

Effect of Common Ions on Adsorption of Hg(II) and Cr(VI) using Chemically Activated Biosorbent By Column Studies

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ABSTRACT

The scope of this study was to evaluate the potential of *Syzygium jambolanum* nut activated with ammonium persulphate as an adsorbent for the removal of Hg(II) and Cr(VI) ions from wastewater. Continuous adsorption study in a fixed-bed column was carried out by using the chemically activated *Syzygium jambolanum* nut carbon (CHSJC) as an adsorbent for the removal of mercury and chromium ions from chlor alkali and electroplating wastewater. The effect of common ions was investigated on the adsorption characteristics of CHSJC. In the absence of a complexing agent, mercury(II) is reduced to elemental form (Hg_0) to varying extent. This could be conveniently overcome by the addition of NaCl to stabilise Hg(II) as $[HgCl_4]^{2-}$. The presence of NaCl up to 50 g/L had no marked effect on the removal of Hg(II) by CHSJC. The presence of anions like bicarbonate and sulphate in the concentration range up to 1000 mg/L did not have any significant change on the uptake of Hg(II) in the column. For Cr(VI), the capacity of adsorption by CHSJC remained unaffected in the presence of chloride and sulphate up to 1000 mg/L. Results revealed that chemically activated *Syzygium jambolanum* nut adsorbent could serve as a low cost alternative to commercial adsorbent for heavy metal ions removal from wastewater even in the presence of common ions.

KEYWORDS: *Syzygium jambolanum* nut, Hg(II), Cr(VI), chloride, bicarbonate, sulphate

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I. INTRODUCTION

Water pollution occurs when harmful substances, often chemicals contaminate a stream, river, lake, ocean or other water bodies, degrading water quality and rendering it toxic to humans or the environment. Industrialization across the globe has a major impact on water pollution. Heavy metal ions like Hg(II), Cr(VI), Pb(II), Cd(II) etc released from the effluents into the water endangers public health.

Mercury(II) is released from various pollution sources, such as mining, municipal waste, and chlor alkali industry into the environment [1]. Mercury(II) undergoes biological methylation (amplification) in food chain. Hg(II) can be converted to a pernicious methyl mercury (CH_3Hg^+) by anaerobic methane synthesising bacteria present in water. Methyl mercury enters the food chain through plankton and is concentrated by a factor of 10^3 or more as it passes up the food chain

to man. This was the case of 'Minamata disease' in 1953-60 in Japan, where about 45 people died after consuming mercury-contaminated fish from Minamata bay. The mercury source was the effluent from a vinyl chloride plant, Minamata Chemical Company, which discharged effluent into the bay. In 1972, in Iraq, 450 villagers died after eating wheat dusted with a mercury containing pesticide [2]. These two tragic events resulted in the awareness of Hg(II) as a pollutant and being studied more extensively than any other trace metal ion. Nervous system, gastrointestinal and renal systems are adversely affected by the ingestion of mercury(II) contaminated water, in which mercury combines with the thiol residues present in the proteins of the human body and impairs the mental and neurological functions [3].

Chromium(VI), is released into the environment from metal ceramics, metal plating, stainless steel, paints, chemicals, and tanning industries. Chromium has two main oxidation states. Cr(III) and Cr(VI) ions. Chromium(III) serves as an essential nutrient in balanced diet for both humans and animals in trace levels. Its deficiency causes disturbance to the glucose and lipid metabolism in humans. However, chromium(VI) is known to be a toxic, non-biodegradable and carcinogenic species. It is highly soluble in water, capable of causing skin allergy, stomach upset and ulcer, respiratory issues, immune system damage, kidney and liver diseases, lung cancer, and sometimes even death [4].

