ISSN 2348 – 8034
Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

Cd and Zn REMOVAL BY BIOSORPTION USING E-COLI

M.Mohan[*1], M.Manoj Kumar[2] and S.Mahendran[3]
[*1,2]Assistant Professor in Civil Engineering, PSNA College of Engineering and Technology, India
[3]Professor of Civil Engineering, PSNA College of Engineering and Technology, India

ABSTRACT

Biosorption treatment is a promising technique for the removal of heavy metals from the industrial waste water. When the pollutant concentration in the waste water is at trace levels, it cannot be easily removed by using the traditional techniques. In such situations biosorption gives a helping hand in removing trace level pollutants. Heavy metals bind to the cell wall of the specific micro organisms which contain metal binding protein in their cell wall. By conducting the experiments on biosorption techniques the ability of the *E-Coli* can very well be estimated. In this project work *E-Coli* organism was isolated from domestic sewage. The synthetic cadmium and zinc solutions were prepared for concentration of 40 ppm, 50 ppm, 60 ppm, 70 ppm, 80 ppm, 90 ppm and 100 ppm for the standardization of Atomic Absorption Spectrophotometer. The cadmium and zinc bearing effluent was collected from the electro plating industry. Using *E-Coli* as the biosorbent, adsorption studies were conducted by varying concentration, contact time and dosage. The optimum contact time and dosage were determined. 82% removal was observed in case of cadmium and 80% removal was achieved in zinc. The Langmuir and Freundlich isotherms were prepared from the above study. It is concluded that the *E-Coli* is effective in removing cadmium and zinc from the waste water generated from the electro plating industry

Keywords: *Bio-sorption, E-coli, Cadmium, Zinc*

I. INTRODUCTION

Heavy metals include all metals with atomic number greater than 23 and specific gravity greater than 5. Heavy metals and their compounds unlike most of the other pollutants occur naturally in the environment also.

The presence of heavy metals in aquatic environments is known to cause severe damage to aquatic life, beside the fact that these metals kill microorganisms during biological treatment of wastewater with a consequent delay of the process of water purification. Most of the heavy metal salts are soluble in water and form aqueous solutions and consequently cannot be separated by ordinary physical means of separation.

Heavy metal pollution in the environment can originate from natural and also from man made sources. The natural sources of heavy metal pollutions are geological weathering and volcanic activities. Effluent from electro plating industries, battery manufacturing units are some of the man made sources of heavy metal pollution. Heavy metals are toxic even at low concentration to human beings and other living organism. Cadmium is toxic even at low concentration. Cadmium can cause hypertension and damages kidney and liver in human beings.

Water polluted with Cadmium affects both flora and fauna in water bodies. Exposure to sub lethal air concentration of cadmium may result in Ansonia, dyspnea and emphysema.

The use of micro organism is believed to have considerable potential in heavy metal treatment for removing the last portion of metal following electro deposition or cementation such as in the processing of wastes.

II. METHOD & MATERIAL

BIOSORPTION

Biosorption can be defined as the ability of biological materials to accumulate heavy metals from wastewater through metabolically mediated or physico-chemical pathways of uptake. Algae, bacteria and fungi and yeasts have proved to be potential metal biosorbents. The search for new technologies involving the removal of toxic metals from wastewaters has directed attention to biosorption, based on metal binding capacities of various biological materials. Then also recovery of heavy metal from the same biological materials. Biosorption of heavy metals by microbial cells has been recognized as a potential alternative to existing technologies for recovery of heavy metals from industrial waste streams. Most studies of biosorption for metal removal have involved the use of either laboratory-grown microorganism or biomass generated by the pharmacology and food processing industries or wastewater treatment units

PROCESS OF BIOSORPTION

The biosorption process involves a solid phase (sorbent or biosorbent; biological material) and a liquid phase (solvent, normally water) containing a dissolved species to be sorbed (sorbate, metal ions). Due to higher affinity of the sorbent for the sorbate species, the latter is attracted and bound there by different mechanisms. The process continues till equilibrium is established between the amount of solid-bound sorbate species and its portion remaining in the solution. The degree of sorbent affinity for the sorbate determines its distribution between the solid and liquid phases.

BIOSORBENT MATERIAL

Strong biosorbent behavior of certain micro-organisms towards metallic ions is a function of the chemical make-up of the microbial cells. This type of biosorbent consists of dead and metabolically inactive cells.

Some types of biosorbents would be broad range, binding and collecting the majority of heavy metals with no specific activity, while others are specific for certain metals. Some laboratories have used easily available biomass whereas others have isolated specific strains of microorganisms and some have also processed the existing raw biomass to a certain degree to improve their biosorption properties.

