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DAIRY WASTEWATER TREATMENT USING MICROALGAE IN KARBALA CITY – IRAQ

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ABSTRACT

The present study aims was included an assessment of an industrial dairy wastewater in karbala- Iraq. This study was conducted for one year (from January to December 2013) and included monthly water analysis for various physic-chemical factors. spirulina sp are belonging to blue green algae viable for biological treatment. The results were showed to reduce nutrient concentrations from wastewater such as, nitrate, phosphorus and sulphate. In addition, the ability of these algae to reduce total hardness, alkalinity, chloride, C.O.D, T.D.S, calcium and magnesium hardness. The recorded ability of this algae on removing nitrate 80 % , active phosphorus 72 % and sulphate 61 % While total hardness 56%, alkalinity was 71% , chloride 56 % , C.O.D 77 % T.D.S 54 %, calcium and magnesium hardness 59% during the tenth day of treatment.

KEYWORDS: Dairy, Wastewater, Treatment, Microalgae, Nutrients

INTRODUCTION

Dairy is one of the industries producing wastewater rich in organic matter and thus leading to creation of odorous and high COD containing water. Discharge of dairy plant effluents to the water resources can lead to destruction of aquatic life and other marine creatures, which can provide more food for microbial consortia and causes further oxygen depletion. The pH of the effluent is alkaline and the organic content is considerably high. The effluent affects the aesthetic value of the receiving water its alkaline pH causes damage to aquatic life[1, 2, 3]

In dairy wastewaters, nitrogen originates mainly from milk proteins, and is either present in organic nitrogen form such as proteins, urea and nucleic acids, or as ions such as NH^{+4}, NO^{-2}, and NO^{-3}. Phosphorus is found mainly in inorganic forms such as orthoactive phosphorus ($PO3^{-4}$) and polyactive phosphorus ($P_2O_4^{-7}$) as well as in organic forms also.[4]

Significant amount of Na, Cl, K, Ca, Mg, Fe, CO, Ni, Mn are also always present in dairy wastewater. The presence of high concentration of Na and Cl is due to the use of large amount of alkaline cleaners in dairy plant.[5]

Biological treatment involves microbial degradation and oxidation of waste in the presence of oxygen. Conventional treatment of dairy wastewater by aerobic processes includes processes such as activated sludge, trickling filters, aerated lagoons, or a combination of these[6].

The dairy industry uses aerobic or anaerobic treatment, or a combination of both, to treat the wastewater. Aerobic systems require an energy source to provide the oxygen required to assimilate the organic matter. Anaerobic systems have been developed for their ability to treat high strength wastes and the utilization of the methane gas.[7]

Industrialization has become a matter of major concern due to its deteriorating activity on environment the dairy effluents consist of milk, milk products and enormous quantity of water. The pH of the effluent is alkaline and the organic content is considerably high. The effluent affects the aesthetic value of the receiving water its alkaline pH causes damage to aquatic life its high BOD depletes the dissolved oxygen content of the aquatic system and in due to course of time creates anaerobic conditions.[8]

Microalgae have been applied to cultivate in many kinds of wastewater to improve water quality for years. Especially grow microalgae in agro-industrial wastewater, which rich in nitrogen and phosphorus pollutants meanwhile microalgae can be used to reduce the inorganic and organic load of these wastewaters at a minimal cost.[9]

Using algae has been shown to be a more cost effective way to remove biochemical oxygen demand, pathogens, phosphorus and nitrogen than activated sludge against the traditional waste water treatment processes at ETPs (effluent treatment plants) which involves high energy costs of mechanical aeration to provide oxygen to aerobic bacteria to consume the organic compounds in the waste water[10]

Bioremediation uses naturally occurring microorganisms (microalgae) to treat wastewater of its nutrients. This method provides an economical and environmentally sustainable and effective treatment method. Algae are an important bioremediation agent, and are already being used by many wastewater facilities.