The tolerance limit for Cr(VI) for discharge into drinking water is 0.05 mg/L and for Hg(II) it is 0.002 mg/L according to USEPA (United States Environment Protection Agency) standard [5]. It is 0.05 mg/L for Cr(VI) and 0.001 for Hg(II) according to Indian Standard [6]. So it is crucial to treat them before discharge. Several processes are useful to remove these heavy metal ions from water and wastewater including chemical precipitations, ion exchange, membrane filtration, floatation, and coagulation flocculation [7]. Adsorption technique is one of the most widely used methods for removal of heavy metals from wastewater due to low-cost and eco friendly materials. Several adsorbents have been used to remove the heavy metal ions from wastewater such as coconut shell, palm kernel oil, melon seeds, coffee husk, pumpkin seeds etc [8]-[12].

Syzygium jambolanum nut is a potential agricultural waste. *Syzygium jambolanum* tree is an evergreen tropical tree. It is commonly called

java plum, jambul, jamun, jaman, black plum, Indian blackberry, jambol, jambolan etc. It grows to 50 to 100 feet tall with oblong opposite leaves. The berry has a single nut which is used for the treatment of diabetic and blood pressure. As the production rate of the nut is high, a large amount of nuts remains a waste. The study here deals with chemically activated high temperature *Syzygium jambolanum* nut carbon (CHSJC) for the effective removal of Hg(II) and Cr(VI) from wastewater by column studies and the effect of common ions on the removal of Hg(II) and Cr(VI). The suitability of CHSJC for the removal of mercury(II) and chromium(VI), was compared with the carbon derived by the pyrolysis of *Syzygium jambolanum* nut and activation in CO₂ atmosphere, high temperature *Syzygium jambolanum* nut carbon (HSJC) and a commercial activated carbon (CAC).

II. METHODOLOGY

Preparation of CHSJC and HSJC

One hundred gram of *Syzygium jambolanum* nut was treated with 100 mL of con. H₂SO₄ for carbonisation purpose in the presence of oxidising chemicals like (NH₄)₂S₂O₈. The material was left in an air oven maintained at 140 – 160 °C for 24 h. The material was repeatedly washed with distilled water followed by 2 % NaHCO₃ solution to remove the free acid and finally left immersed in 2 % NaHCO₃ solution overnight. After separating the material, it was washed with distilled water, dried at 105 ± 5 °C. The dried material was subjected to thermal activation in CO₂ atmosphere by sandwiching the material between powdered CaCO₃ beds in a closed container at 800 – 850 °C for 30 min. The material was washed with water and then soaked in 10 % HCl to remove CaO and undecomposed CaCO₃. After separating the material, it was washed with distilled water, dried at 105 ± 5 °C. The carbon was referred to as CHSJC [13].

HSJC was prepared by keeping the *Syzygium jambolanum* nut at 600 °C for direct carbonisation followed by thermal activation in CO₂ atmosphere in the temperature range of 800-850 °C for 30 min [14].

Commercial activated carbon(CAC) of LOBA chemicals was used for comparison purposes. All the carbons were ground and sieved to separate 20 – 50 mesh ASTM particles.

Batch Studies

One hundred mL of 10 mg/L of Hg(II) solutions containing 10 g/L of NaCl were adjusted to

different pH values in the range of 1.0 – 10.0 and known amounts of CHSJC, HSJC and CAC under study were added to these solutions taken in 300 mL polythene bottles. The solutions were equilibrated for 24 hours in a mechanical shaker. The solutions were filtered and analysed for Hg(II) content using DMA (Direct Mercury Analyser, Milestone Inc). Other parameters such as effect of carbon dose at optimum pH and effect of equilibration time under optimum pH and carbon dosage were also established by the above methods. For removal of Hg(II) content, the optimum pH was fixed at 5.0 for all the three carbons. The minimum carbon dosage for 99 % removal was 0.1 g, 0.2 g and 0.3 g for CHSJC, HSJC and CAC respectively. Whereas the equilibration time needed for maximum removal of Hg(II) was 3 h for CHSJC, 4 h for HSJC and 5 h for CAC.

