Adsorption Studies for Organic Matter Removal from Wastewater by Using Bagasse Flyash in Batch and Column Operations

Sunil J. Kulkarni[1], Ajaygiri K. Goswami[2]

[1] Datta Meghe College of Engineering, Airoli, Navi Mumbai, Maharashtra, India

[2]University Institute of Chemical Technology, Jalgaon, Maharashtra, India

Abstract: ***The affordable and effective treatment of wastewater is critical issue for the developing countries. Various conventional treatment techniques; both biological and nonbiological are being tried. Disposal of domestic sewage of about 29000 MLD from cities and towns is a biggest source of pollution of water bodies in India. Chemical oxygen demand is the amount of oxygen required for the organic matter for its chemical decomposition and BOD is the amount of oxygen required for the biological decomposition. In the present work attempt is done to minimize the pollution parameters like COD, BOD by using bagasse flyash in batch and column operation. It has been observed that 90-95 % removal of organic matter can be obtained by using bagasse flyash. Also optimum values adsorbent doses; contact time and pH were obtained. These values were found to be 2 grams, 100 minutes and 6 respectively.***

Keywords: Disposal of sewage, COD, BOD, Batch and column operation, Fly ash

1. Introduction

Affordable and effective domestic wastewater treatment is a critical issue in public health and disease prevention around the world, particularly so in developing countries which often lack the financial and technical resources necessary for proper treatment facilities. Disposal of domestic sewage of about 29000 MLD from cities and towns is the biggest source of pollution of water bodies in India. A large number of rivers stretches are severely polluted as a result of discharge of domestic sewage. Treatment of domestic sewage and subsequent utilization of treated sewage for irrigation can prevent pollution of water bodies, reduce the demand for fresh water in irrigation sector and result in huge savings in terms of nutritional value of sewage in irrigation. It has been estimated that 70 per cent of the water pollution in the state of Maharashtra is due to domestic sewage.

Chemical oxygen demand is the amount of oxygen required for the organic matter for its chemical decomposition and BOD is the amount of oxygen required for the biological decomposition. Various methods have been tried for organic matter removal of wastewater. A review on anaerobic treatments for domestic and industrial was carried out by Chan et.al. According to him high rate anaerobic–aerobic bioreactors have been increasingly employed for wastewaters with high chemical oxygen demand. [1]. A bioassay using the luminescent bacterium Vibrio-qinghaiensis associated with solid-phase extraction (SPE) was developed for evaluating the variation of ecotoxicity along with the reduction of organic substances in a domestic wastewater treatment plant employing an oxidation ditch process by Ma and Wang.[2]. Short- and long-term effects of temperature on partial nitrification in a sequencing batch reactor treating domestic wastewater were studied by Guo et.al.[3]. Treatment of municipal solid wastes leachate by means of chemical and electro-coagulation was carried out by Veli et. al.[4] Reduction of COD and color of dyeing effluent from a cotton textile mill by adsorption onto bamboo-based activated carbon was carried out by Ahmad and Hameed. [5].

Treatment of wastewater by using the adsorption derived from agricultural waste was carried out by Mohan et. al.[6]. COD and BOD reduction from coffee processing wastewater using Avacado peel carbon was carried out by Devi et.al.[7]. Treatment of domestic wastewater by using a microaerobic membrane bioreactor was tried by Chu et.al.[8]. Removal of refractory compounds from stabilized landfill leachate using an integrated H_2O_2 oxidation and granular activated carbon (GAC) adsorption treatment carried out by Kurniawan and Lo [9]. Treatment of municipal wastewater using laterite-based constructed soil filter was tried by Kadam et.al. [10].

The aim of the current study is to demonstrate the use of bagasse flyash as an adsorbent for purifying the wastewater. The effects of contact time, adsorbent dose and pH on the adsorption are also studied and optimum values of these parameters were reported. A packed column study was also carried out to estimate ideal adsorption time. The ideal adsorption time is the time when the ratio of final to initial concentration of the effluent for a column reaches 0.5. COD and BOD were measured as indicator parameters of water quality.

