Journal of Interdisciplinary and Multidisciplinary Research (JIMR)
E-ISSN:1936-6264| Impact Factor: 8.886|
Vol. 18 Issue 12, Dec- 2023
Available online at: https://www.jimrjournal.com/
(An open access scholarly, peer-reviewed, interdisciplinary, monthly, and fully refereed journal.)

Removal of Zn(II) from Gomati River Water using Low-Cost Biosorbents

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ABSTRACT

The heavy metal pollution in the river Gomati in Jaunpur is a serious environmental problem that affects human health. The removal of metal ions from river water one of the most important environment and economic issue today. This paper presented the kinetics of Zn (II) ions removal/adsorption from river water in which adsorption technique applied for better removal of metal ions as agricultural waste as sugarcane bagasse and rice husk ash both used as low cost biosorbents. The adsorption of Zn(II) by sugarcane bagasse generally increased nearly 10% in comparison to rice husk ash. Thus, the sugarcane bagasse was found to be an effective biosorbents the rice husk ash. The alkaline pH (above 8.0) inhibited adsorption of Zn (II) metal ions in the river water. Due to either availability of small number sites in adsorbents or due to formation of hydrozinkate or zinkate ions in the river water of Gomati river in Jaunpur district. Thus, more adsorption/removal of Zn(II) metal ions by sugarcane bagasse might be due to increase in surface area and their chemical modification. The effect of pH, initial concentration of zinc, temperature, particle size, and isotherm were studied.

KEY WORDS: Heavy metals, Sugar cane bagasse, Rice husk ash, Biosorbent.

Zinc is very widely used metal. The main source of aquatic contamination of Zn are the metal production units and the other industries wastes like pharmaceuticals, electroplating, paints and pigments manufacturing textile and dye industries, which cause serious problem in the environment. In an aquatic environment such as river water of Gomati in which high concentration of heavy metal such as Zn, Fe, Cu, Cd, Cr which accumulate in the water bodies and affect all living in aquatic life. Because these heavy metals released into the environment by various activities tend to persist indefinitely because of their non-biodegradable nature. These metals once discharged into the waste streams, get accumulated throughout the food chain, thus becoming a serious threat to the environment and adversely affecting the health of the people. Metal ions present in the waste water are characterized by their mobility in the liquid phase of ecosystem and by their toxicity to higher life forms even at low concentration. Hence, the removal of toxic and heavy metal contaminants from waste water in one of the most important environmental and economic issues today (R.K. Shrivastava *et al*., 2002). Zinc (Zn^{2+}) one of the heavy metals in priority pollutants list of U.S. Environmental Protection Agency (USEPPA) has been indicated in serious poisoning cases. It causes dehydration, electrolyte imbalance, stomach ache, nausea, dizziness and muscular incardination (NRC, 1997). It is used in dry batteries, construction materials, pigment and painting process. It is widely used in coating iron and other metals in wood preservatives, photographic paper, accelerators for rubber vulcanization, ceramics, textiles, pigments etc (WHO, 1984) and dye industries.

Thus, there are number of physico-chemical methods have been developed for the removal of toxic metal ions from river water/waste water (Dobson and Burgess 2007; Arias and Sen 2009). Biological waste water treatment systems are chiefly designed for the removal of organic matter by activated sludge micro-organisms and the removal of heavy metals in these systems may be regarded as a side benefit. Nowadays efforts have been made to use cheap and available agricultural waste/natural biosorbents products such as sugarcane bagasse, coconut shell, orange peel, rice-husk, maize cob, etc. adsorbents remove heavy metals from waste water (Patil kishor *et al*. 2012; Bernard *et al*. 2013; Santos, *et al*., 2019; Chetsada, *et al*., 2023; Briffa, *et al*., 2020; Putra *et al*., 2014).

Several workers have reported on the potential use of agricultural byproducts as a good substrate for removal of metal ions from river water and waste water. Chemical modification of agricultural adsorbents increase the sorption capacity of adsorbents there by increasing the efficiency of adsorbents (Ajmal *et al*., 2000, Balaji *et al*., 2014; Thakur & Parmar; 2013; Razi *et al*., 2018; Rao, *et al*., 2020). This paper reports on the study of the kinetics of adsorption (K_1) at different pH. The role of pH in Zn (II) adsorption from water of Gomati river in order to find out an appropriate pH range for maximum efficiency by using sugarcane bagasse as well as rice husk ash as biosorbents.

EXPERIMENTAL METHODS:

The experimental methods in which chemical used by analytical grade. Diluted HNO_3 was used for dissolution of Zn. Different concentration were prepared by serial dilution of stock solution by using distilled water. pH of the medium was adjusted by using 0.1 N NaOH or HCl, temperature, particle size and concentration of adsorbent was kept constant at different selected pH. Zn concentration was determined by using spectrophotometer following APHA method.

