International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6, August, 2019

Removing Heavy Metals from Wastewater by using Rice Husk Wastes Fiber

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***Abstract:** Environmental problems increase due to disposal of wastes in large quantities. Industrial wastewater is the most serious pollutants because it contains high concentrations of toxic substances and heavy metals. Agricultural wastes also cause environmental pollutants especially when it is disposed by burning. So, it is necessary to find usage of agricultural wastes as a low cost material for adsorption of heavy metals such as zinc and chromium in industrial wastewater.Rice husk fiber was used in this study to remove zinc and chromium from industrial wastewater. The obtained removal ratios obtained were 94.33% and 89.2% for Zn+2 and Cr (VI), respectively. The study showed that the removal ratio increases by increasing the adsorption contact time and decreasing the flow rate. It also showed that, the removal efficiency for zinc was better than Cr (VI) using rice husk 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.*

***Keywords**: Wastewater treatment, Industrial wastewater treatment, Removal of heavy metals, reuse of solid wastes (agricultural waste).*

I. INTRODUCTION

Pollutions affect negatively on human health and environment due to their physical and chemical properties. The almost studied pollutants existing in wastewater are suspended solids, dissolved solids, biodegradable organics, heavy metals, pathogenic and nutrients. Industrial wastewater is one of the most dangerous sources of water pollution. It is containing relatively high concentrations of heavy metals. Three techniques are mainly used for the removal of heavy metals, physically, chemical and physico-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 water pollution due to industrial wastewater. 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.

Revised Manuscript Received on October 30, 2019.
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II. STUDY OBJECTIVE

This research is mainly devoted to study the suitability of using raw agricultural waste (rice husk 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)).

III. LITERATURE REVIEW

Agriculture waste is one of the important natural materials used for water and wastewater treatment. They can be used without any processing or used after converted to activated carbon to be used as an adsorbent for treatment. Also they can be used as a filter media. Agriculture waste produced from plants through the growth of plant or due to use. Agriculture waste such as rice straw, sugar can bagasse, rice husk, sun flower stalks, banana peel and almond shells was used for wastewater treatment because it is available and low cost material. In spite of electro dialysis, ion exchange and reverse osmosis are new methods used for treatment, adsorption is recent one which acts between liquid and solid phase, so the atoms at a surface are subject to the unbalanced forces of attraction normal to surface plane [1]. Acharya et al. [2] 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. Kadirvelu et al. [3] 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, Hg^{+2}, Pb^{+2}, Cd^{+2}, Ni^{+2}, and Cu^{+2} 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 [5], 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}.

Demirbas et al. [4] 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.

Bansode et al. [5] 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.

Activated carbon was made from carrot juicing waste was used to remove Cd^{+2}, Zn^{+2} and Mn^{+2} from wastewater. The removal efficiencies were 73.5%, 91.75%, and 68.5% respectively [6&7].

Fixed bed of carbonate treated rice husk was studied to be used to remove Cd^{+2} from wastewater. The column was 2cm diameter with different depths of 10, 20 and 30 cm tested at Cd^{+2} concentration of 10 mg/L and flow rate 9.5 mL/min. the results for the different depths of media were 2.96, 5.7, and 8.55 mg/L respectively. So, this agriculture waste media is effective for removing Cd^{+2} from wastewater [8].

Wanvisa Kaewsomboon [9] 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.

Rice husk is used as an economic and cheaper natural material for nickel adsorption from wastewater. The efficiency of removal depends on the physico-chemical characteristics of the adsorbent, adsorbent concentration and other parameters such as pH, contact time, adsorbent dose and initial concentration of nickel. Maximum removal was obtained at pH 6.0 with removal efficiency 51.8% for dilute solution at 20 g/L adsorbent dose [10].

El Nadi [11] studied removal of Zn^{+2} and Cr(VI) from industrial wastewater using raw agricultural wastes of Ficus trees trimming. The removal ratios were 68.67%and 77.80% 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 Ficus trees trimming output.

The study was done by El Nadi [12] using adsorption method for treatment by raw agricultural waste (palm waste fiber) to remove heavy metals, Zn^{+2} and Cr(IV) from industrial wastewater achieves removal ratios 93.67% and 89.20% for Zn^{+2} and Cr(IV), respectively.

Arshad [13] studied using of Palm date pits which is a low cost source of activated carbon to adsorb heavy metals from wastewater. Adsorption was studied for individual elements, and for industrial wastewater samples collected from a tannery and an electroplating factory.

The kinetic studies showed that Cu, Cr^{+6} , and Fe were adsorbed very rapidly within the first 30minutes, while equilibrium was attained within 90min, the optimum pH range for their adsorption was found to be (4.5-6.5), depth of adsorbent layer (70-90)cm, and particle size(0.5-0.75)mm. The adsorption capacity and removal efficiency for individual elements reached 89.17% for Cu, 71.30% for Cr^{+6}, and 85.17% for Fe respectively. As for the removal of heavy metals from industrial wastewater collected from the tannery, removal efficiency reached 85.17% for Cu, 65.42% for Cr^{+6}, and 87.03% for Fe and for the electroplating factory effluent: 82.857% for Cu, 61.65% for Cr+6, and 89% for Fe.

