

## Removal of Heavy Metals Using Rice Husk: A Review

Sneh Lata<sup>1</sup> and S.R. Samadder<sup>2</sup>

<sup>1</sup>*Department of Environmental Science & Engineering,  
Indian School of Mines, Dhanbad-826004, India.*

<sup>2</sup>*Department of Environmental Science & Engineering,  
Indian School of Mines, Dhanbad-826004, India.*

### Abstract

The importance of removal of heavy metals from drinking water has received significant attention of researchers and decision makers across the globe. Bio-adsorbents have emerged as potential remediation materials for the removal of heavy metals and metalloids from both groundwater and surface water. Plants, algae, fungi are some of the biomass derived adsorbents which are capable of removing heavy metals and metalloids from aqueous solution by adsorption. For increasing the adsorption efficiency of bio-adsorbents, treatment of adsorbents is done by using various kinds of treating agents like tartaric acid, NaOH. The bio-adsorbents have affinity for heavy metal ions to form metal complexes or chelates due to having functional groups including carboxyl, hydroxyl, imidazole, sulphhydryl, amino, phosphate, sulfate, thioether, phenol, carbonyl and amide etc. Rice husk (RH) is a low cost (agricultural by-product) bio-adsorbent which has been studied intensively for the removal of various heavy metals and metalloids (such as Pb, Cd, Zn, Ni and As) from both groundwater and surface water. The present study is focused on critical review of previous and current available information on potential of treated and untreated rice husk for the removal of heavy metals and metalloids (arsenic). Various studies on adsorption efficiency of rice husk considering the parameters contact time, adsorbent dose (rice husk), initial concentration of heavy metals, pH, and temperature have been evaluated by many researchers. The present study analyzed those studies and compiled the adsorption efficiency of rice husk and concluded that treated rice husk gave comparatively better adsorption efficiency of heavy metals with compared to that of untreated rice

husk. The treated rice husk can be implemented on large scale industrial applications after field studies.

**Keywords:** Adsorption efficiency; Heavy metals and metalloids; and Rice husk.

## 1. Introduction

The presence of heavy metals in groundwater and surface water has become one of the major environmental worries. Heavy metals such as Pb, Cd, Cu, Zn, Ni, Cr, and metalloids like As in drinking water have adverse impacts on human health such as allergies, hyper pigmentation, skin lesions, skin cancer, neurological effect, hypertension, cardiovascular disease and pulmonary disease (Salem et al, 2000; Smith et al, 2000). The above mentioned heavy metals and metalloids target the liver, kidneys, lungs, brain and bones once absorbed through various path ways (Salem et al, 2000). For removal of heavy metals and metalloids many conventional techniques such as chemical precipitation, membrane filtration, ion exchange, carbon adsorption and co-precipitation have been used. But they are not suitable for high concentration of metals and also not cost effective (Demirbas, 2008). Bioadsorbents have emerged as one of the potential alternatives for removal of heavy metals and metalloids. Plants, algae, fungi are some of the biomass derived adsorbents which are capable of removing heavy metals and metalloids from aqueous solution by adsorption (Mohan et al, 2007). For increasing the adsorption efficiency of bioadsorbents, treatment of adsorbents is done by using various kinds of treating agents like tartaric acid and NaOH (Wong et al, 2003; Kumar and Bandyopadhyay, 2006). The bioadsorbents have affinity for heavy metal ions to form metal complexes or chelates due to having functional groups including carboxyl, hydroxyl, imidazole, sulphhydryl, amino, phosphate, sulfate, thioether, phenol, carbonyl and amide etc (Amin et al, 2006) and chemical treatment increases the number of these functional groups. Rice husk (RH) is a low cost (agricultural by-product) bioadsorbent which has been studied intensively for the removal of various heavy metals and metalloids (such as Pb, Cd, Zn, Ni and As) from both groundwater and surface water. For decontamination of heavy metals from drinking water treated adsorbent (rice husk) is comparatively better than untreated one, because untreated adsorbent can further generate the problems such as low adsorption capacity, high chemical oxygen demand, biological oxygen demand, total organic carbon due to release of soluble organic compounds in plant material (Rice husk)( Ngah and Hanafiah, 2008). Considering reaction time, adsorbent dose, and initial concentration of adsorbate, pH, and temperature, adsorption efficiency of rice husk has been reviewed in this study.

## 2. Physicochemical Characteristics of Rice Husk

Ye et al, (2012) reported physical properties of rice husk such as surface area of  $438.05\text{m}^2/\text{g}$ , bulk density of  $0.3086\text{ g/cm}^3$  and porosity of 0.38 by fraction. The

chemical composition of rice husk by component analysis has been reported as 34.4% cellulose by weight, 29.3% hemicellulose by weight, 19.2% lignin by weight, 17.1% ash by weight, elemental analysis shows 49.3 % oxygen by weight , 44.6 % carbon by weight , and 5.6 % hydrogen by weight and by proximate analysis 59.5% volatiles by weight, 17.1 % ash by weight (composition of mineral ash SiO<sub>2</sub>, K<sub>2</sub>O, MgO, Fe<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>, CaO) and 7.9 % moisture by weight was found (Williams and Nugranad, 2000). As rice husk is insoluble in water, having good chemical stability, structural strength due to high silica content (Lee et al, 1994) so researchers are using it for treating heavy metal from ground water and surface water.

