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STUDY AND COMPARE THE TREATMENT OF DENTALCARE WASTEWATER BY CHEMICAL-ADSORPTION AND BIO-ADSORPTION

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ABSTRACT

In this study, the goal was to treat the JSS dental college wastewater using Chemical Adsorption and Bio-Adsorption. It is critical to select appropriate technologies and treat dental care wastewater properly for the monitoring and management of dental care wastewater discharge into the environment. The main goal was to examine the feasibility of the Chemical adsorbent and Bio-adsorbent to treat dentalcare wastewater. The process of efficiency was evaluated in terms of COD and Bulk of heavy metals. The initial COD values for the samples from Conservative Dentistry and public health (S1), Paediatrics and preventive dentistry (S2) and oral and radiology(S3) are 16990mg/l,5190mg/l and 3450mg/l respectively, but after treatment with chemical adsorbent the values were 3313.05mg/l,1881.375mg/l and 1242mg/l. Then after treatment with Bio-adsorbent the values were 5988.975mg/l,960.150mg/l and 1043.625mg/l respectively. The initial bulk of heavy metals in the Conservative Dentistry and Public Health(S1), Paediatrics and Preventive Dentistry sample (S2) Oral and Radiology sample (S3) are 113.22 mg/l, Nil, and 38.32 mg/l respectively, but after treatment with chemical adsorbent the values were 58.19 mg/l,16.92 mg/l respectively. Then after treatment with Bio-adsorbent the values were60.57 mg/l ,3.143 mg/l respectively.

Keywords: Adsorption, COD, Bulk Of Heavy Metals, Bentonite, Activated Rice Husk.

I. INTRODUCTION

India's healthcare system is a hybrid of public and private providers. However, the majority of private healthcare organizations focus on providing secondary and tertiary care in urban areas. The health-care system provides a wide range of services, such as dental, mental health, laboratory, and diagnostic care. A variety of hospital departments, including those dealing with oral and radiography, Paediatrics and preventive dentistry, conservative dentistry, and public health, generate dental care waste. Dentalcare wastewater, like municipal wastewater, can contain heavy metals found in the environment, antibiotics, disinfectants, an aesthetics, radioactive materials, and pharmaceutical chemicals that have not yet been metabolized. This could have an adverse effect on both the terrestrial and aquatic environments. In communities where there is no epidemic of parasitic and enteric diseases, dental care wastewater must be treated first before being discharged into the municipal sewerage system [1].

Dental amalgam is a pulverized alloy of silver, tin, and copper with liquid (elemental) mercury. By weight, elemental mercury accounts for roughly half (50%) of dental amalgam. Mercury is a bioaccumulative, persistent, and hazardous contaminant. It accumulates in water-deposited sediments after being discharged into the environment, where it transforms into hazardous methylmercury and enters the food chain. Even small amounts pose a risk to the unborn child's development and early years of life, and can lead to serious health problems. Mercury has the potential to harm the lungs, kidneys, skin, eyes, neurological, digestive, and immune systems [2].

II. MATERIALS AND METHODOLOGY

The present study was carried out for the dental wastewater collected from various departments of JSS Dental College & Hospital, JSS Academy of Higher Education and Research, Mysuru, Karnataka, India.

The study area is located at latitude of 12.3428°N and longitude of 76.6525°E. The aerial view of the study area is shown in Figure 1 [3].

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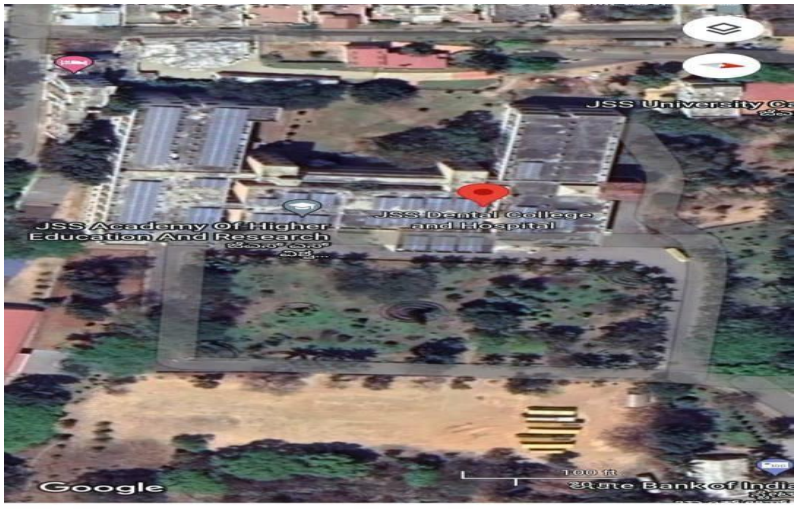

