TREATMENT OF FOOD-AGRO INDUSTRY EFFLUENT BY PHYSICO-CHEMICAL METHODS

A. Panhwar[1*], K. Faryal[2], A. Kandhro[3], N. Brohi[4], K. Ahmed[1] and M. Iqbal[1]

[1] PCSIR, Laboratories Complex, Karachi, Pakistan.
[2] Centre of Environmental Sciences, University of sindh Jamshoro, Pakistan.
[3] M.A. Kazi Institute of Chemistry, University of sindh Jamshoro, Pakistan.
[4] Institute of Microbiology, University of Sindh, Jamshoro, Pakistan.
[*] Corresponding Author Email:aijazap@yahoo.com

ABSTRACT: The sugar industry wastewater contains huge amount of pollutants. Different treatment methods for the effluent are available like biological, ion-exchange, electrocoagulation, ozonation, coagulation-flocculation and adsorption etc. Rapid development by industrialization in developing countries, less environment friendly measures cause of water pollution. This in turn, results in lack of quality for drinking and irrigation. Single treatment way is not feasible to treat the highly polluted effluent and not possible to manage the permissible limits of National Environmental Quality Standards which is getting more strict with passage of time, by the regulatory bodies like Pakistan Environmental Protection Agency in Pakistan. In this study the effluent was treated by coagulation followed by activated charcoal. Three coagulants, alum, ferric chloride and ferrous sulphate were applied. Using different doses of coagulants and activated charcoal achieved remarkable results. The total dissolved solids were decreased upto 87% and total suspended solids upto 98%.

Keywords: Activated carbon, Coagulants, Effluent, Sugarcane, TDS, TSS.

(Received 27.03.2020 Accepted 11.05.2020)

INTRODUCTION

Sugarcane is second largest cash crop grown in Pakistan. Sugarcane industry is the most important, organized industrial sector and second largest organized agro based industry. Agriculture sector of Pakistan play a vital role as its share is 18.9 percent to GDP and engaged around 42.3 percent of labor force in the economy. The crop was cultivated on 1.313 million hectares and 61,768 kilograms per hectare during 2018-19. Pakistan is 5th largest sugarcane producing country with 81.102 million ton in the world (Survey, 2018-19). Basically sugarcane is seasonal industry and operates around 120-180 days per year (November-April). Today there are 89 sugarcane mills are effectively working, out of which 45 are in functional in Punjab, 37 in Sindh and 7 in KPK. Industrial pollution especially industrial wastewater is not only national level issue, it has becomes now an international issue especially wastewater in developing countries. It deteriorates water quality. Industries are very largest source of the development in any country as well as source of well living standard. Wastewater is a serious issue by this industry and biggest threats to our environment. Sugarcane industry consume around 1,500-2,000 litres of water and generate about 1,000 litres of wastewater per tonne of cane crushed (Suman and Capoor, 2018). The wastewater from sugarcane industry contains high level of contaminants such as, suspended solids, organic, inorganic matter and chemicals. Most chemicals used in sugar processing are toxic; if not well treated might ultimately find their course into the streams which make poor quality of fresh water bodies (Moses, *et al*, 2010). Considerably huge quantity of waste is produced throughout the manufacturing process of sugar. The process contains a huge quantity of pollution, mostly suspended solids, organic matter, and press mud, bagasse and air pollutants. A number of chemicals are using in sugarcane industries especially for coagulation of impurities and refining of end products. Ca (OH) 2 is used to make clear and to increase pH of juice. A minor amount of H3PO4 is also added prior to liming to develop clarification (Kushwaha 2015). Release of effluent comprises of total dissolved solids high level, have an adverse impact on aquatic life, as well as make water unfit for drinking and domestic purposes, also reduction in crop production, if used untreated for irrigation. It may cause of corrosion in pipe and water schemes (Brady and Well 2002). Huge amount of suspended solids can cause problems including health and aquatic life. High amount of TSS in any water body is also source of higher concentrations of bacteria, nutrients, pesticides, and metals. The effluent often generates odor and dust, which need to be controlled. If sugarcane industry's effluent not treated properly, it may cause of unpleasant odor while discharged into the surface water bodies (Baraniya and Jodhi, 2018).

