Treatment of food industry wastewater by using activated carbon prepared from waste coconut shell

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Introduction

The environmental pollution is becoming the most challenging threat to the human beings as a result of rapid industrialization and growth population throughout the world. Mostly the areas situated around industrial belts are under stress due to the continuous disposal of the untreated wastes from the various industries (Venkatareddy B.Koppad,*et al*. 2014).Amongst these industries, food industries are major contributors of water and soil pollution. The wastewater from the food industries mainly comprise of high chemical oxygen demand (COD), large amounts of solids, high temperature, considerably amount of nutrients, animal fats and broadly fluctuating of pH. (Mohamed Naizh Abdallh, et al. 2016). Therefore, adequate treatment of food industry effluent is essential before discharging to receiving water bodies and land.

Amongst the various wastewater treatment process, activated carbon adsorption is one of the preferred options to remove organic and inorganic contaminants from industrial wastewater. Activated carbon is a fine black odourless and tasteless powder made from wood or other materials such as refinery residuals, peat, coal, coke, pitches, carbon blacks and nutshells. In recent years, a number of agricultural waste and by-products of cellulosic origin such as bagasse, palm kernel shell, coconut shell, and maize cob have been used as raw materials for production of activated carbon. The use of locally available waste materials for treatment of wastewater is one of the excellent strategies of sustaining economic growth while protecting the environment.

In this work, three different types of food industry wastewater (bakery wastewater, sauce processing wastewater and fish and meat processing wastewater) were treated with activated carbon prepared from local agricultural waste (coconut shell). The effectiveness of coconut shell activated carbon in the removal of organic pollutants in different food industry wastewater were investigated. The effect of process variables such as carbonization temperature, concentration of zinc chloride solution, activation temperature on the production and quality of activated carbon was studied.

Material and Methods

Preparation of Coconut Shell Activated Carbon: Waste coconut shells were collected from Kamaryut market. Raw coconut shells were broken up into pieces and washed thoroughly with water to remove fibers and all impurities and dried in an oven at 110°C for 24 hr. After that they were burnt in a Muffle furnace at 300°C and 350°C for 1 hr. They were then impregnated with zinc chloride solution for 1 hr and 24 hr. The impregnated coconut shell were burnt in a Muffle furnace at 300°C , 350°C, 400°C and 500°C for 1 hr and after that they were washed with 1%HCl solution and distilled water. The prepared activated carbon are ground finely and they are ready to use as adsorbents for wastewater treatment. The prepared activated carbon samples are observed by scanning electron microscopy at University Research Center, Yangon University to know their porous structure.

Treatment of Food Industry Wastewater by using prepared Activated Carbon: Wastewater samples were collected from Bakery factory, Hlaing Tharyar Industrial zone, Sauce processing industry, South Dagon Industrial zone, and Fish and meat processing factory, Dagon Seikkan Industrial zone. The characteristics of raw and treated wastewater samples are analyzed at Environmental engineering laboratory, Yangon Technological University. The wastewater contains certain amount of fats and suspended matters therefore plain sedimentation was carried out to remove them before conducting adsorption experiments.

The experiments were carried out in batch mode for measurement of adsorption capacities. Different amount of adsorbents (coconut shell activated carbon) were used for the treatment of wastewater. At different dosage of adsorbents and using fixed COD concentration of wastewater, equilibrium concentrations were obtained at equilibrium contact time, sometimes many hours to one week without agitation. In another experiment, the select amount of activated carbon was placed in 500mL beaker containing 400 ml of wastewater. The beaker was agitated continuously at different temperatures till equilibrium condition was achieved. Aliquots of 10 mL was pipetted out at time intervals. The contents were centrifuged and COD concentrations were measured.

Results and Conclusions

Prepared activated carbon sample A,B,C,D and E were observed by scanning electron microscopy. Sample F turned into ash because of higher temperature. In comparison of sample A and B, the higher temperature gives more porous structure. By observing SEM of sample C, D and E, high ratio of zinc chloride to activated carbon is favourable to produce richer pore structure. The higher ratio of zinc chloride to activated carbon, the longer impregnation time and the higher temperature gives the better porous structure. Therefore sample E was chosen for treatment of wastewater.

According to the results from adsorption experiments, the rate of adsorption increase with increase in adsorbent dosage because of increase in surface area of adsorbent. It was also observed that the contact time had greater impact on COD removal. Generally, the rate of adsorption increases with time and remains constant after some time due to equilibrium conditions. COD removal efficiency was increased significantly with increasing temperature. It is possible that prepared activated carbon undergoes opening of pores at higher temperatures. Adsorption efficiency depends on the characteristics of wastewater. COD removal efficiency was better in treating sauce processing wastewater than bakery and fish and meat processing wastewater. It is possible that fat molecules contained in bakery and fish and meat processing wastewater may block pores of activated carbon.

