STUDY OF SUGARCANE BAGASSE AND ORANGE PEEL AS ADSORBENT FOR TREATMENT OF INDUSTRIAL EFFLUENT CONTAMINATED WITH NICKEL

Aswathy Mohan[1] & Anjali.S[2]

[1]First Author: Mtech student, Dept. Of Environmental Engineering, KMCT College of women, Kerala, India
[2]Second Author: Assistant Professor, Dept. Of Environmental Engineering, KMCT College of women, Kerala, India

---***---

Abstract – *The wastewater was treated with natural adsorbents such as orange peel and sugarcane bagasse for the removal of heavy metals from electroplating Industry wastewater. Batch adsorption studies conducted for the removal of nickel from the electroplating industrial waste water. The removal of nickel at the different contact time, adsorbent dosage and pH. The result shows that both adsorbents are very effective for electroplating effluent treatment. The optimum conditions of the adsorption on orange peel adsorbent are 60 minutes of contact time, 10 g adsorbent dosage and pH of solution in between 8 and 10. The maximum removal of nickel content observed was 95.21% for 10 g of orange peel adsorbent at neutral solution. The adsorption experiment using sugarcane bagasse optimum conditions are 75 minutes of contact time, 8 g of adsorbent and pH of the solution is 8 to 10. From this study, we can analysis orange peel proved to be very effective biosorbent that sugarcane bagasse for removal of nickel concentration from the electroplating industrial waste water.*

***Key Words*:** **Heavy Metal**, **Biosorption**, **Fruit Peel**, **Agricultural Waste**

1. INTRODUCTION

Water is an essential role in human life and activities associated with industry, agriculture and others and it consider as one of the most fragility part of the environment. In the past century there has been a rapid expansion in industries. Several industries processes generate metal containing waste. Heavy metals contamination has been a critical problem mainly because metal tend to persist and accumulate in the environment. Heavy metals persist in the environment since they cannot be degraded nor destroyed and finally reach the human through food chain [9].

The release of toxic materials like Ni into water has been a major challenge to environmental engineers today due to the pollution of water. Priority should be given to regulate the concentration of these pollutants at the discharge level. Ni is a heavy metal used in a large no. of industries like electroplating, Ni-Cd batteries manufacturing, forging, mining, coal and oil-burning power plants, etc.

Removal of heavy metal bearing industrial effluents has become one of the primary challenges of wastewater treatment. The most widely used technique for the removal of dissolved heavy metals involves the process of neutralization and metal hydroxide precipitation. One of the shortcomings of this technique is the disposal of metal containing sludge arising out of the precipitation process. Hence there is a need for developing economic and eco-friendly methods for waste minimization and fine tuning of the wastewater [4].Adsorption is a promising technique because it can be used to treat much diluted effluents with high removal efficiency, allowing attainment of high standards of water quality, as imposed by public health authorities. In addition, the adsorption process is easy to operate and there is a wide range of adsorbents available, including several materials from renewable sources [2].

Recently, efforts have been made to use cheap and readily available agricultural wastes such as orange peel and sugarcane bagasse as adsorbents to remove heavy metals such as Nickel (Ni) from electroplating industrial waste water.

1.1 OBJECTIVES

The specific objectives of present study are;

- To degrade Nickel content in industrial effluent using orange peel
- To degrade Nickel content in industrial effluent using sugarcane bagasse
- To compare the adsorption capacity of orange peel and sugarcane bagasse

- To identify the optimum conditions in the removal of nickel content by using orange peel and sugarcane bagasse
- To study the isotherm kinetics

1.2 SCOPE OF THE STUDY

1. To improve the adsorption capacities of the studied low cost adsorbents.
2. More experiments can be carried out for various other adsorbents and their effect on contact time, particle size, dosage can be investigated to choose best adsorbents.
3. To reduce the water pollution faced by over water bodies.
4. We can make a pollution free environment.