The treatment of swine and dairymanures by particular algal genera, such as *Spirulina (Arthrospira)*, *Phormidium*, *Chlorella* and *Scenedesmus*[11, 12]

Use of algae for municipal wastewater treatment in ponds is well established Algae growth in wastewater treatment ponds contributes to treatment mainly through dissolved oxygen production and nutrient assimilation. However, the carbon: nitrogen and carbon: phosphorus ratios in domestic sewage and dairy lagoon water are low compared to typical ratios in rapidly-growing algae biomass.[13]

Spirulina maxima, a high protein alga, was grown in effluents from the London municipal waste treatment plant. Optimum growth conditions were developed, the composition of algae and the removal of nitrogen and phosphorus in effluents were studied. The advantages of this process in tertiary waste-water treatment and the quality of the single cell protein were investigated.[14]

Spirulina platensis Percentage reductions in chemicaloxygen demand, ammoniacal-nitrogen and active phosphoruslevels of the digested effluent reached 98.0%, 99.9%and 99.4% respectively.[15]

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.[16]

MATERIALS AND METHODS

The present study carried out study from January to December 2013 PH, electric conductivity (by EC meter type HANNA), salinity (calculated from EC value) calcium, magnesium, chloride, sulphate, chemial oxygen were measured at the field according to standard method[17] Total hardness, T.D.S, T.S.S and alkalinity were determined according.[18] Nitrate, active phosphorus were determined according.[19] Sodium and potassium were Measured by[20].

Inocula

The algae *spirulina sp. powder* obtained from (Martinez Nieto,S.A., Cartagena) Manfactured in Spain was used in this study. (20% inoculum) were grown in Erlemeyer flask (1000 ml) containing 80% of dariy wastewater solution. The cultures incubated at (25 C^{o}) for 10 days and measured physical and chemical analysis [21, 22, 23].

Method of Sample Collection

Waste water samples were collected for Dairy Company and All experiments were performed for the treatment of pollutants and is mediated by a combination plastic containers 5 liter capacity after washing wastewater and then transported directly to the laboratory be no longer than 30 minutes.

Calculate the Percentage of Treatment

The efficiency of pollutant removal was expressed as the percentage ratio of pollutant concentration to that of before and after treatment value.

$$\%Treatment = \frac{before\ treatment\ value - after\ treatment\ value}{before\ treatment\ value} \times 100$$

Statistical Analysis

Analyzed the experiences of the study for some physical and chemical tests for dairy waste water according (t- student) [24].

RESULTS

Figures (1) monthly changes of some physical and chemical tests for dairy waste water during the study period (January 2013 to December 2013) and through the results of this study

The varied ranges of values of electrical conductivity of the wastewater from (1440 – 3630)µ**s** /cm In September and July, respectively, was observed as well as the existence of significant differences between the months and the same pattern of the values of salinity were high and ranged between (922 - 2323) part per thousand respectively.

The rates of pH was inclined to the basal side as it recorded the lowest value of 6.3 In the month of August and the highest value of 8.4 in the month of April. The total value of the lowest and highest rates of Total alkalinity wastewater samples studied between (340- 1450) mg / liter in the month of September and July

The concentrations of total hardness has recorded the lowest rate in 420 mg / liter in the month of December and the highest rate 917 mg / liter in the month May. The total values of the rates of calcium and magnesium hardness between (90-250) mg / liter in the month of December and July, and (67-152) mg / liter in the month of January and November, respectively.

The values ranged concentrations of nitrate (10-45) mg / liter in the month of January and July, active phosphorus ranged (2-17) mg / liter in the month of June and July, Sulfates (206-435) mg / liter.

In the month of October and February, chloride (115-611) mg / liter in the month of November and July, sodium (101-141) mg / liter in the month of March and July, potassium (8-40) mg / liter In the month of March and July. T.D.S (1045-2473), T.S.S (30-307) mg / liter in the month of March September and July respectively

The values of chemical oxygen demand COD during the study period of (1380 - 670) mg / liter in the month of January and November. The results of the statistical analysis of the existence of significant differences between months

