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Removal of Zinc (Zn^{2+}) from Wastewater by using Mangifera Indica Peel

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ABSTRACT

With the commencement of industrial development mankind has witnessed various environmental issues in the society. This industrial development has not only brought growth and prosperity, but eventually disturbed the ecosystem. One of the influences is visible, in the form of water pollution. In the present study, heavy metal contamination of water bodies has been discussed. Effluents from factories contains huge amount of heavy metals in them. Chemical oxidation, chemical precipitation, membrane separation, ion exchange, electro dialysis, reverse osmosis etc. are some of the modern methods adopted in treating waste water contaminated with heavy metals. However these methods are expensive, energy intensive and give toxics as by products.Adsorption has been investigated as a cost-effective, energy efficient, method of removal of heavy metals from wastewater. In the present study, Mangifera indica peel is used as low-cost adsorbent. It has been identified as an effective adsorbent in the removal of Zinc from waste water.

Keywords: Zinc, Adsorption, Mangifera Indica, Adsorption Isotherms.

1. INTRODUCTION:

Treatment of waste water with heavy metals is of special apprehension due to their unmanageable and persistent nature in the environment. Countless methods have been extensively studied in recent years for heavy metal removal from wastewater. Application of low-cost adsorbents obtained from plant wastes as a replacement for costly conventional methods of removing heavy metal ions from wastewater has been reviewed. Due to these reasons researchers and scientists alike have come up with various, economical and reliable experiments that has given excellent results.

Many scientists are attracted to the process of adsorption with activated carbon because of the effectiveness in removal of heavy metal ion at trace quantities.But the process has not been used extensively for its high cost. For that reason, the use of low cost materials as adsorbents for metal removal from wastewater has been highlighted.Materials that have been investigated are bagasse (Onal et al. 2007), coconut shell, tea waste, peanut hull (Oliveira et al. 2009), apple waste (Maranon and Sastre 2005), sawdust (Ajmal et al. 2006), rice husk (Naiya et al. 2009), banana pith (Low et al. 2005),

tree bark (Gundogdu et al. 2009) and activated cotton fibers (Kang et al. 2008), cotton (Roberts and Rowland, 2003), walnut waste (Randall 1974), sugar cane waste and onion skin (Kumar and Dara, 2002), coffee grounds (Macchi, 1986), tea leaves, wool fibre (Balkose and Baltacioglu, 2009), green algae and rice hull, bark and other cellulosic material (Deshkar and Dara ,2008; Freer,2009; Randall 2004,2006,2007), linseed flax straw (Taylor 2011), watermelon shell, orange peel, mangifera indica peel, corn cobs and various tree leaves.

2.METHODOLOGY:

2.1Collection of adsorbent:

The Magnifera Indica peels were collected from the juice shop in REVA University campus and used as an adsorbent for the removal of zinc from wastewater.

2.2Preparation of adsorbent:

With the help of distilled water Magnifera Indica peels are washed to remove dust and other impurities. Then the adsorbents are cut into small pieces and oven dried using hot air oven at 100˚C for 6 hrs. The dried sample is then broken down into fine powder by using domestic mixer. This powder is then sieved through 250mm mesh sizes. Fig 1. shows the process of preparation of adsorbent

Fig: 1.Preparation of adsorbent

2.3. Preparation of wastewater:

The wastewater sample was prepared by using nitrate salts of zinc.To prevent hydrolysis pH of the waste water was adjusted to about 5.

Fig:2.Preparation of wastewater

2.4. Adsorption Experiment:

A measured amount of 1 g of theadsorbent is added 500ml of wastewater and placed in a Jar test apparatus. The paddles are allowed to revolve at 100rpm in wastewater for one hour.

2.5. Filtration:

The treated metal solution is then filtered by using filter paper and then taken for further analysis.

Fig: 3.Filtration of treated wastewater

2.6. Analysis of wastewater:

The initial and final concentrations of wastewater were analysed using complexometric titration of zinc with EDTA complex.

Fig: 4.Analysis of waste water

3.RESULT AND DISCUSSION

Detailed studies were carried out to investigate the effects of different parameters for different initial concentration of the wastewater, the dosage of adsorbent,pH of the solution and time of contact. The uptake of zinc by Mangifera indica peel was studied in batch condition.

