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Use of Rice Husk and Activated Carbon as Adsorbents for Removal of Heavy Metals from Industrial Wastewater

Kanoje Manoj[1], Toche Saurabh[2], Bhor Mayuri[3], Jadhav Pranav[4], Mr. M. B. Patil[5]

[1,2,3,4]Department of Civil Engineering, B.E. Student, MVPS's KBT College of Engineering, Maharashtra, India
[5]Department of Civil Engineering, Assistant Professor, MVPS's KBT College of Engineering, Maharashtra, India

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Abstract - *Water is essential renewable natural resources required for the sustenance of life on earth. Every year numerous hazardous metals are discharged into water bodies from varied industries that are toxic and cause serious injury to aquatic life moreover as human health. Thus, the removal of these heavy metals from industrial waste effluent became a significant issue. There are several typical strategies used for the treatment of commercial waste material like chemical oxidization, membrane separation, reverse diffusion, electrodialysis, etc. however these are expensive and long strategies. This methodology becomes expensive particularly when the metal ion concentration is a smaller amount than 100 mg/lit. The adsorption method is effective for the removal of serious metals from waste material owing to its low cost, simple, and eco-friendly nature of adsorbents. several eco-friendly adsorbents like fruit peels, rice husk, sawdust, etc. are used for the removal of heavy metal ions like lead (Pb), metal (Cd), metal (Cr), zinc (Zn), copper (Cu), arsenic (As), etc. In this paper, we compared the removal efficiency of rice husk and activated carbon for zinc metal removal. We have studied the effect of various parameters like pH, adsorbent dosage, initial concentration, and contact time.*

Key Words: heavy metals, adsorption, wastewater, rice husk, activated carbon, agricultural waste.

1.INTRODUCTION

Water pollution because of development in technology, has become a big problem. Discharge from various industries contains numerous organic and inorganic pollutants. Among these pollutants, heavy metals can be toxic and harmful to humans and different living species [1]. Zinc, cadmium, copper, chromium, nickel, mercury, arsenic, lead, and metallic element are very harmful heavy metals of widespread use in several industries. They originate from sources like metal industries dyes, pesticides, fertilizers, fixing agents, and bleaching agents. In developed countries, legislation is changing into progressively demanding heavy metal limits in effluent [1]. Heavy metals pollution represents a vital problem, with human health issues and high ecological consequences. It is thus essential to eliminate heavy metals from industrial wastewaters before their disposal. Numerous treatment technologies used for the removal of heavy metals elimination that is chemical precipitation, reverse diffusion, ultrafiltration, electrodialysis, and adsorption [2]. The adsorption methodology is also a comparatively new method and is rising as a probably most well-liked method for the removal of heavy metals. Natural adsorbents are those that are obtained from biological material and are relative of low-cost. Surface characteristics and pore structures of adsorbents are the most important properties in adsorption equilibrium for the treatment of effluent. New adsorbents are continuously being developed, introducing new applications for surface assimilation [3].

1.1 Objectives

To remove the heavy metals from industrial effluent by using natural adsorbents- rice husk and activated carbon and also to reduce bacterial as well as the chemical load on the wastewater treatment plant.

1.2 Problem Statement

Water pollution especially has raised severe environmental impacts. There are different types of water contaminants among which the inorganic pollutants are extremely harmful due to their high toxicity and non-biodegradability. Heavy metals have high product demand in the industrial sector. It is an unavoidable raw material for electroplating, automobile, fertilizer, paint, and many other industries. Too much heavy metals can cause nausea, stomach pain, vomiting in humans. While in plants, it results in stunting of the shoot, curling, and rolling of leaves, etc. Thus there is a necessity for the removal of excess amount of heavy metals from wastewater of industries.

1.3 Scope of the study

The adsorption technique is one of the cheapest and inexpensive technique adsorbents for wastewater treatment. There is a demand to develop additional economical selective, cheap, and eco-friendly inexpensive adsorbents for water treatment. A lot of research is to be done for the removal of heavy metals from industrial wastewater using natural adsorbents.

