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Removal of Bismuth (III) with Adsorption Using *Syzygium cumini*

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ABSTRACT
Recently the search for ecofriendly, low-cost adsorbent has become one of the main objectives of researchers. The purpose of this study is to analyze utility of Syzygium cumini for the removal of Bismuth (III) from aqueous system. The influences of solution pH, adsorbate concentration, adsorbent mass, contact time and temperature on the removal of heavy metal were evaluated. Maximum adsorption was observed at room temperature under acidic condition of pH 4.0 with contact time 80 minute at 1.2 gm of adsorbent mass. Fourier transform infrared spectral analysis showed the mechanism of metal adsorption onto the adsorbent surface. Based on these results, Syzygium cumini can be used as a low-cost alternative in adsorption of aqueous system having high concentration of Bismuth (III).
Keywords: *adsorption, low capital, heavy metal, FTIR, Syzygium cumini.*

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INTRODUCTION

Heavy metals and other toxic pollutants discharge into waterways causing water pollution is one of most concerning and frequent pernicious effects of industrial activities [1]. The rise in population and industrial development has negative impact on the environment due to heavy metal discharged [2]. Heavy metal removal from industrial wastewater required high energy or special operational requirements. A substantive amount of conventional sources like oxidation, reduction, ultrafilteration, precipitation, and electrochemical are being promised in the adsorption of toxic metals from waste water. Despite, their limitations include poor efficiency, higher sludge formation and inability to remove metals at higher concentrations [3, 4]. Recently, adsorption method come out to be an appropriate method for wastewater handling because of simplicity, low startup cost, and proficiency for metal ions [5, 6 and 7] and eliminates the pollutants without ruining the quality of water. Now days, the selection of alternative low-cost material such as sorbents for the heavy metal removal has emphasized. The present study focused on use of *Syzygium cumini as* a natural low cost adsorbent for heavy metal elimination from aqueous system was considered. *Syzygium cumini* find its place in numerous traditional systems of medicines like ayurveda, siddha, unnani and homeopathic. Efficiency of *Syzygium cumini* as reducing and stabilizing agent for adsorption of metal ions make it more versatile [8]. This study systematically investigates the adsorption behavior of the metal onto the *Syzygium cumini* by analyzing the impacts of solution pH, adsorbate concentration, adsorbent mass, contact time and temperature. Fourier transforms infrared spectra before and after adsorption of metal suggested the possible functional groups present on the surface. The experimental results can help us to determine the optimum conditions for environmental applications.

MATERIAL AND METHODS

In this study, the collected *Syzygium cumini* barks were washed and dried in sunlight for 5-6 days till became crisp and powdered finely in a mechanical grinder. Powder was used directly as an adsorbent for Bismuth (III) adsorption without any pretreatment.

All the chemicals used were of Analytical Grade. A stock solution of Bismuth (III) ions concentration 1000 mg/L was prepared by dissolving 0.580 gm of Bi $(NO_3)_{2.}5H_2O$ in double distilled water and the working

solutions of various concentrations were prepared freshly from stock solution by making appropriate dilutions.
In this study, adsorption experiment were carried out with considerable amount of adsorbent mass with different initial concentrations of Bismuth (II) from 0.1 mg/ml to 0.5 mg/ml followed by shaking and filteration using Whatman filter paper no.41 and analyzed for final concentration by complexometrically with Ethylene diamine tetra acetic acid (EDTA). The percentage removal of Bismuth (III) was calculated using equation as,

$$\% R = (Ci\text{-}Cf) / Ci \times 100$$

Where R is percentage removal, Ci, Cf expressed in mg/L is the initial and final concentrations of metal ion after treatment with adsorbent respectively.

RESULT AND DISCUSSION

pH effect

In this study, uptake of Bismuth (III) against pH was studied over the range of pH 2.0 to 6.0. The results portrayed in Figure 1. shows the uptake of metal increased due to increased pH value upto a pH 4.0. Deprotonation happens at higher pH, thereby creating more negatively charged adsorbent surface and hence promoting greater uptake of Bismuth (III) by electrostatic attraction [9]. At pH above 4.0 was found to decrease the metal removal efficiency. Higher metal removal 91.20 % observed at pH 4.0.

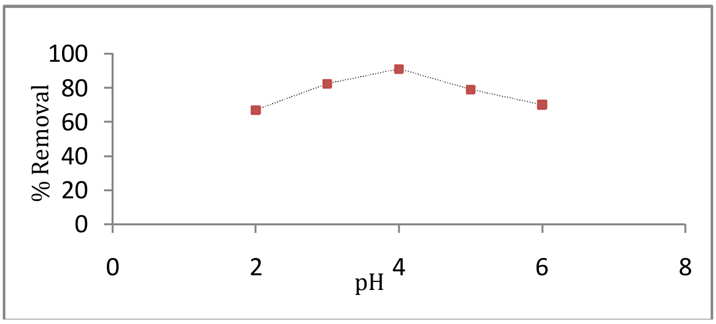

Figure 1: pH effect on adsorption of Bismuth (III)

Adsorbate concentration effect

The effect of adsorbate concentration 0.1 to 0.5 mg/ml on the uptake of metal onto adsorbent mass was investigated. Figure 2. illustrated that, metal removal efficiency and adsorption rate was increased due to an increase in adsorbate concentration. The increase was due to driving force, which gives an improvement in the heavy metal removal efficiency process [10, 11]. Further increase in concentration does not show any significant change due to decreased number of active sites. Adsorbate concentration of 0.4 mg/ml showed 91.18 % of metal removal.