Biosorbents Preparation:

The agricultural byproducts biosorbent which is low-cost used as sugarcane baggase and rice husk ash was collected from local farmers and soaked in hot deionized water and detergent for 24hrs. It was in hot deionized water to remove all debries and air dried. Air dried fiber was ground and sieved through a set of sieves to select the particle size.

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Biosorbents Activation:

The selected both biosorbent as sugarcane bagasse and rice husk ash in which the fiber of sugarcane bagasse was further soaked in 0.3M HNO_3 solution for 24 hrs and filtered through Whatman No. 41 filter paper and rinsed with deionized water, same process for rick husk ash, applied then rinsed both adsorbent were kept into two different bottle which treated with 1M mercepto acetic acid (HS. CH_2COOH) solution and suspensions was stringed for 30 min and mixtures were filtered and residues of each filter paper were then soaked 1M hydroxyl amine (NH_2OH) and filtered through filter paper. Then it was rinsed with distilled deionized water and washed residues were stored in air tight plastic container for metal removal.

Kinetics of Metal Sorption:

The kinetics for metal Zn (II) removal by selected biosorbents in which kinetics of metal sorption studies of Zn(II) were carried out for each adsorbent at different pH and at temperature 35.0±0.1ºC. The initial concentration of metal ion solution was 1.53×10^{-4}M and particle size of the adsorbent was <□□□M. A known amount solution (100ml) was taken in 250ml Erlenmeyer flask. Adsorbent (0.5 gm each) was soaked separately in flask and agitated in a shaker for a fixed time and constant speed (90 rpm). After the agitation for an equilibrium period the supernatant solution was filtered through whatman filter No. 41 and uptake was determined spectrophotometrically by using filtrate. Adsorption dynamics was calculated by taking adsorption rate constant. First order reversible reaction kinetics was used for the rate of reaction (Putra *et al*., 2014; Arias and Sen, 2009).

RESULTS AND DISCUSSION

There are many factors which influence metal ion Zn (II) sorption, including the nature of the biosorbents (sugarcane bagasse and rice husk ash) the effect of pH of the solution of metal ions, temperature, surface area to volume ratio, initial metal concentration and metal affinity to biosorbent. Biosorption is a highly efficient and selective process for removal of metal ions in which the use of agricultural adsorbents as sugarcane bagasse and rice husk ash is a well known low-cost biosorbents. The present paper explains the effect of pH on the treatment of Zn (II) by using biosorbents. The influence of pH of the metal ions solution on sorption of Zinc (II) a agricultural wastes/biosorbents. The adsorption of Zn (II) by agricultural waste as sugarcane bagasse and rice husk ash is presented in Fig.1 and Fig. 2. The change in pH of the solution has no effect on the basic nature of the time growth adsorption curves and period of saturation. The time growth adsorption of Zn (II) by two biosorbents suggested that the removal was initially rapid and finally became constant due to the slow removal near saturation. The variation in percent adsorption at different pH value shown by both biosorbents.

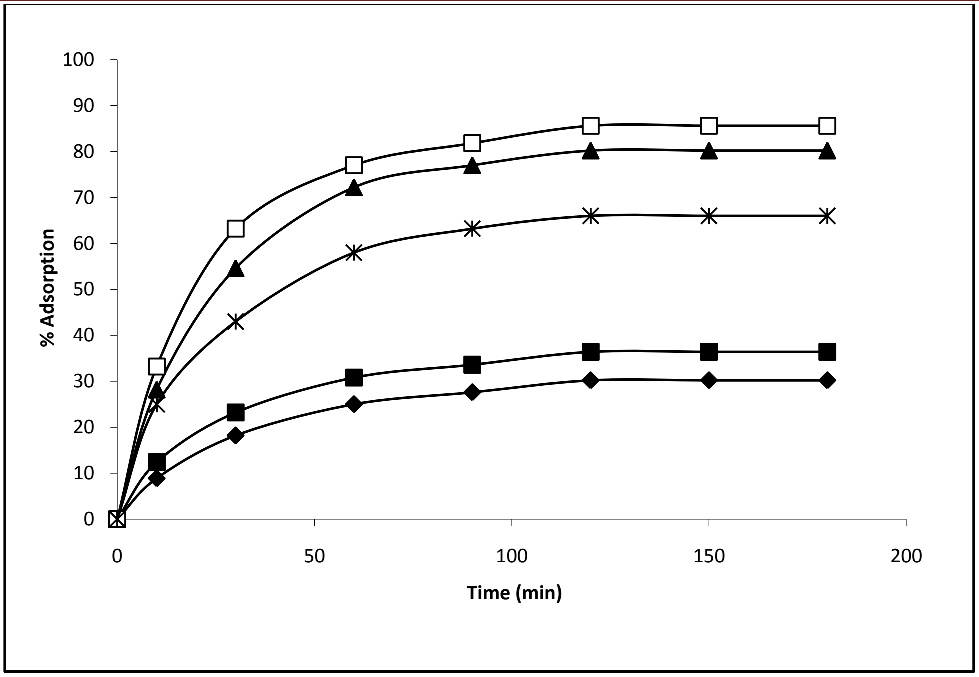

Fig.1: Time variation of adsorption of Zn(II) on sugarcane bagasse at different pH (Concentration 1.53×10–4M; Particle size <53M; Temperature: 35.0±0.5ºC)