Recent biosorption experiments have focused attention on waste materials, which are by-products or the waste materials from large-scale industrial operations. For e.g. the waste mycelia available from fermentation processes, olive mill solid residues (Pagnanelli, et al 2002), activated sludge from sewage treatment plants (Hammaini et aI. 2003), biosolids (Norton et al 2003), aquatic macrophytes (Keskinkan et aI. 2003), etc.

Although abundant natural materials of cellulostic nature have been suggested as biosorbents, very less work has been actually done in that respect.

The mechanism of biosorption is complex, mainly ion exchange, chelation, adsorption by physical forces,entrapment in inter and intrafibrilliar capillaries and spaces of the structural polysaccharide network as a result of the concentration gradient and diffusion through cell walls and membranes. Choice of metal for biosorption process

SYNTHETIC CADMIUM SOLUTION

Synthetic Cadmium solutions of concentration 40ppm, 50ppm, 60ppm, 70ppm80ppm, 90ppm &100ppm were prepared by dissolving Cadmium chloride salt in distilled water for the draw the standard graph for Atomic adsorption spectro photo meter.

BIOSORPTION EXPERIMENT

The adsorption of heavy metal from the industrial effluent was added to wet cells suspension of the selected strain at the optimum dosage and contact time .The adsorption test was conducted in an incubator shaker (250 rpm) at 30oC. The samples were taken after 6 h incubation for the dried cell suspension. For wet cell suspension, 0.5% (w/v) NaCl was included and the samples were taken after 1h ,2h, 3hincubation . The supernatants of the samples were analyzed and the percentage of each metal removal calculated.

ANALYSIS OF CADMIUM & ZINC USING ATOMIC ADSORPTION SPECTRO PHOTOMETER

Atomic adsorption spectro photo meter was used to analyze the initial and the residual concentrations after each and every experiment. This instrument is more accurate in analyzing the heavy metals (Model GBC 902).

III. RESULT & DISCUSSION

In the biosorption of the tested metals Cadmium and Zinc by the *E.coli*, most of the metal ions were sequestered from solutions within the first three hours and almost no increase in the level of bound metals have been occurred after this time interval. The comparison of the sorption performance of the biosorbent added in different weight by volume (W/V) ratios was achieved under the same environmental conditions (i.e. Temperature, agitation speed, etc.). Biosorption equilibrium isotherms were plotted for the metal uptake Q against the residual metal concentrations in solution. The Q versus C_f sorption isotherm relationship was mathematically expressed by linearized Langmuir and Freundlich models. The higher the values of k and n and the lower the value of b, the higher the affinity of the biomass Describe the standard Fig plotted on concentrations of heavy metal against initial optical density for Cadmium and Zinc respectively. Table 5.2 to Table 5.56, describe summaries of linear regression data for Langmuir and Freundlich isotherms for Cd and Zn biosorption using nonliving biomass of E-Coli species. Table 3.1 and 3.2 describe the reaction rates of Cd and Zn. The values of $1/C_f$ was plotted against the values of $1/Q$ yielding straight line relationships for each of Cd and Zn as individual metal ions. Similarly the values of Log C_f were plotted against the values of Log Q, also giving straight lines for Cd and Zn metals. The summary of linear regression data for Langmuir and Freundlich isotherms for Cd and Zn biosorption using nonliving biomass of *E.coli*. The values of $1/C_f$ were plotted against the values of 1/Q yielding straight line relationships for each of Cd and Zn as individual metal ions. Similarly the values of Log C_f were plotted against the values of Log Q, also giving straight lines for Cd and Zn metals. The Q_{max} (maximum adsorption capacity) as derived from the Langmuir isotherm and the Freundlich constant k were obtained from the linear equations of both models.

As indicated from the Tables, the coefficients of determination (R^2) of both models were more or less greater than 0.9 and in case of Cd and Zn their coefficients were close to one, indicating that both models adequately describe the experimental data of these metal biosorption experiments.

The metal removal studies were illustrated graphically which showed that their removals differed with the difference of metal and with the different operating conditions. Maximum Cd and Zn removal was found to be around 82% and 81.% respectively. Generally Cd and Zn removal was ranged between 73% to 85% and 70% to 84% respectively in industrial effluent solution. The Cd and Zn removal increased gradually with the increase of the metal influent. The percentage Cd and Zn removal ranged between 80% to 83% and 77% to 81% respectively.

BIOSORPTION EXPERIMENTS FOR *E.COLI* EVALUATION

The isolation of *E.coli* chosen for Cadmium and Zinc removal from the prepared industrial effluent solution was done. Batch study to assess the parameters influencing adsorption process such as contact time, optimum dosage, initial Cadmium and Zinc concentration and to predict the approximate Cadmium and Zinc that was removed.

