2012 International Conference on Environmental, Biomedical and Biotechnology
IPCBEE vol.41 (2012) © (2012) IACSIT Press, Singapore

Treatments of Industrials Wastewater by Using Microalgae

Sara AL-Rajhia, Nitin Raut, Fatma AL-Qasmi, Mariam Qasmi and Amal Al Saadi

FOE, Sohar University, Sohar, Sultanate of Oman

Abstract. Many industrial areas in the world, show increase in generating of wastewater nowadays. The beer brewing, soy sauce, poultry, pulp and paper, dairy and poultry processes are produce large amount of wastewater. The effluent form this processes contain high concentrated CO_2 and nitrogen and also it's is very harmful to the human and to the environment. This wastewater must be treated for disposal or reusing again in the processes. The best methods to treat brewing, soy sauces pulp and paper, dairy and poultry wastewater are by using biological treatment method by cultivation microalgae. For each processes they are different method to treat the waste but the product will be biofuel. The final microalgae biomass obtained, considering its protein and fatty acid content and the absence of heavy metals in significant amount, can be appropriate for use as animal feed or for biofuel production. This paper reviews the treatment techniques for industrial wastewater (brewing, soy sauces pulp and paper, dairy and poultry).

Keywords: Microalgae, Wastewater, Brewing, Poultry, Pulp, Soy sauces, DW

1. Introduction

Microalgae are aquatic organisms. They are microscopic and single-cell organisms that live in fresh water and marine environments. Thus, they are at the bottom of the food chain with many living things depending upon them. With the recent research and interest into using algae for producing Biodiesel they have the potential to become even more important. The advantages of employed microalgae in treatment of waste water:

- Cost effective
- Low energy requirement
- Production of useful biomass
- Reduction in sludge formation
- Remove heavy metals
- Algae contain more than 50% of oil in its biomass.
- They provide much higher yields of biomass and fuels, 10-100 times higher than comparable energy crops.
- They can be grown under conditions which are unsuitable for conventional crop production.

Microalgae are capable of fixing CO2 in the atmosphere, thus facilitating the reduction of increasing atmospheric CO2 levels, which are now considered a global problem. Algae biofuel is non-toxic, contains no sulphur, and is highly biodegradable.

Many industries in the world produce huge amount of wastewater from their processes such as; food industry, iron and steel industry, nuclear industry, olive oil mill industry and textile industry. Wastewater is any water that discharging from domestic residences and industrial effluent that containing poison solids. There are numerous processes that can be used to clean up waste waters depending on the type and extent of contamination. Most wastewater is treated in industrial-scale wastewater treatment plants (WWTPs) which may include physical, chemical and biological treatment processes. Each industry has its own aim and method to treat the produced wastewater. For example, treatment of textile dye wastewater by using anaerobic batch reactor and the aim is to reduce COD (Carbon Oxygen Demands) and colour of the

wastewater so the plant can reuse the water or deposit it to the land safely[3]. Also, olive oil mill wastewater aiming to growing a mixture of microbial biomass strains by combining both chemical and biological treatment. This microbial biomass used is as an additive to animal feed[8].

On the other hand, the treatment of beer brewery wastewater has three methods to treat the wastewater. The first one is physical method by applying physical forces to remove coarse matter. This way allows the suspended pollutants to settle out or to float at the top of the reactor; most of the time the resulting is incomplete contaminant removal or separation and has yield to little success. The second method is chemical method; this method used same chemicals to reach the desire treatment product. The biological method is third method that has most effective and yield the exact product because of some advantages:

- treatment technology is mature
- high efficiency in COD(Carbon Oxygen Demands) and BOD (Biological Oxygen Demands) removal, ranging from 80 to 90%
- Low investment cost[9].

Table 1: Characteristics of the brewery effluent.

Parameter	Range of values
BOD5	560-4,778 mg O2 L-1
COD	565-7,837 mg O2 L-1
Ammonia	3.07-106.44 mg L-1
Nitrate	1.86-11.16 mg L-1
Total phosphates	56.98-325.75 mg L-1

Soy Sauce process is increasing in production in very a large scale and in general it yields to serious waste disposal problem. From previous studies that done by, they used acrylic columns to produces effluent with high nitrogen concentration and also the solution had 3% sodium chloride concentration. This waste was suitable to cultivation of marine microalgae and produced ethanol [2]. pulp and paper, dairy and poultry wastewater were treated to remove all heavy metals and produce biofuel [10].

2. Literature review

Soy Sauce, beer brewery, pulp and paper, dairy and poultry processes had its own method to process the treated water.

