Algae- means of biodegradation and way of making biofuel from wastewater

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***Abstract*— Rajasthan due to many constraints is always searching for new avenues of renewable energy. In this line energy can be economically produced from wastewater (from different sources). Autotrophs play an important role in remediation of wastewater particularly domestic waste through its photosynthetic ability. The biodegradation involves the degradation of organic matter to smaller molecules (CO_2, NH_3, PO_4 etc.), and requires constant supply of oxygen. The process of supplying oxygen is expensive, tedious, and requires a lot of expertise and manpower. These problems are overcome by growing micro algae in the ponds and tanks where wastewater treatment is carried out. The algae release the O_2 while carrying out the photosynthesis which ensures a continuous supply of oxygen for biodegradation. The added benefit is the resulting biomass that can be used as biofuel feedstock. Using algae for wastewater treatment offers some interesting advantages over conventional wastewater treatment. The advantages of algae-based treatment include cost effective treatment, low energy requirement, reduction in sludge formation and production of algal biomass. Algae can be used not only to treat municipal wastewater but also industrial wastewater. Algae play a major role in aerobic treatment of waste in the secondary treatment process. Algae based municipal wastewater treatment systems are mainly used for nutrient removal (removal of nitrogen and phosphorous).Algae have the ability to accumulate the heavy metals and thereby remove toxic compounds from the wastewater. In some cases, algae also play a role in the removal of pathogens in the tertiary treatment stage. Algae will be grown in treated wastewater. As they grow, the algae take in nutrients from the water that otherwise would be discharged into the near by river. This amounts to an extra scrubbing of the wastewater to make it better for the environment. The microscopic algae crop will be dried and converted to biodiesel by means of a proprietary reactor which then can be used to power the engine of a vehicle. To investigate the role of algae in wastewater treatment and its conversion into biofuel, polluted water samples were collected from different places in Rajasthan.**

Keywords— Biofuel, biodiesel, algae, wastewater treatment, nutrient removal, biodegradation

INTRODUCTION

Rajasthan the second largest state in India, has many Polluted sites. Every day, millions of cubic metres of sanitary sewage are flushed from homes, businesses, institutions and industries through sink drains and toilets into city sewer systems. Municipal wastewater contains sanitary sewage and is sometimes combined with water from rain, draining off rooftops, lawns, parking lots and roads. The sewer system either takes the wastewater to a municipal wastewater treatment plant or releases it directly into a lake, river or ocean.

Municipal wastewater is one of the largest sources of pollution, by volume, to surface water in Rajasthan. Municipal wastewater normally receives treatment before being released into the environment. The higher the level of treatment provided by a wastewater treatment plant, the cleaner the effluent and the smaller the impact on the environment. Despite treatment, pollutants remain in treated wastewater discharged into surface waters. Treated wastewater may contain grit, debris, biological wastes, disease-causing bacteria, nutrients, and hundreds of chemicals such as those in drugs and in personal care products like shampoo and cosmetics.

At the same time, the increasing use of fossil resources for both energy and manufacturing purposes is accepted to be unsustainable. It results in increasing emission of Green House Gases (GHG), mainly CO2, which are understood to be the reason for rising atmospheric temperature, causing a major change of the earth's climate. Fossil resources are also limited and their availability is assumed to peak within the next decades, which is a serious threat to the worlds' energy security.

MUNICIPAL WASTE WATER TREATMENT

In order to produce a clean effluent that can be safely discharged to watercourses, wastewater treatment plant operations use three or four distinct stages of treatment to remove harmful contaminants. Each of these stages mimics and accelerates processes that occur in nature. Preliminary wastewater treatment extracts coarse solids and grit through screens and other filtering devices. These coarse materials are not incorporated in biosolids. Primary wastewater treatment usually involves gravity sedimentation of screened wastewater to remove settled solids. Half of the solids suspended in wastewater are removed through primary treatment. The residual material from this process is a concentrated suspension called primary sludge, which will undergo further treatment to become biosolids. Tertiary treatment removes specific substances of concern after secondary treatment using a number of physical, chemical or biological processes. The major disadvantages associated with current wastewater treatment practices are:

Many wastewater treatment processes generate large amounts of sludge that must be sent off-site for disposal. Handling and disposal of this sludge is typically the largest single cost component in the operation of a wastewater treatment plant.

Most wastewater treatment processes cannot effectively respond to diurnal, seasonal, or long-term variations in the composition of wastewater. A treatment process that may be effective in treating wastewater during one time of the year may not be as effective at effective in treating wastewater during one time of the year may not be as effective at treating wastewater during another time of the year.

High energy requirements will make many wastewater treatment methods unsuitable for low per-capita energy consumption regions.

High operation and maintenance requirements, including production of large volumes of sludge (solid waste material), make them economically unviable for many regions.

Using algae for wastewater treatment offers some interesting advantages over conventional wastewater treatment.