2. THEORETICAL BACKGROUND

i. Electroplating

Electroplating is a process that uses an electric current to reduce dissolved metal cations so that they form a thin coherent metal coating on an electrode. The term is also used for electrical oxidation of anions on to a solid substrate, as in the formation of silver chloride on silver wire to make silver/silver-chloride electrodes. Electroplating is primarily used to change the surface properties of an object, but may also be used to build up thickness on undersized parts or to form objects by electroforming.

ii. Nickel

The selection of this heavy metal ion was not random, but due to the toxic impact of nickel to environment. Effluent wastewaters from processes such as electroplating, metal finishing, metallurgical, chemical manufacturing and battery manufacturing industries contain toxic substances, metal acids, alkalis, and other substances. Removal of heavy metals such as nickel from aqueous solutions is necessary because of the frequent appearance of these metals in waste streams. This problem has received considerable attention in recent years due primarily to concern that those heavy metals in the waste streams can be readily absorbed by marine animals and directly enter the human food chains, thus presenting a high health risk to consumers.

Nickel is a naturally occurring element widely used in many industrial applications for the shipbuilding, automobile, electrical, oil, food and chemical industries. Although it is not harmful in low quantities, nickel is toxic to humans and animals when in high concentrations. Nickel can be present in wastewater as a result of human activities. Sources of nickel in wastewater include ship cruise effluents, industrial applications and the chemical industry.

iii. Adsorption:

"Adsorption" may be defined as the process of accumulation of any substance giving higher concentration of molecular species on the surface of another substance as compared to that in the bulk. When a solid surface is exposed to a gas or a liquid, molecules from the gas or the solution phase accumulate or concentrate at the surface. The phenomenon of concentration of molecules of a gas or liquid at a solid surface is called adsorption. "Adsorption" is a well established and powerful technique for treating domestic and industrial effluents. In water treatment, the most widely method is "adsorption" onto the surface of activated carbon.

iv. Adsorption Isotherm

Adsorption process is usually studied through graphs known as adsorption isotherm. Adsorption is the amount of adsorbate on the adsorbent as a function if its pressure or concentration at constant temperature. The quantity adsorbed is nearly always normalized by the mass of the adsorbent to allow comparison of different materials.

v. Low cost adsorbents

Orange peel

Orange peel is abundant in soft drink industries and usually treated as wastes. It contains many functional groups, such as carboxyl and hydroxyl, thus making it a potential adsorbent material for removing metals. Several studies have been proposed in literatures about using modified orange waste in relation with heavy metal adsorption from water. Some of the studies show the modified orange peel adsorbent preparation and study the adsorption capacity of this adsorbent for removal of five heavy metal ions ($Cu2+$, $Cd2+$, $Pb2+$, $Zn2+$ and $Ni2+$).

Sugarcane bagasse

The sugar industry is one of the most important agro based industries in India. The bagasse fly ash, an industrial solid waste generated from the sugar industry, causes a great disposal problem and it is currently being used as filler in building materials. Our earlier efforts on the utilization of solid waste materials being generated in some prime industries for the removal of toxic metals have been very successful. In the present work, an attempt has been made to develop an inexpensive adsorbent system for the removal of cadmium and nickel from wastewater using bagasse fly ash. Bagasse pitch is a waste product from sugar refining industry. It is the name given to the residual cane pulp remaining after sugar has been extracted. Bagasse pitch is composed largely of cellulose, pentosan, and lignin. The studied on adsorption of Cd (II), Ni (II) and Pb(II) onto functionalized formic lignin from sugar cane bagasse. They have stated that the Pb (II) adsorption process obeys Langmuir's model and Cd (II) presents adsorption in multilayer, especially when the temperature is higher than 30ºC.

3. MATERIAL AND METHODS

The various methodologies adopted for the removal of heavy metal as nickel from electroplating effluent using orange peel and sugarcane bagasse are discussed in the following section

3.1 PROCEDURE FOR EFFLUENT TREATMENT WITH ORANGE PEEL AND SUGARCANE BAGASSE

3.1.1 Apparatus

Apparatus used for this work are, AAS (atomic adsorption spectrophotometer), electronic weighing balance, conical flask, stop watch, mechanical shaker

3.1.2 Preparation of adsorbent (orange peel)

Collected the orange peel from fruit shop and juice shop at Ernakulam locality. The orange peel washed with tap water to remove possible foreign material present. Then the washed sample was sun dried for 7 to 10 days. Then the sun dried orange peel was grained and sieved to less than 250 µm prior to use in sorption. The grained powder stored in airtight container.