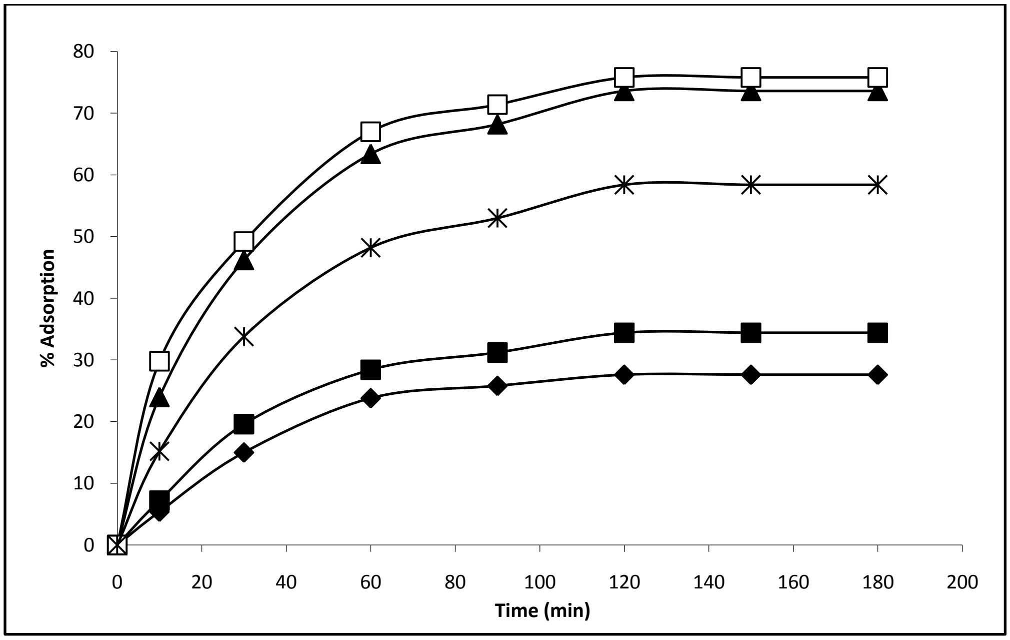

Fig.2: Time variation of adsorption of Zn(II) on Rice husk ash at different pH (Concentration 1.53×10–4M; Particle size <53M; Temperature: 35.0±0.5ºC)

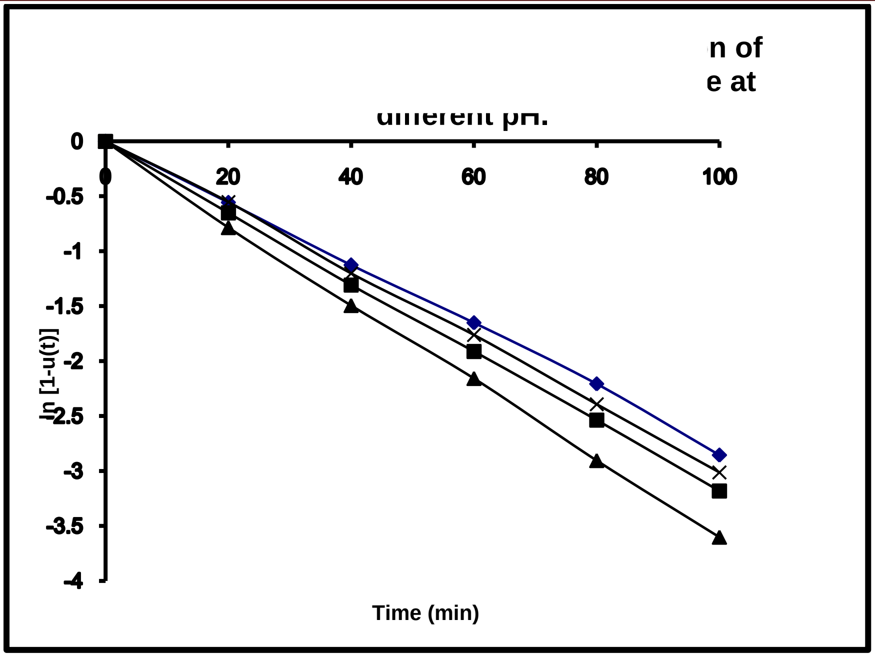

Fig.-3: Rate constant plot for adsorption of Zn (II) on sugarcane bagasse at different pH.