Figure 1: Aerial View of study area

The study area comprises of nine departments viz., Oral Medicine and Radiology, Paedodontics and Preventive Dentistry, Oral Maxillofacial Surgery, Conservative dentistry and Endodontics, Public Health Dentistry, Periodontology, Prosthodontics and Crown & Bridge, Orthodontics & Dentofacial Orthopaedics and Oral Pathology and Microbiology. Among nine departments, three departments' samples (Oral Medicine and Radiology, Paedodontics & Preventive Dentistry and combined Conservative dentistry & Endodontics and Public Health Dentistry) were choosen for present study because these departments house minor operational therapy, biological and chemical laboratories, diagnosis, etc. Compared to Paedodontics & Preventive dentistry, Oral Medicine and Radiology, Conservative Dentistry and Public Health Dentistry have a heavier patient load, which leads to more usage of water and eventually generation of wastewater too [4].

Sampling

Grab samples were collected from combined Conservative dentistry and Endodontics and Public Health Dentistry(S1), Paedodontics and Preventive Dentistry(S2) and Oral Medicine and Radiology(S3). The sampling was done in the month of March 2022. The collected wastewater samples were preserved in sample preservatory at 4°C till its experimental use. Plate 3.1shows the sampling point at study area [5].

Chemical Adsorbent – Bentonite

Commercially available chemical adsorbent Bentonite was used to determine its capacity to treat the samples of dental care facility [6].

Preparation of Bio-Adsorbent

The rice husk was the bio-adsorbent used in the present study. The rice husk was collected from neighboring rice mill in Mysuru, Karnataka, India. To get remove the dirt and soluble pollutants, it was repeatedly washed with distilled water. Then, it was dried in a Hot Air Oven for 72 hours at 100°C. Then the rice husk was carbonized by using, muffle furnace at 550°C for 15 minutes, which resulted in the production of activated rice husk [7].

Figure 2 shows the cleaning of rice husk before using it for experimental study. Figure 3 depicts the Muffle furnace used for carbonization of Rice Husk. Figure 4shows the Carbonized Rice Husk.

Figure 2: Cleaning of rice husk

Figure 3: Depicts the Muffle furnace used for carbonization of Rice Husk

Figure 4: Carbonized Rice Husk

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Batch Study

To determine the adsorbent's maximal capacity to reduce the concentration of COD and Bulk of Heavy Metals, batch tests were conducted on samples. In batch study, 200 ml of sample was taken and a fixed adsorbent dosage of 1% and 2% were added to samples separately in a beaker. The sample along with adsorbent was agitated using Magnetic Stirrer at 180 – 190 rpm for 2 hours. During the agitation, at an interval of every 15 minutes sample was collected from the beaker and analyzed for COD and Bulk of Heavy Metals [8].

Figure 5 and 6 shows Batch study for chemical adsorption by Bentonite and Bio-adsorption by rice husk.

Figure 5: Batch study for chemical adsorption

Figure 6: Batch study for Bio-Adsorption

III. RESULTS AND DISCUSSION

Analysis of the wastewater samples were conducted in accordance with the standard analytical methods (APHA, 2015) [9]. The physico-chemical characterization of all three wastewater samples were carried out separately in the laboratory. The physico-chemical characteristics measured and its method of determination is tabulated in Table 1.

Table 1. Initial concentration of Physico-chemical Characteristics of raw Dental Care Wastewater

Sl. No	Parameters	units	S1	S2	S3
1	pH	-	7.41	7.75	7.62
2	Temperature	℃	23℃	25.7℃	24℃
3	Turbidity	NTU	40NTU	36NTU	90NTU
4	Alkalinity as $CaCO_3$	mg/l	668mg/l	560mg/l	620mg/l
5	Total Hardness	mg/l	680mg/l	480mg/l	535mg/l
6	Calcium Hardness	mg/l	372mg/l	200mg/l	230mg/l
7	Chloride	mg/l	1666.15mg/l	1595.25mg/l	1676.20mg/l
8	COD	mg/l	16990mg/l	5190mg/l	3450mg/l
9	Total solid	mg/l	2300mg/l	6800mg/l	5600mg/l
10	Nitrate	mg/l	32mg/l	35mg/l	38mg/l
11	Phosphate	mg/l	52mg/l	53.6 mg/l	68.2mg/l
12	Bulk of heavy metals	mg/l	113.22 mg/l	Nil	38.32mg/l
13	BOD_5	mg/l	410mg/l	328mg/l	468mg/l

Batch Study by Chemical Adsorbent

COD

The samples were treated for 1% and 2% dosage of chemical adsorbent (Bentonite) in a batch study. During the batch study of 2 hours, the samples were collected at a frequency of every 15 min for the determination of COD.

