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Usage of Palm Wastes Fiber In Removing Heavy Metals From Wastewater

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ABSTRACT

The problem of the environmental pollution is created by the continuous and accelerated disposal of wastes. One of the main contaminate is the industrial wastewater. Most of industrial wastewater contains high concentration of toxic heavy metals. In this study, the adsorption method using raw agricultural wastes (palm waste fiber) to remove heavy metals Zn^{+2} and Cr(VI) from industrial wastewater was made. The obtained removal ratios using palm waste fiber were 93.67%, 89.20% for Zn^{+2} and Cr(VI), respectively. The result showed that, the removal efficiency increased by increasing the adsorption contact time, and the flow rate were decreased. It also showed that, the removal efficiency for zinc better than Cr(VI) using palm waste fiber. The success of use the cheap adsorbent as adsorbent material from the agricultural waste in industrial wastewater treatment open the door for the existing factories to treat their wastewater with low cost that has no effect on their profits and prevent any punishment for environmental pollution.

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INTRODUCTION

One of the main sources of water pollution is industrial wastewater. Most of industrial wastewater containing relatively high levels of heavy metals, that represent the most serious source of water pollution. There are mainly three techniques for the removal of heavy metals, physically, chemical and physic-chemical techniques. Each technique is difference in the optimum conditions, efficiency, chemical residues and operating cost.

Most of chemical and engineering Industrial wastewater containing relatively high levels of traces metals. Certain metals in low concentrations are harmless, but become more toxic in combination with other metals or under specific environmental conditions such as zinc and chromium. These metals represent the most serious source of natural water pollution. This raise the need to treat these metals from industrial wastewater before its disposal to water streams. Most of treatment applied methods are with high cost due to the required chemicals and power.

Study Objective:

This research is mainly devoted to study the suitability of using raw agricultural waste (palm waste fiber) as a low cost adsorbent material for decreasing the concentrations of some heavy metals that appeared mostly in the industrial wastewater as Zinc ($Zn+^2$) and Chromium (Cr(VI).

Literature Review:

There are mainly three techniques for the removal of heavy metals, physically, chemically and physic-chemically techniques. Each technique is difference in the optimum conditions, efficiency, chemical residues and operating cost. In spite of electro dialysis, ion exchange and reverse osmosis are new methods used for treatment, adsorption is recent one.

Adsorption process acts between liquid and solid phase. In this process, the atoms at a surface are subject to the unbalanced forces of attraction normal to surface plane (Board, *et al.*, 1997).

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Rengaraj, et al,(2002), Studied the adsorption of cobalt, chromium and nickel from aqueous solutions on IRN77 cation-exchange resin comparatively. The percentage removal of cobalt, chromium and nickel was examined by varying experimental conditions, viz. dosage of adsorbent, pH of the solution and contact time. It was found that more than 95% removal was achieved under optimal conditions.

Aly, et al., (2010), studied the adsorption of copper, lead and manganese from simulated wastewater on activated carbon prepared from carrot juicing waste. study was carried out under varying experimental conditions temperature, contact time and pH . It was found that the adsorption of heavy metals above increased with increasing pH and contact time.

Kadirvelu *et al*. (2001), studied the removal of heavy metals from industrial wastewater by adsorption onto activated carbon prepared from an agricultural solid waste. The activated carbon was prepared from coirpith by a chemical activation method and characterized. The adsorption of toxic heavy metals, Hg2+, Pb2+, Cd2+, Ni2+, and Cu2+ was studied using synthetic solutions. The adsorption of toxic heavy metals from industrial wastewater, onto coirpith carbon, increased with increase in pH from 2 to 6 and remained constant up to 10. The resulting carbon is expected to be an economical product for the removal of toxic heavy metals from industrial wastewater.

Rice husk as a low-value agricultural by-product can be made into sorbent materials for heavy metal and dye removal. It has been investigated by [4], as a replacement for currently expensive methods of heavy metal removal from solutions. The heavy metals being studied are: As+5, Au+3, Cr+4, Cu+2 and Pb+2, Fe+3, Mn+2, Zn+2 and Cd+2.