Table 1.1 Preparation of Coconut Shell Activated Carbon

Sample No	Burning before impregnated with $ZnCl_2$.	Weight ratio of $ZnCl_2$ to Activated Carbon	Impregnating Time	Burning after impregnated with $ZnCl_2$.
A	300°C for 1 hr	1:1	1 hr	300°C for 1 hr
B	350°C for 1 hr	1:1	1 hr	350°C for 1 hr
C	-	1:4	24 hr	400°C for 1 hr
D	-	1:2	24 hr	400°C for 1 hr
E	-	3:4	24 hr	400°C for 1 hr
F	-	3:4	24 hr	500°C for 1 hr

Table 1.2 Batch Adsorption results of treatment of wastewater by using prepared activated carbon. (volume of wastewater = 200mL)

Bakery wastewater (Initial COD concentration = 3200mg/L)			Sauce processing wastewater (Initial COD concentration = 3840mg/L)			Fish and meat processing wastewater (Initial COD concentration = 3180mg/L)		
Mass of AC(g)	Equilibrium COD conc: (mg/L)	COD removal %	Mass of AC(g)	Equilibrium COD conc: (mg/L)	COD removal %	Mass of AC(g)	Equilibrium COD conc: (mg/L)	COD removal %
1	2590	19.06	0.5	1550	59.63	1	2050	35.5
2	2420	24.38	1	1280	66.67	2	1820	42.77
3	2360	26.25	1.5	960	75	3	1340	57.86
4	2220	30.63	2	640	83.33	4	980	69.18
5	2100	34.38	2.5	420	89.1	5	880	72.33

Table 1.3 Experimental results of adsorption of food industry wastewater by the prepared activated carbon at different temperature. (volume of wastewater =400mL, rpm=300)

Bakery wastewater (Initial COD conc: = 2680mg/L, Mass of AC= 10 g)			Sauce processing wastewater (Initial COD conc: = 3360mg/L, Mass of AC= 1 g)			Fish and meat processing wastewater (Initial COD conc: = 3450mg/L Mass of AC=3g)		
Time (min)	COD removal % at 100°C	COD removal % at 200°C	Time (min)	COD removal % at 100°C	COD removal % at 200°C	Time (min)	COD removal % at 100°C	COD removal % at 200°C
30	3.73	8.34	15	16.35	18.29	15	15.94	18.55
60	10.45	24.25	30	28.57	39	30	22.32	28.1
90	17.54	32.1	45	43.75	50	45	35.9	42.6
120	23.5	40.3	60	57.14	71.43	60	43.2	49
150	29.1	47.34	90	64.29	84.83	90	54.2	64.9
180	28.35	47.76	120	71.13	89.9	120	64.6	73.3
-			150	71.43	89.9	150	73.6	77.4

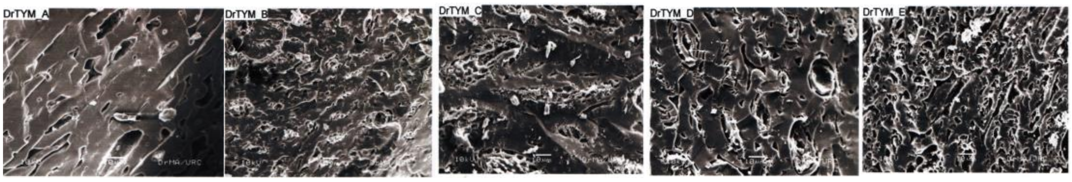

Figure 1.1 Scanning electron micrograph (SEM) of prepared activated carbon.

References

Venkatareddy B.Koppad (2014), Development of isotherms to evaluate removal of dyes using adsorbents. *The International Journal of Science & Technoledge.,* **2**(6), 116–124.

Mohamed Nazih Abdallh (2016), Industrial wastewater treatment of food industry using best techniques. *International Journal of Engineering and Science Invention.,* **5**(8), 15–28.

Rahman M.A, Asadullah M (2006), Preparation and characterization of activated charcoal as an adsorbent. *Journal of Surface Sci. Technol*., **22**(3-4), 133-140

Mantell C.S (1951), Adsorption in Chemical Engineering Series. 2nd Ed. McGrawHill Book Co.,Inc.,

John W.Hassler (1974), Purification with Activated Carbon: Industrial, Commercial, Environmental. Chemical Publishing Co.,Inc. New York, N.Y.