover, because this cultivation technology is carried out in the open air, the water level can be effected by from evaporation and rainfall. Besides that, biomass productivity is limited by contamination with unwanted algal species and organism that feed on algae. Studied by Lee showed that some algal species like Dunalilla sp., Spirulina sp. Chlorella sp.are resistance to the culture in open pond system.

2. Closed photobioreactors

Closed photobioreactors can be grouped into two major classes: covered raceways and tubular reactors (Richmond and A., 1990). Closed photobioreactors usually have better light penetrating characteristics than open ponds; the light path is usually less than 30 mm, which make it possible to sustain high biomass and productivity with less retention time than is possible in ponds. Basically, these reactors are a closed system consisting of a clear tube within which the algae grow. The algae are circulated by means of a pump and the system also has a gas exchange unit where CO2 can be added and photosynthetically produced O2 is stripped from the medium. If necessary, a heat exchanger is also added to either cool (in tropical areas) or heat (in temperate areas) the culture.

3. Immobilized cultivation system

Immobilized system can be defined as the cell of the algae is trapped in a solid medium and is prevented from moving independently. This system can solve the harvesting problem. To immobilize the algae, algae cells are trapped in substances in wastewater diffuse through the cell. Immobilized system has been tested for several wastewater treatments and it is proved that entrapped algae are able to efficiently remove nitrogen and phosphorus from secondary effluent and be considered a tertiary wastewater treatment. It will be interesting to confirm the feasibility of using immobilized microalgae and cyanobacteria for removing nitrate, ammonium, and phosphate from high volume effluent discharges. It has been reported that Phormidium laminosum immobilized on polymer foam has the potential to remove nitrate in a continuous-flow system with uptake efficiencies above 90%.

3.HARVESTING TECHNIQUES

Harvesting of microalgae is crucial for wastewater treatment in order to separate both nutrients and BOD from the water. There are some methods that are used for the harvesting of microalgae as sedimentation, floatation, filtration, centrifugation, biological filtration etc.

1. Filtration

Filtration is the most simple and cost effective harvesting method. Filtration can be carried out either in small or large scale. Filtration can be done by using filter paper in laboratory scale or using coarse screening in a large scale harvesting of microalgae. For the filtration harvesting method, rotary vacuum and the chamber filter appears to be commonly employed type of filter in fairly large size of microalgae. The advantages of these filters are they can be used in continuous operation and useful when sterility and contaminant is not reviewed. However, filtration is only suitable for harvesting fairly large microalgae (e.g. spirulina platensis) and not succeeds to separate bacteria size microalgae like scenedesmus, dunaliella or chlorella species.

2.Sedimentation and floatation

Using sedimentation or flotation, the biomass can be concentrated already in the water, which in turn can be decanted. Sedimentation without addition of chemicals is the most common method in full-scale facilities .Flotation processes operate more efficiently and rapidly than sedimentation and achieve a higher solids fraction (up to 7 %) in the concentrate, but these on the other hand can be more expensive. Many algal species are particularly difficult to sediment without treatment due to their natural tendency to float in order to catch enough light. Flotation of unicellular algae without flocculation may also be very difficult due to the hydrophilic cell surface on which air bubbles will not attach. Algae can be flocculated by addition of various chemical flocculants such as alum, lime, FeCl3, cationic polyelectrolytes, and Ca (OH)2 . A major disadvantage of adding these chemicals, however, is that they can cause secondary pollution. Some toxically safe flocculating agents recognized are e.g. potato starch derivatives, and these are suitable for initiating sedimentation.

3. Centrifugation

Centrifugation harvesting method can be applied to almost every type of microalgae. Centrifugation is using the same sedimentation principal but with addition with enhanced gravitational force to increase the sedimentation rate. However, there are some disadvantages of centrifugation which is microalgal cells structure can damage due to the exposure to high gravitational and shear forces.

4. Biological filtration

Biological filtration means feeding of easily harvested filter feeders with algae, and is consequently a form of aquaculture. Complete food chains starting with wastewater have been studied in order to develop integrated systems able to generate useful biomass simultaneously with effluent purification. Pathogen safety of such biomass does not appear to be of major concern although more complete and systematic monitoring of pathogens should be made before the final edible biomass (fish in general) is available for human consumption.