IV. 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 two runs one for obtaining the best media depth & the second to get the best rate of filtration. The work was done on the illustrated pilot shown in picture (1) according to the following steps:

- Submerged the agricultural waste (rice husk waste fiber), picture (2), in the distilled 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 3.7gm zinc sulfate in 50 L distilled water to obtain 30ppm conc. of zinc. Also, dissolving about 14.2gm of potassium chromate in 50 L distilled water to obtain 50ppm conc. of chrome.
- Putting the rice husk waste fiber in the columns, picture (1), 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.

Picture (1): The pilot

Picture (2): Rice husk

V. RESULTS & DISCUSSIONS

The results of using rice husk waste fiber in removing zinc from wastewater are shown in tables (1) and (2) and figures (1) and (2).

Table (1) Results of run I in part I

Days	Zinc Conc. At Inflow	Conc. Of Zinc At The Effluent				Temp	PH
		Col. 1 (20cm depth)	Col. 2 (40cm depth)	Col. 3 (60cm depth)	Col. 4 (80cm depth)		
1	30	18.60	16.25	13.00	8.7	26	6.5
2	30	17.50	15.04	11.84	8.3	27	6.5
3	30	16.20	13.29	10.56	7.5	26	6.5
4	30	14.80	11.89	9.58	6.1	25	6.5
5	30	12.90	10.71	8.18	4.9	24	6.5
6	30	11.80	9.49	7.11	3.2	26	6.5
7	30	11.80	8.93	6.51	2.7	25	6.5
8	30	11.30	8.56	6.04	2.4	25	6.5
9	30	11.10	7.99	5.99	2.1	26	6.5
10	30	11.25	7.98	5.95	1.7	24	6.5
11	30	11.50	7.81	5.32	1.7	21	6.5
12	30	11.80	7.63	3.57	1.8	20	6.5
13	30	12.10	7.65	3.90	2.5	23	6.5
14	30	12.40	6.50	4.30	3.2	22	6.5
15	30	13.10	7.5	4.80	4.4	20	6.5

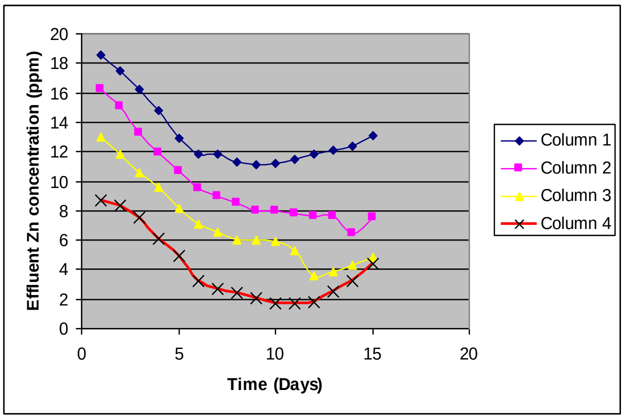

Figure (1): Time versus the effluent Zn concentration in Run I

From table (1) & figure (1) the best media depth was the 80 cm in removal efficiency for Zinc 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 [4] that mentioned that for more contact time to the media the removal efficiency increase.

Table (2) Results of run II in part I

Days	Zinc Conc. At Inflow	Conc. Of Zinc At The Effluent of 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	13.49	10.55	8.84	7.89	22	6.5
2	30	11.21	10.07	8.17	7.03	20	6.5
3	30	10.90	9.41	7.51	5.8	21	6.5
4	30	10.36	8.74	6.46	4.66	20	6.5
5	30	9.40	8.65	5.61	3.71	19	6.5
6	30	9.70	8.65	4.28	2.76	20	6.5
7	30	10.17	8.65	3.61	2.47	18	6.5
8	30	10.80	9.03	3.61	2.2	19	6.5
9	30	11.90	9.88	3.71	2.0	18	6.5
10	30	12.70	10.64	4.00	1.81	19	6.5

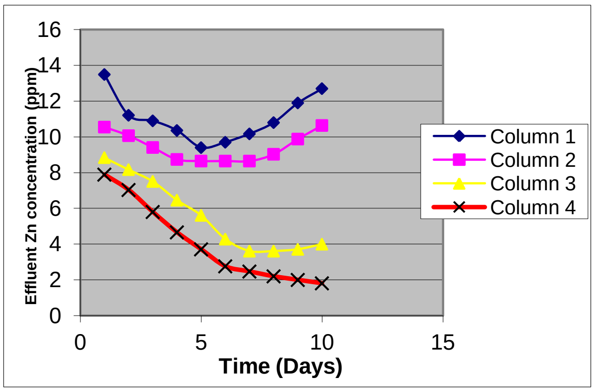

Figure (2): Time versus the effluent Zn concentration in Run II

From table (2) & figure (3) the best removal efficiency for Zinc achieved with the lower hydraulic load which is 1l/h this is due to the lower water velocity increased the adsorption to take place easier and faster. This also meets the adsorption general criteria [2] that also used for all media types.