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The average reduction in COD with 1% seeding and 2 % seeding are tabulated in Table 2 and Table 3 respectively.

Table 2: Average Percentage Reduction in COD with 1% Seeding by Chemical Adsorbent (Bentonite).

Contact time in Min	S1	S2	S3
0	0	0	0
15	12.6	23.82	15.23
30	23.5	35.26	23.37
45	36.5	59.64	46.07
60	48.6	76.43	60.37
75	64.30	78.95	56.00
90	75.5	71.93	58.11
105	75.32	68.39	56.51
120	73.06	63.09	52.36

Table 3: Average Percentage Reduction in COD with 2% Seeding by Chemical Adsorbent (Bentonite).

Contact time in min	S1	S2	S3
0	0	0	0
15	19.16	35.85	17.37
30	41.96	63.56	33.03
45	56.38	78.50	64.40
60	68.93	81.50	62.71
75	80.60	80.08	60.25
90	76.52	71.85	60.92
105	73.30	65.97	56.85
120	70.89	63.52	57.17

The graphical representation of percentage reduction in COD with 1% seeding and 2% seeding are shown in Figure 7 and Figure 8 respectively.

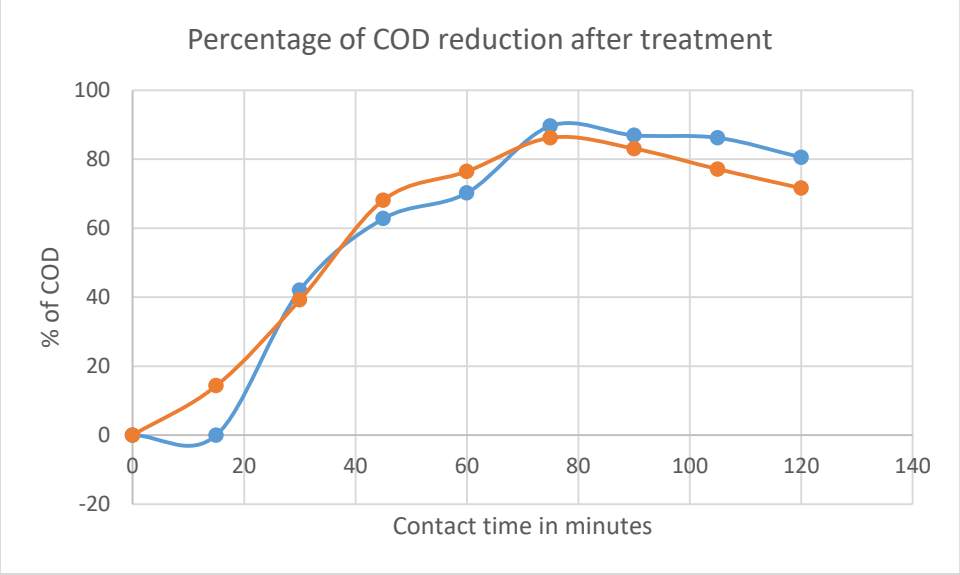

Figure 7: Average Percentage reduction in COD with 1% Chemical Adsorbent Seeding.