Fig 3.1 orange peels

Fig 3.2 orange peel powder

3.1.3 Preparation of adsorbent (sugarcane bagasse)

Collected the sugarcane bagasse from juice shop at Ernakulam locality. The sugarcane bagasse washed with tap water to remove possible foreign material present. Then the washed

Fig 3.3 sugarcane bagasse

sample was sun dried for 7 to 10 days. Then the sun dried sample was grained and sieved to less than 500 µm prior to use in sorption. The grained powder stored in airtight container.

Fig 3.4 sugarcane bagasse powder

Fig 3.5 powders stored in airtight container

3.1.4 Collection of Effluent

The waste water was collected from the effluent discharge point of Prasis electroplating industry at palarivattom, Ernakulam. It was carefully bottled in a plastic container and was immediately taken to a laboratory for analysis.

3.2 BATCH ADSORPTION STUDIES ON ORANGE PEEL AND SUGARCANE BAGASSE

Batch adsorption experiment for orange peel powder and sugarcane bagasse powder can be carried out by using 250 ml Erlenmeyer flask. The effect of different parameters such as adsorbent dosage, contact time, pH and initial concentration were studied. Previously prepared orange peel powder was added to the effluent sample. The conical

flask containing the effluent and adsorbent powder was placed on a mechanical shaker (120 rpm) at a room temperature for a particular period for agitation at different agitation rate. The suspension was filtered. Atomic adsorption spectroscopy (AAS) was used to analyze the concentration of nickel ions present in the filtrate.
The amount of nickel adsorbent per unit of orange peel powder mass at equilibrium, q_e (mg/g), calculated from the following equation:

$$q_e = \frac{(C_o - C_e)v}{w}$$

Where C_o and C_e are the initial and equilibrium concentration, of the effluent in mg/l, respectively, v is the volume of effluent in litres, and w is the mass of adsorbent used (g). The percentage of nickel removal by adsorbent was calculated using the following equation.

$$R(\%) = \frac{C_o - C}{C_o} \times 100$$

3.2.1 Effect of contact time

For studying the effect of contact time, five samples of 200ml were taken in 250 ml conical flask and 6 gms of sorbent material was added. The flasks were stirred. The samples were analyzed after each half hour interval. To determine the optimum contact time, analyzed the amount of adsorption of each sample. Analyse the concentration of nickel by AAS.

3.2.2 Effect of adsorbent dosage

For studying the effect of sorbent dosage, five samples of 200 ml were taken in 250ml conical flask and 2, 4, 6, 8,10 and 12 gms of sorbent material was added to each sample for optimum shaking time kept other conditions constant. Analyse the concentration of nickel by AAS. Experiments were conducted till equilibrium.

3.2.3 Effect of pH

To determine the effect of pH, add acid or base to the effluent solution in order to change the pH. Freshly hydrochloric acid and sodium hydroxide were used to change the pH. After setting the pH of the range 2, 4,6, 6.5, 8and 10, 200 ml sample solution pipette out in to each flask and add optimum dosage of adsorbents to it undergo shaking for optimum time. Determine the absorbance of each sample and hence obtained the optimum pH with. Analyse the concentration of nickel by AAS.

3.2.4 Effect of initial concentration

To study the effect of nickel concentration, 10 grams of adsorbent added to 200 ml nickel solution of concentration 50 mg/l and kept shaking for optimum contact time. Same procedure repeated with different initial concentration 50,100,150,200,250&300 and kept other conditions constant. Then filtered and analysed for optimum amount of nickel concentration.

Finally langmuir isotherm and freundlich isotherm studies were conducted after the completion of batch adsorption studies. Isotherms were drawn by using the values of adsorption capacity at equilibrium (mg/g) and the supernatant equilibrium concentration of the system (mg/l).