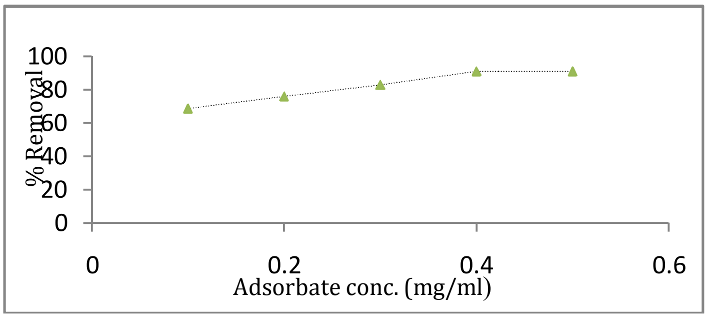

Figure 2: Effect of adsorbate conc. on Bismuth (III) adsorption

Adsorbent mass effect

The results depicted in Figure 3. clearly show that increase of adsorbent mass increases percentage adsorption from 0.1 to 1.6 gm/30 ml. At higher amount of adsorbent mass more and more binding sites were made present on the adsorbent for metal ions complexation, thereby promoting the ability to apatite higher metal uptake [12]. Once the equilibrium state was attained, further increment of adsorbent mass did not increase the percentage removal. Optimum adsorbent mass 1.2 gm /30 ml gave 89.10 % metal removal.

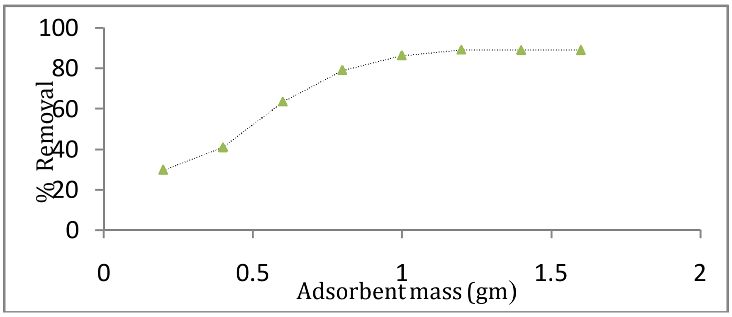

Figure 3: Adsobent mass effect on adsorption of Bismuth (III)

Processing time effect

Increasing the processing time from 10 to 120 minutes on Bismuth (III) adsorption using adsorbent mass 1.2 gm/30 ml at 0.4 mg/ml of concentartion was studied. As the processing time increased upto 80 minutes, the uptake of Bismuth (III) also increased and then attained equilibrium slowly at 120 minute shown in Figure 4. Increasing processing time does not show any increase. This may be attributed to the presence of large number of vacant surface sites on the biomass [13]. The maximum percentage removal was 94.35 % at 80 minutes.

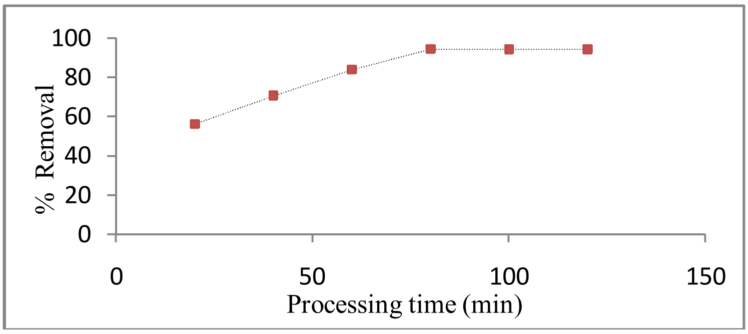

Figure 4: Processing time effect on adsorption of Bismuth (III]

Temperature effect

Adsorption efficiency by increasing temperature in the range of 25 to 65 ^{0}C was evaluated in this study. As shown in Figure 5. seen that as adsorbent mass exhibited to high temperatures used, resulted into increasing adsorption capacities and this could be attributed to exothermic nature of the process [14]. Maximum percentage removal of Bismuth (III) was found to be 89.66 % at 55 ^{0}C.