2. Methodology

For carrying out batch operation, 100 ml of effluent was taken in a 300 ml beaker and adsorbent was added to it. It was kept on shaker for required time depending on the batch and filtered with Whitman filter paper. The COD and BOD of the samples were also found experimentally. For column operation, on lab scale a column of diameter 5.3 cm and height of 100 cm was taken. Bagasse flyash and sand were mixed in 1:1 proportion and filled in packed column. Before charging the material in the bed, a sand filter was prepared at the bottom of the column and above that the packing material was charged. The effluent was allowed to flow by gravity through the bed. The flow was controlled by using needle valve. Treated effluent was collected at the bottom and analyzed.

3. Results and Discussion

3.1 Effect of Adsorbent Dose

Figure 1 shows the effect of adsorbent dose on COD. Various amounts of adsorbents were taken in a 100 ml conical flasks ranging from 0.5 to 5 grams and kept on sieve shaker for 90 minutes. These samples ware filtered and analyzed. It was observed from the figure that COD decreases sharply up to adsorbent dose of 2 grams. This is because of the fact that increasing adsorbent dosage increases surface area for adsorption. Further increase in the adsorbent dose does not affect the COD. It may be because of the fact that high amount of adsorbent sites may not come properly in contact of adsorbate. A 2 grams/100 ml is found to be optimum dose.

Figure 1 shows the effect of adsorbent dose on COD. Various amounts of adsorbents were taken in a 100 ml conical flasks ranging from 0.5 to 5 grams and kept on sieve shaker for 90 minutes. These samples ware filtered and analyzed. It was observed from the figure that COD decreases sharply up to adsorbent dose of 2 grams. This is because of the fact that increasing adsorbent dosage increases surface area for adsorption. Further increase in the adsorbent dose does not affect the COD. It may be because of the fact that high amount of adsorbent sites may not come properly in contact of adsorbate. A 2 grams/100 ml is found to be optimum dose.

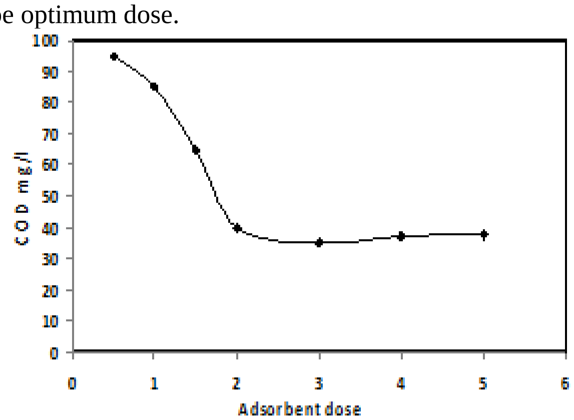

Figure 1: Effect of Adsorbent Dose

3.2 Effect of Contact Time

Figure 2 shows the effect of contact time on COD. For studying this effect, 100 ml of the effluent was taken in 300 ml conical flak. The adsorbent dose of 2 grams was taken. The samples were kept on shakers. They were analyzed after each half an hour's interval. The decrease in COD is significant up to contact time of 100 minutes. After that the COD remains almost constant. This may be due to the attainment of equilibrium between the adsorbent and adsorbate. So 100 minutes contact time and 2 grams of the adsorbent dose are the optimum parameters.

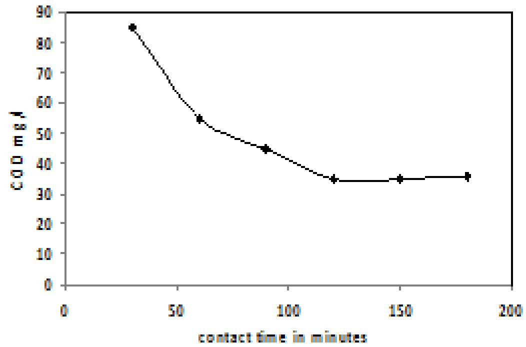

Figure 2: Effect of Contact Time

3.3 Effect of pH

Figure 3 shows the effect of pH on COD. The optimum pH was found to be 6 for the adsorption purpose. Adsorption phenomenon is analogous to ion exchange process. The pH of the aqueous solution has significant effect on adsorption by the adsorbent. The pH of the solution also influences the actives sites and therefore, the solution chemistry.