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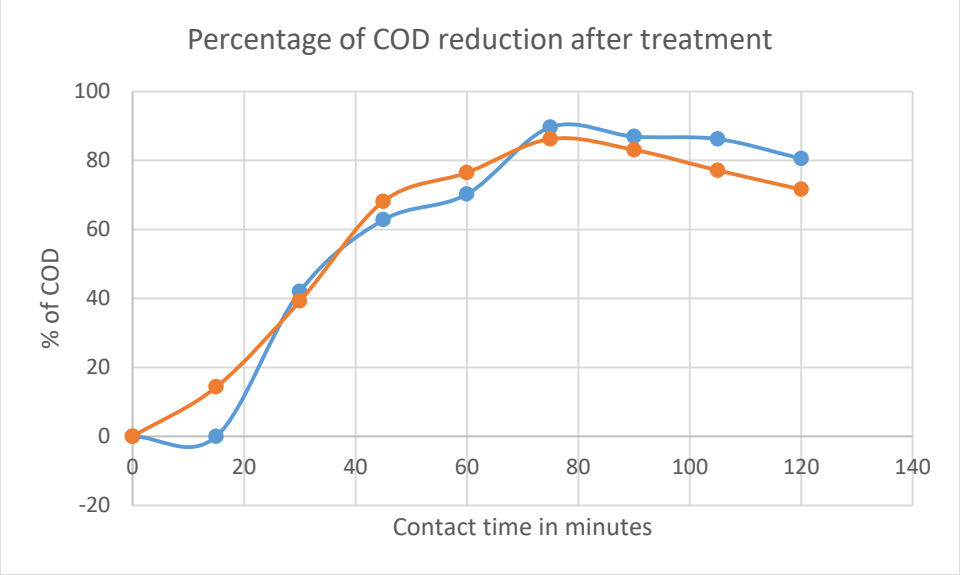

Figure 8: Average percentage reduction in COD with 2% Chemical Adsorbent Seeding.

At 1% seeding the optimum percentage removal of COD by use of Bentonite clay was 75.5%, 78.95% and 60.37% in S1, S2, and S3 respectively. Whereas, at 2% seeding, the optimum percentage removal of Bentonite clay was 80.60%, 81.50% and 64.40% in S1, S2, and S3 respectively. Compared to 1%, at 2% seeding the removal efficiency is high because as the amount of adsorbent added increased, the adsorbent molecules contain more vacant sites on the carbon due to higher concentration, the efficiency increases. Higher percentage of COD removal was observed in S2 (i.e., 78.95% and 81.50%) and lower percentage of COD removal was observed in S3 (i.e., 60.37% and 64.4%).

Bulk of heavy metals

The samples were treated for 1% and 2% dosage of Chemical- adsorbent (Bentonite) in a batch study. During the batch study of 2 hours, the samples were collected at a frequency of every 15 min for the Bulk of Heavy Metals concentration determination. The average reduction in Bulk of heavy metals with 1% seeding and 2% seeding are tabulated in Table 4 and Table 5 respectively.

Table 4: Average Percentage Reduction in Bulk of heavy metals with 1% Seeding by Chemical Adsorbent (Bentonite).

Contact time in min	S1	S3
0	0	0
15	5.79	9.42
30	9.90	14.53
45	19.00	21.41
60	26.11	32.60
75	37.04	47.83
90	41.79	56.02
105	49.02	52.66
120	42.13	46.83

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Table 5: Average Percentage Reduction in Bulk of heavy metals with 2% Seeding by Chemical-Adsorbent (Bentonite)

Contact time in min	S1	S2
0	0	0
15	10.78	13.80
30	16.16	29.95
45	29.30	42.60
60	39.24	53.72
75	44.00	59.10
90	46.68	56.13
105	44.17	52.00
120	41.58	50.02

The graphical representation of percentage reduction in concentration of Bulk of heavy metals with 1% seeding and 2% seeding of chemical adsorbent (Bentonite) are shown in Figure 9 and Figure 10 respectively.

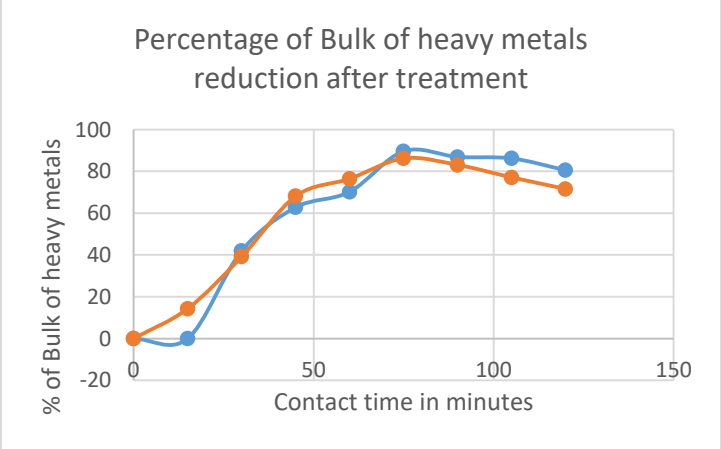

Figure 9: Average Percentage reduction in Bulk of heavy metals with 1% Chemical Adsorbent Seeding.