Table 1. Sugarcane production in major countries (FAO, 2013).

Countries	Area Cultivated (million ha)	Annual production (million ton)	Average production (ton/hac)
Brazil	8.14	648	79.7
India	5.06	348	68.9
China	1.71	124	73.1
Pakistan	1.24	64	51.5
Thailand	1.05	73	69.7
Mexico	0.67	51	76.4
Colombia	0.38	39	100.4
Australia	0.39	34	87.1
South Africa	0.43	21	48.2
Cuba	0.38	16	41.3

MATERIAL AND METHODS

The purpose of the work is to determination of the physico-chemical parameters, TDS, TSS, characteristics of the effluent. The second and important part of the research work to treat the industrial effluent. Wastewater samples from ten different sugarcane industries (01Litre each; replicated 3x) were collected from ten different sugarcane industries from their discharging point.

Instruments, Chemical reagents and Glasswares: Analysis of total dissolved solids (TDS) was carried out by immersing the meter probe in sample. Throughout the experiment, the sample was stirred vigorously using glass stirring rod. Then observed results were noted. While TSS level in the collected water samples was determined using gravimetric method. Plastic and glasswares were cleaned by soaking in 2M of HNO3 solution for overnight. Different sizes of beakers & flasks (volumetric & conical) pipettes, burettes, cylinders etc.

Sampling and its preparation: The effluent samples were collected in cleaned plastic bottles from the point of their discharge and subjected to physico- chemical parameters by using standard procedures. As per moral obligation with the managements of the industries owners, the details are not mentioned in this paper. Standard protocols/procedures have been used for the collection, transportation, storage and chemical analysis of the samples. The samples were collected in air tight plastic sampling bottles and placed in an icebox to preserve the inherent characteristics of the effluents (Panhwar *et al*., 2019).

Experimental method: Measured wastewater 1000 ml was taken in a capacity of 2 liter beaker. Alum, ferric chloride and ferrous sulphate were added as 100 mg, 200 mg and 400 mg, to the samples. Stirring was done by using magnetic stirrer followed by sedimentation and filtered after settling, using watmann 42 filter paper (Panhwar *et al*., 2020).

Statistical analysis: All experimental data were examined in triplicate and calculations (mean+std) were done by Excel.

Software used: MS Office Excel software used for results

RESULTS AND DISCUSSION

Treatment Methods: There are numerous physical and chemical methods for the removal of contamination from industries wastewater, including chemical coagulation, adsorption, ion exchange, reverse osmosis and electrodialysis. Among all these methods the *c*hemical coagulation and adsorption methods are very effective and widely used for industries wastewater treatment including sugar wastewater.

Selection of Coagulants*:* It is very important to select coagulants for the treatment of sugarcane industry effluent, which is a significant step for the study. Numerous research studies have been reported on the analysis of coagulation–flocculation for the treatment of sugarcane industry effluent, their performance optimization, i.e. selection of the best suitable coagulant, determination of experimental conditions, and evaluation of pH effects and study of flocculants addition (Holt *et al.*, 2002).

Chemical coagulation: Treatment was carried out for the efficiency of various coagulants and dosing the samples with a range of various coagulants in different concentrations of 100, 200 and 400 mg/l. The coagulation performed by mixing one liter of wastewater samples. After the addition of chemicals (alum, ferric chloride and ferrous sulphate) the wastewater was rapidly stirred at 200 rpm for five minute, 150 rpm for twenty five minutes and then slowly stirred at 80 rpm for more 30 minutes. The wastewater was then allowed to settle for 60 minutes and then filtered by watsman 42 paper. After filtration, the samples were analysed. The best results were achieved by using dose of 200 mg/l. (Panhwar *et al*., 2020).