2. MATERIALS AND METHODS

2.1 Rice Husk

Rice husk is an agricultural waste. It can be easily available at rice mills. In recent years attention has been focused on utilization of unmodified and modified rice husk as an adsorbent for treatment of wastewater. It was observed that modified rice husk is potentially useful material for removal of heavy metals from industrial waste water.

2.2 Activated Carbon

Activated carbon(AC) is one of the common material for the treatment of wastewater. It is considered very effective for the removal of heavy metals from industrial effluent. AC is not harmful to human health and doesn't have vital drawbacks. Therefore they are often applied for the treatment of industrial effluent [4].

2.3 Industrial Sample

The industrial wastewater sample for the study was collected from an electroplating industry that contains a Zinc concentration of 88.72 mg/lit. The study of water quality for Industrial effluent is taken into account because the large volume of wastewater effluents containing hazardous metals are discharged into treatment plants resulting in deterioration of the quality of water of natural resources.

2.4 Adsorption

Adsorption is considered one of the most, economical, and eco-friendly techniques for the treatment of industrial wastewater. It is a mass transfer method in that the heavy metal ions are transferred from the solution to the surface of adsorbents due to physical or chemical interactions. The classical mechanism of adsorption is divided into three stages in (1) diffusion of adsorbate to the surface of adsorbents (2) accumulation into pores of adsorbent, and (3) monolayer build-up of adsorbate on the surface of the adsorbent [5]. Depending upon the forces acting between adsorbent and adsorbate, the adsorption process can be categorized into physical adsorption and chemical adsorption. In physical adsorption, the forces acting are physical forces like weak Van der Waals forces while in chemical adsorption it's strong chemical forces. The process of adsorption is especially influenced by several factors like initial metal ion concentration, pH of the answer, contact time, adsorbent dosage, etc.

2.5 Effect of pH on adsorption

The adsorption capacity of the natural adsorbents of agro wastes will increase with increasing pH scale of effluent to be treated till an optimum adsorption level. As the optimum adsorption level gets reached, it remains constant [6].

2.6 Effect of contact time on adsorption

The metal ions removal efficiency increases with a rise in contact time before the equilibrium condition is reached. After equilibrium condition, the efficiency of adsorption remains constant. At the initial stage rate of adsorption is very high due to the presence of a large surface area of adsorbents [7]

2.7 Effect of adsorbent dosage on adsorption

The adsorption capacity of the adsorbents increases with the increase in adsorbent dose. With the increase in adsorbent dose, the surface area of adsorption also increases, which increases adsorption capacity [6].

2.8 Preparation of adsorbents

Rice husk was collected from the rice mill located at Nashik. It was washed with pure water several times to remove dust particles present in it. Then the washed materials were kept in a hot air oven at 60-degreeCelsius for 24 hours. The dried samples were taken out and sieved through Indian Standard sieves. Activated carbon was also crushed and sieved through Indian Standard sieves. The particles that passed through 300 μm and retained in 150 μm were collected into separate containers.

2.9 Adsorption experiment

The batch adsorption experiment was carried by preparing a series of 1000-ml wastewater effluent samples, containing the different quantities of adsorbent as 5g/lit, 10g/lit, and 15g /lit of rice husk and activated carbons one by one. Each sample is stirred for 1hr and 2hr. At the end of the experiment, the samples were filtered through a Whatman filter paper. The initial and residual metal concentrations within the filtered samples were determined by using atomic absorption spectrophotometry IS 3025-part49-1994. Finally, the efficiency of rice husk and activated carbon is calculated.

3. RESULT AND DISCUSSION

3.1 Test result before the treatment

The test results before the treatment of wastewater using natural adsorbents are as follows

Table -1: Test results before treatment

Parameters	Results	Unit
pH	4.12	-

BOD	131.11	mg/lit
DO	1.23	mg/lit
Electrical conductivity	8240	µ mhos/cm
Zinc	88.72	mg/lit

3.2 Test result after the treatment

The test results after the addition of the rice husk and activated carbon with concentrations of 5 g/lit, 10 g/lit, 15 g/lit and performing all above test on the wastewater sample are as follows.