BATCH ADSORPTION EXPERIMENTS

The initial concentration of industrial effluent solution treated in the batch reactor was 10 ml. Batch reactor has been employed in these experiments to assess the influence of the following basic parameters on the adsorption process.

Time adsorption studies

To evaluate the kinetics of Cadmium and Zinc adsorption on *E.coli*

Kinetics of Cadmium and Zinc adsorption for the industrial effluent with *E.coli*

Isotherm study to evaluate the equilibrium characteristics of *E.coli*

Table Concentration versus initial optical density of Cadmium

Concentration	0	40	50	60	70	80	90	100
Initial Optical Density	0	0.031	0.039	0.047	0.054	0.062	0.070	0.075

BATCH ADSORPTION STUDY

LANGMUIR AND FREUNDLICH ISOTHERM ON CADMIUM

LANGMUIR ISOTHERM TEST FOR *E.COLI* ON CADMIUM

Waste treated	: Industrial Cadmium solution
Volume of waste treated	: 10ml
Adsorbent	: *E.COLI*
Mixing arrangement	: Centrifuge
Time of contact	: 2hr.
Weight per Volume of biosorbent	: Variable

LANGMUIR ISOTHERM TEST FOR *E.COLI* ON CADMIUM

Sl.No	**Weight of Adsorbent added (m) in ml**	**Maximum Cd uptake for 54 ppm**	**Weight of Cadmium adsorbed at equilibrium concenyration (X) in mg X=Cd uptake *10ml/1000**	Equilibrium Cadmium concentration in mg/l C_f	$1/C_f$	X/m	1/(X/m)
1	1	44	0.44	10	0.10	0.44	2.27
2	1.5	42	0.42	12	0.08	0.28	3.57
3	2	45	0.45	9	0.11	0.225	4.44
4	2.5	47	0.47	7	0.14	0.188	5.32

FREUNDLICH ISOTHERM TEST FOR *E.COLI*

LANGMUIR AND FREUNDLICH ISOTHERM ON ZINC

LANGMUIR ISOTHERM TEST FOR E.COLI ON ZINC

Waste treated : Industrial Zinc solution

Volume of waste treated : 10ml

Adsorbent : *E.COLI*

Mixing arrangement : Centrifuge

Time of contact : 3hr.

Weight per Volume of biosorbent : Variable

5.7 RESULTS FROM ISOTHERMS

The amount of metal bound by the biosorbents was calculated as follows:

$Q = v(C_i\text{-}C_f)/m$

Where Q is the metal uptake (mg metal per g biosorbent), v the liquid sample volume (ml), Ci the initial concentration of the metal in the solution (mg/L), C_f the final (equilibrium) concentration of the metal in the solution (mg/L) and m the amount of the added biosorbent on the dry basis (mg).

Sorption models were chosen for comparison with experimental data:

The Langmuir model, $Q = Q_{max}\, bC_f / 1+bC_f$

Where Q max is the maximum metal uptake under the given conditions, b a constant related to the affinity between the biosorbent and sorbate.

Linearized Langmuir model $1/Q= 1/Qmax\ (1/b\ C_f +1)$

The Freundlich model, $Q = k\ C_f\ (1/n)$ Where k and n are Freundlich constants, which correlated to the maximum adsorption capacity and adsorption intensity, respectively.

Linearized Freundlich equation

$Log\ Q = Log\ k +1/n\ Log\ C_f$

For Cadmium

Linearized Langmuir model $1/Q= 1/Qmax\ (1/b\ C_f +1)$ for the metal *E.coli* was arrived as linear equation, Y = 0.8609x+1.82. From the above equation,

$Q_{max} = 0.535$

b = 2.11

The dimensionless value RL is given by the formula,

$RL = 1/(1+(b*C_i))$

Where Q max is the maximum metal uptake under the given conditions, b is a constant related to the affinity between the biosorbent and sorbate, C_i is the initial concentration (54).

RL = 0.008

RL < 1. Hence, the behaviour of isotherm is favourable.

Linearized Freundlich model Log Q = Log k +1/n Log C_f for the *E.coli* was arrived as linear equation, Y = O.1198X-0.87, From the above equation,

K = 0.135

n = 8.35

Where k and n are Freundlich constants, which correlated to the maximum adsorption capaCity and adsorption intensity, respectively.

The dimensionless value RL is given by the formula,

RL = 1/(1+(k*C_i))

RL = 0.1206

RL < 1. Hence, the behaviour of isotherm is favourable.

For Zinc

Linearized Langmuir model 1/Q= 1/Qmax (1/b C_f +1) for the *E.coli* was arrived as linear equation, Y =0.1654X+0.22, From the above equation,

Qmax = 4.5

b =1.33

Where Q max is the maximum metal uptake under the given conditions, b is a constant related to the affinity between the biosorbent and sorbate, C_i is the initial concentration (257 ppm).