Treatment of Waste Water by Algae *Spirulina Sp*

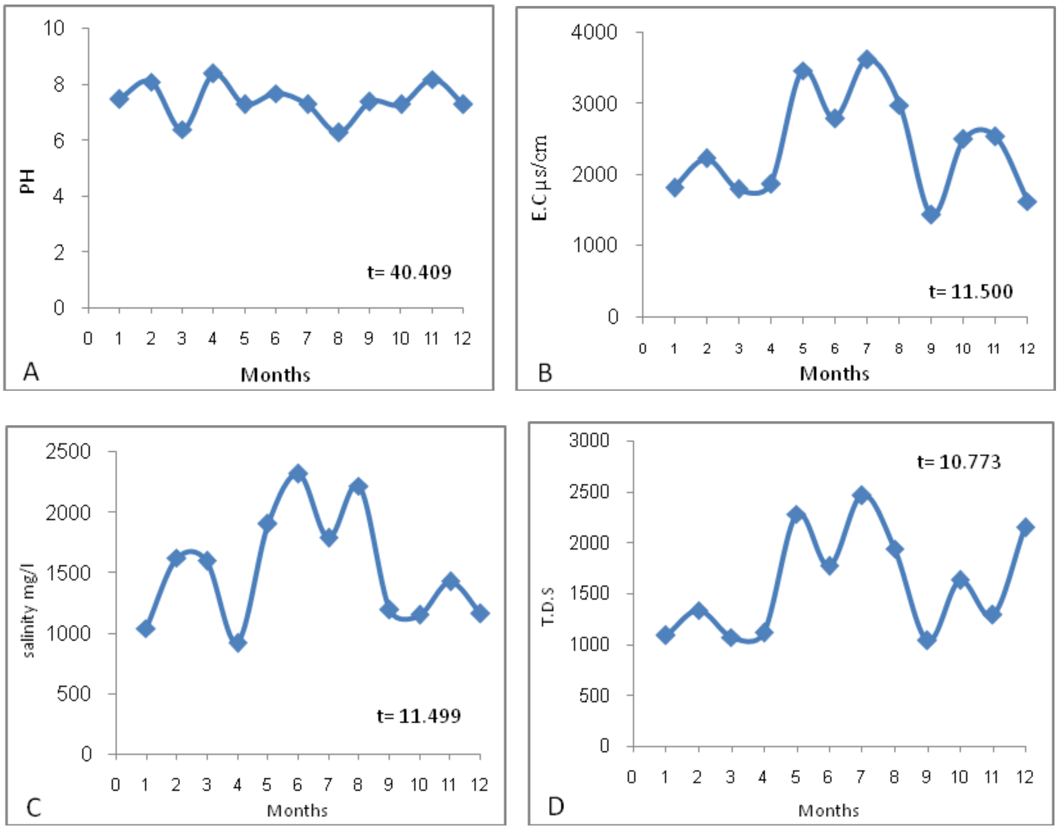
Table 1 and Figure 2 show the values and the percentage some physical and chemical tests for dairy waste water treatment with *spirulina* sp. Removal rate recorded in the first day of each of the electrical conductivity 13% to reach to the removal rate 55% in the tenth day.