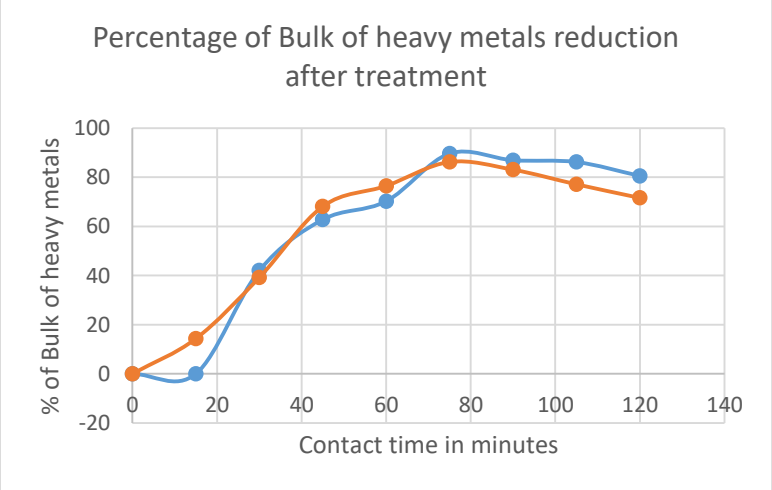

Figure 10: Average Percentage reduction in Bulk of heavy metals with 2% Chemical Adsorbent Seeding.

In sample S2 the initial concentration of Bulk of Heavy Metals was absent hence batch study was conducted only for S1 and S3. At 1% seeding, the optimum percentage reduction of Bulk of Heavy metals concentration by using Bentonite was 49.02% and 56.02% in S1 and S3 respectively. At 2% seeding 46.68% and 59.10% in S1 and S3

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respectively. However, the literatures reviewed in chapter 2, indicate that the efficiency in reducing heavy metals by bentonite in the refinery business is between 92% and 94% with the dose of the adsorbent closer to 6g/ml and 8g/ml and the contact duration was closer to 1 hour and 2 hours. In this study, higher percentage of Bulk of heavy metals reduction was observed in S3(i.e., 56.02% with 1% seeding and 59.10% with 2% seeding) and lower percentage removal was observed in S1 (i.e., 49.02% with 1% seeding and 46.68% with 2% seeding).

Batch Study by Bio-Adsorbent

COD

The samples were treated for 1% and 2% dosage of bio-adsorbent (Activated Rice Husk) in a batch study. During the batch study of 2 hours, the samples were collected at a frequency of every 15 min for the determination of COD. The average percentage reduction in COD with 1% seeding and 2 % seeding by Bio-adsorbent (Activated Rice Husk) are tabulated in Table 6 and Table 7 respectively.

Table 6: Average Percentage reduction in COD with 1% Seeding by Bio-Adsorbent (Activated rice husk)

Contact time in min	S1	S2	S3
0	0	0	0
15	8.46	7.45	9.20
30	16.43	17.11	16.00
45	26.90	28.44	33.60
60	35.94	34.00	56.00
75	46.12	50.05	68.50
90	60.78	62.66	66.45
105	58.37	64.03	62.92
120	55.67	57.44	60.00

Table 7: Average Percentage reduction in COD with 2% Seeding by Bio-Adsorbent (Activated rice husk)

Contact time in min	S1	S2	S3
0	0	0	0
15	11.35	18.31	13.50
30	26.64	34.08	29.19
45	36.91	47.82	49.01
60	57.59	55.41	69.49
75	64.75	63.57	65.00
90	64.01	63.86	67.28
105	62.43	61.43	63.15
120	58.26	55.09	60.00

The graphical representation of percentage reduction in COD with 1% seeding and 2% seeding by using bio-adsorbent (Activated Rice Husk) are shown in Figure 11 and Figure 12 respectively.