3.1.Effect of pH:

The effect of pH was studied by varying the pH value from 2 to 9. The pH of the wastewater of are adjusted by adding 0.1N of sulphuric acid or 0.1N of sodium hydroxide.The effect of pH on the adsorption of Zn (II) by Mangifera indica peel is shown in Fig5. At pH 4, the removal efficiency of Zn(II) was identified to be maximum of 59.42%.The lowest removal efficiency of Zn (II) was identified as 19.52% at a pH of 9.The result has been identified hasthe pH of 2 to 4 there is an increase in the % removal efficiency of Zn (II) from the wastewater. The investigation hasestablished that there was a reduction in the % removal of Zn (II) from wastewater from a pH of 5 to9.

Table.1. Effect of pH for Zn- Mangifera Indica peel

SI. No	pH	Initial concentration [mg/l]	Final concentration [mg/l]	% removal of Zn

1.	2	50	39.34	21.32
2.	3	50	29.88	40.24
3.	4	50	20.29	59.42
4.	5	50	23.82	52.36
5.	6	50	25.84	48.32
6.	7	50	32.59	34.82
7.	8	50	38.91	22.18
8.	9	50	40.24	19.52

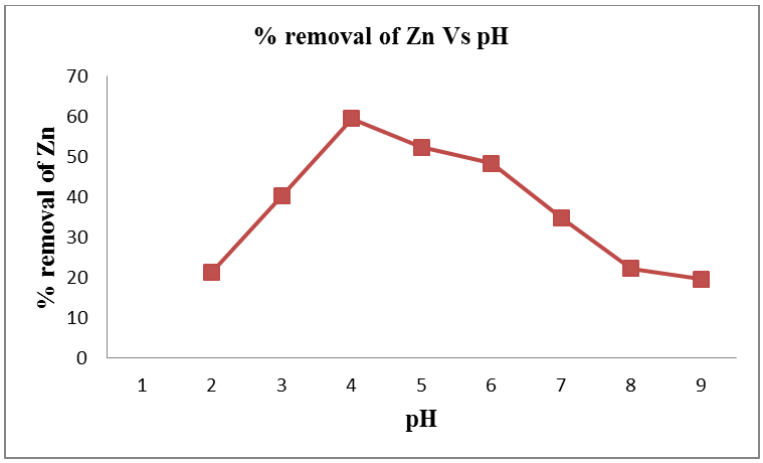

Fig. 5. Effect of pH - Mangifera Indica peel.

(Initial concentration=50mg/l, Adsorbent dosage=1g/500ml,

pH=2 to 9, Temp=25±2˚C, Contact time=60 min, Maximum % removal of Zn at pH=4)

3.2. Effect of adsorbent dose:

The effects of varying dosage of adsorbent in the removal of Zn (II) from wastewater are studied by varying the dosage from 0.5 to 3g in 500 ml.The effect of varying dosage of adsorbentforthe removal of Zn (II) is shown in Fig 6. The studied showed that the adsorptions of Zn (II) areincreasedwhen the dosage of adsorbent are increased from 0.5 to 2.5 g in 500ml. The adsorption of Zn (II) was identified to be reached equilibrium above 2.5g in 500ml.A dosage of 2.5g/500ml as 67.50% was recognized as the optimum dosage in the removal of Zn(II) from wastewater. Additionalincreases of adsorbent dose did not show evident improvement in adsorption.

Table.2. Effect of adsorbent dosage- Mangifera Indica peel

SI. No	**Dose [g/500ml]**	**Initial concentration [mg/l]**	**Final concentration [mg/l]**	**% removal of Zn**
1.	0.5	50	32.36	35.28
2.	1	50	29.05	41.90
3.	1.5	50	20.37	59.26
4.	2	50	16.39	59.26
5.	2.5	50	16.25	67.50
6.	3	50	16.04	67.92

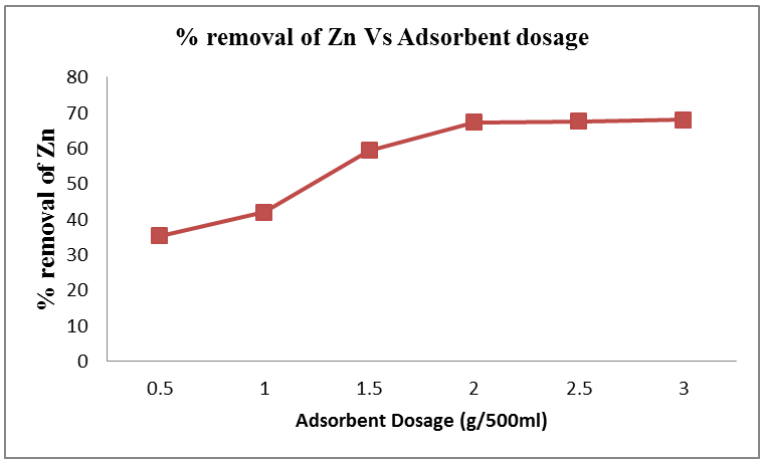

Fig. 6 Effect of adsorbent dosage- Mangifera Indica peel
(Initial concentration=50mg/l, Adsorbent dosage=0.5to3g/500ml,
pH=4, Temp=25±2˚C, Contact time=60 min,
Maximum % removal of Zn at adsorbent dosage=2.5g/500ml)