Kazemipour *et al*., (2007), studied the adsorption of copper, zinc, lead and cadmium from industrial wastewater on activated carbon prepared from Apricot stone and Nuts shell. These were carbonized at optimized time and temperature of heating 15 minutes at 800 ˚C.

Bansode *et al*., (2003), studied the adsorption of (Cu+2, Pb+2, Zn+2) commonly found in municipal and industrial wastewater on activated carbon prepared from pecan shell. The results showed that acid-activated pecan shell carbon adsorbed more lead ion and zinc ion than any of the other carbons, especially at carbon doses of 0.2–1.0%. However, steam-activated pecan shell carbon adsorbed more copper ion than the other carbons, particularly using carbon doses above 0.2%. In general, 200 and carbon dioxide-activated pecan shell carbons were poor metal ion adsorbents. The results indicate that acid- and steam-activated pecan shell is effective metal ion adsorbents.

Demirbas *et al*., (2002), studied the adsorption of Ni+2 from aqueous solutions on activated carbon prepared from Hazelnut shell. This study was carried out under varying experimental conditions of initial metal ion concentration, temperature and particle size. It was found that the adsorption of Ni +2 was increased with increasing particle size.

Kaewsomboon (2006), studied the removal of lead from battery manufacturing wastewater by egg shell. Parameters of contact time, initial pH and dose of egg shell were investigated. In this study, the optimum dose of egg shell was 1.0 gm with a contact time of 90 minutes.

Acharya *et al*., (2009), studied the adsorption of chromium (VI) on activated carbon prepared from Tamarind wood with zinc chloride activation. Adsorption studies were carried out by varying initial metal ion concentration and temperature. The results indicate that the Tamarind wood activated could be used to effectively adsorb chromium (VI) from aqueous solutions.

MATERIALS AND METHODS

The study experimental work was done on two main parts. Part I for zinc removal and part II for chromium removal, each part was consisted from three runs one for determining the best media size the second for obtaining the best media depth & the third to get the best rate of filtration. The work was done according to the following steps:

- Submerged the agricultural waste (palm waste fiber) in the tap water for a sufficient time (nearly about one weak) to prevent any expansion in the media during our experimental work.
- Prepare the synthetic wastewater by dissolving about 3.704gm zinc sulfate in 50 L tap water to obtain 30ppm conc. of zinc. Also, dissolving about 14.204gm of potassium chromate in 50 L tap water to obtain 50ppm conc. of chrome.
- Putting the palm waste fiber in the columns according to each run requirement.
- Make the head of wastewater above the surface of the media 1m.
- Open the control valve for each column to allow the required flow to path through the media according to each run.
- Make the flow to be continuous flow and take 8 samples every day, 4 samples from the effluent of each column, 4 samples from the influent of each column.
- Measure the conc. of heavy metals (zinc, chrome) with PH & Temp. for each sample.

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Course palm waste fiber **Fine palm waste fiber**

RESULTS AND DISCUSSIONS

The results of using palm waste fiber in removing zinc from wastewater are shown in tables from (1) to (3) and figures from (1) to (3).

Table 1: Results of run I in part I

Days	Zinc Conc. At Inflow	Conc. Of Zinc At The Effluent				Temp.	PH
		Col. 1 (fine media 40cm depth)	Col. 2 (fine media 60cm depth)	Col. 3 (course media 40cm depth)	Col. 4 (course media 60cm depth)		
1	30	13.50	10.00	19	16	25	6.5
2	30	12.56	8.54	17.52	15.13	24	6.5
3	30	10.23	7.12	16.35	13.99	24	6.5
4	30	8.88	6.58	14.98	12.58	25	6.5
5	30	7.53	5.23	13.89	11.12	24	6.5
6	30	6.87	4.11	12.12	10.11	26	6.5
7	30	6.34	3.89	11.51	9.12	23	6.5
8	30	6.12	3.55	10.99	8.52	23	6.5
9	30	6.09	3.49	9.89	8.48	22	6.5
10	30	6.08	3.47	9.85	8.43	21	6.5
11	30	6.08	3.46	9.75	8.23	20	6.5