4. RESULT AND DISCUSSION

i. Effect on contact time

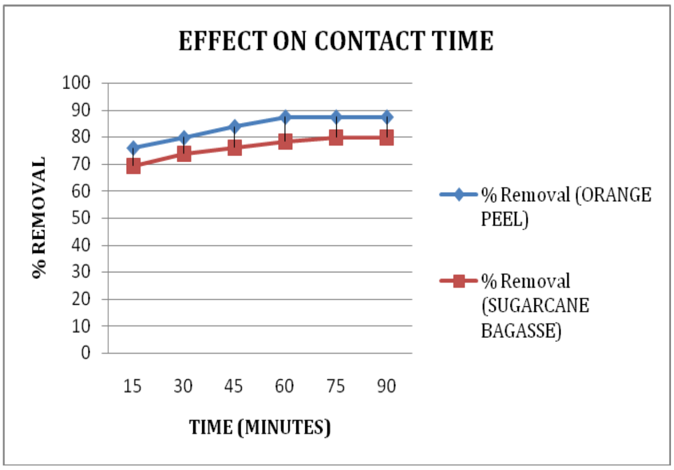

Fig 4.1 effect of contact time on adsorbents

The data obtained from the adsorption of Nickel on orange peel, showed that a constant time 60 minutes was sufficient to achieve equilibrium and adsorption did not change significantly with further increase of time. In the case of sugarcane bagasse the equilibrium is attained after 75 minutes and there was almost no adsorption beyond this time. This is due to number of free adsorption sites are higher in initial stage after sometime the number of free site will be decreased and the adsorption rate will be constant or slow because of slower diffusion of solute into the interior of adsorbent. The study shows that orange peels have high nickel removal efficiency with lower time than sugarcane bagasse.

ii. Effect on adsorbent dosage

From the study of effect of adsorbent dosage we can see that orange peel have high nickel removal efficiency at 10 g of adsorbent. It was observed that adsorption of nickel increased with the increase of the amount of adsorbents and then attained a value at equilibrium.

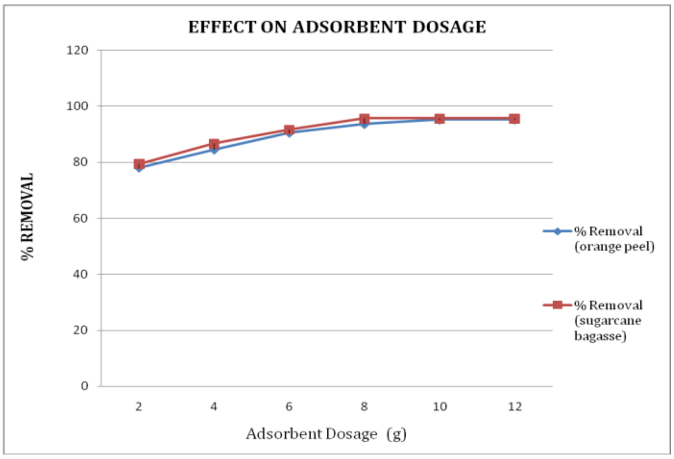

Fig 4.2 effect on adsorbent dosage

The increase of dosage increases adsorbent sites thus surface area of contact with the nickel increases consequently leads to a better adsorption. In the orange peel, 95.71% removal was observed at optimum adsorbent dosage of 10 g and sugarcane bagasse adsorbent removed 95.64% at optimum dosage of 8 g. Sugarcane bagasse shows high removal efficiency that orange peel with lesser amount of adsorbent.