3.3.Effect of contact time:

The study about the effect of contact time showed the contact time required for the maximum removal of Zn (II) from the wastewater. Fig.7 shows the %removal of Zn (II) with time varying from 15 to 120minutes. The results showed the % removal of Zn (II) is increased with an increase in the time of contact between the adsorbent and wastewater. It can be concluded that the rate of the % removal increase with time up to 90 minutes then it becomes constant. The maximum % removal of Zn (II) was identified as 70.10% at a contact time of 90 minutes.

Table 3: Effect of contact time – Mangifera Indica peel.

S. No	Time (min)	Initial concentration [mg/l]	Final concentration [mg/l]	% removal of Zn
1.	15	50	39.99	20.02
2.	30	50	32.86	34.28
3.	45	50	28.99	42.02
4.	60	50	24.35	51.30
5.	75	50	18.64	62.72
6.	90	50	14.95	70.10
7.	105	50	14.72	70.56
8.	120	50	14.53	70.94

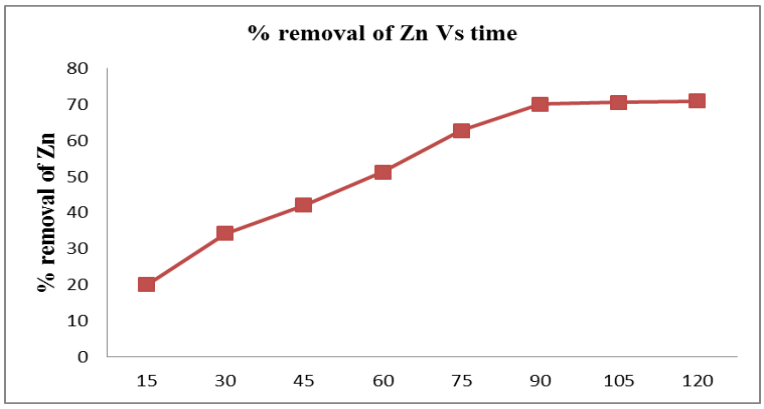

Fig.7. Effect of adsorbent dosage- Mangifera Indica peel
(Initial concentration=50mg/l, Adsorbent dosage=2.5g/500ml,
pH=4, Temp=25±2˚C, Contact time=0 to120 min,
Effective contact time for maximum removal of Zn =90 min)

3.4. Effect of initial concentration :

The initial concentration of heavy metals in wastewater shows the rate of adsorption. Fig.8 shows the % removal of Zn (II) for the varying initial concentration.The study showed that at lower concentrations the % removal efficiency is high. Due to saturation of adsorption sites, more metal ions are left unadsorbed in solution at higher concentrations.

The initial metal ion concentrations vary from 25 to 125mg/l and % removal are identified.The results showed that at higher concentration of wastewater the removal rate of Zn (II) are less (39.59% for 125mg/l) and at lower concentration the removal rate are high (80.16% for 25mg/l).

Table.4. Effect ofvarying concentration of metal ions - Mangifera Indica peel

S. No	Initial concentration (mg/l)	Final concentration (mg/l)	% removal of Zn
1.	25	4.96	80.16
2.	50	14.81	70.38
3.	75	30.58	59.23
4.	100	53.68	46.32
5.	125	75.51	39.59