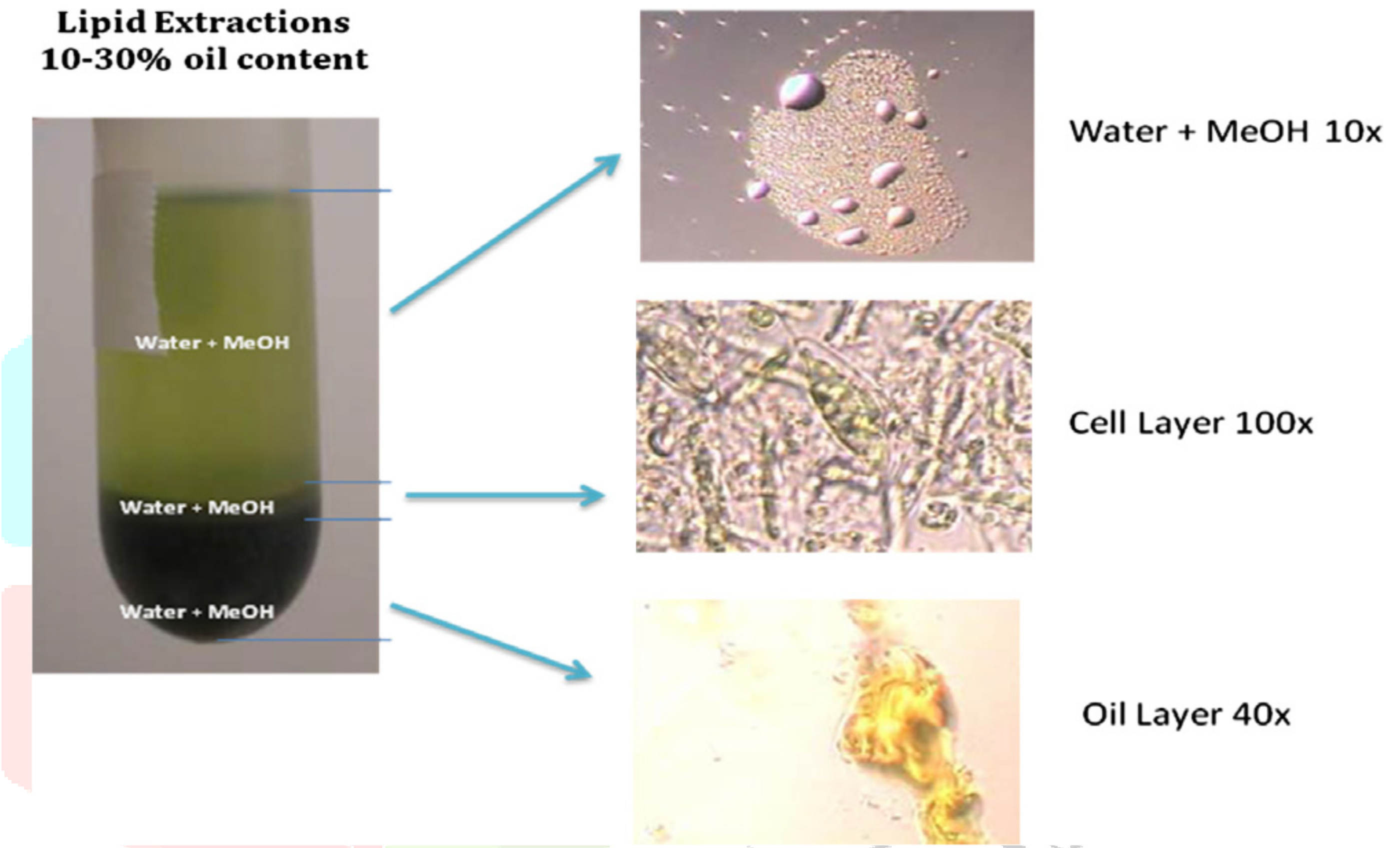
<u>RECOMMENDATION ON OPERATION -</u>

Wastewater is naturally abundance in nutrient that can be used for algal growth. From the entire factors effecting algal growth and treatment efficiency, it is likely that the major factors are carbon and light. Light is the important parameter to be consider and hence in open culture the depth of culture and turbulence are major factors to obtain optimum performance. For the humid climate like India, where rain may affect the performance of wastewater treatment and algal growth, greenhouse would be recommended. By observing the properties and ability of the microalgae in the uptake of carbon, nitrogen, phosphorus and heavy metal, microalgae show a potential in wastewater treatment for various types of effluent.

It is recommended for starting a microalgae wastewater treatment by inoculating large variety of algae because this will create a mixture of algae where the best suited species will strive and grow faster and dominate the treatment steps. This approach requires less supervision and operation than if a particular algal is chosen to be cultivated for any purpose.

Utilization of harvested algae biomass in biogas production-

Waste-grown microalgae are a potentially important biomassfor biofuelproduction. However, most of the wastewater treatmentponds systems do not use algae harvesting. Those that do typically return the biomass to the ponds, where it decomposes on the pond floor, releasing methane to the atmosphere and degrading water quality. Instead, the algae biomass could be processed for lipid extraction to be used in transportation fuel or it can be anaerobically digested to make biogas.



Result-

The study shows the ability of microalgae to uptake the carbon, nitrogen, phosphorus and heavy metal, and microalgae have a potential for the treatment of wastewater for various types of effluent.

Sewage and industrial wastewater is naturally enriched in nutrient that can be used for algal growth. It also observed that the major factors that effecting algal growth and treatment efficiency are carbon dioxide and light.

The various studies conducted to treat the wastewater using microalgae shows that themicroalgae reactor has a significance reduction in nutrients, BOD and COD and other toxic chemicals but increase in Total solids due to the growth of microalgae, so it is recommended before discharging the treated wastewater in the stream, it is necessary to remove microalgae from the treated effluent to meet general standards of wastewater discharge.

The nutrients removal efficiency of microalgae based wastewater treatment system is very high. The system has a removal efficiency of 78-99% of Nitrogen and Phosphorus.

The treatment system also succeeds to remove 40-65% of COD, BOD and other impurities present in wastewater.

The high concentration of N and P in most waste waters also means these wastewaters may possibly be used as cheap nutrient sources for algal biomass production. This algalbiomass could be used for:

1. methane production,
2. composting,
3. production of liquid fuels ((pseudo-vegetable fuels),
4. as animal feed or in aquaculture and
5. Production of fine chemicals.

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