Bioadsorption of Thermal Waste Using Low Cost Adsorbent

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Abstract: **An increase in population causing rapid industrialization was found to consequently increase the generation of wastewater. Heavy metals are the major toxicants found in industrial wastewaters. Conventional methods for the removal of metal ions such as chemical precipitation and membrane filtration are exceptionally expensive. Biosorption and bioaccumulation are eco-friendly alternatives for bioadsorption process. An Orange, Mosambi, Lemon and Banana peel, a discarded organic waste which is used to produce bioadsorbent. The orange and lemon peel based bioadsorbent was assessed for removal of heavy metal pollutant. Fly Ash, a waste of the Raichur Thermal Power Plants has been utilized as an adsorbate. The various experimental conditions such as pH, particle sizes, adsorbent dosage and variation of temperature which effects the heavy metal pollutant adsorption were investigated for orange and lemon peel. The percentage of adsorption was found to be more for orange & lemon peel. The maximum adsorption capacity of orange and lemon peel was observed at pH4 of about 53% and 31% respectively, 30°C of temperature of about 37% and 21% respectively, 100 µ of particle size 100 of about 81% and 82% respectively and 1gm of adsorbent dosage of about 21% and 22% respectively.**

***Keywords*— Heavy metal, biosorption, fruit peels, bioadsorbent, polymath software**

I. INTRODUCTION

Rapid development has directed to increased disposal of heavy metals into the environment. Therefore, waste treatment is considered to be the most important goals for industry. At present plenty of heavy metals are found in drinking water, air and soil due to increased use of these poisonous compounds. Disparate organic pollutants, the majority of which are vulnerable to biological degradation, heavy metal ions do not degrade into harmless end products(Ozcan ., et al 2005). Contamination of lakes and streams due to the existence of heavy metals which flows from the natural aquatic ecosystem, as these contaminants gets adsorbed onto the soil and then flows in to the lakes etc. has cause the serious problem to human health(Rajkumar,S.A.,. et al 1998) Therefore, it is necessary to search for new technologies to remove toxic metals from wastewaters has focused attention on biosorption, which depends on metal binding property to various biological materials.

Raichur Thermal Power Station is situated about 20 kms, north of Raichur. There are 7 units of 210 MW capacities each. The annual generation is around 10,000 Million Units. Roughly, 7 Million tonnes of coal are received every year. In this process studies were carried out biosorption of thermal waste obtained from RTPP using organic waste as bioadsorbent which is an environmental and eco-friendly method. The waste material used in the generally available at a very cheap rate. [Bhatnagar et al., 2010].

Raichur Thermal Power Plant generates about 1.5 million tonnes of fly ash annually which causes environmental problems. 20% of the ash produced is wet bottom ash which is allowed to settle into the ash bund. Though considered safer than fly-ash, bottom ash has also been found to contain heavy metals which can be dangerous to public health (Bhatnagar et al., 2010). The fly-ash which gets generated during the burning of coal gets dispersed into the air and hence harm the atmosphere. The fly ash gets deposited on the surrounding land area, thereby making the land infertile. The fly-ash may also cause severe breathing problems for humans.

Bioadsorption method is been seen as a new, eco-friendly alternative approach against conventional methods of clearing the thermal wastes (Narayana et al.,1989). Hence in this study, we aimed to access the ability of different fruit peels as bioadsorbent which are usually considered as organic wastes.

II. MATERIAL AND METHODS

Thermal waste (ash) was collected from Raichur thermal power plant. It was packed in closed cover and used whenever it was necessary. Thermal waste was used as adsorbate. Thermal waste of 1000mg was dissolved in 100ml distilled water used for the experiment. The lemon, banana, orange, mosambi peel were collected from kitchen or juice centre and orange, lemon peel used for complete experiments.

A. Preparation and characterization of adsorbent

The collected banana peel, lemon, mosambi and orange peel from various fruit juice centers where it was treated as waste and washed three times with tap water and three times with distilled water to remove external dirt, were cut into small pieces using scissor. The wetted peel were kept in air for removing the free water from the surface and dried in hot air oven at 65-75°C for nearly one week. The dried peel were grounded into powder and again washed with water in order remove colour, kept in a hot air oven at 65-75°C for one week. When all the fruit skins got dried up, next processes such as grinding, screening was carried out. After grinding, screening was done by using different sieve sizes of 300µ, 200µ, 150µ and last sieve of 100 µ. The dried different sizes peel powder kept in air tied bottle for experimental uses and used as adsorbent.