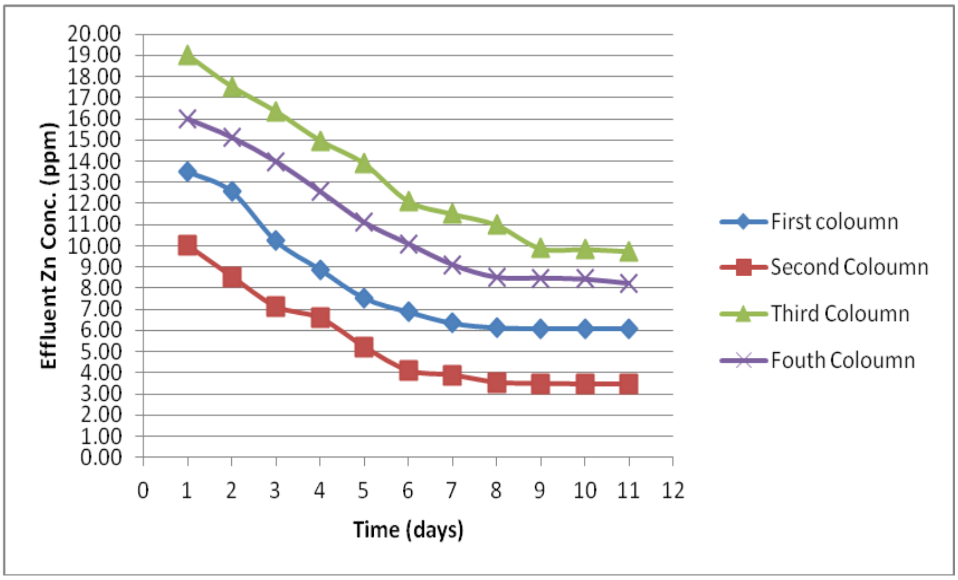

Fig. 1: Effluent Zn concentration versus Time in Run I.

From table (1) & figure (1) the fine size was the better than coarse size in removal efficiency for Zinc by about 16% in both applied depths. This meets the previous studies *(Rengaraj*, 2002), *(Aly,* 2010) &

(Kazemipour, 2007), that explained this due to the increase of media surface for adsorption and decrease the voids sizing that prevent the big ions to pass through it.

Table 2: Results of run II in part I

Days	Zinc Conc. At Inflow	Conc. Of Zinc At The Effluent of fine media				Temp.	PH
		Col. 1 (20cm depth)	Col. 2 (40cm depth)	Col. 3 (60cm depth)	Col. 4 (80cm depth)		
1	30	17.50	13.8	10.4	8.4	27	6.5
2	30	16.60	12.7	8.7	7.4	27	6.5
3	30	15.10	10.3	7.2	6.1	26	6.5
4	30	13.80	8.9	6.6	4.8	25	6.5
5	30	12.10	7.55	5.3	3.9	25	6.5
6	30	11.80	6.9	4.1	2.9	25	6.5
7	30	11.50	6.4	3.9	2.5	25	6.5
8	30	11.20	6.1	3.7	2.3	26	6.5
9	30	11.10	6.1	3.6	2.1	26	6.5
10	30	11.30	6.1	3.5	1.9	25	6.5
11	30	11.50	6.1	3.5	1.9	20	6.5
12	30	11.80	6.5	3.5	1.9	20	6.5
13	30	12.10	6.8	3.9	2.6	20	6.5
14	30	12.40	7.2	4.3	3.4	20	6.5
15	30	13.10	7.5	4.8	4.6	20	6.5
16	30	14.20	8.6	6.4	5.8	20	6.5

