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# Performance Analysis of Lead and Cadmium Removal from Bisolute System Using Rice Bran

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**Abstract:** ***A study was carried out to find out efficiency of rice bran in removal of heavy metals such as lead and cadmium from bisolute system. The different experimental conditions such as temperature, adsorbent amount, adsorbent particle size and concentration were studied. The results showed that 100% removal was achieved for both lead and cadmium by using rice bran at 30$^0$C, contact time 100-140 minute and adsorbent particle size 150 BSS. The removal of lead and cadmium was attributed to their affinity to the physical and chemical properties of rice bran.***

**Keywords:** Adsorption, Lead, Cadmium, Synthetic wastewater

## 1. Introduction

Rice bran is an agricultural waste material generated in rice producing countries, especially in Asia. The annual world rice production is approximately 500 million metric tons. Rice bran is composed of the **aleurone layer** of the rice, and some part of the endosperm and germ, which are rich sources of proteins, lipids, vitamins and trace minerals. Rice bran and its oil contain large concentration of several compounds that could potentially prevent chronic diseases such as coronary heart disease and cancer. During these studies, it was noted that rice bran contained high levels of both **tocopherol and tocotrienols**, which compromise vitamin E and act as antioxidants in the body. These compounds not only have no pollution effects but they are nutritious to the plants and human beings. Therefore, the uses of rice bran to eliminate pollution from water and its comparison with other expensive methods such as conventional ion exchangers reveal the significance of the rice bran. Unfortunately, up to now only a few studies have been carried out in this field.

Pollution of surface and ground water caused by human and industrial activities has been recorded as a major problem in the global context. Water pollution considered as the leading universal cause of 80 % of diseases. According to the United Nations Organization reports there are 1.1 billion people still do not have access to safe supply of drinking water; the majority of them are among the world's poorest and developing countries. Every day, there are thousands of chemicals discharged directly and indirectly into water bodies without further treatment for elimination of the included harmful compounds**.** Heavy metals are without doubt and well thought-out as the most hazardous and harmful metals even if they present as traces, since they accumulate in the tissue of living organisms

A number of techniques has been developed over the decades for the removal of toxic heavy metal ions from aqueous solutions, like precipitation, ion exchange and adsorption, etc. Adsorption is the most popular and widely used process for removing heavy metals from water and waste effluents. The conventional methods vig. precipitation, ion exchange and adsorption have been frequently practiced for the removal of heavy metals from water.

Man's awareness of the importance of waste utilization and the detrimental effects of heavy metal pollution has led to considerable research efforts aimed at understanding the interaction of metal with wastes and hence the ultimate use of wastes for the removal of heavy metal from wastewater. Several natural and waste materials have been demonstrated to remove heavy metals from wastewater. Agro-wastes are currently receiving attention as raw materials (adsorbents) for water pollution control due to their low cost and easy availability.

Adsorption by low cost adsorbents is one of the physico-chemical treatment processes and is an effective purification and separation techniques used in wastewater treatments in removing pollutants from their aqueous solutions. This process can be considered as a cheap method with simple design and low cost. The utilization of agricultural waste materials is increasingly becoming a vital concern because these wastes represent unused resources and in many cases present serious disposal problems. Numerous waste biomass sources are available in different parts of the world, several authors have reported studies on various low cost adsorbents such as: bark waste (Randall 1974), banana pith (Low et. al., 1995) sago waste (Quek et. al., 1998), cassava waste (Abia et. al., 2003), peanut skin (Randall et. al., 1974), sphagnum mass peat (Shan et. al., 1996), saw dust (Yu et. al., 2001 and Asadi et. al., 2008), rice husk (Lee and Low 1997), bagasse pith (Mckay G., El. G. and Nasser M.M.,1987), rice bran (Montanher et. al., 2005; Ajmal et. al., 2003), leaves (King et. al., 2006), Fly ash (Gupta et. al., 1988) and potato husk (Abdo et. al., 2011), peanut shell (Wafwoyo et. al., 1999), coir dust (Shukla et al., 2006), wheat bran (Farajzadeh, A.B. Monji, 2004), sea weeds (Hashim and Chu 2004) and (Strik, J. S., 2000), tea waste (Ahluwalia and Goyal, 2005), coffee waste (Maccgi et al.,1986) and tree bark (Sarin and Pant, 2006). All the above materials are inexpensive and available in a great quantity.