B. Effect of Experimental conditions:

The experimental conditions such as pH, particle sizes, adsorbent dosage, contact time, temperature effect on adsorption were investigated for orange and lemon peel.

C. Effect of various adsorbents

The effect of various adsorbents for thermal waste (ash) adsorption was investigated with 5g of adsorbents in 100 ml water containing 1000mg of thermal waste. The conical flasks were stirred on magnetic stirrer for 15min at 3000 rpm at room temperature. After 2h, the solution was filtered and filtrate was taken to check absorbance at 380nm and the same procedure was followed for all types of peel.

D. Effect of particle sizes

The grounded peel were graded with standard sieves sizes of 300µ, 200µ, 150µ, and 100µ. Adsorbent peel of 2g from each graded sizes of were added to four conical flasks with 100 ml distilled water containing 1000mg thermal waste (ash) concentration and stirred on magnetic stirrer for 15min at 3000rpm After every half an hour, the solution was filtered and filtrate was taken to check absorbance at 380nm.

E. Effect of pH

The effect of pH for thermal waste (ash) adsorption onto orange and lemon peel of two standard sieve size of 150µ and100µ particle was investigated with 1.0g of both peel in 100 ml water containing 1000mg of thermal waste and each sample were adjusted to pH between 4 to 8 using either 1N HCl or NaOH solution. The conical flasks were stirred on magnetic stirrer for 15min with 3000 rpm at room temperature. After every half an hour, the solution was filtered and filtrate was taken to check absorbance at 380nm.

F. Effect of Temperature

The effect of temperature on adsorption of thermal waste were examined with different temperature of 20-50°C for 1000mg thermal waste (ash) concentration with 1gm orange and lemon peel in 100 ml water was investigated for both 150µ and 100µ sieve size particle (Demirbas et al., 2009). After every half an hour, the solution was filtered and filtrate was taken to check absorbance at 380nm.

G. Effect of adsorbent dose

The effect of bioadsorbent doses on equilibrium uptake of thermal waste was investigated for both sieve size 150µ and 100µ particle with adsorbent masses of 0.1, 0.3, 0.5 and 1 g per 100 ml of distilled water contained 500mg of thermal waste. The conical flasks were stirred on magnetic stirrer for 15min with 3000 rpm at room temperature .After every half an hour, the solution was filtered and filtrate was taken to check absorbance at 380nm.

III. RESULTS AND DISCUSSION

The preparation methods are the key factor for any type of bioadsorbent, because morphological properties such as particle size and shape, binding surface area, and overall removal capacity depend on it(Wang, X., Qin, Y. (2005). Simple, easy to prepare and use, hazard free and environment friendly treatments are the requirement for sustainable preparation of bioadsorbent. Considering the above, this project is used simple and non-treated preparation methods rather than the expensive and high-tech pyrolysis and non-environment friendly acid/base pre-treatment methods (Ozcan et al., 2005). The novelty of this project is that simply the peels were cut, wash, dry and ground to powder and used for experiments.

A. Determination of Heavy Metal:

Iron is more concentrated compared to other heavy metal. Iron exists in two forms, soluble ferrous iron (Fe^{2+}) and insoluble ferric particulate iron (Fe^{3+})(Sharma, D.C ., et al 1993). The iron in water is generally present in the ferric state. Iron typically enters water bodies in the form of ferrous iron (Fe^{2+}), which can be oxidized to ferric iron (Fe^{3+}) by the oxygen dissolved in water.

Table 1: Heavy metal determination in thermal waste (ash)

Test	**Results (in ppm)**	**Test method**
Lead (Pb)	14.63	AAS
Copper (Cu)	4.22	AAS
Zinc (Zn)	16.86	AAS
Chromium (Cr)	Less than 0.1	AAS
Iron (Fe)	4613.50	AAS

B. Orange and Lemon peels are better adsorbents than other organic wastes tested:

The effect of various adsorbent on thermal waste adsorption was investigated. Below Figure shows the removal of thermal waste has increased for orange by 81% and lemon peel by 82% compared to mosambi and banana by 70% and 76% respectively.