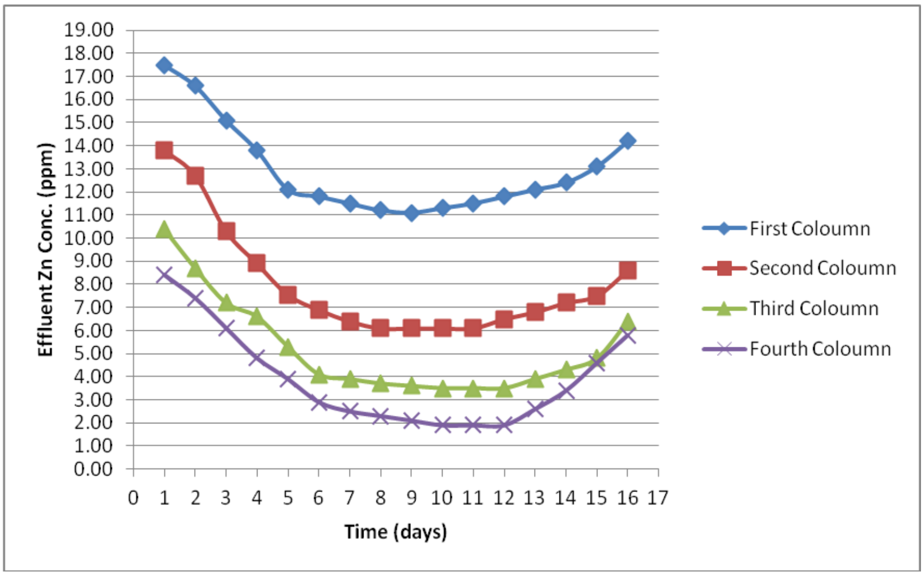

Fig. 2: Time versus the effluent Zn concentration in Run II

From table (2) & figure (2) the best media depth was the 80 cm in removal efficiency for Zinc by about compared with depths of 20, 40 & 60 cm. This was logically due to the more area available for adsorption to take place. Also, this meets the previous studies (Demirbas, 2002) **&** (Kaewsomboon,2006) that mentioned that for more contact time to the media the removal efficiency increase.

Table 3: Results of run III in part I

Days	Zinc Conc. At Inflow	Conc. Of Zinc At The Effluent of fine media with 80cm depth				Temp.	PH
		Col.1 (flow rate 4l/h)	Col.2 (flow rate 3l/h)	Col.3 (flow rate 2l/h)	Col.4 (flow rate 1l/h)		
1	30	13.20	11.1	9.3	8.3	21	6.5
2	30	11.80	10.6	8.6	7.4	20	6.5
3	30	10.90	9.9	7.9	6.1	21	6.5
4	30	10.50	9.2	6.8	4.9	20	6.5
5	30	9.90	9.1	5.9	3.9	19	6.5
6	30	10.20	9.1	4.5	2.9	19	6.5
7	30	10.70	9.1	3.8	2.6	18	6.5
8	30	11.40	9.5	3.8	2.3	18	6.5
9	30	12.50	10.4	3.9	2.1	19	6.5
10	30	13.40	11.2	4.1	1.9	19	6.5

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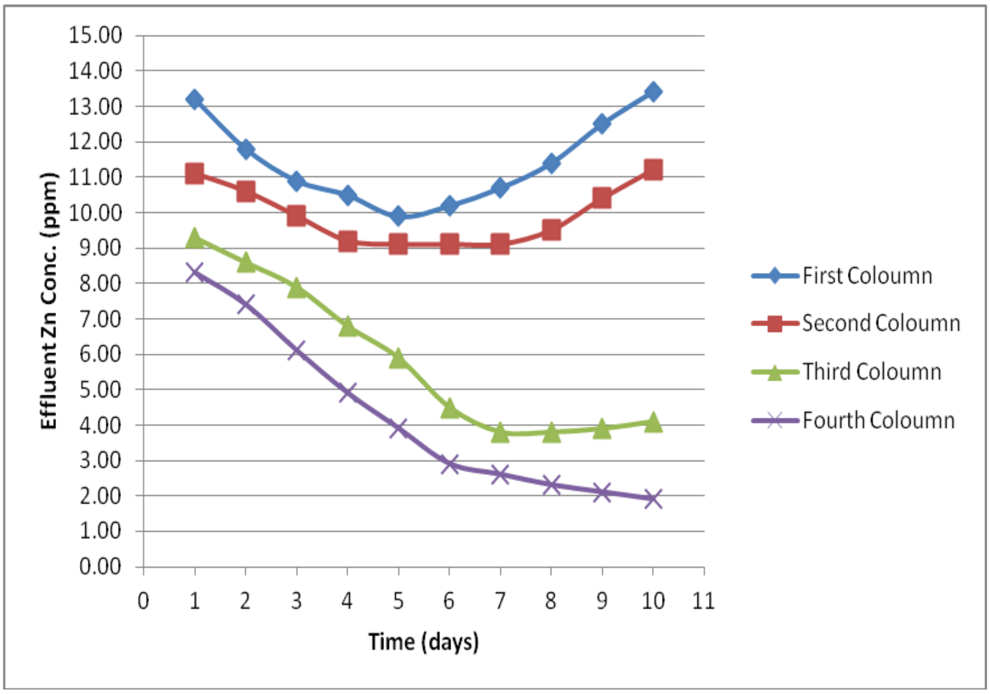