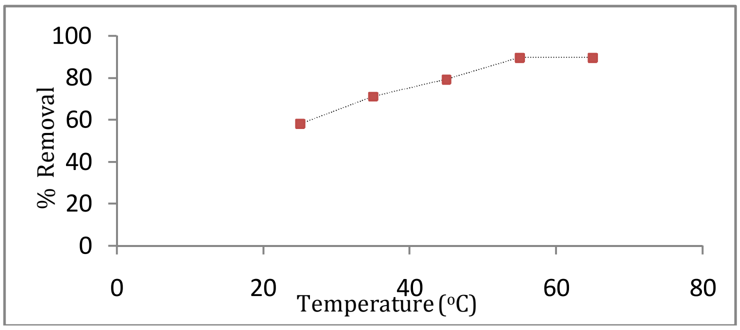

Figure 5: Temperature effect on adsorption of Bismuth (III]

FTIR technique

The surface functional group studies for *Syzygium cumini* as an adsorbent was performed by using FTIR technique. The FTIR spectra were recorded in the 4000-650 cm^{-1} region before and after the adsorption of Bismuth (III) ions presented in Figure 6. and Figure 7. respectively. Absorption peak in the range

3269.85 cm-1 to 3470.76 cm-1 attributes to vibrations of amine and hydroxyl groups. The broad peak intensity found at 3334 cm-1 and the chemical modification observed corresponds to the change of the environment due to the adsorption of Bismuth (III). The band observed in the range of 2848.26 cm-1 to 2916.65 cm-1 corresponds the elongation vibration of –CH stretching groups (Aliphatic). Absorption peak of *Syzygium cumini* obtained at 1504.14 cm-1, 1617.29 cm-1 attributed to the carboxyl groups and vibrations of N-H bond has shifted at slightly longer and shorter wavelength at 1510.12 cm-1 and 1604 cm-1 respectively after the adsorption of Bismuth (III) ion. The wavelength at 1315.80 cm-1 before adsorption has became more prominent and shifted larger at 1325 cm-1, due to adsorption of Bismuth (III) indicates presence of –NH bond. The CN stretching vibration due to the band observed at 1016.89 cm-1 shifted at longer wave number to 1024 cm-1 after the adsorption of metal. Functional groups present on the surface of adsorbent mass are involved in the adsorption process.

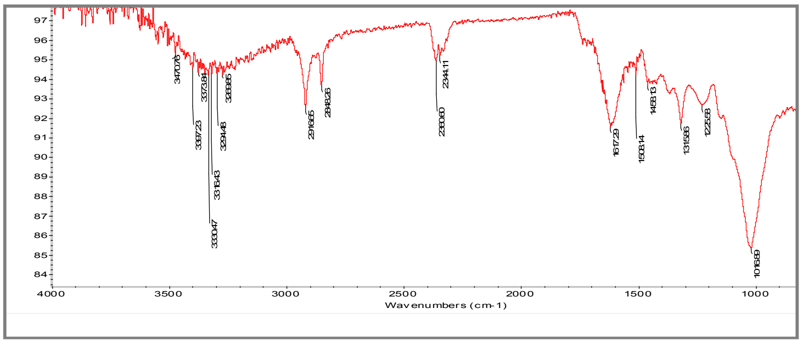

Figure 6: FTIR of adsorbent before adsorption of Bismuth (III]

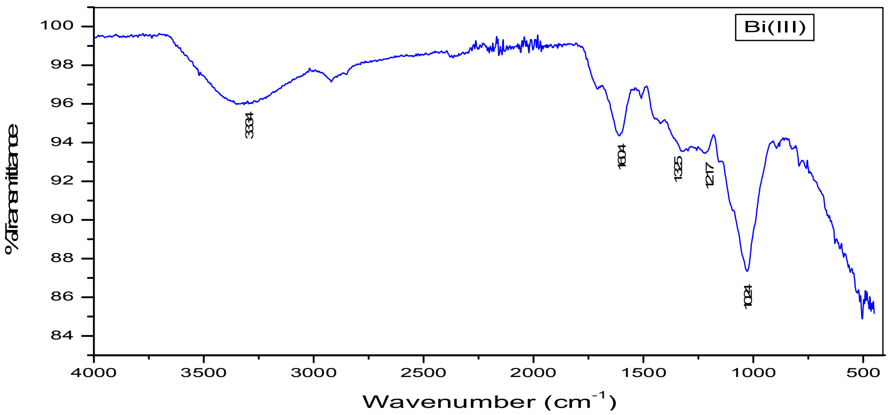

Figure 7: FTIR of adsorbent after adsorption of Bismuth (III]

CONCLUSION

The present investigation shows the adsorption behavior of Bismuth onto the *Syzygium cumini* from aqueous system. Owing to the increasing pH, there was an increase in the uptake of metal. The uptake of Bismuth (III) ions by adsorbent mass was found to be increased by increasing the adsorbate concentration 0.4 mg/ml and adsorbent mass. The optimum time for metal to reach equilibrium was 80 minutes and showing the exothermic nature. The adsorption capacity of *Syzygium cumini* was superior due to presence of hydroxyl and amine groups. The high adsorption capacities of *Syzygium cumini* with their advantages such as reusability, non aggressive nature, abundance form, easy handling technology and effective in terms of capital make it a better alternative over the other commercial adsorbents for the uptake of heavy metal ions.

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CONFLICT OF INTEREST
This work is original and not published anywhere.

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