For Cr(VI), batch studies were done by using mechanical shaker. 100 mL of 10 mg/L Cr(VI) solutions were taken in 300 mL polythene bottles and adjusted to pH 1.0 to 6.0 with 0.5 g each of CHSJC, HSJC and CAC and equilibrated for 24 h. Then it was filtered and analysed for Cr(VI) by using UV- Visible spectrophotometer at 540 nm by standard methods [15]. For maximum removal of Cr(VI) the optimum pH was fixed at 2.0 at which HCrO_4^- ions were predominant. The minimum carbon dosage was 0.1 g, 0.2 g and 0.3 g for CHSJC, HSJC and CAC respectively for the quantitative removal of Cr(VI). The equilibration time needed for maximum removal was 4 h for CHSJC, 5 h and 6 h for HSJC and CAC respectively [13].

Column studies

Column studies were carried out using 15g each of CHSJC and HSJC and 20g of CAC packed in a 2.5 cm diameter glass column to evaluate the effect of bed height and flow rate. The carbon under study was made into slurry with distilled water and transferred slowly to the glass column packed at the bottom with glass wool. The bed was washed several times with water. Polythene tubes were connected to the bottles with a tap at the bottom. The other end of the tubing was connected to a socket containing a flow regulating valve. The outlet of the valve was fixed to the top of the glass column which was kept at a lower level. The columns were provided with pinch cocks at the bottom to control the flow rates. For the column experiments a pressure head of 10-15cm (4" -6") was maintained over the carbon beds. The inflow

and outflow rates were maintained constant. Figure 1 shows the schematic representation of the column.

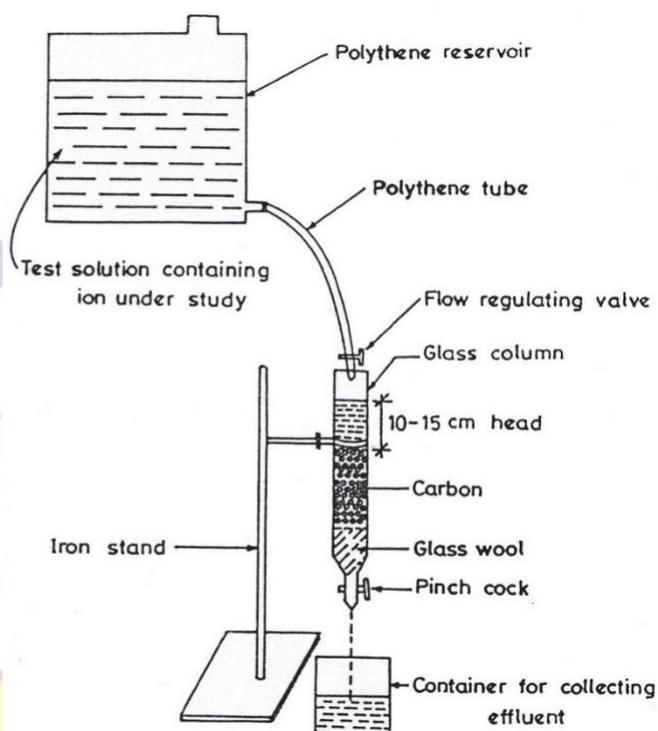


Figure 1. Schematic representation of the column

Effect of flow rate and bed height for removal of Hg(II)

To establish the optimum flow rate for maximum uptake of Hg(II), column experiments were carried out using 10 mg/L of Hg(II) solution containing 10 g/L of NaCl adjusted to a pH of 5.0 in the varying flow rates of 10-20 mL/min to percolate through the carbon under study. Under the experimental conditions, Hg(II) forms an anionic complex $[\text{HgCl}_4]^{2-}$ with NaCl and inhibited the reduction of Hg(II) to Hg_0 by the elemental carbon. For all the three carbons the rate of flow had a considerable influence on Hg(II) removal and was maximum when maintained between 11-16 mL/min. In the optimal flow rate range, CHSJC removal of Hg(II) remained at 80 mg. Removal of Hg(II) by HSJC was 60 mg and by CAC it was 40 mg. So an optimum flow rate was fixed as 14 mL/min for all the carbons.