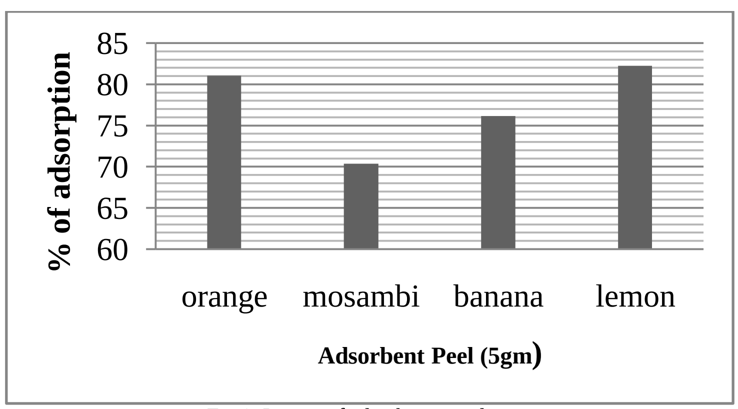

Fig 1: Impact of adsorbent on adsorption

C. Acidic condition favors better adsorption:

Results presented in figure 2 shows the maximum removal took place at pH 4, thermal waste adsorption was found to increase for orange peel and for lemon peel from at pH 4, indicates that the maximum adsorption affinities take place in moderately and slightly acidic medium. The pH could influence the metal binding sites. Earlier studies with other organic materials has also showed that acidic condition do favor adsorption. For example, biosorption of ferric iron on to husk of *Cicer arientinum* was observed at *p*H 2.5 (Ahalya et al., 2006).

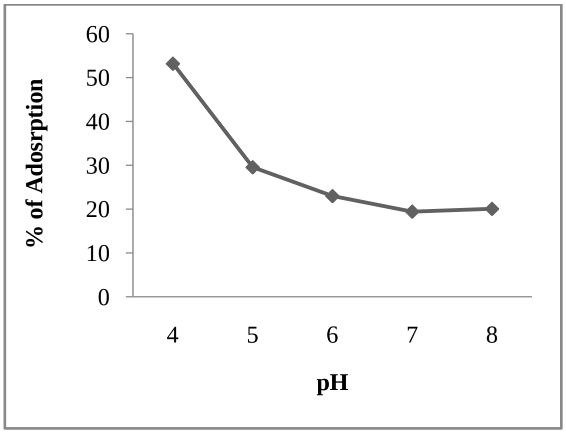

Fig 2: Impact of different pH on orange peel as an adsorbent

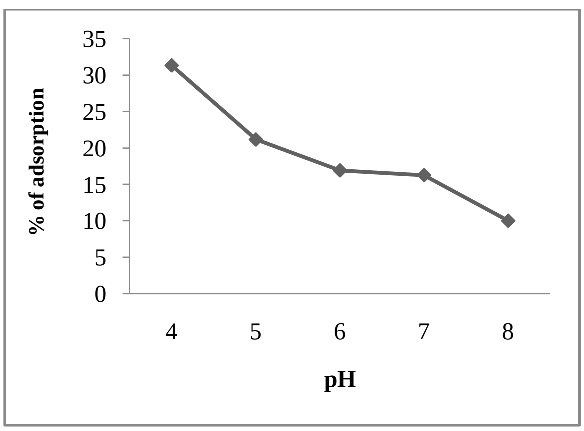

Fig 3: Impact of different pH on Lemon peel as an adsorbent

D. Adsorption reduces as temperature rises:

The thermal effects of thermal waste (ash) adsorption onto orange and lemon peel, temperature variation experiments were conducted at 20, 30, 40 and 50°C, with an initial thermal waste (ash) concentration between of 1000mg.

Figure 4 & 5 Shows the decrease in percentage of adsorption with rise in temperature may be due to the desorption caused by an increase in the available thermal energy. Higher temperature induces higher mobility of the adsorbate causing desorption. At 30°C maximum percentage of adsorption was seen for both orange and lemon peel of 37 % and 21% respectively.