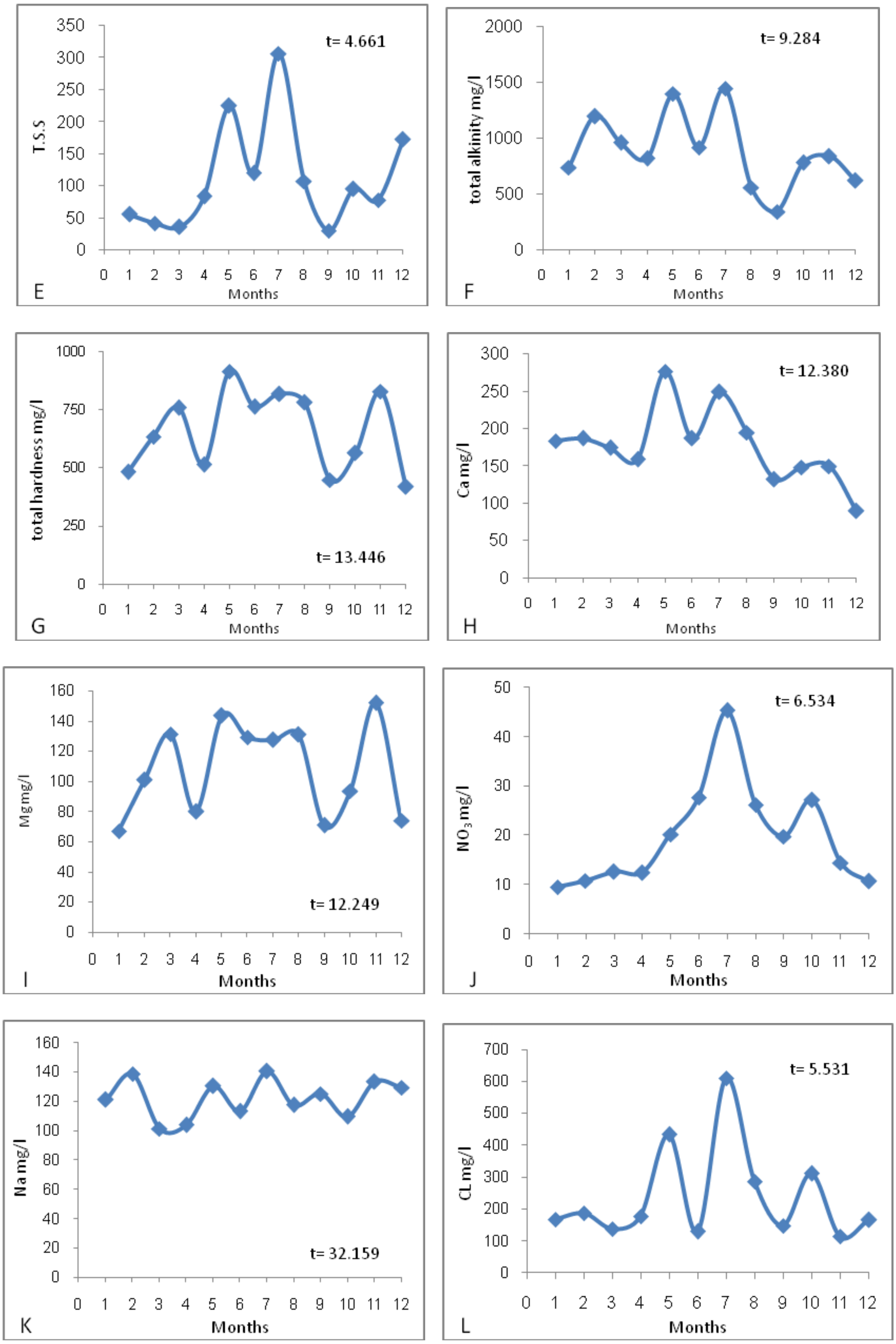
The results showed a continuous decline of plant nutrients (nitrate, active phosphorus, sulphate) from the first day until the tenth day when the waste-water treatment Where the percentage of removal in the first day of 22%, 18%, 18% and increased the rate of removal to 80%, 72%, 61% respectively in the tenth day.