The amount of mercury removed varied with bed height. In the case of CHSJC and HSJC, a minimum bed height of 8.0 cm provided by packing the 2.5 cm diameter column with 15 g of carbons should be maintained for the capacity per unit weight of carbon to remain constant. In the case of CAC, the minimum bed height should be 10.5 cm which was provided by 20 g of carbon. At optimum

bed height and flow rate, the uptake of Hg(II) by CHSJC, HSJC and CAC were found to be 80 mg/15 g, 60 mg/15 g and 40 mg/20 g respectively. This corresponded to the removal of 5.33 mg/g by CHSJC, 4 mg/g by HSJC and 2 mg/g CAC. At the optimal bed height and flow rate, CHSJC was 1.33 times as effective as HSJC and 2.67 times as effective as CAC.

Effect of flow rate and bed height for removal of Cr(VI)

To establish the optimum flow rate for maximum uptake of Cr(VI), column experiments were carried out using 100 mg/L of Cr(VI) solution adjusted to a pH of 2.0 in the varying flow rates of 10-20 mL/min to percolate through the carbon under study. For Cr(VI), the rate of flow had a considerable influence and was maximum when maintained from 11 - 16 mL/min. In the optimal flow rate range, the removal of Cr(VI) was maximum with CHSJC (300 mg) as compared to HSJC (160 mg) and CAC (100 mg). So a flow rate of 14 mL/min was maintained for all carbons.

A minimum bed height of 8.0 cm provided by 15 g CHSJC /HSJC should be maintained for the capacity per unit weight of carbons to remain constant. Similarly for CAC, a minimum bed height of 10.5 cm provided by 20 g of carbon should be maintained for maximum capacity. At the optimal bed height and flow rate, the uptake of Cr(VI) was found to be 300 mg/15 g, 160 mg/15 g and 100 mg/20 g for CHSJC, HSJC and CAC respectively. This corresponded to the uptake of 20 mg/g, 10.67 mg/g and 5 mg/g by CHSJC, HSJC and CAC respectively. So at the optimum bed height and flow rate, CHSJC was nearly 2 times as effective as HSJC and 4 times as effective as CAC.

Effect of anions on uptake of Hg(II) by the carbons

For Hg(II) removal the influence of the presence of sulphate and bicarbonate on the uptake of Hg(II) by the carbons were evaluated. The ion under study in the concentration range of 100 - 1000 mg/L was added to Hg(II) solution as sodium salt and the influence of each ion was separately evaluated. The solution was allowed to flow through the carbon column at a flow rate of 14 mL/min after adjusting the pH to 5.0. Analysis of Hg(II) content in the effluent was performed by collecting 200 mL lots separately. As soon as the Hg(II) level in the 200 mL effluent lot collected exceeded 0.002 mg/L, the percolation of Hg(II) solution was stopped. The results are summarised in Tables 1 to 3.

Effect of anions on uptake of Cr(VI) by the carbons

For Cr(VI) removal, the influence of common anions on the capacity of the carbons was evaluated. The ions examined included chloride and sulphate. (In chromium plating industries in order to activate the surface prior to plating acid dip process is given by immersion into 5 % sulphuric acid). The anions up to 1000 mg/L were added to the Cr(VI) solutions in the form of sodium salt and the influence of each was separately evaluated. 15 g of CHSJC/HSJC and 20 g of CAC were used for charging the 2.5 cm diameter columns. Solutions containing 100 mg/L of Cr(VI) at pH 2.0 containing varying amounts from 200 - 1000 mg/L of the ion under study were made to flow at a rate of 14 mL/min. Each lot of 200 mL was separately collected and analysed for Cr(VI) content. Percolation of Cr(VI) solution was stopped as soon as the Cr(VI) concentration in the collected lot exceeded 0.05 mg/L. The capacities were calculated and the results are shown in Tables 4 to 6.