The results of using rice husk waste fiber in removing chromium (Cr(VI)) from wastewater are shown in tables from (3) & (4) and figures from (3) & (4).

Table (3) Result of run I in part II

Days	Chromium Conc. At Inflow	Conc. Of Chromium At The Effluent				Temp	PH
		Col. 1 (20 cm depth)	Col. 2 (40cm depth)	Col. 3 (60cm depth)	Col. 4 (80cm depth)		
1	50	25.3	18.7	15.8	13.70	12	6.5
2	50	23.7	17.1	14.40	12.30	11	6.5
3	50	22.2	15.7	13.20	11.60	9	6.5
4	50	20.8	14.5	12.60	9.80	7	6.5
5	50	19.3	13.2	11.80	8.50	7	6.5
6	50	18.4	12.8	11.20	6.80	8	6.5
7	50	17.5	11.6	10.40	6.90	12	6.5
8	50	16.7	10.9	9.40	5.50	14	6.5
9	50	15.2	9.9	8.50	5.40	14	6.5
10	50	15.2	9.9	7.90	6.50	15	6.5
11	50	15.4	9.3	7.50	6.30	17	6.5
12	50	15.3	9.2	7.30	6.40	15	6.5
13	50	15.5	9.4	7.30	6.30	15	6.5
14	50	16.1	10.2	6.40	6.90	14	6.5
15	50	15.6	9.3	6.50	7.30	15	6.5

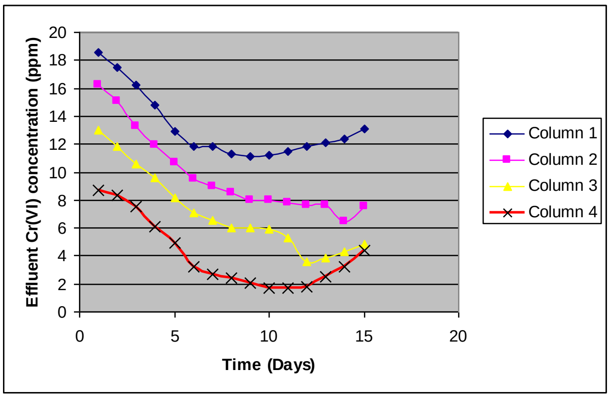

Figure (3): Time versus the effluent Cr (VI) concentration in Run II

From table (3) & figure (3) 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 [9] that mentioned that the removal efficiency increase by increasing the contact time with the adsorbent material.

Table (4) Result of run II in part II

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	20.1	18.7	16.7	14.3	15	6.5
2	50	19.7	17.4	15.80	13.20	17	6.5
3	50	18.3	16.1	14.30	12.10	16	6.5
4	50	16.7	15.1	13.20	10.30	14	6.5
5	50	15.4	13.9	12.60	9.50	14	6.5
6	50	13.8	12.3	11.10	8.20	15	6.5
7	50	12.7	11.5	10.6	6.90	16	6.5
8	50	12.6	10.8	9.5	6.70	14	6.5
9	50	12.6	10.7	9.5	6.40	12	6.5
10	50	11.7	9.9	8.9	6.40	15	6.5

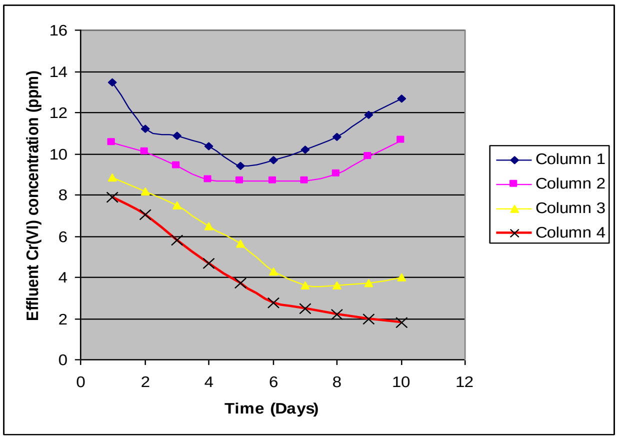

Figure (4): Time versus the effluent Cr (VI) concentration in Run II

From table (4) & figure (4) the more efficient in removing chromium achieved with the lowest hydraulic load which is 1l/h this is due to the lower water velocity which increased the adsorption phenomena to take place easier and faster. This also meets the adsorption general criteria [4, 6& 7] that also used for all media types. From the previous tables and figures the more efficiency in removing heavy metals from waste water is depth of media 80cm and flow rate 1l/h, where its removal efficiency is 94.33%, 89.20% for Zn^{+2} and Cr(VI), respectively.

Retrieval Number F9055088619/2019©BEIESP
DOI: 10.35940/ijeat.F9055.088619
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication

VI. 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 rice husk waste fiber is highly effective in removing zinc and chromium from wastewater where its efficiency is 94.33% for Zn+2 and 89.20% for Cr(VI), respectively.
3. The rice husk waste fiber achieved the highest removal efficiencies with 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

VII. 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 activated 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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