## 2. Materials and Methods

### 2.1 Preparation of Adsorbent

The adsorbent was extensively washed with running tap water for 20 to 30 minutes to remove dirt and other particulate matter followed by washing in double distilled water. Then it was dried in to direct fast sunlight at 40-45$^0$C. The dried adsorbent was ground in a grinder and sieved for desired particle size.

### 2.2 Selection of Adsorbent

50 ml of artificially prepared wastewater with 1.0 gm of the adsorbent was taken in reagent bottles and shaken in thermo-stated water bath-shaker for different time intervals. The 1.0 gm. amount of different adsorbent e.g. Wheat bran, Saw dust. Tea waste, Rice husk, Eucalyptus bark powder, Coconut shell powder and Rice bran were added in different reagent bottles for 20-60 minutes in thermo-stated water bath shaker at 200- 250 rpm. Then after 60 minute all the samples were centrifuged and supernatant collected in 25 ml. volumetric flask. After some time filtered samples were subjected to the Atomic Absorption spectrometer [SHIMADZOO 7000 AAS]. After analysis rice bran had shown high removal quality as adsorbents for managing the lead and cadmium effluents in bisolute system were selected.

### 2.3 Metal Analysis

The change in Pb(II) and Cd (II) concentration due to adsorption was determined by Shimmadzu 7000 Atomic Absorption Spectrophotometer. The percentage of Pb and Cd ion removal due to adsorption was calculated as % Pb and Cd as removal
$=[100-(C_t X100/C_0)]$

### 2.4 Study of Process Parameter

The effect of five parameters, Heavy metal concentration, adsorbent dose, contact time, temperature and particle size were studied.

## 3. Results and Discussion

The release of toxic metals has disastrous effects on the ecosystem. Various chemical and physical methods are being used presently for the removal of toxic heavy metals from the effluents but these methods are either cost prohibited or not practicable on account of operational shortcomings. Now a day, various agro-waste bio-sorbent materials are being investigated for the removal of heavy metals by adsorption process. Agro-wastes have proved to be costs effective adsorbents for the removal of heavy metals from the aqueous streams.

### 3.1 Effect of Concentration

From the graph in figure 1& 2 it was observed that as the concentration increased from 0.6 to 2.0 ppm the rate of adsorption decreased. In this way metal concentration showed an inverse relation with adsorption, i.e. maximum adsorption occurs at minimum concentration of metal ions. It may be so because greater number of metal ions in the solution causes more number of collisions. Removal was found to be 100 and 97.4 for Pb and Cd respectively with 0.6 ppm concentration (figure 1 and 2).

### 3.2 Effect of Mesh Size

For this purpose, ground rice bran was graded with different by sieves of mesh size 52, 100 and 150. The absorbance of obtained solution from filtration of the rice bran are recorded at adsorptive lines of the studied elements and compared with the absorbance of standard solution. The small particle (higher mesh) size showed the best results i.e. the maximum adsorption of the metal from the sample solution. It may be so because the equal quantity of different particle size provide different number of particles and thus different surface area and binding sites. Larger particles provide minimum number of binding sites exposed to the solution molecules and the smallest particle size provides largest surface area and more binding sites are available for metal ions to get bind. This can be shown in figure 3 & 4. Maximum removal was found to be 100 % for both Pb and Cd with 150 BSS particle size (figure 3 and 4).

### 3.3 Effect of Adsorbent Amount

The amount of adsorbent is clearly an important parameter that affects the adsorption process as shown in figure 5&6. As illustrated by the figure metal removal efficiency increases with increase in adsorbent dose, since contact surface of adsorbent particles is increased. Maximum removal was found to be 81.6 and 98.3 for Pb and Cd respectively with 1.5 g adsorbent amount (figure 5 and 6).

### 3.4 Effect of Temperature

Effect of temperature during a studies is shown in figure 7 & 8. At low temperature i.e. at 0$^0$ C the kinetic energy of metal ions is low and less metal ions reached the adsorbent's active sites so less percentage adsorption was observed as the temperature increased the kinetic energy of metal ions in the solution also increases so maximum number of metal ions reached to the adsorbent surface. But further increase in the temperature caused the kinetic energy of the metal ion in the solution increased so much that they start to unbind by the adsorbent surface. So the maximum adsorption occurred at 45$^0$**C** (figure 7 and 8).