III. RESULTS AND DISCUSSION

It was found that from Table 1 to 3 there was no significant change in the capacity of carbons in the concentration range up to 1000 mg/L for sulphate and bicarbonate ions and it could be inferred that the surface of carbon adsorbed Hg(II) as $[HgCl_4]_2^-$ in preference to sulphate and bicarbonate ions.

The capacity of the carbons to adsorb Cr(VI) remained unaffected for all the carbons in the presence of chloride and sulphate even when present at 1000 mg/L level as seen from Table 4 to 6.

Application

In chlor-alkali plants, mercury is used as a moving cathode in the cell. In mercury cell, process mercury remains in closed circulation in primary and secondary cells. The source of mercury contamination in wastewater arises through the cell house wash water and leakage of brine solution. The general characteristics of wastewater from chlor-alkali plant are shown below:

Characteristics of chlor-alkali plant wastewater

Mercury(II)content	=	5-10 mg/L
Chlorides	=	10- 50 g/L
Active chlorine	=	> 5mg/L

pH	=	>11
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The utility value of the prepared carbon for the treatment of synthetic chlor-alkali plant wastewater was analysed. As the concentration of chloride in the effluent can range from 10 g/L to 50 g/L, the influence of higher concentration of chloride on the removal of Hg(II) by the three carbons was examined. Sufficient amount of NaCl to cover the concentration range 10 - 50 g/L was added to a series of solutions containing 10 mg/L of Hg(II). The solutions were adjusted to pH 5.0 and allowed to pass through a 8.0 cm long CHSJC / HSJC bed and 10.5 cm long CAC bed at a flow rate of 14 mL/min. As soon as the Hg(II) content in the effluent lot collected exceeded 0.002 mg/L, the percolation of Hg(II) solution was stopped. The capacity of the carbons was calculated and is shown in Table 7 to 9. It was evident that the presence of sodium chloride up to 50 g/L showed no marked effect on the capacity of all the carbons.

Chlor-alkali plant wastewater containing 10 mg/L of Hg(II) with 50 g/L of NaCl and 5 mg/L of active chlorine was taken for studies. Sufficient amount of sodium sulphite was added until the solution was free from chlorine (O-tolidine test). After adjusting the solution to pH 5.0, the solution was stored in a container. 15 g of CHSJC, 15 g of HSJC and 20 g of CAC were separately taken in the 2.5 cm diameter glass columns to provide a height of 8.0 cm with CHSJC/HSJC and 10.5 cm with CAC. The wastewater containing the Hg(II) was allowed to pass through the carbon bed under study at a flow rate of 14 mL/min. Lot of 200 mL fractions were separately collected and analysed for Hg(II) content. Percolation was stopped as soon as Hg(II) concentration in the lot exceeded 0.002 mg. The uptakes of carbons were calculated and are given in Table 10.

The carbon beds were then regenerated by passing 250 mL of 1 % solution of NaOH containing 2 % Na₂S at a flow rate of 5 mL/min from a reservoir. After thoroughly washing, the carbon bed was used for 5 cycles of operation. Each bed was put to use for 5 cycles of operation and at

optimum bed height and flow rate the uptake of Hg(II) by CHSJC, HSJC and CAC were 80 mg/15 g, 60 mg/15 g and 40 mg/20 g respectively. This corresponded to the removal of 5.33 mg/g by CHSJC 4 mg/g by HSJC and 2 mg/g by CAC. The capacity was unaffected up to five cycles of operation for complete regeneration as the recovery of mercury(II) remained almost quantitative in each cycle. From the above results, it could be inferred that the removal and recovery of Hg(II) as [HgCl₄]²⁻ from synthetic chlor alkali plant by CHSJC was more than that of HSJC and CAC and the prepared chemically activated carbon could be a new source for the removal of Hg(II) from wastewater without the production of any elemental mercury since Hg(II) is in the form of stable [HgCl₄]²⁻.

The suitability of the carbon derived by chemical activation of *Syzygium jambolanum* nut carbon for the removal of chromium species from synthetic plating wastewater was evaluated.