### 3. Materials and Methods

Collection of rice husk may be done from local rice mill and may be prepared as an adsorbent by sieving through different sieve sizes to get the various particle size of rice husk. The untreated adsorbent (RH) is prepared by washing it with tap water followed by distilled water (Ranjan et al, 2008; Amin et al, 2006), but the treated adsorbent (RH) is prepared by soaking the adsorbent for sometime (soaking time varies for different treating agent) with treating agent like epichlorohydrin (ERH) (Kumar and Bandyopadhyay, 2006), tartaric acid (Wong et al, 2002), orthophosphoric acid (Dada et al, 2013), and polyaniline (Lashkenari et al, 2011). Adsorption capacities of treated and untreated rice husk at various parameters are shown in Table 1.

**Table 1:** Adsorption capacity of treated and untreated adsorbent (Rice husk)

Modifying agents	Metals removed	Parameters	Adsorption Capacity(mg/gn isotherm)	Adsorption isotherm	References
Untreated	As (III)	pH-7,temp.-20°C	0.139	Langmuir	Ranjan et al (2009)
	As (V)	pH-4, temp.-20°C	0.147		
Water washed	Cd (II)	pH - 6.6 to 6.8,temp. 28-30°C,initial Cd concentration - 10 mg/L, Particle size 505 µm	8.58	Langmuir	Kumar and Bandyopadhyay (2006)
Epichlorohydrin treated rice husk (ERH)			11.12		
Sodium bicarbonate treated rice husk (NCRH)			16.18		
NaOH treated rice husk (NRH)			20.24		
Tartaric acid (TA)	Cu(II)	pH-5.2-5.3,	29	Langmuir	Wong et al

	Pb(II)	Temp.- 27.2 <sup>0</sup> C	108		(2003)
sodium carbonate, sodium hydroxide,4M N- (3-chloro-2- hydroxypropyl) trimethylammoniu m chloride (quaternized rice husk)	As (V)	pH-7.5, temp.- 28±2 <sup>0</sup> C	18.98	Langmuir	Lee et al (1999)
Orthophosphoric acid(O-PA)	Pb(II)	pH- 6.30– 6.50	138.89	Langmuir	Dada et al (2013)
Untreated	Pb (II)	pH 4	4.23	--	Tarley and Arruda (2004)
	Cd (II)		1.42		
Pulverized rice husk	As(V)	--	615.11	--	Roy et al (1993)
Polyaniline/ HCl/distilled water	As	pH- 10, adsorbent dosage of 10 g/L and equilibrium time 30 minutes.	34.48	Freundlich	Lashkenari et al (2011)
Rice husk based Activated carbon (carbonized at temp. 400 <sup>0</sup> C (RHAC4), 600 <sup>0</sup> C (RHAC6), 800 <sup>0</sup> C (RHAC8) respectively )	Ni	Temp.- at room temp., Contact time- 30 min. (for Ni),15 min. (for Zn and Pb)	2.69(RHAC4)	--	Taha et al (2011)
	Zn		3.88(RHAC6)		
	Pb		6.23(RHAC8)		
			5.28(RHAC4)		
			5.38(RHAC6)		
			6.17(RHAC8)		
			6.01(RHAC4)		
			6.06(RHAC6)		
			6.17(RHAC8)		

#### 4. Results and Discussion

Untreated or water washed rice husk that has been used for removal of As (V) (Ranjan et al, 2008), Cd (Kumar and Bandyopadhyay, 2006), Pb and Cd (Tarley and Arruda, 2004), the adsorption capacity for these were found to be 0.147mg/g, 8.58 mg/g, 4.23 mg/g, 1.42 mg/g respectively. After chemical treatment it has been found that adsorption capacity of rice husk is increased to 11.2mg/g (with ERH), 20.24mg/g (with NRH), 16.18mg/g (with NCRH) for Cd (II) (Kumar and Bandyopadhyay, 2006), 29mg/g (with TA) and 108 mg/g(with TA) for Cu(II) and Pb(II) respectively (Wong et

al, 2003), 138.89 mg/g(with O-PA) for Pb(II) (Dada et al, 2013), 615.11mg/g (pulverized rice husk) for As (V) (Roy et al, 1993). Taha et al, (2011) observed adsorption efficiency for Pb (II) that is 6.01 mg/g (RHAC4), 6.06 mg/g (RHAC6), and 6.17 mg/g (RHAC8); for Zn it is 5.28 mg/g (RHAC4), 5.38 mg/g (at RHAC6), 6.17 mg/g (at RHAC8); for Ni 2.69 mg/g (RHAC4), 3.88 mg/g (RHAC6), and 6.23mg/g (RHAC8) (Table 1).