Shirai F., et.al., 1998, investigated the treatment of soy sauce effluent including four types of microalgae and they are Chlamydomonas sp., Dunaliella sp., Nannochloropsis oculata and Tetraselmis terathele. The precultivation of microalgae was carried in Erd-Schreiber modified medium (ESM).1Kg soil mixed with 1L of distilled water (DW). The mixture was heated to 2hr than cooled and filtered. The DW was added to make up a total 1L and kept at 121◦C for 20 min. Microalgae were inoculated into a test tube that containing 9 ml of ESM.The mixture put it in 7 days with shaking at 130 rev/ min at 25◦C. And also, supplied by a white fluorescent lamp was used as light source. The experiment was performed using the prepped soil extract waste that diluted with seawater in the same conditions and the microalgae were cultured in 500ml Erlenmeyer flask with cotton wool plug canting 150ml of the extract solution at 25◦C for 10 days. The cells were collected by centrifugation and washed by DW. The cells were disrupted by putting it in frozen at -20C.

Ethanol extracted by these steps. 10mg of dried cell at 105˚Cin 100mL Erlenmyer flask was mixed with 50mL of DW. The PH was adjusted at 4.5 by using of 1M HCL. The suspension was autoclaved for 20 min at 121˚C, than cooled. 1mg of Glucozym AF6 was added to the suspension for one day at 58˚C. The saccharifed suspenion was centrifuged and passing through membrane filter. The amount of AF6 was measured by used an enzymatic method. IAM4140 cells were added to the saccharified solution contiouesly at 25˚C for 5 days. The amount of ethanol extracted from the formation process was assayed by an enzymatic method.

Simate S.,et.al., 2011, There are sever types of microalgae like consortium (microalgae, cyanobacteria and bacteria) and autochonous that can be used for beer brewery treatment. The experiment examined two types of effluent brewery. The first one effluent diluted with deionised water and the cultures medium was at temperature 25˚C, with continuous light and aeration. The growth of consortium was obtained by direct counting or chlorophyll determination. The second method was completely effluent in different concentration to test which concentration will yield to the required product (biofuel). The experiment is very complicated and has many steps but the idea is to grow microalgae with bacteria because bacteria can use ammonia from the effluent as nitrate and release CO2 during metabolis. The CO2 is necessary for microalgae to carry out photosynthesis. The COD, BOD and phosphate will reduce so the wastewater could discharge safety. Fatty acid and heavy metals consumed during the growth and the left out from solution could be used as solid produced from it animal feed or biofuel production.

The Oilgae Guide report, reports poultry industry treating microalgae. Poultry industry includes all chickens, turkeys, ducks and ratites. The effluent have proteins and carbohydrates from meat, fats, blood, skin and feathers and also grit and other inorganic matter, high levels of nitrogen, phosphorus, and chlorine, pathogens like salmonella and Campylobacter . The aim from the treatment are remove all nitrogen and phosphorous to neutralize orders and also reduce sludge. Algal treatment process is Nutrient assimilation using High Rate Algal Ponds (HRAP).

Table 2: Characteristics of Poultry effluent

Characteristics	Values
PH	7-7.6
Colour	Brownish grey
Total solids(mg/L)	1400-3900
Total suspended solids (mg/L)	300-950
Total volatile solids (mg/L)	800-1800
BOD5(mg/L)	750-1890
Total BOD(mg/L)	3000-4800
Soluble COD(mg/L)	1030-3000
VFA (mg/Las acetate)	250-240
Alkalinity(mg/L as CaCO3)	600-1340
Phosphates (mg/L)	16-32
Ammonia Nitrogen (mg/L)	16-165
TKN(mg/L)	109-325
Oil and Grease (mg/L)	800-1385
Protein (mg/L)	580-1000

The Oilgae Guide report, Pulp and paper mill is also generates large volumes of wastewater. The characteristics of the wastewater are highly heterogeneous waste that contains wood and other raw.

Table 3 :Characteristics of Pulp and paper effluent

Parameter	Concentration(mg/L)
COD	2238- 3566(2903)
BOD5	945- 1530(1237)
TSS	950- 3400(2175)
PH	7.2- 7.6 (7.4)

Because of high concentration of BOD and COD, it cannot discharge of the wastewater to river or sea. It must be treated before disposal to environment. Pulp and paper waste can be treated by using an Anaerobic Fixed Film reactor. The process utilizes bacteria to break down biodegradable material in the absence of oxygen with supply of pH, nutrient and temperature as an important requirement for the system. The treatment applied to reduce the BOD5 by 53%, COD by 89% and lead metal. The product was biogas.