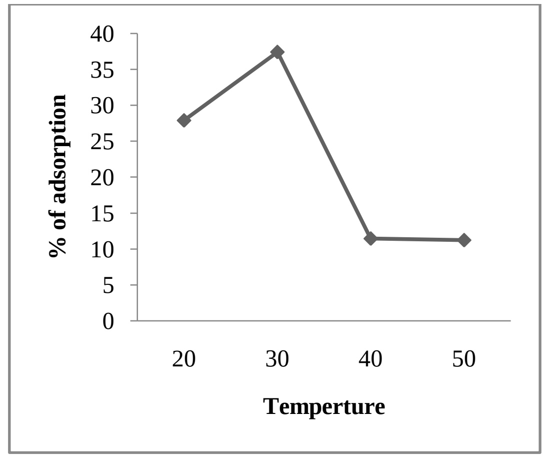

Fig 4: Impact of different temperature on orange peel as an adsorbent

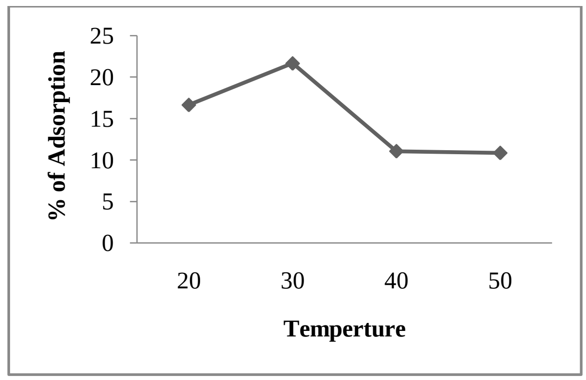

Fig 5: Impact of different temperature on Lemon peel as an adsorbent

E. Different range of adsorbent doses improvises the rate of adsorption:

Dose dependent experiments show that thermal effluent (ash) removal was low at lower doses and gradually increased with increasing in doses, latter at higher doses, the thermal waste (ash) removal again decreased. Fig 6 & 7 indicates that the highest thermal waste (ash) removal of 12% to 21% for orange and for lemon peel of 9% to 22% was obtained by the initial thermal waste (Ash) concentration of 500mg achieved with respect to dose of 0.1 to 1.0 g for both orange and lemon peel.

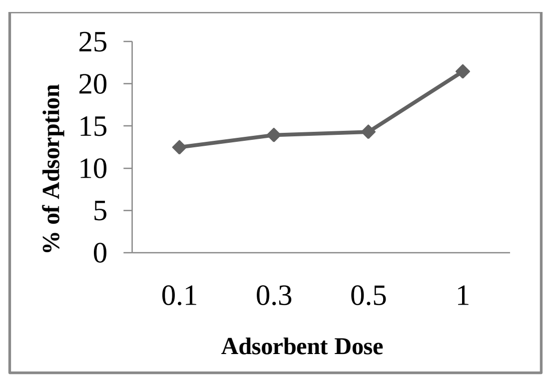

Fig 6: Impact of different dose of orange peel as an adsorbent

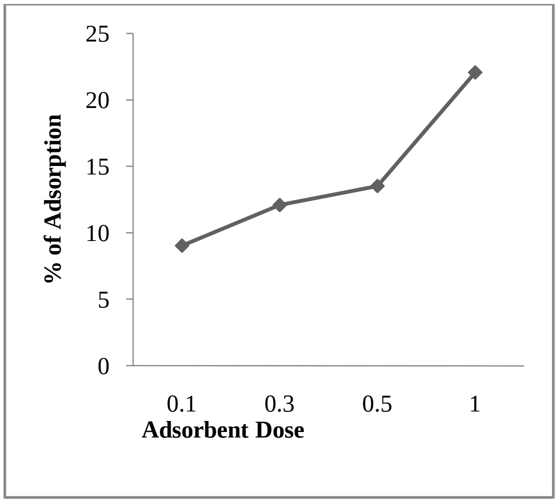

Fig 7: Variation in Temperature on Lemon peel as adsorbent

F. Adsorption increases as particle size reduces:

The effect of particle size on the adsorption of thermal waste (ash) was investigated in the range of 300-100µ. The effects of particles on adsorption were conducted for four particle sizes at room temperature. The exposure and availability of binding sites depend on particle shapes and sizes of adsorbent (Saravanane,. et al 1998) Fig 8 & 9 shows the removal of thermal waste was increased from 21 to 35 % for orange peel and 24 to 37 % for lemon peel by decreasing the particle sizes from 300µm to 100µm. This behavior can be attributed to the surface area of the adsorbent increase, size of the particle decrease, there by the number of active sites on the adsorbent are better exposed to the adsorbate, leading to higher adsorption capacity since adsorption is a surface process(Vimal, C., et al 2007). Apart from that, particles with smaller size also moved faster in the solution compared to larger particles, consequently, the adsorption rate was faster (Sengil and Ozacar, 2008). The OD value for orange and lemon peel with graphical representation is shown below.