The rate of removal of total alkalinity , total hardness and calcium hardness in the first day 20% ,15% and 9 % of the model and taken to increase up to 71% , 56%, 59% respectively in the tenth day.

While removal rates reached of T.D.S and chloride in the first day 17 %, 20% to reach to the removal rate 54 % and 56 % respectively in the tenth day.

Finally, the percentage of removal chemical oxygen demand COD in the first day 25 % and continued to reach 77 % in the tenth day. It showed good efficiency in the removal of pollutants from waste water during the treatment period

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H
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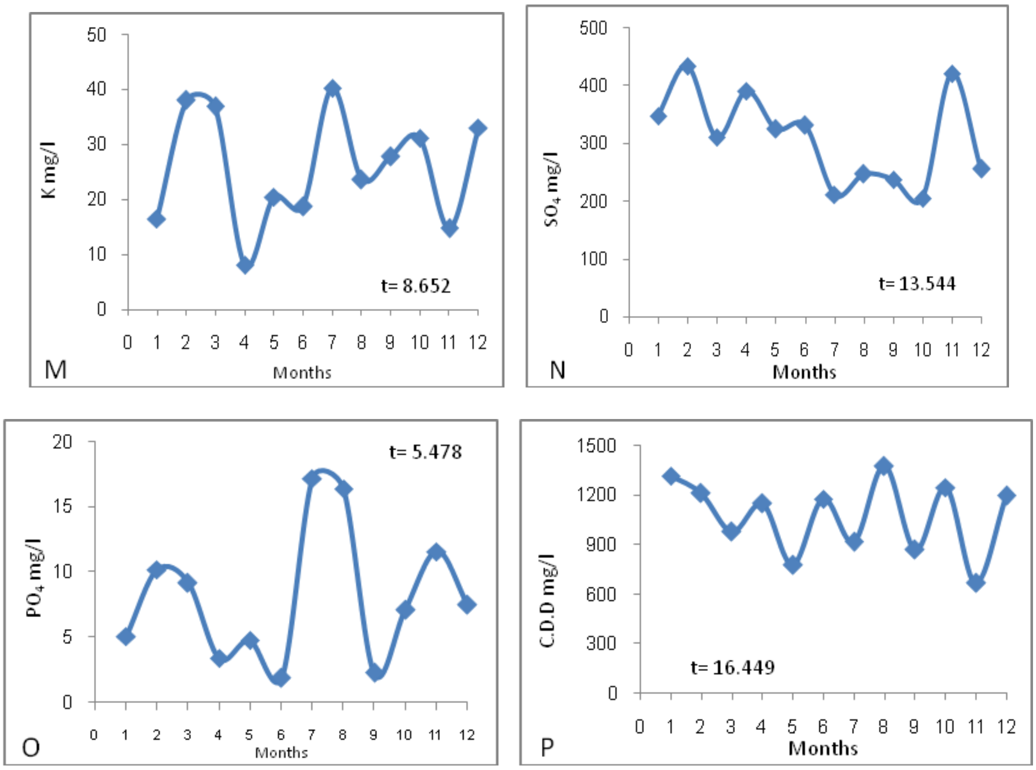
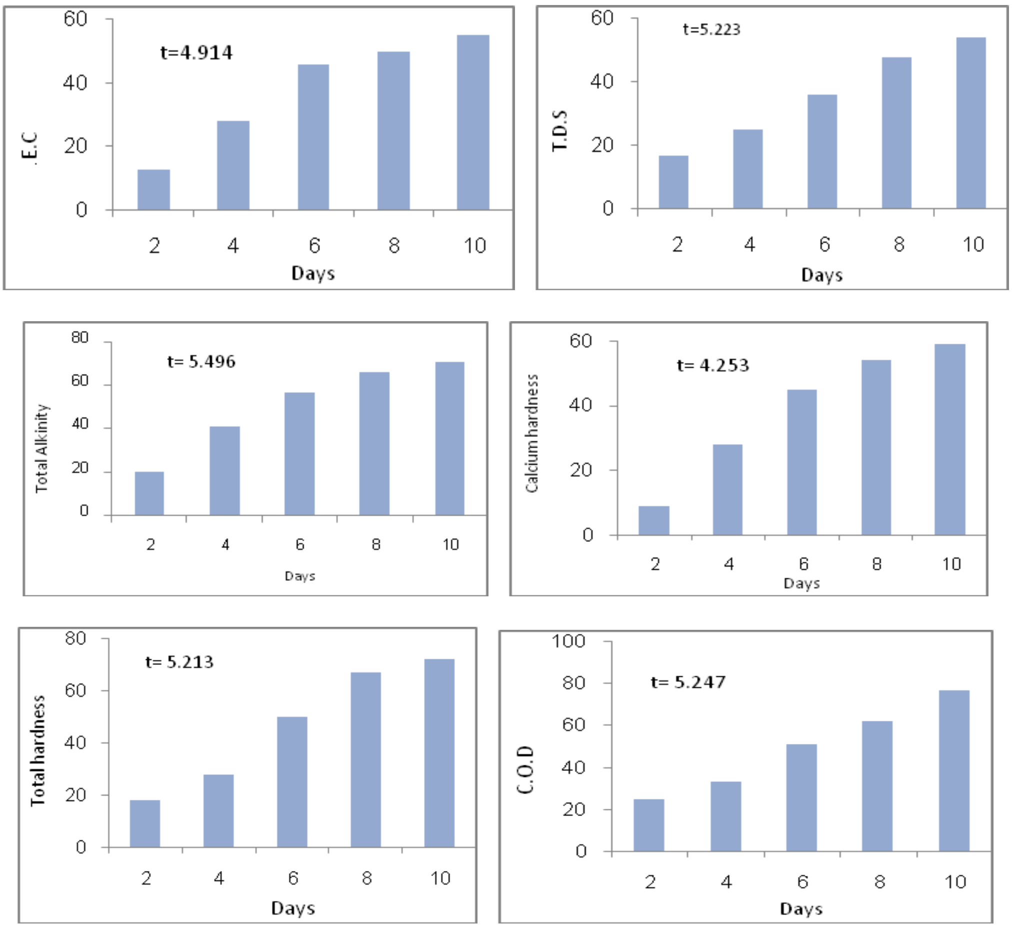


Figure 1: Monthly Changes of Some Physical and Chemical Tests for Dairy Waste Water