iii. Effect on pH

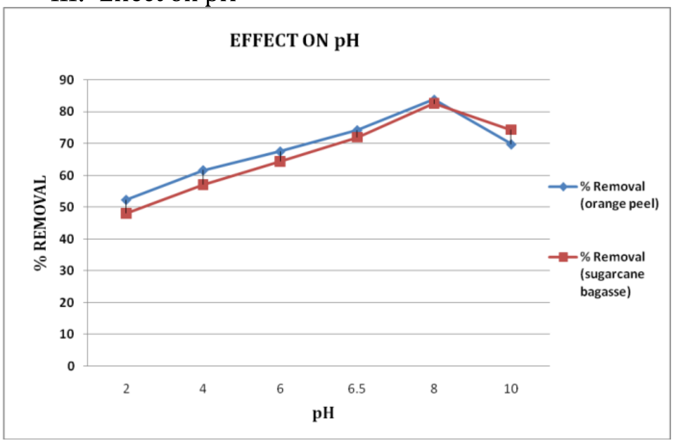

Fig 4.3 effect on initial concentration

The effect of pH on the percentage of the nickel removal on orange peel and sugarcane bagasse is shown in graph under various other fixed operating conditions. The initial pH of adsorption medium is one of the most important parameters affecting the adsorption process. From the above table it is seen that percentage of nickel removal was high at the pH of 8 to 10 in the case of orange peel adsorbent and sugarcane bagasse removal efficiency at pH 8 to 10 is same as to orange peel efficiency range.

iv. Effect on initial concentration

The effect of initial concentration on the percentage of the nickel removal on orange peel and sugarcane bagasse is shown in the graph under various other fixed operating conditions.

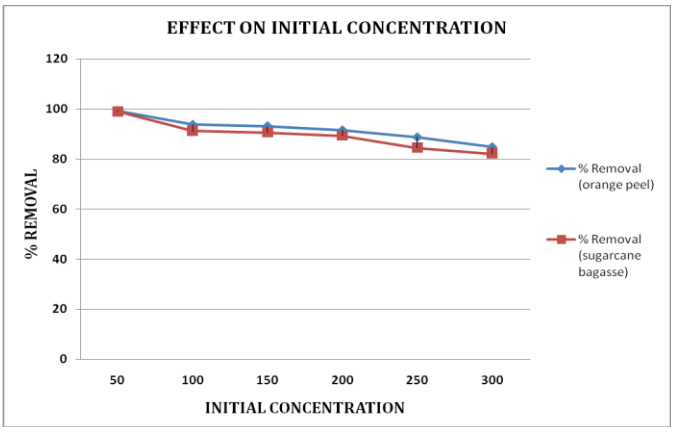

Fig 4.4 effect on initial concentration

The initial concentration of adsorption medium is one of the most important parameters affecting the adsorption process. From the above table it is seen that percentage of nickel removal was high at the concentration 50 mg/l in both case of orange peel adsorbent and sugarcane bagasse.

5. ISOTHERMAL STUDIES ON ORANGE PEEL AND SUGARCANE BAGASSE

5.1 Langmuir adsorption isotherm

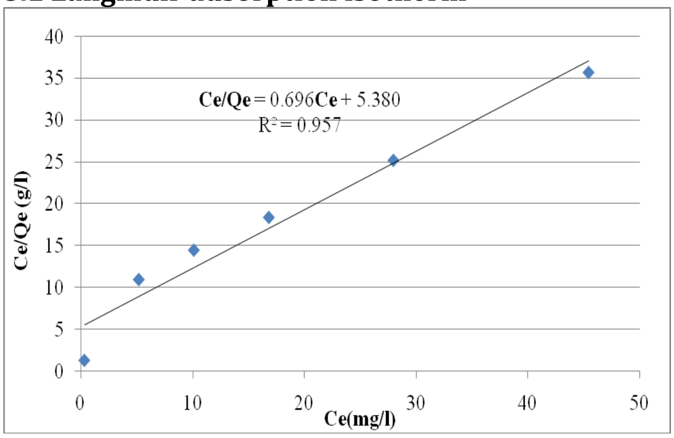

Fig. 5.1 langmuir isotherm of orange peel

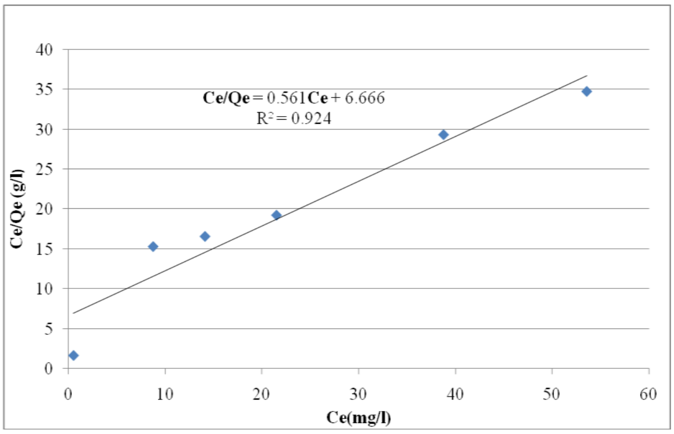

Fig. 5.2 Langmuir isotherm of sugarcane bagasse

The linear form of Langmuir isotherm is given below.