Table -2: Test results after treatment using rice husk for 1 hour contact time

Parameters	Results			Unit
	5 g/lit	10 g/lit	15 g/lit	
pH	4.28	4.31	4.43	-
BOD	104.66	96.8	90.45	mg/lit
DO	1.31	1.38	1.41	mg/lit
Electrical conductivity	7120	7030	6910	µ mhos/cm
Zinc	58.67	52.92	49.34	mg/lit

Table 3 Test results after treatment using rice husk for 2 hour contact time

Parameters	Results			Unit
	5 g/lit	10 g/lit	15 g/lit	
pH	4.41	4.59	4.64	-
BOD	99.91	94.85	87.47	mg/lit
DO	1.36	1.51	1.65	mg/lit
Electrical conductivity	6970	6730	6150	µ mhos/cm
Zinc	54.89	49.62	43.29	mg/lit

Table 4 Test results after treatment using activated carbon for 1 hour contact time

Parameters	Results			Unit
	5 g/lit	10 g/lit	15 g/lit	
pH	4.73	5.01	5.12	-
BOD	88.71	73.15	67.84	mg/lit
DO	1.48	1.61	1.93	mg/lit
Electrical conductivity	6810	6530	5890	µ mhos/cm
Zinc	43.01	33.99	30.86	mg/lit

Table 5 Test results after treatment using activated carbon for 2 hour contact time

Parameters	Results			Unit
	5 g/lit	10 g/lit	15 g/lit	
pH	4.95	5.23	5.31	-
BOD	76.43	65.31	59.43	mg/lit
DO	1.79	2.02	2.21	mg/lit
Electrical conductivity	6610	5950	5410	µ mhos/cm
Zinc	39.91	30.78	24.35	mg/lit

3.3 Graphical representation of results

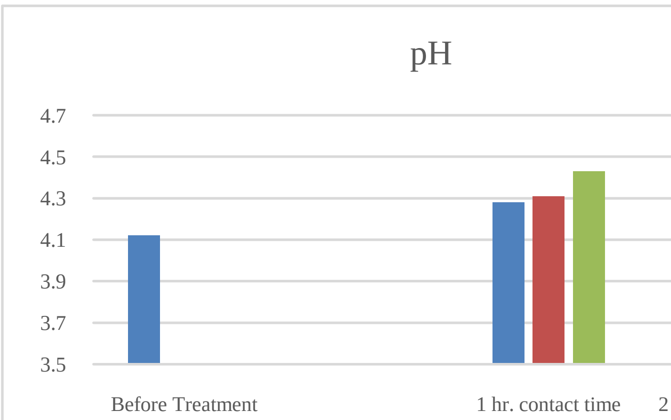

Figure 1 Effect of different concentrations of rice husk on pH value of industrial wastewater sample

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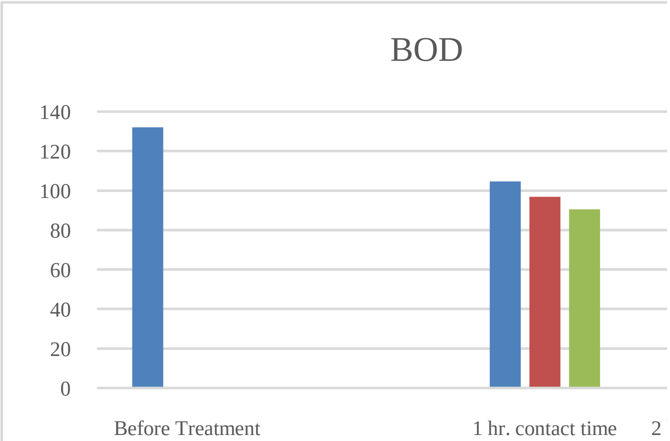