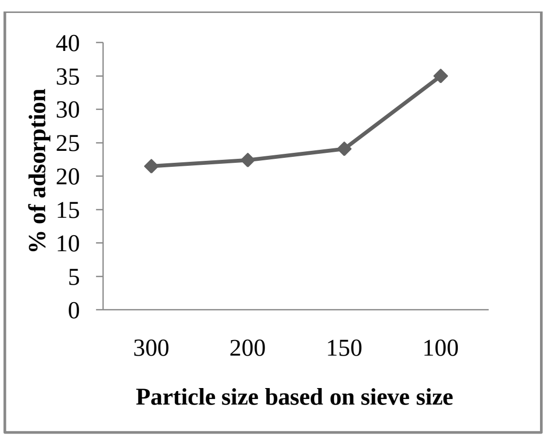

Fig 8: Impact of particle sizes for orange peel

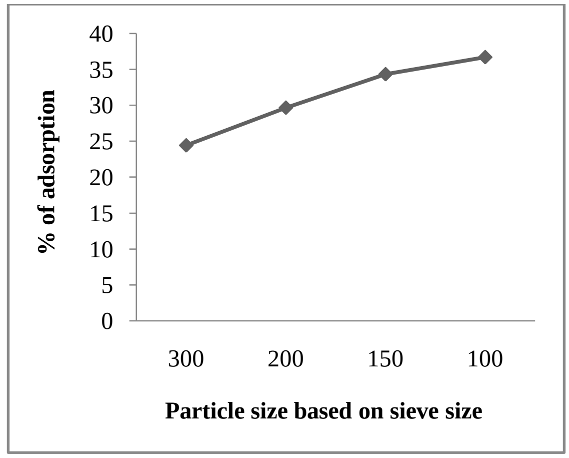

Fig 9: Impact of particle sizes for Lemon peel

IV. CONCLUSION

Continuous discharge of industrial, domestic and agricultural wastes in rivers and lakes causes deposit of pollutants in sediments. Such pollutants include heavy metals, which cannot be destroyed through biological degradation, as is the case with most organic pollutants. The problem of heavy metal pollution in water and aquatic organisms including fish, needs continuous monitoring and surveillance as these elements do not degrade and tend to biomagnify in man through food chain (Thirumavalavan, M.,. et al 2010) Hence there is a need to remove the heavy metals from the aquatic ecosystems. Cost effectiveness and technical applicability are the two important key factors for selecting effective low cost adsorbent for heavy metal removal. Decrease in percentage of adsorption with increase in temperature indicates that the process is exothermic in nature and so low temperatures favor the adsorption process.

REFERENCES

[1]. Ahalya, N., Kanamadi, R.D., Ramachandra, T.V. (2006). “Biosorption of Iron (III) using the husk of Cicer arientinum”. *Indian Journal of Chemical Technology*, 13, pp 122-127.
[2]. Bhatnagar, A., Minochaa, K., Sillanpa, M. (2010). “Adsorptive removal of cobalt from aqueous solution A. by utilizing lemon peel as biosorbent”. *Biochemical Eng. J.* Vol. 48, p 181–186.
[3]. Narayana, Nagesh., Krishnaiah, Abburi. (1989) “A study on removel of Chromium by adsorption on bituminous coal from systemic effluents”. *Indian J. Env. Health*, 31:04,304- 308.
[4]. Ozcan, A., Ozcan, A.S., Tunali, S., Akar, T., Kiran, I. (2005). “Determination of the equilibrium, kinetic and thermodynamic parameters of adsorption of copper(II) ions onto seeds of Capsicum annuum”. *Journal of Hazardous Materials*, 124(1–3), 200-208.
[5]. Rajkumar,S.A., Katyal, T., Satake, M.(1998), “Environmental pollution”. *Anmol Publications*,pg 87-90.
[6]. Saravanane, R., Sundararajan, T., Sivammurthy, Reddy.(1998) " Studies of the removal of heavy metals from wastewater using chemically modified low cost adsorbents ". *Journ. Of the IPHEJndia*, Vol. 1998: 02: 46-55.
[7]. Sharma, D.C., Forster, C.F. (1993). “Removal of hexavelent chromium using sphagnum moss peat”. *Water Res*. Vol 27(7): pg1201-1208.
[8]. Thirumavalavan, M., Lai, Y.L., Lin, L.C., Lee, J.F. (2010). “Cellulose-Based Native and Surface Modified Fruit Peels for the Adsorption of Heavy Metal Ions from Aqueous Solution:

Langmuir Adsorption Isotherms". *J. Chem. Eng*. Data Vol.55, p 1186–1192.

[9]. Vimal, C., Srivastava, Indra D. Mall., Indra, M. Mishra. (2007). *Ind. Eng. Chem. Res, 46,* 5697- 5706.

[10]. Wang, X., Qin, Y. (2005). "Equilibrium sorption isotherms for of Cu2+ on rice bran". *Process Biochemistry*, 40(2), 677-680.