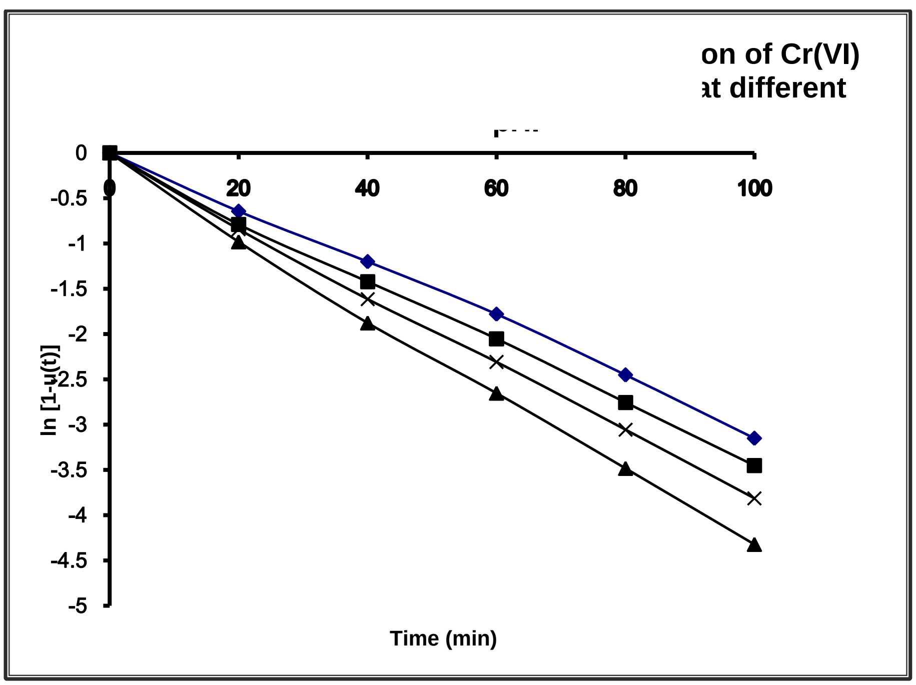

Fig.-4: Rate constant plot for adsorption of Zn (II) on

rice husk ash at different pH.

The adsorption of Zn (II) by biosorbents as sugarcane bagasse and rice husk ash increased 30.2% (at pH 4.5) to 85.6 (at pH 8.5) and 27.6 (at pH 4.5) to 75.8 (at pH 8.5) respectively. The pH range at pH = 8.5 high value for both biosorbents as in Fig.1 and Fig.-2. Thus the sugarcane bagasse was found more efficient biosorbent than rice husk ash. Because the sugarcane bagasse was maximum uptake which was adsorbed at pH = 8.5, might be due to increase in surface area.

It has been reported that surface area has a great effect on the sorption capacities of adsorbents (Abia and Asuque, 2006). Over all rate constant (k^1) and rate constant of adsorption k^1 and rate constant of adsorption k1 at different pH for both biosorbents sugarcane bagasse and rice husk ash was calculated and result were presented as in Fig. 3 & 4. It is obvious from the results that pH of the medium affected these rate constants in accordance with the extent of adsorption.

The variation in cation adsorption may be explained on the basis of surface hydroxylation, presence of oxides at solid solution interface in adsorbents (Ajay Kumar *et al*., 2009 & Balaji *et al*., 2014). Increase in adsorption above 8.5 might be due to availability of small number sites in both cases for adsorption as reported earlier for the adsorption of Zn(II) by silica (Pandey *et al*., 1985). At higher pH formation of hydrozinkate and zinkate ions cannot be ruled out (Singh *et al*., 1988). Thus more adsorption of Zn (II) by sugarcane bagasse might be due to increase in the surface area of adsorbents which increased with chemical modification and has a great effect on the sorption capacities of adsorbents than rice husk ash. So, the use of low cost biosorbents.

CONCLUSION

The aim of study to evaluate the potential of an agricultural byproduct as sugarcane bagasse which is low-cost biosorbent. The adsorption of Zn(II) chemical kinetics was rapid in the initial stage followed by slow rate of adsorption. The experimental results showed that under optimized conditions sugarcane bagasse can be used as an better adsorbents than rice husk ash for the removal of Zn (II) in alkaline medium which may be quite useful to develop an appropriate technology for designing waste water treatment, using low-cost biosorbent by adjusting at different pH values of the solution for the removal of metal from water pollutants with maximum efficiency for the sugarcane bagasse low-cost biosorbents.

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