Figure 2 Effect of different concentrations of rice husk on BOD of industrial wastewater sample

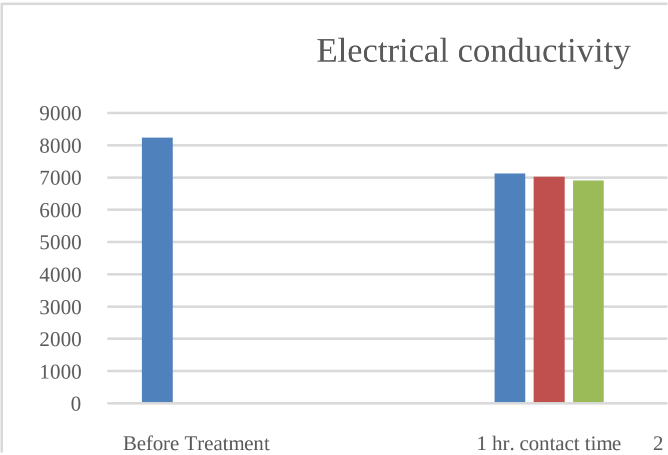

Figure 3 Effect of different concentrations of rice husk on electrical conductivity of industrial wastewater sample

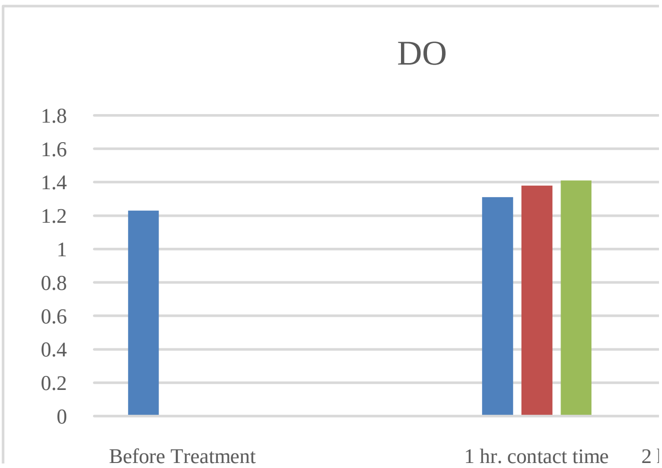

Figure 4 Effect of different concentrations of rice husk on DO of industrial wastewater sample

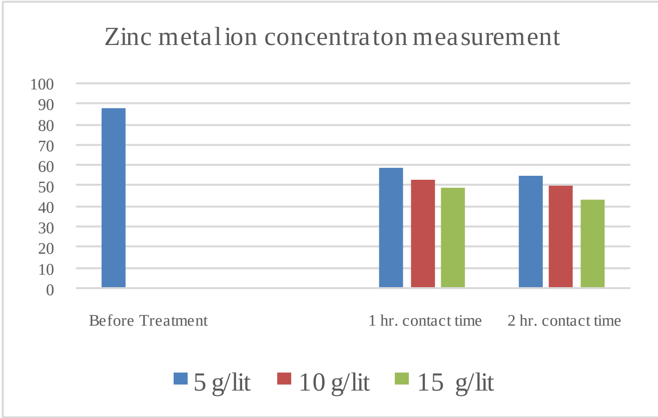

Figure 5 Effect of different concentrations of rice husk on Zinc metal ion in industrial wastewater sample

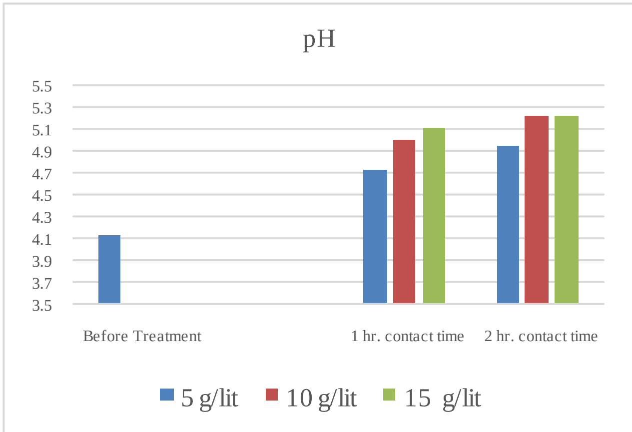

Figure 6 Effect of different concentrations of activated carbon on pH value of industrial wastewater sample