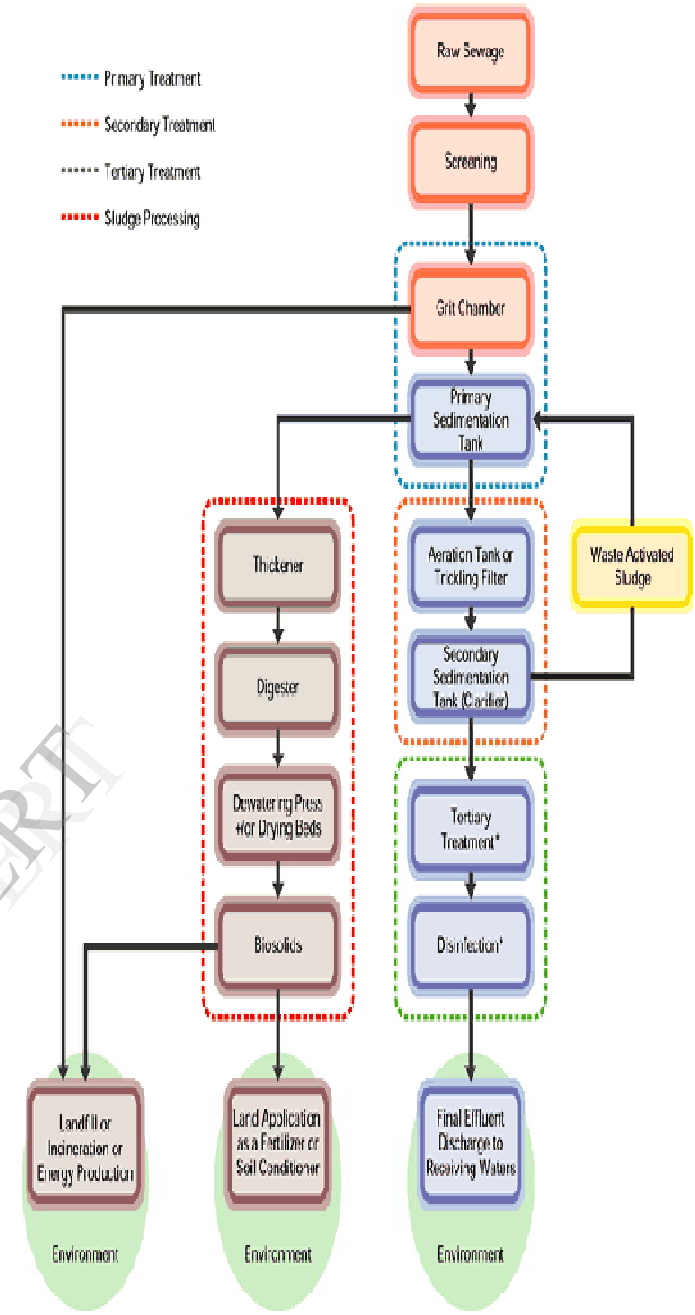
ENERGY FROM ALGAE

Algae present an exciting opportunity for researchers owing to their diverse applications and its potential to be a major source of biofuels. Algae are already being used in a wide variety of industries and applications, and many newer applications are being discovered. Algae research provides an environmentally friendly solution for serious global threats like greenhouse gas emissions. The bioremediation potential from algae makes it possible to use algae for cost effective CO_2 sequestration and wastewater treatment. While academic research into algae fuels started over three decades ago, the intensity of research activities has accelerated tremendously in the past few years. This has been a consequence of the realization of algae's potential as a source of biofuel. As of January 2013, about two hundred universities worldwide have serious research programmes in algae biofuels. Microalgae require several things to grow. Because they are photosynthetic, they need a light source, carbon dioxide, water, and inorganic salts. The growth medium must contribute the inorganic elements that help make up the algal cell, such as nitrogen, phosphorus, iron, and sometimes silicon.

ADVANTAGES OF ALGAE WASTEWATER TREATMENT

Cost Effective - It has been shown to be a more cost effective way to remove biochemical oxygen demand, pathogens, phosphorus and nitrogen than activated sludge process and other secondary treatment processes.

Low Energy Requirements - Traditional wastewater treatment processes involve the high energy costs of mechanical aeration to provide oxygen to aerobic bacteria to consume the organic compounds in the wastewater, whereas in algae based wastewater treatment, algae provides the oxygen for aerobic bacteria. Aeration is an energy intensive process, accounting for 45 to 75% of a wastewater treatment plant's total energy costs. Algae provide an efficient way to consume nutrients and provide the aerobic bacteria with the needed oxygen through photosynthesis. Roughly one kg of BOD removed in an activated sludge process requires one kWh of electricity for aeration, which produces one kg of fossil CO2 from power generation By contrast, one kg of BOD removed by photosynthetic



*Tertiary Treatment and Disinfection will occur only at some facilities where a very high quality effluent is required.

oxygenation requires no energy inputs and produces enough algal biomass to generate biofuel that can produce one kWh of electric power.

Reductions in Sludge Formation - In conventional wastewater treatment systems the main aim is to minimize or eliminate the sludge. Industrial effluents are conventionally treated using a variety of hazardous chemicals for pH correction, sludge removal, color removal and odor removal. Extensive use of chemicals for effluent treatment results in huge amounts of sludge which forms the so called hazardous solid waste generated by the industry and finally disposed by depositing them in landfills. In algae wastewater treatment facilities, the resulting sludge with algal biomass is energy rich which can

be further processed to make biofuel or other valuable products such as fertilizers. Algal technology avoids use of chemicals and the whole process of effluent treatment is simplified. There is considerable reduction in sludge formation.