Fig. 3: Time versus the effluent Zn concentration in Run III

From table (3) & figure (3) the best removal efficiency for Zinc achieved with the lower hydraulic load which is 1l/h this due to the lower water velocity increased the adsorption to take place easier and faster. This also meets the adsorption general criteria (Acharya, 2009) **&** (El Nadi, 2012) that also used for all media types.

The results of using palm waste fiber in removing chromium (Cr(VI)) from wastewater are shown in tables from (4) to (6) and figures from (4) to (6).

Table 4: Result of run I in part II

Days	Chromium Conc. At Inflow	Conc. Of Chromium At The Effluent				Temp.	PH
		Col. 1 (fine media with 40cm depth)	Col. 2 (fine media with 60cm depth)	Col. 3 (course media with 40cm depth)	Col. 4 (course media with 60cm depth)		
1	50	15.30	12.60	25.3	21.2	22	6.5
2	50	13.50	10.90	22.7	18.9	18	6.5
3	50	11.80	9.40	19.9	17.2	15	6.5
4	50	10.60	8.60	17.4	15.6	25	6.5
5	50	9.40	7.50	15.4	13.7	24	6.5
6	50	8.80	6.90	13.8	12.1	26	6.5
7	50	8.50	6.40	13.2	11.8	23	6.5
8	50	8.40	6.40	13.1	11.7	23	6.5
9	50	8.40	6.30	13	11.6	22	6.5
10	50	8.30	6.30	12.9	11.6	21	6.5
11	50	8.30	6.30	12.9	11.5	20	6.5

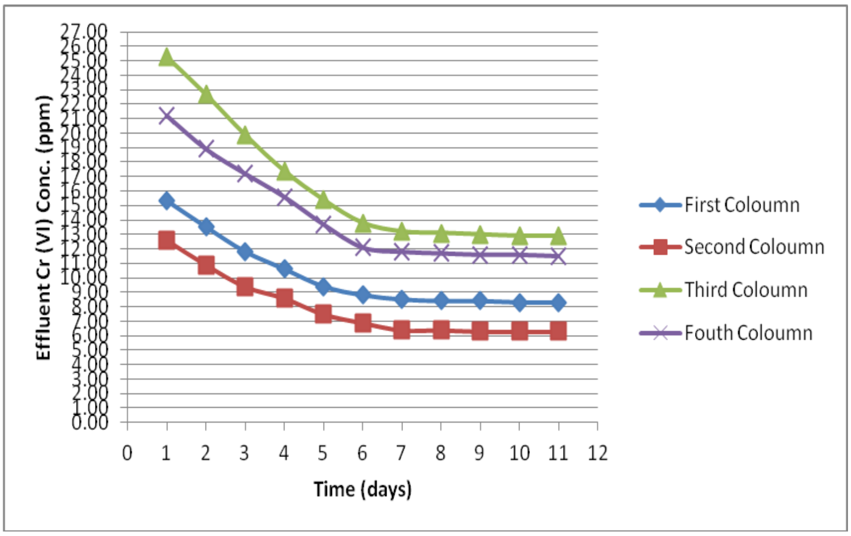

Fig. 4: Time versus the effluent Cr (VI) concentration in Run I

From table (4) & figure (4) the fine size of the palm waste fiber was the better than coarse size in removal efficiency for chromium by nearly 60 % in both applied depths. This meets the previous studies *(Rengaraj*, 2002), *(Aly*, 2010) & (Kazemipour, 2007), that illustrate this due to the increasing of contact surface for adsorption and decrease the voids sizing that prevent the large ions to pass through it.