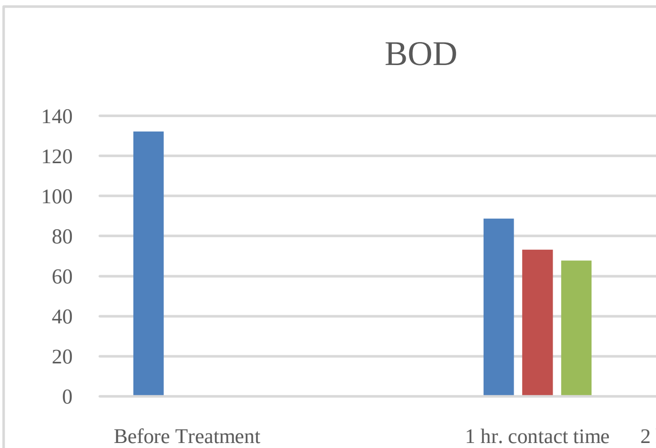

Figure 7 Effect of different concentrations of activated carbon on BOD of industrial wastewater sample

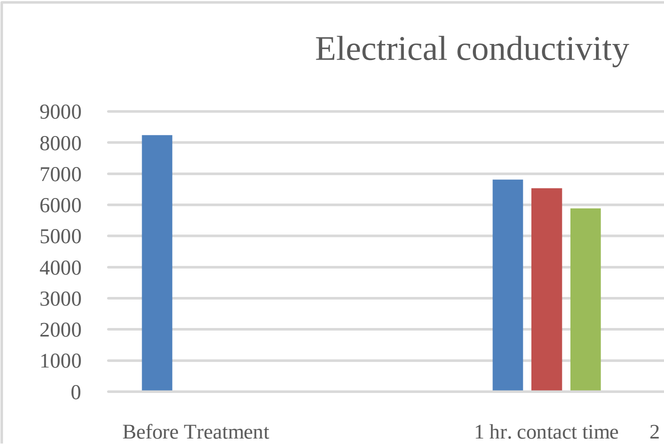

Figure 8 Effect of different concentrations of activated carbon on electrical conductivity of industrial wastewater sample

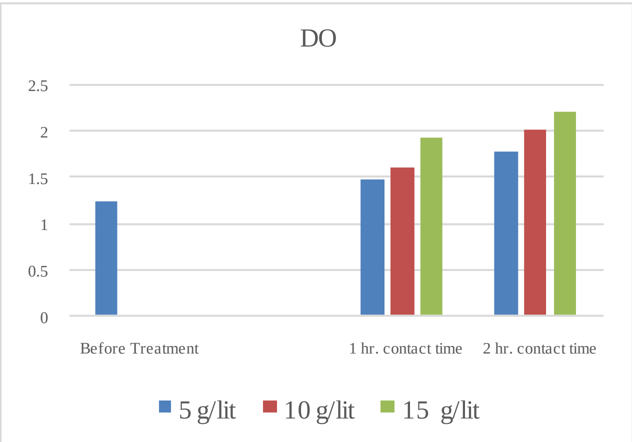

Figure 9 Effect of different concentrations of activated carbon on DO of industrial wastewater sample