The GHG Emission Reduction – The US Environmental Protection Agency (EPA) has specifically identified conventional wastewater treatment plants as major contributors to greenhouse gases. Algae based wastewater treatment also releases CO2 but the algae consume more CO2 while growing than that is being released by the plant, this makes the entire system carbon negative.

Production of Useful Algal Biomass – The resulting algae biomass is a source of useful products such as biodiesel. Previous research in the early 1990's by the National Renewable Energy Laboratory (NREL) showed that under controlled conditions algae are capable of producing 40 times the amount of oil for biofuel per unit area of land, compared to terrestrial oilseed crops such as soy and canola (Sheehan et al., 1998).

ALGAE-BASED TREATMENT SYSTEM – DESIGN AND CONSTRUCTION

It is suggested that wastewaters in Rajasthan can be used to generate energy in form of biofuel using algae. To construct algae based wastewater treatment system it is essential to consider both wastewater treatment as well as algal cultivation. Cell retention time, nutrient addition rate, water depth, and degree of mixing are the common parameters consider for growth of algae. In addition to these parameters BOD reduction, TDS reduction, pH, Nitrogen removal rate and Phosphorus removal rate are commonly considered for wastewater treatment. Hence the system was designed accordingly to allow the growth of algae as well as wastewater treatment. Two types of wastewater treatment systems can be currently and economically used for algae based treatment which can be incorporated in secondary treatment stages.

Waste Stabilization Pond Systems (WSPs), High Rate Algal Ponds(HRAP)

WASTE STABILIZATION POND SYSTEMS

Role of Algae in WSPs

Wastewater treatment in Waste Stabilization Ponds (WSPs) is "green treatment" achieved by the mutuali bacteria to consume the organic compounds in the wastewater, whereas in algae based wastewater treatment, algae provides the oxygen for aerobic bacteria. Aeration is an energy intensive process, accounting for 45 to 75% of a wastewater treatment plant's total energy costs. Algae provide an efficient way to consume nutrients and provide the aerobic bacteria with the needed oxygen through photosynthesis. Roughly one kg of BOD removed in an activated sludge process requires one kWh of electricity for aeration, which produces one kg of fossil CO2 from power generation By contrast, one kg of BOD removed by photosynthetic growth of microalgae and heterotrophic bacteria. The algae produce oxygen from water as a by-product of photosynthesis. This oxygen is used by the bacteria as they aerobically bio-oxidize the organic compounds in the wastewater. An end-product of this bio-oxidation is carbon dioxide, which is fixed into cell carbon by the algae during photosynthesis.

HIGH RATE ALGAL POND SYSTEMS

Role of Algae in HRAP

The HRAP is a combination of intensified oxidation ponds and an algal reactor. HRAP are shallow, paddlewheel-mixed open raceway ponds and provide far more efficient wastewater treatment than conventional oxidation ponds. This is primarily as a result of intense algal photosynthesis providing saturated oxygen to drive aerobic treatment and assimilation of wastewater nutrients into algal biomass. In the table below are some statistics of waste water analysis at different sites in Rajasthan, which can be effectively be converted into biofuel using algae.

Table 1: AVERAGE COMPOSITION OF DOMESTIC WASTEWATER AT ONE SITE IN RAJASTHAN

Constituent	**Concentration mg/l**
Dissolved solids (TDS)	2100
Suspended solids	900
Nitrogen (as N)	150
Phosphorus (as P)	25
Alkalinity (as $CaCO_3$)	850
Sulphate (as SO_4)	90
BOD_5	770
COD[1]	1830
TOC[2]	220

[1] COD is chemical oxygen demand
[2] TOC is total organic carbon

Table 2: CHEMICAL COMPOSITION OF INDUSTRIAL WASTEWATERS ON TWO SITES IN RAJASTHAN

Constituent	**Site1**		**Site2**	
	Unit	**Concentration**	**Unit**	**Concentration**
pH		7.80		7.1
Na^+	me/l	24.60	mg/l	205
Ca^{2+}	me/l	1.50	mg/l	128

Mg^{2+}	me/l	3.20	mg/l	96
K^{+}	me/l	1.80	mg/l	35
Cl^{-}	me/l	62.00	mg/l	320
SO_4^{2-}	me/l	35.00	mg/l	138
CO_3	me/l	1.10		-
HCO_3^{-}	me/l	6.60		-
NH_4^{+}	mg/l	2.50		-
NO_3^{-}	mg/l	10.10		-
P	mg/l	8.50		-
Mn	mg/l	0.20	mg/l	0.7
Cu	mg/l	1.10	mg/l	0.4
Zn	mg/l	0.80	mg/l	1.4

Result and Discussion

These Polluted Waters can be treated with algal growth to convert it into useful energy source. At least it produces enough energy to run a small scale industry nearby .At the same time the hazardous CO_2 is also utilized for algal growth. This could be the best "Best out of Waste."

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