The dimensionless value RL is given by the formula,

RL = 1/(1+(b*C_i))

RL = 0.002

RL < 1. Hence, the behaviour of isotherm is favourable.

Linearized Freundlich model Log Q = Log k +1/n Log C_f for the *E.coli* was arrived as linear equation, Y =0.0851X-0.68,From the above equation,

K =0.208

n = 11.75

Where k and n are Freundlich constants, which correlated to the maximum adsorption capaCity and adsorption intensity, respectively.

The dimensionless value RL is given by the formula,

RL = 1/(1+(k*C_i))

RL = 0.018

RL < 1. Hence, the behaviour of isotherm is favourable.

IV. CONCLUSION

The following conclusions were arrived from the present study on the ability of E-Coli species in removing Cadmium and Zinc from industrial effluents solution.

1. From the results it is very clear that the E-Coli species efficiently removes Cadmium and Zinc from the respective industrial effluents solution.

2. From the biosorption studies using E-Coli, the percentage removal was found to increase with contact time for the E-Coli species dosages, 0.5 ml, 1ml, 1.5ml, 2.0ml and 2.5ml. After the optimum contact time of 3hour, the percentage removal of the metals decreased for all the dosages. The percentage cadmium removal for a dosage of 2 ml E-Coli organism for a contact time of 2 hour at a concentration of 54 ppm was 82.5%. In this period for dosages of 0.5 ml, 1ml, 1.5ml and 2ml the efficiency was a minimum of 63.2% and a maximum of 82.6%. The percentage Zinc removal for a dosage of 2 ml E-Coli organism for a contact time of 3 hour at a concentration of 257 ppm was 81%. In this period for dosages of 0.5 ml, 1ml, 1.5ml, and 2ml, the efficiency was a minimum of 62% and a maximum of 81%.

3. From the isotherms, it was observed that E-Coli organism was in conformity with Langmuir and Freundlich adsorption isotherm.

4. The Langmuir constants for E-Coli organism used in the removal of

Cadmium were arrived as,

Q_{max} = 0.535

b = 2.11

R_L = 0.008

5. The Freundlich constants for E-Coli organism used in the removal of

Cadmium were arrived as,

K = 0.135

n = 8.35

R_L = 0.1206

6. The Rate of reaction for E-Coli organism used in the removal of

DOI- 10.5281/zenodo.182299
Impact Factor- 4.022

Cadmium were arrived as,

k = -----------

7. The Langmuir constants for E-Coli organism used in the removal of

Zinc were arrived as,

$Q_{max} = 4.5$

b = 1.33

$R_L = 0.002$

8. The Freundlich constants for E-Coli organism used in the removal of

Zinc were arrived as,

K = 0.208

n = 11.75

$R_L = 0.018$

9 . The Rate of reaction for E-Coli organism used in the removal of

Zinc was arrived as,

REFERENCES

1. *A. H. Hawari, C. N. Mulligan, "Biosorption of Pb(II), Cd (II), Cu(II) and Ni(II) by Anaerobic Granular Biomass," Bioresource Technology, Vol. 97, No. 4, March 2006, pp. 692-700.*
2. *Davis TA, Volesky B, Mucci A (2003) A review of the biochemistry of heavy metal biosorption by brown algae. Water Res 37: 4311–4330. doi: 10.1016/s0043-1354(03)00293-8.*
3. *Abdel-Aty AM, Nabila SA, Hany HA, and Rizka KA. J Advanced Research 2013; 4: 367–374.*
4. *Chen Z, Ma W, and Han M. J Hazard Mater 2008; 155: 327-333.*
5. *Riaz M, Nadeem R, Hanif MA, Ansari TM, and Rehman KU. Pb (II) J. Hazard. Mater 2009; 161: 88-94.*
6. *Nasuha NH, and Mohd Din AT. J. Hazard. Mater 2010; 175: 126-132.*
7. *Kumar R, Singh R, Kumar N, Bishnoi K, and Bishnoi NR.,. Bacillus brevis, J Chem. Eng 2009; 146: 401*
8. *Jalali R, Ghafourian H, Asef Y, Davarpanah SJ, and Sepehr S. J Hazardous Materials 2002; 92 (3):253*
9. *Matsumara, Y., Yoshikata, K., Kunisaki, S. & Tsuchido, T. (2003) Mode of Bactericidal action of Silver Zeolite and Its comparison with That of Silver Nitrate. Applied and Environmental Microbiology: 4278-4281*
10. *13. Rivera-Garza, M., Olguıń , M.T., Garcıá -Sosa, I., Alcántara, D. & Rodrıṅ uez-Fuentes, G. (2000) Silver supported on natural Mexican zeolite as an antibacterial material. Microporous and Mesoporous Materials 39(3): 431–444*