## 4. Conclusion

Rice bran is a good adsorbent for removal of Pb and Cd from wastewater. Pb and Cd both were showed 100% adsorption at 0.6 ppm concentration, 30$^0$C and 1 gm. and 150 BSS particle size of adsorbent amount. Adsorptive properties of rice bran adsorbent largely depend on the source of biomass and treatment given to the adsorbent. The physical and chemical properties of the adsorbent such as surface area of particle size, adsorbent amount, concentration and temperature determine the adsorption characteristics of a material. Rice bran used for this study was not treated chemically. However, results shows that rice bran is a better adsorbent compared to some of the adsorbents.

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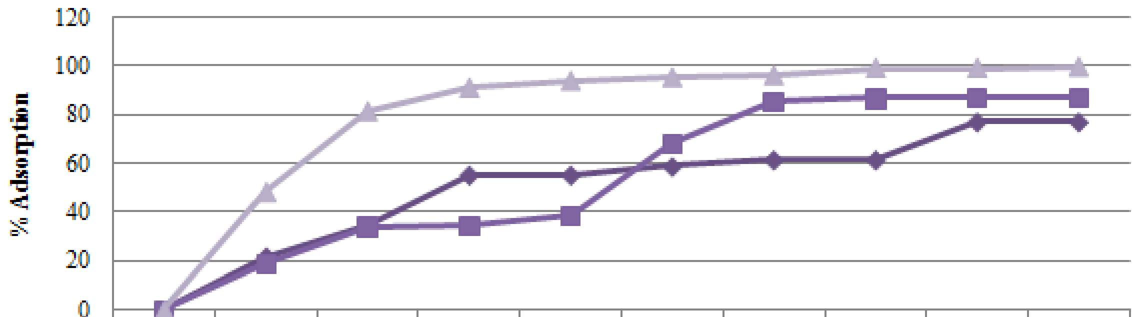
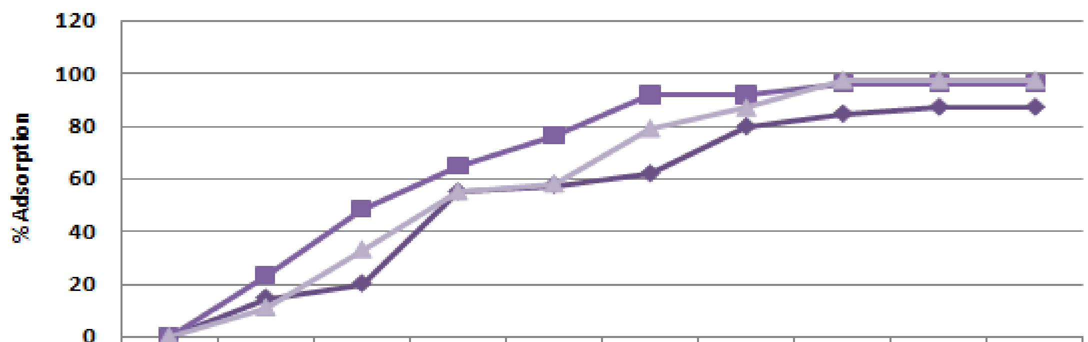



| | 10 | 20 | 30 | 40 | 60 | 80 | 100 | 120 | 140 | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.0ppm | 0 | 21.8 | 34.2 | 55.48 | 55.48 | 59 | 61.75 | 61.75 | 77.395 | 77.395 |
| 1.0ppm | 0 | 18.68 | 34.11 | 34.3 | 38.66 | 68.58 | 85.55 | 86.88 | 87.04 | 87.14 |
| 0.6 ppm | 0 | 48.48 | 81.66 | 91.33 | 94.16 | 95.55 | 96.45 | 99.55 | 99.55 | 100 |

Contact Time (Minute)