The composition of Synthetic plating wastewater is

Chromium(VI)	=	100 mg/L
Chromium(III)	=	3 mg/L
Iron	=	5 mg/L
Sulphate	=	250 mg/L
pH	=	3.5

After adjusting the pH to 2.0, the synthetic solution was percolated through a 2.5 cm diameter glass column containing 15 g of CHSJC/HSJC and 20 g of CAC to provide the height of 8 cm and 10.5 cm with a flow rate of 14 mL/min till the concentration of Cr(VI) in the eluent collected exceeded 0.05 mg/L. The adsorbed Cr(VI) was recovered as chromate using a mixture of 1 M NaOH and 10 % H₂O₂. The regenerated carbon after washing as above was put to repeated use. The capacity remained unaffected up to 5 cycles of adsorption and desorption operation. Cr(VI) could be removed to the average of 84.9 %, 81.4 % and 79.9 % by CHSJC, HSJC and CAC respectively. The remaining chromium was desorbed as Cr(III) using 2 M HCl. The uptakes of carbons were calculated and are given in Table 11.

Table 1. Effect of common anions on the removal of Hg(II) as HgCl₄₂- by CHSJC

Weight of carbon = 15 g (for CHSJC and HSJC) , 20 g for CAC
 Hg(II) conc. = 10 mg/L
 Bed height = 8 cm(for CHSJC and HSJC) , 10.5 cm for CAC
 NaCl conc. = 10 mg/L
 Flow rate = 14 mL/min
 Break point = 0.002 mg/L
 pH = 5.0 ± 0.2

Lot of 200 mL fractions	Sulphate (mg/L)						Bicarbonate (mg/L)					
	200		600		1000		200		600		1000	
	Hg(II) found (mg)	Hg(II) removed (mg)										
Upto 39	ND	78.0000										
40	ND	2.0000	ND	2.0000	ND	2.0000	ND	2.0000	0.0003	1.9997	0.0001	1.9999
41	0.0005	-	0.0006	-	0.0005	-	0.0006	-	0.0006	-	0.0005	-
Uptake (mg)		80.0000		80.0000		80.0000		80.0000		79.9997		79.9999
Capacity (mg/g)		5.33		5.33		5.33		5.33		5.33		5.33

ND - Not detected

Table 2. Effect of common anions on the removal of Hg(II) as HgCl₄₂- by HSJC

Lot of 200 mL fractions	Sulphate (mg/L)						Bicarbonate (mg/L)					
	200		600		1000		200		600		1000	
	Hg(II) found (mg)	Hg(II) removed (mg)										
Upto 29	ND	58.0000										
30	ND	2.0000	0.0002	1.9998								
31	0.0005	-	0.0006	-	0.0006	-	0.0007	-	0.0006	-	0.0005	-
Uptake (mg)		60.0000		60.0000		60.0000		60.0000		60.0000		59.9998
Capacity (mg/g)		4		4		4		4		4		4

Table 3 Effect of common anions on the removal of Hg(II) as HgCl₂ by CAC

Lot of 200 mL fractions	Sulphate (mg/L)						Bicarbonate (mg/L)					
	200		600		1000		200		600		1000	
	Hg(II) found (mg)	Hg(II) removed (mg)										
Upto 19	ND	38.0000										
20	ND	2.0000										
21	0.0005	-	0.0007	-	0.0006	-	0.0006	-	0.0005	-	0.0006	-
Uptake (mg)		40.0000		40.0000		40.0000		40.0000		40.0000		40.0000
Capacity (mg/g)		2		2		2		2		2		2

Table 4. Effect of common anions on the removal of Cr(VI) by CHSJC

Cr(VI) conc. = 100 mg/L
 Flow rate = 14 mL/min
 Weight of carbon = 15 g (for CHSJC and HSJC), 20 g for CAC
 Bed height = 8 cm (for CHSJC and HSJC), 10.5 cm for CAC
 pH = 2.0 ± 0.2
 Break point = 0.05 mg/L
 (0.01 mg/200 mL)