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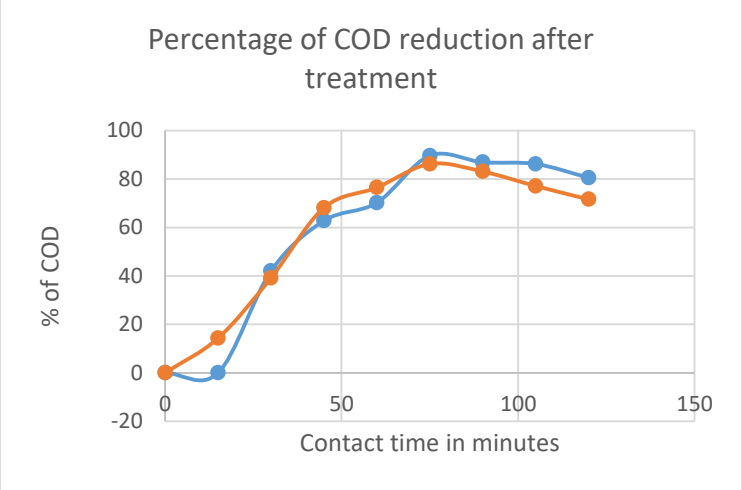

Figure 11: Average percentage reduction in COD with 1% Bio Adsorbent Seeding

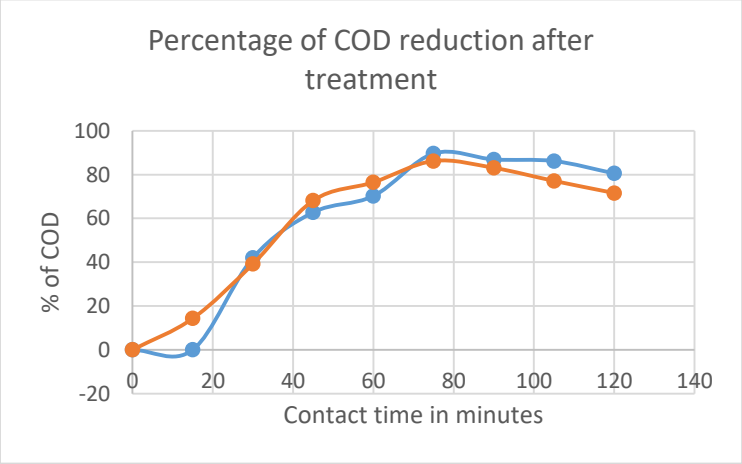

Figure 12: Average percentage reduction in COD with 2% Bio Adsorbent Seeding

At 1% seeding the optimum percentage reduction of COD by using of activated rice husk was 60.78%, 64.03% and 68.50% in S1, S2 and S3 respectively. Further, at 2% seeding the reduction was observed as 64.75%, 63.86% and 69.49% in S1, S2, and S3 respectively. Then the maximum reduction of COD in S3 (i.e.,68.50% with 1% seeding and 69.49% with 2% seeding). The minimum reduction of COD in S1 (i.e., 60.78% and 64.75% with 1% and 2% respectively).

Bulk of heavy metals

The samples were treated for 1% and 2% dosage of Bio- adsorbent (Rice husk) in a batch study. During the batch study of 2 hours, the samples were collected at a frequency of every 15 min for the Bulk of Heavy Metals concentration determination. The average reduction in Bulk of heavy metals with 1% seeding and 2% seeding are tabulated in Table 8 and Table 9 respectively.

Table 8: Average Percentage Reduction in Bulk of heavy metals with 1% Seeding by Bio-Adsorbent (Rice husk)

Contact time in min	S1	S2
0	0	0
15	13 68	14.31
30	42.00	39.19
45	62.76	68.13
60	70.22	76.48

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75	89.64	86.23
90	86.92	83.08
105	86.20	77.12
120	80.55	71.59

Table 9: Average Percentage Reduction in Bulk of heavy metals with 2% Seeding by Bio-Adsorbent (Rice husk)

Contact time in minute	S1	S2
0	0	0
15	27.60	26.23
30	56.50	62.2
45	70.37	84.86
60	91.01	91.42
75	86.52	87.19
90	85.11	86.05
105	85.86	86.17
120	84.79	81.03

The graphical representation of percentage reduction in Bulk of Heavy metals with 1% seeding and 2% seeding by using bio-adsorbent (Activated Rice Husk) are shown in Figure 13 and Figure 14 respectively.