Column experiment by adsorption: Once achievement by coagulation experimentation, the column/adsorption study was done with dose of 5g on laboratory scale. Experiments were carried out in glass column having 75 cm length and 2.75 diameters (Panhwar *et al*., 2020). Adsorbent was filled in the column and at the top and bottom glass beds were filled for the supporting purpose, at flow rate 1000 ml/60minutes (Patel and Painter, 2017).

It is fact that substantial level production of wastewater during sugar production process. This contains organic material and toxic metals, which causes pollute our surface and groundwater as well as fertile soil. The high concentration of total suspended solids can affects the aquatic life as well as creates problems for human health. The high intensity of total suspended solids may block the photosynthesis process, which is threat to plants. The high level amount of TDS from the sugar mills creates problems including reduces soil fertility and crop production.

Table 2. Results before and after chemical coagulation (n=3 mg/L).

Parameters	Before Treatment	Alum	Ferric chloride	Ferrous sulphate
TDS	2630	1640	1716	1801
TSS	401	18	29	38

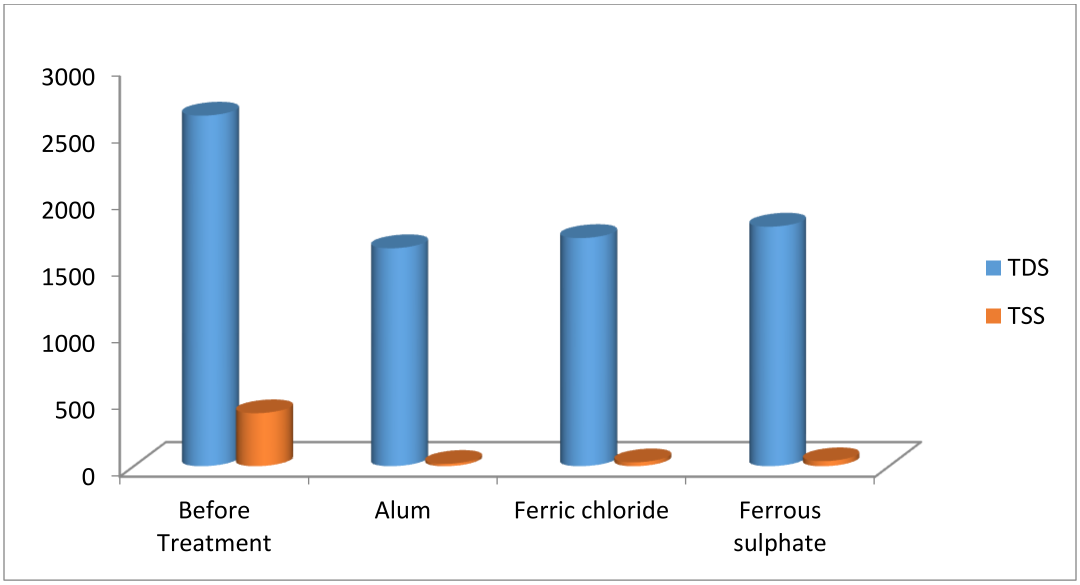

Figure 1. Results before and after chemical coagulation

Effects of alum concentration: By using alum concentration, removal efficiencies for total dissolved solids, total suspended solids were noted 1640, 18 mg/l, respectively.

Effects of ferric chloride concentration: With using same concentration of ferric chloride, removal the results for total dissolved solids, total suspended solids were noted 1716, 29 mg/l, respectively.

Effects of ferrous sulphate concentration: After using ferrous sulphate concentration, the removal efficiency of total dissolved solids, total suspended solids were 1801, 38 mg/l, respectively with ferrous sulphate.

Table 3. Treatment results with activated carbon (n=3 mg/L).

Parameters	Alum+AC	Ferric chloride+AC	Ferrous sulphate+AC
TDS	324	321	341
TSS	06	12	18

Effects of activated carbon: After chemical coagulation with different coagulants, the samples were further treated by column study with activated charcoal. Activated carbon proved more effective for the removal of contamination including inorganic pollutant. The samples were treated with activated charcoal, and results found satisfactory. The result of sample no. 1 showed 324, 26 of total dissolved solids and total suspended solids respectively. The results of sample No.2 were noted 321, 12 mg/l respectively, while the results of sample No. 3 were noted 341, 18 mg/l for TDS and TSS respectively.