Lot of 200 mL fractions	Sulphate (mg/L)						Chloride (mg/L)					
	200		600		1000		200		600		1000	
	Cr(VI) found (mg)	Cr(VI) removed (mg)										
Up to 14	ND	280.00										
15	ND	20.00										
16	0.03	-	0.03	-	0.05	-	0.05	-	0.05	-	0.04	-
Uptake (mg)		300.00		300.00		300.00		300.00		300.00		300.00
Capacity (mg/g)		20.00		20.00		20.00		20.00		20.00		20.00

ND- Not detected

Table 5 Effect of common anions on the removal of Cr(VI) by HSJC

	Sulphate (mg/L)						Chloride (mg/L)					
	200		600		1000		200		600		1000	
	Cr(VI) found (mg)	Cr(VI) removed (mg)										
Up to 7	ND	140.00										
8	ND	20.00										
9	0.02	-	0.03	-	0.02	-	0.05	-	0.04	-	0.04	-
Uptake (mg)		160.00		160.00		160.00		160.00		160.00		160.00
Capacity (mg/g)		10.67		10.67		10.67		10.67		10.67		10.67

Table 6. Effect of common anions on the removal of Cr(VI) by CAC

Lot of 200 mL fractions	Sulphate (mg/L)						Chloride (mg/L)					
	200		600		1000		200		600		1000	
	Cr(VI) found (mg)	Cr(VI) removed (mg)										
Up to 4	ND	80.00										
5	ND	20.00										
6	0.03	-	0.03	-	0.02	-	0.04	-	0.04	-	0.05	-
Uptake (mg)		100.00		100.00		100.00		100.00		100.00		100.00
Capacity (mg/g)		5		5		5		5		5		5

Table 7. Effect of chloride on the removal of Hg(II) as HgCl₄²⁻ by CHSJC in synthetic chlor alkali plant wastewater

Weight of carbon = 15 g (for CHSJC and HSJC) , 20 g for CAC
 Bed height = 8 cm (for CHSJC and HSJC) , 10.5 cm for CAC
 Flow rate = 14 mL/min
 Hg(II) conc. = 10 mg/L
 Break point = 0.002 mg/L
 pH = 5.0 ± 0.2

Lot of 200 mL fractions	Sodium chloride (g/L)								
	10			25			50		
	Fraction Lot	Hg(II) found (mg)	Hg(II) removed (mg)	Fraction Lot	Hg(II) found (mg)	Hg(II) removed (mg)	Fraction Lot	Hg(II) found (mg)	Hg(II) removed (mg)

	Upto 39	ND	78.0000	Upto 39	ND	78.0000	Upto 39	ND	78.0000
	40	ND	2.0000	40	0.0001	1.9999	40	0.0001	1.9998
	41	0.0005	-	41	0.0005	-	41	0.0005	-
Uptake (mg)			80.0000			79.9999			79.9998
Capacity (mg/g)			5.33			5.33			5.33

ND - Not detected

Table 8 Effect of chloride on the removal of Hg(II) as HgCl₄²⁻ by HSJC in synthetic chlor alkali plant wastewater

Lot of 200 mL fractions	Sodium chloride (g/L)								
	10			25			50		
	Fraction Lot	Hg(II) found (mg)	Hg(II) removed (mg)	Fraction Lot	Hg(II) found (mg)	Hg(II) removed (mg)	Fraction Lot	Hg(II) found (mg)	Hg(II) removed (mg)
	Upto 29	ND	58.0000	Upto 29	ND	58.0000	Upto 29	ND	58.0000
	30	ND	2.0000	30	ND	2.0000	30	0.0001	1.9999
	31	0.0007	-	31	0.0007	-	31	0.0007	-
Uptake (mg)			60.0000			60.0000			59.9999
Capacity (mg/g)			4			4			4

Table 9. Effect of chloride on the removal of Hg(II) as HgCl₄²⁻ by CAC in synthetic chlor alkali plant wastewater