$$\frac{C_e}{Q_e} = \frac{1}{q_{max}} C_e + \frac{1}{K_L q_{max}}$$

$$q_e = \frac{(C_o - C_e)V}{W}$$

$\frac{C_e}{Q_e}$ Vs C_e for various concentrations is plotted

Separation factor, $R_L = \frac{1}{1+C_o K_L}$

R^2 is a statistic that explains the amount of variance accounted for in the relationship between two (or more) variables. Sometimes R^2 is called coefficient of determination, and it gives as square of correlation coefficient. The coefficient of determination range between 0 and 1. R^2 value larger than 0.5 is usually considered as significant relationship. Extremely high R^2 values indicating considerably better fit isotherm. Here is a value obtained as in the case of orange peel and sugarcane bagasse are 0.957 & 0.924. It shows that in both case it better fit for Langmuir isotherm.

5.2 Freundlich adsorption isotherm

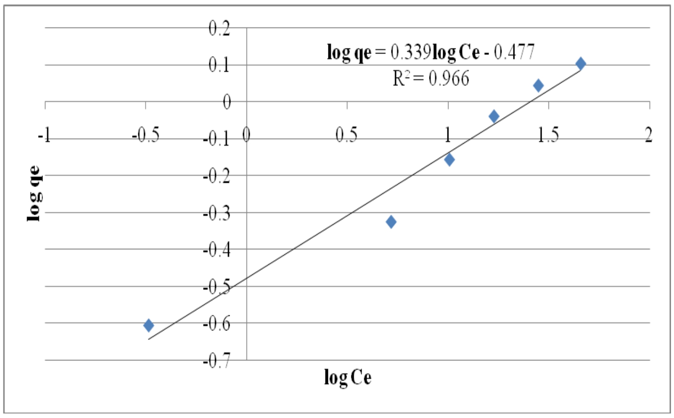

Fig.5.3 freundlich isotherm of orange peel

The linear form of Freundlich isotherm is given below.

Log qe = (1/n) log Ce + log K_F

$$q_e = \frac{(C_o - C_e)V}{W}$$

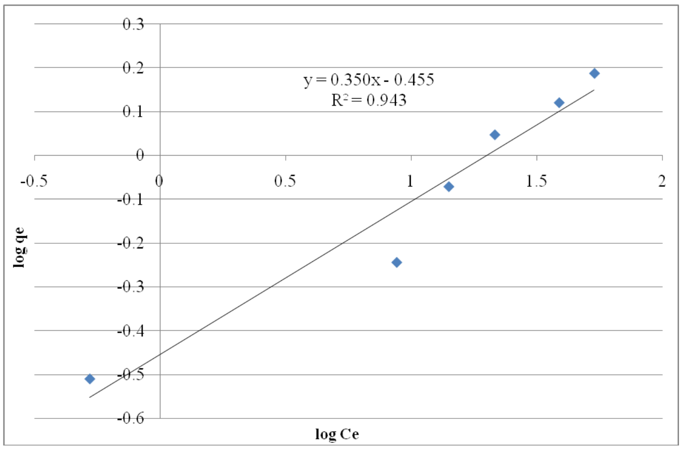

Fig.5.4 freundlich isotherm of sugarcane bagasse

A favourable adsorption tends to have Freundlich constant n between 1 and 10. The obtained n value is within in the limits. So the adsorption is good fit to freundlich isotherm. R2 value larger than 0.5 is usually considered as significant relationship. Extremely high R2 values indicating considerably better fit isotherm. Here is a value obtained as 0.966 & 0.943. It shows that better fit for Langmuir isotherm.