Comparative study with reported research work: The wastewater from Sugarcane industry is not only responsible for degrade surface water body, fertile soil but also responsible for groundwater pollution. Hence, it was revealed that it is a great threat to our environment, if effluent directly released into irrigation and drainage network, ultimately reason for toxicity of surface and groundwater quality as well as for aquatic life and ecological habitat. It was also advised that treated effluent from Sugarcane industries may dilute with fresh water which may be suitable for irrigation as well as reuse for industrial processing (Qureshi *et al*., 2015). 04 g/l of activated carbon (in first group) reduced the total dissolved solids with 92.86% efficiency of elimination. The system achieved TSS removal efficiency of 88.97%. Increasing the activated carbon dosage to 6 g/l in the second group raised the TDS removal efficiency to 93.91%. The removal efficiency of TSS was raised upto 90.21%. In the third group the average concentration of TDS in the influent sample was about hundred percent high comparing to the second group. In brief, it can be said that using activated carbon is more effective in removing TDS (Saleh *et al*., 2015). Total suspended solids of treated samples and got results from 15500 mg/L in untreated and only 200 mg/L in the treated water at dosage of 1-10 g of alum, which represented mean percentage efficiency of 13.33%, 26.66%, 33.33%, 40%, 46.66%, 67.74%, 80.64%, 86.66%, 93.33% and 98.70% (Mbaeze *et al*., 2017).