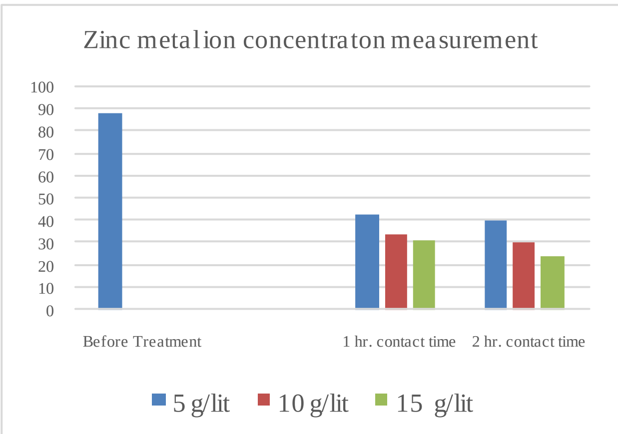

Figure 10 Effect of different concentration of activated carbon on Zinc metal ion in industrial wastewater sample.

3.4 Result analysis

Data recorded from above tables showed that pH of the wastewater does not significantly changed after treatment of rice husk and activated carbon. The initial pH was 4.12 and optimum pH after treatment with rice husk and activated carbon is 4.64 and 5.31 which is less than the permissible limit i.e. 5.5 to 9 for wastewater disposal. Hence additional treatment is required for treatment of pH. BOD is reduced upto 20.17%, 26.17% and 30.01% for 1-hour contact time using 5g/lit, 10g/lit and 15g/lit of rice husk and 23.79%, 27.66% and 33.28% for 2-hour contact time using 5g/lit, 10g/lit and 15g/lit of rice husk. By using activated carbon BOD is reduced upto 32.33%, 44.20%, and 48.25% for 1-hour contact time and 41.70%, 50.18% and 54.67% for contact time of 2hour. There is slight increase in dissolved oxygen level after treatment of industrial wastewater. The DO is increased from 1.23 mg/lit to 1.31, 1.38and 1.41 mg/lit using rice husk for 1-hour contact time and 1.23 mg/lit to 1.36, 1.51 and 1.65 mg/lit for 2-hour contact time. By using activated carbon DO increases from 1.23 mg/lit to 1.48, 1.61 and 1.93 mg/lit for 1-hour contact time and 1.23 to 1.79, 2.02 and 2.21 mg/lit for 2-hour contact time. Increasing DO is a good sign as it is essential for the survival of aquatic life. Electrical conductivity is also slightly reduced from 8240 µ mhos/cm to 7120, 7030 and 6910 µ mhos/cm for 1-hour contact time using rice husk and 8240 µ mhos/cm to 6970, 6730 and 6150 µ mhos/cm for 2-hour contact time. Using activated carbon electrical conductivity is reduced from 8240 µ mhos/cm to 6810, 6530 and 5890 µ mhos/cm for 1-hour contact time and 8240 µ mhos/cm to 6610, 5950 and 5410 µ mhos/cm for 2-hour contact time.

Zinc concentration is reduced by 33.86%, 40.35% and 44.38% using rice husk for 1-hour contact time and 38.12%, 44.07% and 51.20% for 2 hour of contact time. Using activated carbon zinc concentration is reduced by 51.53%, 61.68% and 65.21% for 1 hour of contact time and 55.02%, 65.30% and 72.55% for 2 hour of contact time. Results obtained from the study of various parameters are not upto the permissible limits of the disposal of wastewater. But it can be observed that all the wastewater parameters can be achieved in permissible limits by certain increase in dosage of adsorbents and additional treatment.

4. CONCLUSIONS

From the above results, it is found that rice husk and activated carbon both are effective for the treatment of industrial effluent. However, activated carbon is more efficient for the removal of heavy metals as compared to rice husk. It is observed that the capacity of adsorption depends on the quantity of dose of adsorbent and the contact time. However, there is not a significant effect on pH of rice husk and activated carbon. Hence additional treatment is required for the treatment of pH. DO value is slightly increased after the treatment. BOD is significantly reduced upto 48.25% and

54.67% using rice husk and activated carbon. Zinc concentration is also reduced upto 51.2% and 72.55% using rice husk and activated carbon. A dose of 15 g/lit of activated carbon with a contact time of 2hr is most efficient for the removal of Zn from industrial wastewater effluent.

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