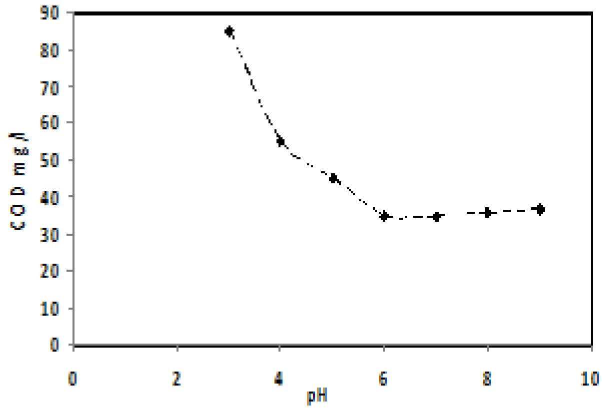

Figure 3: Effect of pH

3.4 Continuous Column Operation

For carrying out column operation, the adsorbent mixed with sand was filled up to 60 cm height in the column. The average adsorbent particle size was 0.181 mm and that of sand was 4.75 mm. The average particle size was 2.46 mm. The flow rate was adjusted to avoid the buildup of effluent in the column. It was 60 ml/minute .The pH of the effluent was kept at 6. The effluent samples were collected at 20 minutes interval for analysis Figure 4 shows variation in COD and BOD at various time intervals for the column operation.

It is observed from this figure that the COD and BOD increases rapidly 200 minutes and further increase becomes insignificant, It reaches the values of 170 mg/l and 86 mg/l after time interval of 300 min. Ideal adsorption time is 200 minutes, considering BOD and COD as the inlet and outlet parameters.

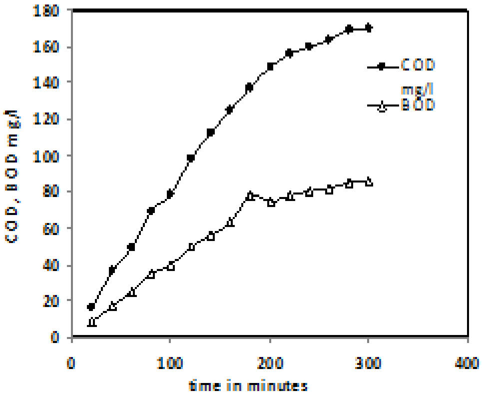

Figure 4: Variation of outlet COD and BOD with time for packed column

4. Regeneration and Disposal of Flyash

Regeneration can be carried out by chemical, thermal, solvant and biological methods. In thermal regeneration adsorbent is heated in multihearth furnace in the presence of steam, to volatilize and carbonize sorbed material. The char residue is then activated. Generally regeneration methods other than thermal will not be effective if a mixture of organics has been adsorbed. Only a portion of sorbed materials will be removed by a given solvant, hot gas, chemical or biologic regeneration procedure.Therefore performance of adsorbent will consistently decrease on successive regenerations, and after few regenerations, the adsorbent usually has to be discarded. Thermal regeneration is most versatile, and because most granular carbon treatment systems remove a complex mixture of organics, it is far the most widely used.Disposal of flyash is a universal problem. Flyash that is obtained after using in effluent treatment plant for removal of organic matter is obviously rich in organic content. At present flyash is disposed in the form of slurry in flyash ponds. The major environmental concern from flyash discharge and disposal is organic pollution of surface and ground water. Even dumping of flyash creates similar problem.Flyash precipitated from air by rain finds their way to the surface water unless flyash ponds are properly sealed. These efforts are made to utilize flyash in productive methods as pozzolona in making of cement, raw materials for making bricks, treatment of sewage and polluted water, fire resistant materials, insulation materials, raw material for glass etc. There is scope for development of effective disposal systems for flyash. Controlled disposal of flyash in stack and its disposal on ground is recommended.