Lot of 200 mL fractions	Sodium chloride (g/L)								
	10			25			50		
	Fraction Lot	Hg(II) found (mg)	Hg(II) removed (mg)	Fraction Lot	Hg(II) found (mg)	Hg(II) removed (mg)	Fraction Lot	Hg(II) found (mg)	Hg(II) removed (mg)
	Upto 19	ND	38.0000	Upto 19	ND	38.0000	Upto 19	ND	38.0000
	20	ND	2.0000	20	ND	2.0000	20	0.0001	1.9999
	21	0.0005	-	21	0.0006	-	21	0.0006	-
Uptake (mg)			40.0000			40.0000			39.9999
Capacity (mg/g)			2			2			2

Table : 10 Application of activated carbon for the treatment of synthetic chlor – alkali plant wastewater

Hg(II) = 10 mg/L pH = 5.0 NaCl = 50g/L Bed height =8cm (for CHSJC and HSJC) , 10.5(cm for CAC) Flow rate = 14mL/ min

Carbon	Hg(II) removal and recovery	Cycle No					Average value (mg)	Particle size degradation after 5 cycles (%)
		I	II	III	IV	V		
CHSJC 15g	Hg(II) removed	80	80	80	79.999	79.999	79.9996	1.16
	Hg(II) recovered	79.2	79	79	79.19	79.15	79.108	
HSJC 15g	Hg(II) removed	60	60	59.999	60	60	59.9998	1.34
	Hg(II) recovered	59	58.7	59	58.5	59	58.84	
CAC 20g	Hg(II) removed	40	40	40	40	39.999	39.996	1.38
	Hg(II) recovered	38.9	38.8	38.8	38.7	38.7	38.78	

Table : 11 Application of activated carbon for the treatment of synthetic electroplating plant wastewater

Cr(VI)= 100 mg/L pH = 2 Bed height =8 cm (for CHSJC and HSJC) , 10.5 cm (for CAC) Flow rate = 14mL/ min

Carbon	Cr(II) removal and recovery	Cycle No					Average value (mg)	Particle size degradation after 5 cycles (%)
		I	II	III	IV	V		
CHSJC 15g	Cr(II) removed	300	300	300	300	299.99	299.998	1.14
	Cr(II) recovered	255	254.5	254.2	254	253.5	254.24	
HSJC 15g	Cr(II) removed	160	160	159.99	159.99	159.99	159.994	1.35
	Cr(II) recovered	131	130.7	130	129.8	129	130.1	
CAC 20g	Cr(II) removed	100	100	100	99.99	99.99	99.996	1.3
	Cr(II) recovered	80.5	80.2	80	79.6	79	79.86	

IV. CONCLUSION

The studies has shown that the carbon derived by reacting *Syzygium jambolanum* nut with sulphuric acid in the presence of ammonium persulphate, after thermal activation in CO₂ atmosphere (CHSJC) is considerably superior to the thermally activated carbon (HSJC) and commercial activated carbon (CAC) for the removal of Hg(II) and Cr(VI) from aqueous solutions. At optimum bed height and flow rate, the uptake of Hg(II) by CHSJC, HSJC and CAC were found to be 80 mg/15 g, 60 mg/15 g and 40 mg/20 g respectively. It was found that there was no significant change in the capacity of carbons in the concentration range up to 1000 mg/L for sulphate and bicarbonate ions.. The presence of NaCl up to 50 g/L had no marked effect on the removal of Hg(II). For Cr(VI), at optimum pH of 2.0, the capacity of CHSJC was found to be 20 mg/g as against 10.67 mg/g for HSJC and 5 mg/g for CAC in the column studies The capacity remained unaffected in the presence of chloride and sulphate up to 1000 mg/L. The removal and recovery of Hg(II) as [HgCl₄]²⁻ from synthetic chlor-alkali plant and also the removal and recovery of Cr(VI) from synthetic plating wastewater by CHSJC was more than that of HSJC and CAC and the prepared chemically activated *Syzygium jambolanum* nut carbon could be a new low cost biosorbent, for the removal of Hg(II) and Cr(VI) from wastewater even in the presence of common ions.

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