6. CONCLUSIONS

The entailment of this study is to reduce the nickel concentration in the industrial waste water using orange peel powder and sugarcane bagasse biosorbents. The biosorption performance is strongly affected by parameters such as contact time, adsorbent dosage, pH and initial concentration. The optimum conditions of the adsorption on orange peel adsorbent are 60 minutes of contact time, 10 g adsorbent dosage and pH of solution in between 8 and 10. The maximum removal of nickel content observed was 95.21% for 10 g of orange peel adsorbent at neutral solution. The adsorption experiment using sugarcane bagasse optimum conditions are 75 minutes of contact time, 8 g of adsorbent and pH of the solution is 8 to 10.

The adsorption process of nickel on orange peel and sugarcane bagasse is follows Langmuir and Freundlich isotherms.

From this study, it can be concluded that the orange peel proved to be very effective biosorbent that sugarcane bagasse for removal of nickel concentration from the electroplating industrial waste water.

REFERENCES

[1] Swarnabala Jena, Rajesh Kumar Sahoo (2017) Removal of Pb(II) from Aqueous Solution Using Fruits Peel as a Low Cost Adsorbent. International Journal of Science, Engineering and Technology

[2] Sonali R. Dhokpande1, Jayant P. Kaware (2017) Biosorptive Nickel Removal by Fruit Peel Waste: Batch, Kinetic and Isotherm Studies. International Journal of Research in Chemistry and Environment

[3] Muhammad Abid, Nabeel Khan Niazi, Irshad Bibi (2015) Arsenic (V) biosorption by charred orange peel in aqueous environments. International Journal of Phytoremediation

[4] Nasim Ahmad Khan, Shaliza Ibrahim and Piarapakaran Subramaniam (2004) Elimination of Heavy Metals from Wastewater Using Agricultural Wastes as Adsorbents.

[5] AhmedA.Abdelhafez, JianhuaLi (2015) Removal of Pb (II) from aqueous solution by using biochars derived from sugarcane bagasse and orange peel. Journal of the Taiwan Institute of Chemical Engineers

[6] R. Ayyappan, A. Carmalin Sophia (2003) Removal of Pb(II) from aqueous solution using carbon derived from agricultural wastes. Process biochemistry

[7] I. L. Rodríguez Rico,· R. J. Cabrera Carrazana (2018) Modeling the mass transfer in biosorption of Cr (VI) y Ni (II) by natural sugarcane bagasse. Applied Water Science

[8] Sami Guiza (2016) Biosorption of heavy metal from aqueous solution using cellulosic waste orange peel. Ecological Engineering

[9] Dhiraj Sud, Garima Mahajan, M.P. Kaur (2008) Agricultural waste material as potential adsorbent for sequestering heavy metal ions from aqueous solutions – A review. Bioresource Technology

[10] Guo Xueyi, Liang Sha, Tian Qinghua (2011) Removal of Heavy Metal Ions from Aqueous Solutions by Adsorption Using Modified Orange Peel as Adsorbent. Advanced Materials Research

[11] M.A. Barakat (2011) New trends in removing heavy metals from industrial wastewater. Arabian Journal of Chemistry

[12] Vinod K. Guptaa,, C.K. Jain, Imran Ali, M. Sharma (2003) Removal of cadmium and nickel from wastewater using bagasse fly ash—a sugar industry waste. Water Research

[13] Nirav P. Raval, Prapti U. Shah, Nisha K. Shah (2016) Adsorptive removal of nickel (II) ions from aqueous environment: A review. Journal of Environmental Management

[14] Monika Kumari and Sanjay K Sharma (2018) Biosorption Of Ni(Ii), Zn(Ii), Cd(Ii) And Pb(Ii) Ions From Water And Waste Water Using Different Biosorbents: A Review. International Journal of Recent Scientific Research

[15] Tonni Agustiono Kurniawan, Gilbert Y.S. Chan, Wai-hung Lo, Sandhya Babel (2005) Comparisons of low-cost adsorbents for treating wastewaters laden with heavy metals. Science of the Total Environment