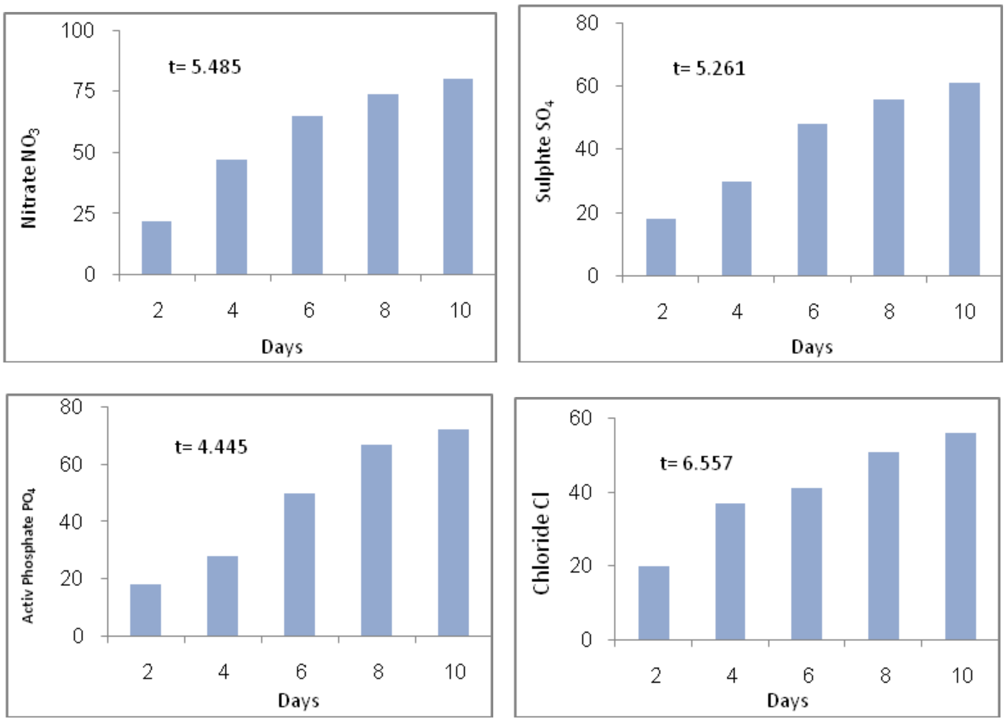


Figure 2: The Percentage of the Total Removal of Dairy Waste Water with *Spirulina* sp

Table 1: The Values of Some Physical and Chemical Tests for Dairy Waste Water Treatment with *Spirulina* sp

Parameter	Before Treatment	Days					T test
		2	4	6	8	10	
E.C.	4750	4150	3432	2586	2377	2115	7.499
T.D.S	3587	2987	2689	2287	1854	1619	8.357
Total Alkalinity	1246	996	736	541	420	358	5.038
Total hardness	819	700	570	460	390	362	7.434
Calcium hardness	218	198	158	120	100	90	6.833
Active phosphorus PO_4	8.2	6.7	5.9	4.1	2.7	2.3	5.221
Sulphte SO_4	728	600	510	380	320	287	6.678
Nitrate NO_3	89	69	47	31	23	18	4.04
Chloride Cl	1281	1021	811	754	627	560	7.698
C.O.D	1300	970	870	630	490	300	5.166

DISCUSSIONS

The results of the current study, the ability of algae to remove pollutants. The results of the present study was to high pH values of (6.3-8.4) during the treatment period and interpreted the research that the values of the exponent of hydrogen (pH) of the medium increases if the ratio of the absorption of phosphorus into energy that is derived from the process of photosynthesis or respiration as influenced by the absorption of phosphorus by many factors most important of pH, temperature and light intensity as it was observed that the pH by precipitating phosphorus. [25, 26]

Play algae play an important role in the biochemistry of the land for more than three billion years ago, through their participation in the recycling of ground elements (C, N, O, S, P) and requirements important and necessary for the growth of green algae (phosphorus, nitrogen, sulfur, calcium, magnesium). May be present naturally or are added salts. [27]

The nitrogen also important components for the growth of phytoplankton and other neighborhoods as entering in the manufacture of amino acids and proteins through the analysis of algal cells, the natural rate of atoms which is (1.6) atom of carbon and (16) atom of nitrogen and (1) atom phosphorus. [28]

In general, algae vary in their use of nitrogen Photos some prefer ammonia and urea and the other part of them as they prefer nitrates under certain circumstances prefer organic nitrogen. [29]

For example, enter the nitrogen in the formation of amino acids and nucleotides of the algal cells (amino acid - Nucleotides) The phosphorus contributes to the generation of energy (ATP-ADP-Phospholipids) and calcium importance applied in the work Djint and calcium carbonate (Alginate - Calcium Carbonate), while the role of magnesium is essential in building chlorophyll (Chlorophyll). [30]

And enters the sulfur in the formation of two amino acids, Cysteine & Methioinine which it plays a key role in the formation of covalent disulfide Alasrh (Covalent Disulfide bond formation) and to accelerate the installation of the tripartite protein (tertiarly protein structure). As well as its importance in the work of fat (thylakoid lipida) and can be considered from the requirements of energy (ATP - dependent) of algae and biomass of algae are not affected only the presence of nutrients but also affected by other factors such as light, temperature, pH and density communities. [31]