Table 5: Result of run II in part II

Days	Chromium Conc. At Inflow	Conc. Of Chromium At The Effluent				Temp.	PH
		Col. 1 (fine media with 20 cm depth)	Col. 2 (fine media with 40cm depth)	Col. 3 (fine media with 60cm depth)	Col. 4 (fine media with 80cm depth)		
1	50	24.7	17.3	14.70	12.80	10	6.5
2	50	22.9	16.1	13.20	11.90	10	6.5
3	50	21.3	14.8	12.40	10.70	8	6.5
4	50	19.8	13.2	11.50	8.80	5	6.5
5	50	18.4	12.1	10.70	7.50	5	6.5
6	50	17.2	11.5	10.20	6.80	8	6.5
7	50	16.5	10.8	9.50	5.90	10	6.5
8	50	15.8	9.9	8.60	5.50	12	6.5
9	50	15.9	9.2	7.50	5.40	12	6.5
10	50	15.9	8.9	6.90	5.40	15	6.5
11	50	15.9	8.3	6.50	5.40	15	6.5
12	50	15.9	8.3	6.40	5.40	13	6.5
13	50	15.9	8.3	6.40	5.30	15	6.5
14	50	16.1	8.3	6.40	5.90	15	6.5
15	50	16.4	8.3	6.50	6.20	16	6.5
16	50	17.1	8.9	6.70	6.50	15	6.5
17	50	18.3	9.2	7.30	6.90	13	6.5

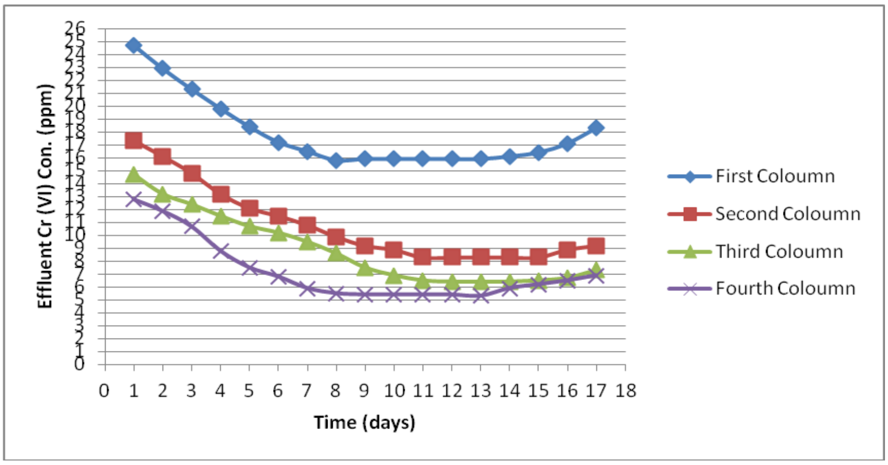

Fig. 5: Time versus the effluent Cr (VI) concentration in Run II

From table (5) & figure (5) the best media depth in removal efficiency for chromium was the 80 cm compared with depths of 20, 40 & 60 cm. This was logically due to the more area available and small voids for adsorption to take place. Also, this meets the previous studies (Kaewsomboon, 2006) **&** (El Nadi, 2012) that mentioned that the removal efficiency increase by increasing the contact time with the adsorbent material.

Table 6: Result of run III in part II for phase I

Days	Chromium Conc. At Inflow	Conc. Of Chromium At The Effluent of fine media with 80cm depth				Temp.	PH
		Col. 1 (flow rate 4l/h)	Col. 2 (flow rate 3l/h)	Col. 3 (flow rate 2l/h)	Col. 4 (flow rate 1l/h)		
1	50	19.5	17.9	15.50	13.10	13	6.5
2	50	18.3	16.5	14.30	12.30	16	6.5
3	50	17.1	15.2	13.20	11.10	15	6.5
4	50	15.8	14.2	12.10	9.20	13	6.5
5	50	14.2	13.1	11.70	8.10	13	6.5
6	50	12.9	11.5	10.20	7.30	14	6.5
7	50	11.8	10.8	9.50	5.90	13	6.5
8	50	11.7	9.9	8.60	5.40	13	6.5
9	50	11.7	9.8	8.60	5.40	12	6.5
10	50	11.7	9.8	8.60	5.40	16	6.5