5. Conclusion

The results of present investigation show that, the bagasse flyash has been found to be an effective adsorbent for the removal of organic matter from the effluent. Although higher doses of bagasse flyash are required for the COD and BOD removal, the operation is feasible because of low cost of bagasse flyash. In the column operation 92-95 % COD removal is observed. Further for more effective operation adsorption column in series can be used. Pressure drops are quite high in Bagasse flyash column. For reducing pressure drop bagasse flyash can be used in the form of small pellets. Also bagasse flyash of larger size can be used.

References

[1] Yi Jing Chan, Mei Fong Chong, Chung Lim Law, D.G. Hassell "A review on anaerobic–aerobic treatment of industrial and municipal wastewater", Chemical Engineering Journal, LCV(1), pp. 1-18.,2011

[2] Xiaoyan Y. Ma, Xiaochang C. Wang, Yongjun J. Liu "Study of the variation of ecotoxicity at different stages of domestic wastewater treatment using Vibrioqinghaiensis p.Q67",Journal of Hazardous Materials, LCXXXX(1-3), pp.100-105,2011.

[3] Jianhua Guo, Yongzhen Peng, Huijun Huang, Shuying Wang, Shijian Ge, Jingrong Zhang, Zhongwei Wang " Short- and long-term effects of temperature on partial nitrification in a sequencing batch reactor treating domestic wastewater",Journal of Hazardous Materials, LCXXVIII(1-3), pp.471-479,2010.

[4] Sevil Veli, Tuba Ozturk, Anatoly Dimoglo "Treatment of municipal solid wastes leachate by means of chemical and electrocoagulation Separation and Purification Technology", CI,(1), pp. 82-88,2008.

[5] A.A. Ahmad, B.H. Hameed "Reduction of COD and color of dyeing effluent from a cotton textile mill by adsorption onto bamboo-based activated carbon Journal of Hazardous Materials", LCXXII(2-3),pp.1538-1543,2009.

[6] Dinesh Mohan, Kunwar P. Singh, Vinod K. Singh Wastewater treatment using low cost activated carbons derived from agricultural byproducts—A case study",Journal of Hazardous Materials", LCII(3), pp.1045-1053,2008.

[7] Rani Devi,Vijender Singh, Ashok Kumar "COD and BOD reduction from coffee processing wastewater using Avacado peel carbon Bioresource Technology, CXXXXVIII(1), pp. 1853-1860,2008.

[8] Libing Chu, Xingwen Zhang, Fenglin Yang, Xiaohui Li "Treatment of domestic wastewater by using a microaerobic membrane bioreactor" Desalination, LCXXXXVIIII, pp.181-192, 2006.

[9] Tonni Agustiono Kurniawan, Wai-hung Lo "Removal of refractory compounds from stabilized landfill leachate using an integrated H_2O_2 oxidation and granular activated carbon (GAC) adsorption treatment", Water Research, XXXXIII(6),pp.4079-4091,2009.

[10] Avinash M. Kadam, Pravin D. Nemade, G.H. Oza, H.S. Shankar "Treatment of municipal wastewater using laterite-based constructed soil filter" , Ecological Engineering, XXXV(7),pp.1051-1061,2009.

Author Profile

Mr. Sunil J. Kulkarni has completed his Masters in Chemical Engineering from Tatyasaheb Kore Institute of Engineering and Technology, Warananagar. He is working as Assistant Professor in Chemical Engineering Department of Datta Meghe College of Engineering, Airoli, Navi Mumbai, India. He has published 10 international review and research papers and presented 15 research papers in international conferences. His area of research includes adsorption, heat transfer augmentation, environmental engineering. He is member of many professional bodies such as ISTE (Indian Society of Technical Education). He is on the reviewer board of many international journals and reviewed many international papers.

Mr. Ajayagiri Goswami has completed his Masters in Chemical Technology from Nagpur University. He has presented and published more than 15 international research papers. His area of interest includes biodiesel and process control. He has about 16 years of teaching experience and working on various academic and regulatory committees in north Maharashtra University.