Research found that algae have the ability to cut through the basal formation of calcium carbonate mediated process (Calcification) as well as the consumption of algae for CO_2 gas in the water is essential to the process of photosynthesis (Photosynthesis) and thus reduced the basal. [25]

He also said Traviso and others that can remove nutrients from waste water and sewage own cattle manure (Sewage & Cattle-manure) using three types of eukaryotic algae C. vulgaris & C. kessleri & S. quadricauda using different methods of purifying them (K-Carrageenan and Sodium alginade and Immobilization). [32]

In the city of Isfahan - Iran managed to researchers from the wastewater treatment textile by transcribing and oxidation biological that lead to reduce the color and the requirement is vital for oxygen (BOD) and the requirement of chemical oxygen (COD) percent (100-97) -% (83-76) and% (97-92), respectively. [33]

It was found that Spirulina sp. cells were capable of the selective removal of trace elements from the effluent of a copper smelter and refinery, which contained elevated levels of mercury, cadmium and ammonia–nitrogen. After treatment, the concentration of all the contaminants fulfilled the environmental requirements. [34]

REFERENCES

1. Harush D**.**; Hampannavar U and Mallikarjunaswami M.(2011) . Treatment of dairy wastewater using aerobic biodegradation and coagulation. International Journal of Environmental Sciences and Research. College of Engineering and Technology, India. Vol. **1**, No. 1, 2011, pp. 23-26

2. Ebrahimi A. & Asadi M. (2009). Dairy Wastewater Treatment Using Three-Stage Rotating Biological Contactor (NRBC). School of Civil-Environmental Engineering, Babol Noshirvani University of Technology. Vol. **22**, No. 2, PP: 107-114.

3. Jin Hur, Bo-Mi Lee, Tae-Hwan Lee and Dae-Hee Park. 2010. Estimation of Biological Oxygen Demand and Chemical Oxygen Demand for Combined Sewer Systems Using Synchronous Fluorescence Spectra. Sensors, 10: 2460-2471.

4. Demirel, B., Yenigun, O., and Onay, T. T. (2005). Anaerobic treatment of dairy wastewaters: A review. *Process Biochem.* **40**: 2583–2595.

5. Prakash. K., VIMAL C., and INDRA D. (2011). An Overview of Various Technologies for the Treatment of Dairy Wastewaters. Department of Chemical Engineering, Indian Institute of Technology, India. Critical Reviews in Food Science and Nutrition, Vol. **51** PP:442–452

6. Carta-Escobar, F., Pereda-Marin, J., Alvarez-Mateos, P., Romero-Guzman, F., Duran-Barrantes, M. M., and Barriga-Mateos, F., (2004).Aerobic purification of dairy wastewater in continuous regime. Part I: Analysis of the biodegradation process in two reactor configurations. *Biochem. Eng. J.* **21**: 183–191.

7. Bharati S. and Shinkar. N (2013). Comparative Study of Various Treatments for Dairy Industry Wastewater. Journal of Engineering (IOSRJEN) Vol. **3**, Issue 8 ISSN: 2250-3021, pp-ISSN: 2278-8719

8. Silambarasan, T. Vikramathithan1, M. and Kalaichelvan P.T. (2012). Biological treatment of dairy effluent by microalgae. World Journal of Science and Technology 2(7):132-134.

9. Wang, T.; Liu, H. and Yen L (2013). Use of Anthropic Acclimated *Spirulina platensis* (*Arthrospira platensis*) Bio-adsorption in the Treatment of Swine Farm Wastewater. *Int. J. Agric. Biol*., 15: 107-112.

10. Ashish B, Monica B, Juhi P. (2012). Potential of Treated Dairy Waste Water for the Cultivation of Algae and Waste Water Treatment by Algae. Universal Journal of Environmental Research and Technology. Vol. **2**, Issue 1: 101-104

11. Oilgae, 2010 Oilgae Guide to Algae-based Wastewater Treatment: A Sample Report (April 2010).

12. Walter W. & Ann C. (2001). Growth of benthic freshwater algae on dairy manures. *Journal of Applied Phycology* **13:** 301–306, 2001.