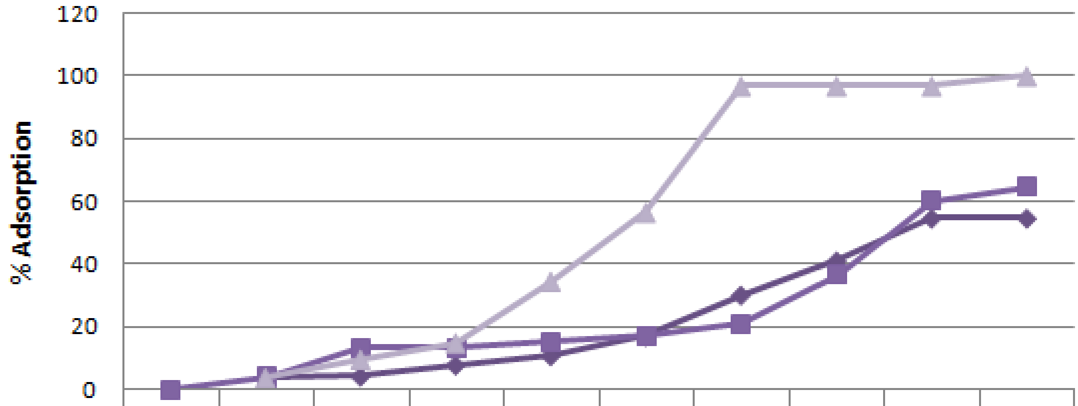
**Figure 1:** Plot Showing extract of Adsorption of Pb on Rice Bran at Different Initial Concentrations




| | 10 | 20 | 30 | 40 | 60 | 80 | 100 | 120 | 140 | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.0ppm | 0 | 14.55 | 20 | 54.83 | 57.34 | 61.75 | 79.6 | 84.4 | 86.95 | 86.95 |
| 1.0 ppm | 0 | 23.18 | 48.48 | 64.48 | 76.35 | 91.62 | 91.62 | 95.96 | 95.96 | 95.96 |
| 0.6 ppm | 0 | 11 | 33 | 55 | 58 | 79 | 86.88 | 97.4 | 97.4 | 97.4 |

Contact Time (Minute)

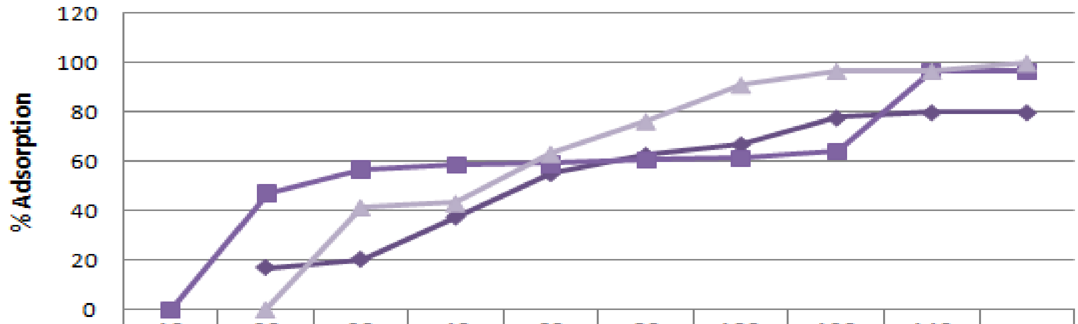
**Figure 2:** Plot Showing extract of Adsorption of Cd on Rice Bran at Different Initial Concentrations




| | 10 | 20 | 30 | 40 | 60 | 80 | 100 | 120 | 140 | |
|---|---|---|---|---|---|---|---|---|---|---|
| 52BSS | | 3.5 | 3.866 | 7.5 | 10.5 | 16.7 | 30 | 40.983 | 54.69 | 54.69 |
| 100BSS | 0 | 3.866 | 13.067 | 13.067 | 15.034 | 17 | 20.917 | 36.6 | 60.13 | 64.35 |
| 150 BSS | | 3.866 | 9.733 | 14.966 | 34.634 | 56.57 | 96.79 | 96.79 | 96.79 | 100 |

Contact Time (Minute)

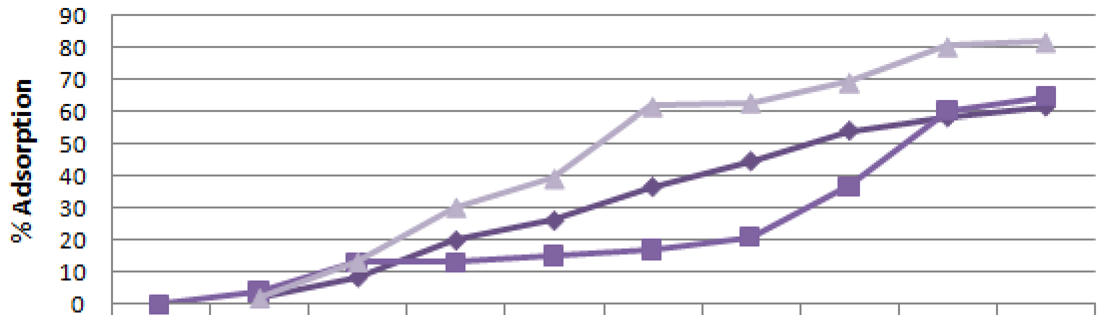
**Figure 3:** Plot Showing extract of Adsorption of Pb on Rice Bran of Different Mesh Sizes