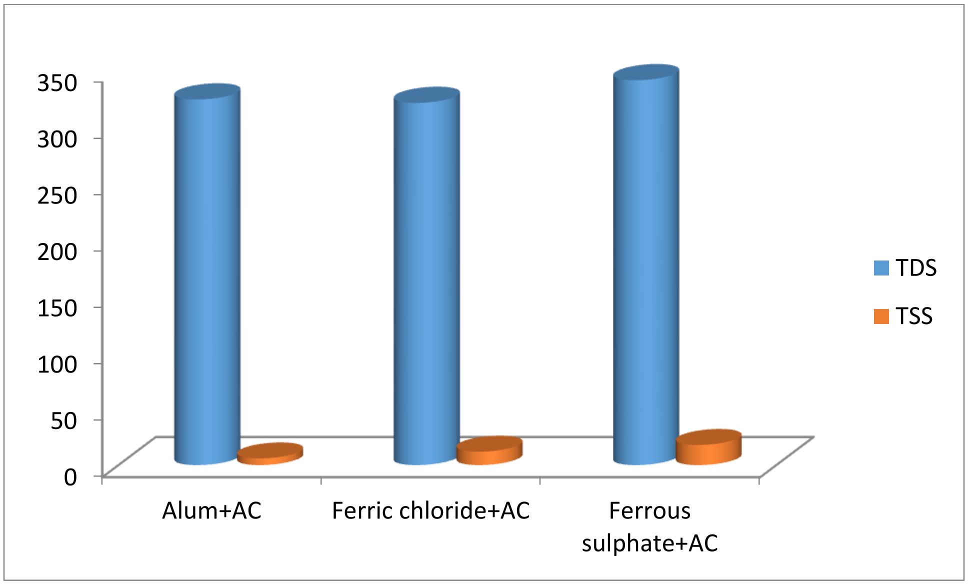

Figure 2. Treatment results with activated carbon

Conclusion: The results shows that waste water discharged from different sugar industries is highly polluted and exceeds the prescribed NEQS limits for irrigation, discharge in sewage lines and public use, it is clearly shows that, without proper treatment the industrial wastewater cannot be used for both purposes. Three common coagulants were used for chemical coagulation. The conclusion of this work showed that total dissolved solids and total suspended solids were effectively removed at coagulant dose of 200 mg/l. Coagulation process using alum, ferric chloride and ferrous sulphate were more effective for removing of the contamination at different concentrations. The contamination of the samples did not decrease when more quantity of coagulants used and best results achieved using 200 mg/l in all three coagulants. As comparison between coagulants the alum has greater removal efficiency than the rest of coagulants used. Hence, the use combination of alum and activated carbon can reduce the contamination from sugarcane industry effectively. Using different doses of coagulants and activated charcoal achieved remarkable results. The total dissolved solids were decreased upto 87% and total suspended solids upto 98%. In Pakistan mostly sugarcane industries are using biological treatment process, which is time consuming and occupy more space. The tertiary treatment like adsorption using activated carbon is need of hour. After tertiary treatment with activated carbon, the treated water can be utilized for the irrigation purpose.

REFERENCES

Baraniya and Dr. Jodhi. (2018). A Study on the Physico-Chemical Characteristics of Sugar Mills Effluents. International Journal of Advance Engineering and Research Development. 5 (03): 509-516.

FAO, Food and Agriculture Organization of United Nations (2013) http://www.fao.org/statistics/en/(accessed on 01.09.2014).

K, P. Holt., Barton, G. W., Wark, M., and Mitchell, C. A., (2002). A Quantitative Comparison between Chemical Dosing and Electrocoagulation, Colloids and Surfaces. A: Physicochemical Engineering Aspects. 211 (2–3): 233-248.

MC, Mbaeze, Agbazue VE, Orjioke NM (2017) Comparative Assessment of Performance of Aluminium Sulphate (Alum) and Ferrous Sulphate as Coagulants in Water Treatment. Mod Chem Appl 5: 233. doi: 10.4172/2329-6798.1000233.

Moses, A. N., N. N. Destaings, N. E. Masinde, and J. B. Miima, (2010). Effluent discharge by Mumias Sugar Company in Kenya: An empirical investigation of the pollution of River Nzoia. Sacha Journal Environmental Studies. 01 (01): 1-30.

N.C, Brady., and Well, R.R. (2002). The Nature and Properties of Soils. 12th Edition, Pearson Education Inc., (New Delhi). 42-43.

Pakistan Economic Survey report, (2018-19).

Panhwar, Aijaz., Aftab Kandhro, Nusrat Jalbani, Khalida Faryal, M. Saffar Mirjat, Gulzar H. Jhatial, Sofia Qaiser. (2019). Assessment of Groundwater Quality Affected by Open Dumping Site in Hyderabad Pakistan. International Journal of Environmental Chemistry. 5 (1): 49-59.

Panhwar, Aijaz ., Dr. Khalida Faryal, Dr. Aftab Kandhro, Kamran Ahmed, Mansoor Iqbal (2020). Chemical Treatment of Sugarcane Industry Effluent. Journal of Chemical, Biological and Physical Sciences. 10 (2): 221-227.

Patel, Dhaval and Prof. Z.Z.Painter (2017). Batch and Column Study for Treatment of Sugar Industry Effluent by Using Low-cost Adsorbent. IJARIIE. 3 (3): 26-33.

Prakash, Jai Kushwaha. (2015) A review on sugar industry wastewater: sources, treatment technologies, and reuse, Desalination and Water Treatment. 53 (2): 309-318, DOI: 10.1080/19443994.2013.838526.

Prakash, Suman. and Ajay Capoor (2018). Sugar Mill Effluent Induced Histological Changes in Kidney of Channa punctatus. Journal of Advanced Laboratory Research in Biology. 9 (1): 32-35.

Qureshi, Abdul Latif., Ali Asghar Mahessar, Muhammad Ehsan-Ul-Haq Leghari, Bakhshal Khan Lashari, and Fateh Muhammad Mari (2015). Impact of Releasing Wastewater of Sugar Industries into Drainage System of LBOD, Sindh, Pakistan. International Journal of Environmental Science and Development. 6 (5): 381-386.

Saleh, Y. Mamdouh., Gaber El Enany, Medhat H. Elzahar, Moustafa H. Omran. Industrial Wastewater Treatment Improvements Using Activated Carbon. International Conference on Energy, Ecology, Environment and Sustainable Development at: Miami, USA. March 2015.