13. Woertz, I.; Feffer, A.; Lundquist, T. and Nelson,y. (2000). Algae grown on dairy and municipal wastewater for simultaneous nutrient removal and lipid production for biofuel feedstock. Civil and Environmental Engineering Departmen, California Polytechnic Statet University, San Luis Obispo, CA 93407.

14. Kosaric, N., Nguyen, H. T. and Bergougnou, M. A. (2004), Growth of *Spirulina maxima* algae in effluents from secondary waste-water treatment plants. Biotechnol. Bioeng., 16: 881–896. doi: 10.1002/bit.260160703

15. Phang, S; Miah, M; Yeoh, B and Hashim, M. (2000) *Spirulina* cultivation in digested sago starch factory wastewater**.** Journal of Applied phycology . Vol. **12**, Issue 3-5, pp: 395 – 400.

16. Sara .R; Nitin. R; Mariam; Fatma .Q and Amal. S. (2012). Treatments of Industrials Wastewater by Using Microalgae. *International Conference on Environmental, Biomedical and Biotechnology*. Vol. **41**. PP: 217 -221.

17. American public health association (APHA). (1985). Standard method for examination of Water and Waste Water, 16th. Ed. New York

18. Lind, O.T. (1979). Handbook of common method in limnology. C.V. Mosby Co., St. Louis. 199 pp.

19. Parsons, T.R.; Mait, Y. and Laulli, C.M. (1984). A manual of chemical and biological methods for seawater analysis pergamone press Oxford.

20. American public Health Association (APHA) (2003) Standard method for the examination of water and wastewater 20th ed. Washington .Dc, USA

21. Velasco, A (2007).Evaluation of marine algae as a source of biogas in two stage anaerobic reactor system. *Biomass and Bioenergy*., Doi:10. 1016/ J. biombioe. 2007.10.005.

22. Christian. A; Senthil .C and Nagamani .B (2009) Anaerobic Co-digestion of Dairy Manure and Algal Biomass for Biogas Production.

23. Deependra .S, Ashish **B***;* Monica B and Juhi P (2012). Potential of Treated Dairy Waste Water for the Cultivation of Algae and Waste Water Treatment by Algae. Department of Microbiology, M.D.S. University, Ajmer (Rajasthan) India. Universal Journal of Environmental Research and Technology. Vol. **2**, Issue 1: 101-104.

24. Glantz, S.A. (2005). Primer of biostatics. 5th ed. P.208-310. Mac Graw, USA.

25. Graham, L.E. and Wilcox, L.W. (2000). Algae. Prentice-Hall, Inc. upper Suddle River, NJ07458. Wisconsin University.

26. Tang, E.P.; Vicent, W.F.; Proulx, D.; Lessard, P. and De la Noue, J. (1997). Polar cyanobacteria versus green algae for tertiary wastewater treatment in cool climates. J. Appl. Phycol., Vol. **9**, pp. 371-381.

27. Eric. j; Ryan .D and Craig .F .(2013) . Efficient Use of Algal Biomass Residues for Biopower Production with Nutrient Recycle: Final Project Report. Washington state university (wsu).

28. Reynold, C.S. (1984). The ecology of fresh water phytoplankton Cambridge Univ. press. Cambridge. pp. 384.

29. Delly, Fatima Abdul Hassan, Thaer Ibrahim, Fatima Chgat, hoping Abbas. (2001). The use of inorganic fertilizers in the production of the Mass alga Chlorella vulgaris. Journal of the Faculty of Education for Girls, pp. 512-507.

30. Mandalam, R.K. and Palsson, B. (1998). Elemental balancing of biomass and medium composition enhances growth capacity in high density *Chlorella vulgaris* cultures. Department of chemical engineering, Michigan University, Michigan.

31. Oh-Hama, T. and Miyachi, S. (1988). Algal culture systems. Microalgae biotechnology, Gambridge University Press, Cambridge.

32. Travieso, L.; Benitez, F.; Weiland, P.; Sanchez, E.; Dupeyron, R. and Dominguez, A.R. (1996). Experiments on immobilization of microalgae for nutrient removal in wastewater treatments. Bio resource technology, Vol. **55**, pp. 181-186.

33. Ghoreishi, S.M. and Haghighi, R. (2003). Chemical catalytic reaction and biological oxidation for treatment of non-biodegradable textile effluent. Journal of chemical engineering, Vol. **95**, pp. 163-169.

34. Chojnacka. K.; Chojnacki A. and Go´recka H. (2003). Trace element removal by *Spirulina* sp. from copper smelter and refinery effluents. Hydrometallurgy 73 (2004) 147–153.