| | 10 | 20 | 30 | 40 | 60 | 80 | 100 | 120 | 140 | |
|---|---|---|---|---|---|---|---|---|---|---|
| 52 BSS | | 16.66 | 20 | 37.31 | 55 | 62.43 | 66.78 | 77.68 | 79.88 | 79.88 |
| 100 BSS | 0 | 47.25 | 56.91 | 58.63 | 59.16 | 61.01 | 61.31 | 64.06 | 96.66 | 96.66 |
| 150 BSS | | 0 | 41.5 | 43.16 | 63.17 | 76.35 | 91.08 | 96.79 | 96.79 | 100 |

Contact Time (Minute)

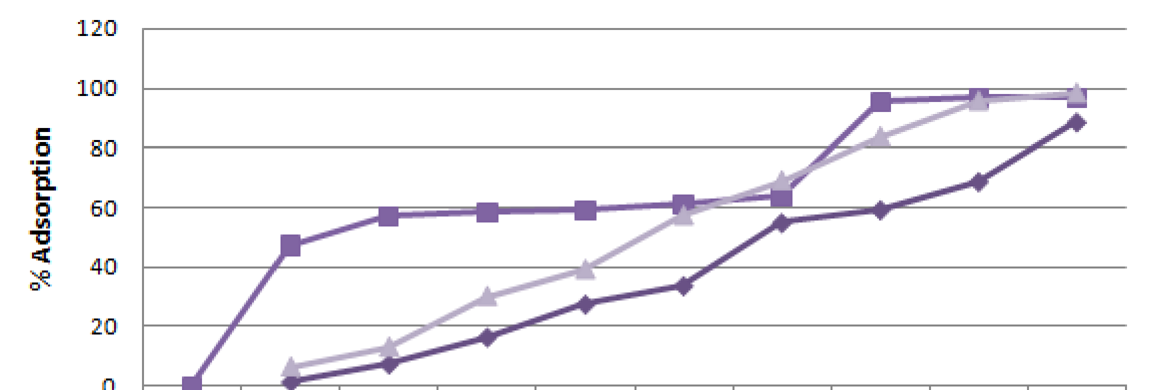
**Figure 4:** Plot Showing Extract of Adsorption of Cd on Rice Bran of Different Mesh Sizes




| | 10 | 20 | 30 | 40 | 60 | 80 | 100 | 120 | 140 | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.5 g. | | 1.83 | 8.33 | 19.83 | 26 | 36.5 | 44.5 | 54 | 58.16 | 61.33 |
| 1.0 gm | 0 | 3.866 | 13.067 | 13.067 | 15.034 | 17 | 20.917 | 36.6 | 60.13 | 64.35 |
| 1.5 gm | | 1.83 | 13.16 | 30.16 | 39.16 | 61.5 | 62.6 | 69 | 80.15 | 81.616 |

Contact Time (Minute)

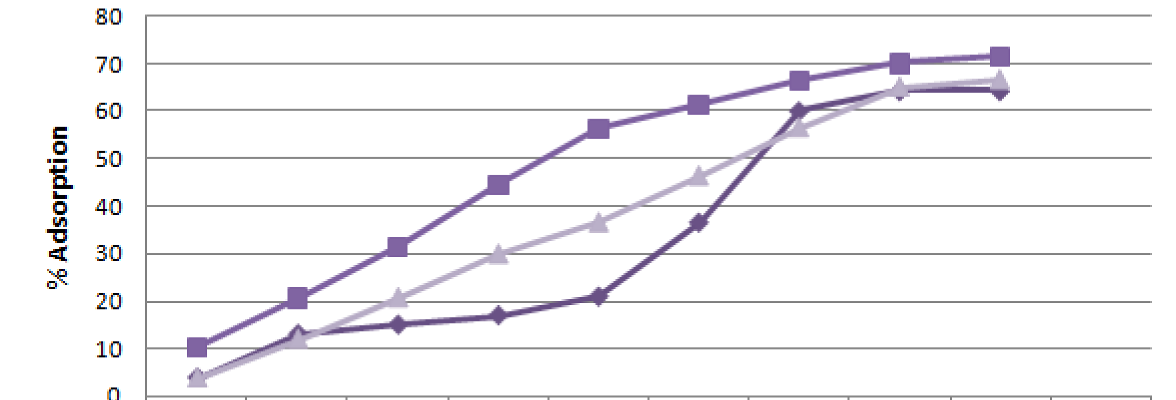
**Figure 5:** Plot Showing percentage Adsorption of Pb on Rice Bran at Different Adsorbent Amounts