## 5. Conclusion

This review summarizes the various studies on removal of heavy metals using rice husk which revealed that treated rice husk attracted more attention than untreated one due to comparatively higher adsorption capacity favored by higher number of active binding sites, improved ion exchange properties and enhancement of functional groups after chemical treatment. The treated rice husk may be implemented on large scale industrial applications after field studies.

## 6. Acknowledgements

The authors gratefully acknowledge the support provided by Department of Environmental Science & Engineering, Indian School of Mines, Dhanbad.

## References

- [1] Amin, M. N., Kaneco, S., Kitagawa, T., Begum, A., H., Katsumata, Suzuki, T. and Ohta, K., (2006), Removal of Arsenic in Aqueous Solutions by Adsorption onto Waste Rice Husk, *Ind. Eng. Chem. Res.* 2006, 45, 8105-8110.
- [2] Chuah, T.G., Jumariah, A., Azni, I., Katayon, S., Thomas Choong, S., Y., (2005), Rice husk as a potentially low-cost biosorbent for heavy metal and dye removal: an overview, *Desalination* 175 (2005) 305-316.
- [3] Dada A. O., Ojediran, J. O., and Olalekan, A.P., (2013), Sorption of Pb<sup>2+</sup> from Aqueous Solution onto Modified Rice Husk: Isotherms Studies, *Hindawi Publishing Corporation Advances in Physical Chemistry Vol. 2013*, Article ID 842425, 6.
- [4] Demirbas, A., (2008), Heavy metal adsorption onto agro-based waste materials: A review, *Journal of Hazardous Materials* 157 (2008) 220-229.
- [5] Kumar, U., Bandyopadhyay, M., (2006), Sorption of cadmium from aqueous solution using pretreated rice husk, *Bioresource Technology* 97, 104-109.
- [6] Lashkenari, M.S., Davodi, B., and Eisazadeh, H., (2011), Removal of arsenic from aqueous solution using polyaniline/rice husk nanocomposite, *Korean J. Chem. Eng.*, 28(7), 1532-1538.
- [7] Lee, C.K., Low, K.S., Liew, S.C., Choo, C.S., (1999), Removal of arsenic(V) from aqueous solution by quaternized rice husk, *Environ. Technol.* 20, 971-978.

- [8] Mohan, M., Pittman Jr., C., U., (2007), Arsenic removal from water/wastewater using adsorbents-A critical review, *Journal of Hazardous Materials* 142, 1–53.
- [9] Ngah, W., S.,W, Hanafiah, M.A.K.M., (2008), Removal of heavy metal ions from wastewater by chemically modified plant wastes as adsorbents: A review, *Bioresource Technology* 99, 3935–3948.
- [10] Ranjan, D., Talat, M., Hasan, S., H., (2009), Biosorption of arsenic from aqueous solution using agricultural residue ‘rice polish’, *Journal of Hazardous Materials* 166, 1050–1059.
- [11] Roy D.,Greenlaw, P.,N., and Shane, B.,S.,(1993), Adsorption of heavy metals by green algae and ground rice hulls, *J. Environ. Sci. Health*, A28 (1) 37-50.
- [12] Salem,H.,M., Eweida,E.,A., and Farag, A., (2000), Heavy metals in drinking water and their environmental impact on human health, *ICEHM2000*, Cairo University, Egypt, page 542- 556.
- [13] Smith, A. H., Lingas, E. O., and Rahman, M., (2000), Contamination of drinking water by arsenic in Bangladesh: A public health emergency, *World Health Organization*, 78: 1093-1103.
- [14] Taha, M.,F., Kiat, C.,F., Shaharun, M.,S., Raml, A.,(2011), Removal of Ni(II), Zn(II) and Pb(II) ions from Single Metal Aqueous Solution using Activated Carbon Prepared from Rice Husk, *World Academy of Science, Engineering and Technology* 60.
- [15] Tarley, C.,R.,T., Arruda, M.,A.,Z., (2004), Biosorption of heavy metals using rice milling by products. Characterisation and application for removal of metals from aqueous effluents, *Chemosphere* 54, 987–995.
- [16] Williams, P. T.; Nugranad, N., (2000), Comparison of products from the pyrolysis and catalytic pyrolysis of rice husks, *Energy* 2000, 25, 493.
- [17] Wong, K.K., Lee, C.K., Low, K.S., Haron, M.J., (2003), Removal of Cu and Pb by tartaric acid modified rice husk from aqueous solutions, *Chemosphere* 50 , 23–28.
- [18] Ye, H., Zhang, L., Zhang, B., Wu, G., Du, D., (2012), Adsorptive removal of Cu(II) from aqueous solution using modified rice husk, *International Journal of Engineering Research and Applications (IJERA)*, Vol. 2, Issue 2, pp.855-863.