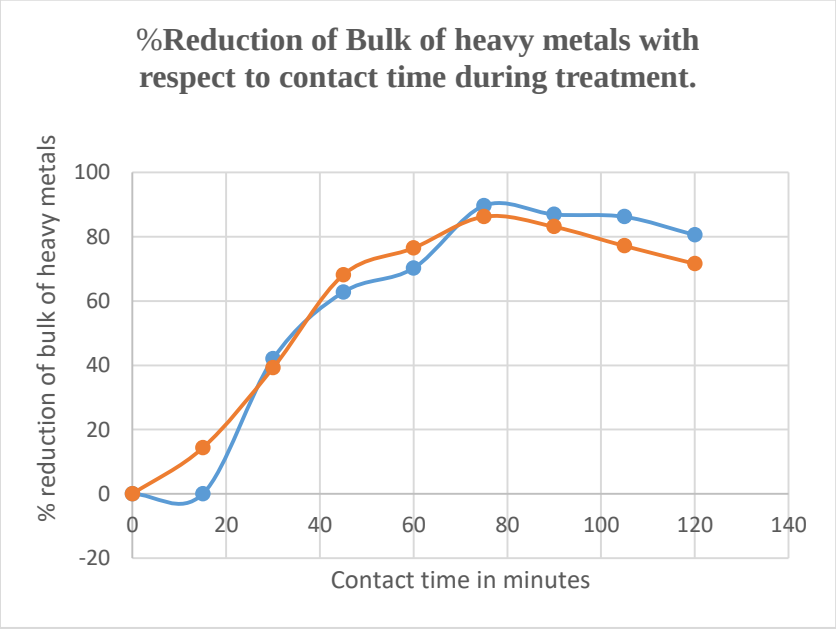

Figure 13: Average percentage reduction in Bulk of heavy metals with 1% Bio Adsorbent Seeding.

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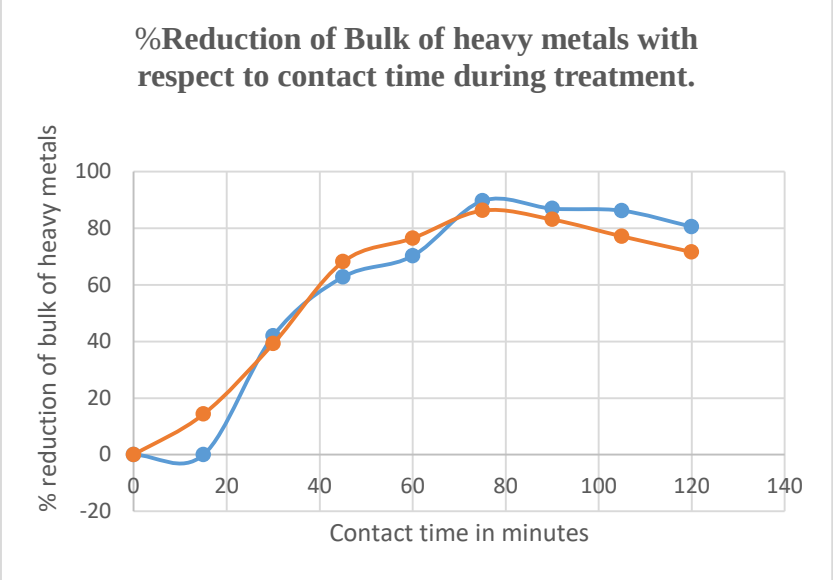

Figure 14: Average percentage reduction in Bulk of heavy metals with 2% Bio Adsorbent Seeding.

With 1% seeding, the optimum percentage reduction in Bulk of Heavy metals concentration by using activated rice husk was 89.64%, 86.23% in S1, and S3 respectively. But, at 2% seeding, percentage reduction in Bulk of Heavy metals concentration by using activated rice husk was 91.01%and 91.42% in S1 and S3 respectively. Compares to gray wastewater, dairy wastewater, refinery wastewater in which orange peels and coconut shells are used as adsorbent for contact time of 30minutes even though the efficiency was between 85-90%. In this batch study the efficiency is 91.42 (S3) for 2% seeding carbonized rice husk.

IV. CONCLUSION

Pollutants are present in the wastewater produced by JSS Dental College's various departments; thus, it must be adequately treated before being released into the environment to avoid environmental problems. Both chemical and biological adsorption have been used. Adsorption batch studies are carried out with magnetic stirrers set to 180-200 rpm. The efficiency of chemical and biological adsorption is evaluated. The primary goal of the treatability investigation was to reduce the concentrations of two parameters such as COD and bulk heavy metals. Based on the above-mentioned experimental findings, it is clear that chemical adsorption utilizing bentonite is ineffective at removing COD and bulk amounts of heavy metals, and Activated rice husk is efficient in removing Bulk of heavy metals.

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