| | 10 | 20 | 30 | 40 | 60 | 80 | 100 | 120 | 140 | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.5 g. | | 1.46 | 7.5 | 16.55 | 27.6 | 33.81 | 55 | 59.34 | 68.83 | 88.684 |
| 1.0 gm | 0 | 47.25 | 56.91 | 58.63 | 59.16 | 61.01 | 64.06 | 95.65 | 96.66 | 96.66 |
| 1.5 gm | | 6.45 | 13.166 | 30.166 | 39.166 | 57.33 | 69 | 83.66 | 95.65 | 98.31 |

**Contact Time (Minute)**

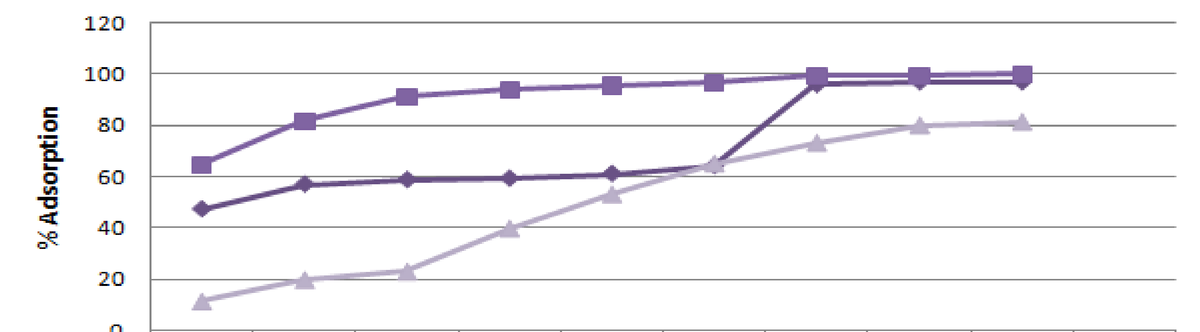
**Figure 6:** Plot Showing percentage Adsorption of Cd on Rice Bran at Different Adsorbent Amounts




| | 10 | 20 | 30 | 40 | 60 | 80 | 100 | 120 | 140 | |
|---|---|---|---|---|---|---|---|---|---|---|
| 30 C | 3.866 | 13.067 | 15.034 | 17 | 20.917 | 36.6 | 60.13 | 64.35 | 64.35 | |
| 45 C | 10.333 | 20.666 | 31.333 | 44.5 | 56.483 | 61.5 | 66.533 | 70.033 | 71.5 | |
| 55 C | 3.8333 | 12 | 20.666 | 29.833 | 36.5 | 46.316 | 56.483 | 65 | 66.533 | |

**Contact Time (Minute)**

**Figure 7:** Plot Showing % Adsorption of Pb on Rice Bran at Different Temperatures




| | 10 | 20 | 30 | 40 | 60 | 80 | 100 | 120 | 140 | |
|---|---|---|---|---|---|---|---|---|---|---|
| 30 C | 47.25 | 56.91 | 58.63 | 59.16 | 61.01 | 64.06 | 95.65 | 96.66 | 96.66 | |
| 45 C | 64.48 | 81.66 | 91.33 | 94.16 | 95.55 | 96.45 | 99.5 | 99.55 | 100 | |
| 55 C | 11.466 | 19.816 | 22.983 | 39.683 | 53.15 | 64.95 | 73.016 | 79.8 | 81.116 | |

**Contact Time (Minute)**

**Figure 8:** Plot Showing % Adsorption of Cd on Rice Bran at Different Temperatures