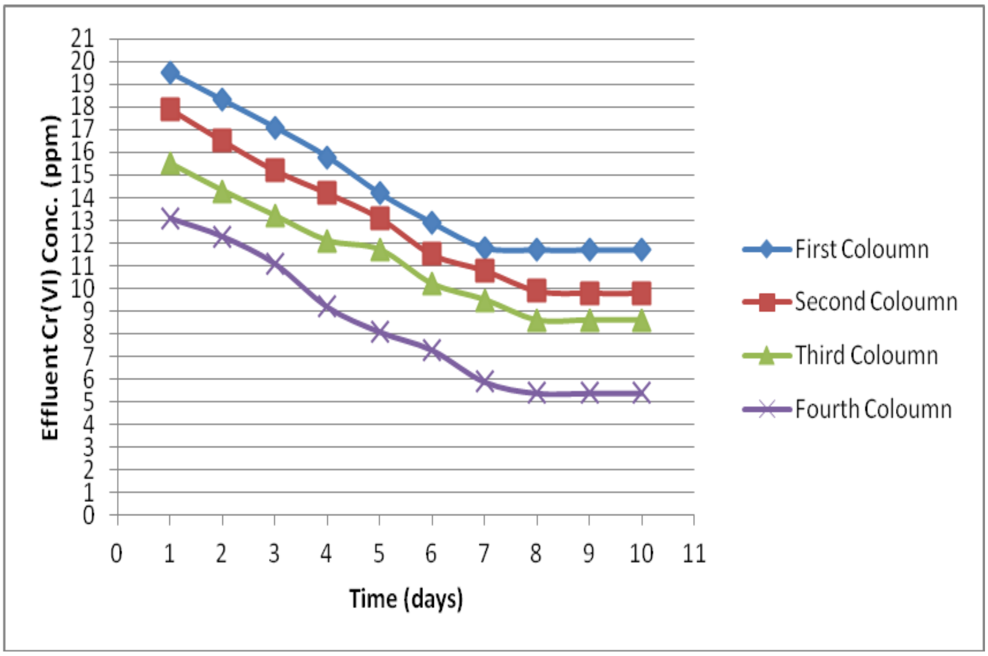

Fig. 6: Time versus the effluent Cr (VI) concentration in Run III

From table (6) & figure (6) the more efficient in removing chromium achieved with the lowest hydraulic load which is 1l/h this due to the lower water velocity which increased the adsorption phenomena to take place easier and faster. This also meets the adsorption general criteria (Demirbas,2002) & (El Nadi, 2012) that also used for all media types.

From the previous tables and figures the more efficiency in removing heavy metals from waste water is the fine size with depth 80cm and flow rate 1l/h, where its removal efficiency is 93.67%, 89.20% for Zn^{+2} and Cr(VI), respectively.

Conclusion:

The study concluded the following:

1. The adsorption method is easier in application for removal of heavy metals with high removal efficiency, and has low cost specially when using agricultural wastes as adsorbent.
2. The palm waste fiber is highly effective in removing zinc and chromium from wastewater where its efficiency is 93.67% for Zn^{+2} and 89.20% for Cr(VI), respectively.
3. The palm waste fiber achieved the highest removal efficiencies with the fine size as best size, 80 cm as the best depth and under hydraulic load 1l/h as the optimum load.

4. The pH of water did not change through the study, so it did not affect the removal efficiency of heavy metals using this type of agricultural wastes.
5. The change in water temperature didn't affect the efficiency of this type of agricultural wastes in removing heavy metals

Recommendations:

The study produced the following recommendations:

- It is recommended to reuse the raw agricultural wastes in removing differ kinds of heavy metals instead of burning it to produce activated carbon and pollute the environment.
- Other agriculture wastes which used as actived carbon may be used as raw agricultural waste for removal of heavy metals for industrial wastewater at factories of low level of zinc or chromium at the effluent.
- It is recommended to use these agricultural wastes at factories of high level of zinc or chromium, to minimize the cost of treatment of wastewater.

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