Woertz I., ET. al., 2009, investigated the dairy wastewater is sours of low cast of lipid for production of liquid biofuel. The study was investigated in lipid productivity and nutrient removal by cultured a green algae in diary from and municipal wastewater with supply of CO2. On the first cultured in dairy wastewater , The duration of experiment was 6 days batch cultures and outdoor in bench-Scale.17bmg\day\L was the maximum extracted of lipid and After 12 days, it were the maximum removal of ammonium and orthophosphate removals were 96 and 99%. The second cultured was in municipal wastewater. It was treated in semicontinous indoor cultures from 2-4 days hydraulic residence times (HRTs) . The maximum lipid extracted 24mg\day\L. In 3 day, it was absorbed that rate of removal of ammonium and orthophosphate was 99%. The results from both types of wastewater suggest that CO2-supplemented algae cultures can simultaneously remove dissolved nitrogen and phosphorus to low levels while generating a feedstock potentially useful for liquid biofuels production.

3. Result and Dissociation

The soy sauce waste with green algae of Dundiella does not containing polyunsaturated fatty acid. The disruption the cells were easy and also doesn't have a rigid cell. However, ethanol can be extracted easily. The decreasing of organic substance content the medium was noted so the treatment of waste water by using microalgae might be possible. On other hand, half of nitrogen, amino acids and total phosphorus are consumed. The optimum pH for cultivating Dunalilla at 8.5.

Beer Brewery effluent was experimented in different sets (1:1) and (1:2) (effluent: deionised water) mixed with mixture of microalgae and autochonous. From both experiments proved that cultivation of microalgae inside the diluted effluent (1:1) more efficient than other culture mediums. Also, higher removals of heavy metals like phosphors and nitrogen[6].

Pulp and paper and poultry wastewater were treated by using microalgae. The treatment was aim to remove all heavy metal and nutrients from the wastewater to produce biofuel or animal feed. There are 1.8 million dairy cows in California. Using algae, we can treat dairy waste, produce energy and reduce greenhouse gas emissions[5].

4. Conclusion

Many industries have a large scale production wastewater. Each one has its own method of treatment by using microalgae. The product is clean water and safely to discharged or reusing in process again or extract biofuel. From the soy sauce treatment, one can extract ethanol from Dunaliella sp. which grows in soy sauce waste more than other species. Beer brewing, pulp and paper and dairy and poultry treatment, the goal for the treatments are to remove all the heavy metals by employ consortium so it can produce feed animal or biofuel. This all treatments it can improve it by experimented in pilot plant.

5. Acknowledgement

The authors express their gratitude and thanks for the help and cooperation from the Faculty of Engineering, Sohar University and The Research Council, Oman for sponsoring and funding the research project titled "Harnessing Clean and green energy via integrated treatment of wastewater ".

6. References

[1] E.Tarlan, F. Dilek, B. and U.Yetis. Effectiveness of algae in the treatment of a wood-based pulp and paper industry wastewater. Bioresource Technology, vol 84, pp. 1 – 5, Effluent Treatment and Possible Applications, 2002.

[2] F. Shirai, K. Kunii, C. Sato, Y.Teramoto, E.Mizuki, S. Murao, S. Nakayama . Cultivation of microalgae in the solution from the desalting process of soy sauce waste treatment and utilization of the algal biomass for ethanol fermentation. World Journal of Microbiology &Biotechnology, 1998.

[3] G.Gnanapragasam, M.Senthilkumar, V.Arutchelvan, T.Velayutham, S. Nagarajan . Bio-Kinetic analysis on treatment of textile dye wastewater using anaerobic batch reacter. Department of Civil Engineering ,India, 2010.

[4] I. Woertz, A. Feffer, T. Lundquist, Y. Nelson. Algae Grown on Dairy and Municipal Wastewater for Simultaneous

Nutrient Removal and Lipid Production for Biofuel Feedstock. Journal of Environmomental Engineering, 2009.

[5] Leong Soo Kwan. Effect of Organic Loading Rates on Pulp and Paper Wastewater Treatment Using an Anaerobic Upflow Fixed-Film Reactor. International Conference on Biology, Environment and Chemistry IPCBEE vol.1 ,IACSIT Press, Singapore, 2011.

[6] M.Filomena, S.Oliveria, P.Castro, N.Bandrra, R.Morais. On the Utilization of Microalgae for Brewery of the Produced Biomass. The Institute of Brewing & Distilling,2010.

[7] R. Rajakumar, T. Meenambal, J. Rajesh Banu, T. Yeom I. Treatment of poultry slaughterhouse wastewater in upflow anaerobic filter under low upflow velocity. Karnataka, India,2010.

[8] S. Laconi, G. Molle, A. Cabiddu, R. Pompei. Bioremediation of Olive Oil Mill Wastewater and Production of microbial biomass. Biodegradation, Volume 18, Number 5, 559-566,Springer Science and Business Media, 2006.

[9] S. Semite, J. Culet, S. Like, E. Musapatika, S. Ndlovu, L. Walubita, A. Alvarez. The treatment of brewery wastewater for reuse :state of the art. Department of Civil Engineering, Colombia, 2011.

[10] The Oilgae Guide report', http://www.oilgae.com/ref/report/report.html, 2009.