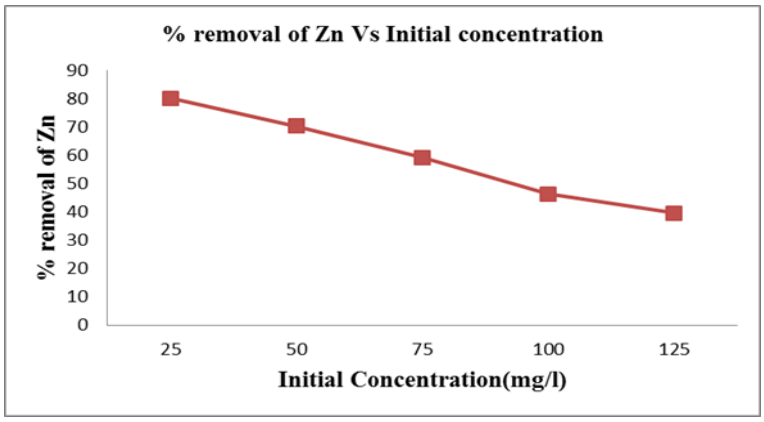

Fig.8. Effect of varying initial concentration- Mangifera Indica peel
(Initial concentration=25to125 mg/l, Adsorbent dosage=2.5g/500ml,
pH=4, Temp=25±2˚C, Contact time=90 min
Effective removal of Zn for initial concentration =70.38% in 50mg/l

4. ADSORPTION ISOTHERMS:

The batch adsorption experiments were carried out to find the adsorption capacity of the Mangifera Indica peel as an adsorbent

The investigation results identified for the adsorption of Zn(II) on Mangifera indica peel at room temperature (25 ± 1^0C) at optimum dosage of adsorbent and contact time were The experimental results obtained for the adsorption of zinc on Mangifera indica peel at room temperature (25 ± 1^0C) at optimum conditions of contact time and dose of adsorbent were initiate to obey the Freundlich adsorption isotherm

$$\frac{X}{M}=K_fC_e^{1/n}$$

The logarithmic form of the equation becomes,

$$\log\frac{X}{M}=\log K_f+\frac{1}{n}\log C_e$$

Here K_f and n are the constants representing the adsorption capacity and intensity of adsorption, respectively.

The Langmuir model represents one of the first theoretical treatments of non-linear sorption, and has been successfully applied to a wide range of systems that exhibit limiting or maximum sorption capacities. The Langmuir isotherm is given by:

$$\frac{X}{M}=\frac{abCe}{1+bCe}$$

The Langmuir isotherm constants (a and b) can be calculated by plotting 1/(X/M) versus ($1/C_e$) and making use of above equation rewritten as:

$$\frac{1}{X/M}=\frac{1}{a}+\frac{1}{ab}\frac{1}{Ce}$$

Table 5: Data for adsorption isotherms for Zn(II)- Mangifera indica peel

S.No	Initial Conc. (mg/l)	Final Conc. (mg/l)	Dose M (g)	X (mg/l)	X/M (mg/g-l)	Log (X/M)	Log Ce	1/(X/M)	1/Ce
1.	25	4.96	2	20.04	10.02	1.00	0.69	0.099	0.202
2.	50	14.81	2	35.19	17.59	1.25	1.17	0.056	0.07
3.	75	30.58	2	44.42	22.21	1.35	1.49	0.045	0.03
4.	100	53.68	2	46.32	23.16	1.36	1.73	0.043	0.02
5.	125	75.51	2	49.49	24.75	1.39	1.87	0.040	0.01

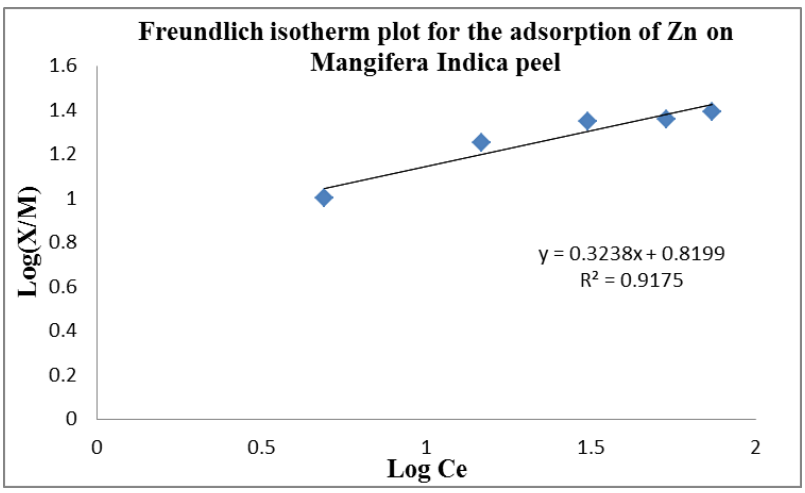

Fig:9.Freundlich isotherm plot for the adsorption of Zn (II)- Mangifera indica peel

(Adsorption capacity (K_f) =6.31 mg/g & Adsorption intensity(n)=3.04)

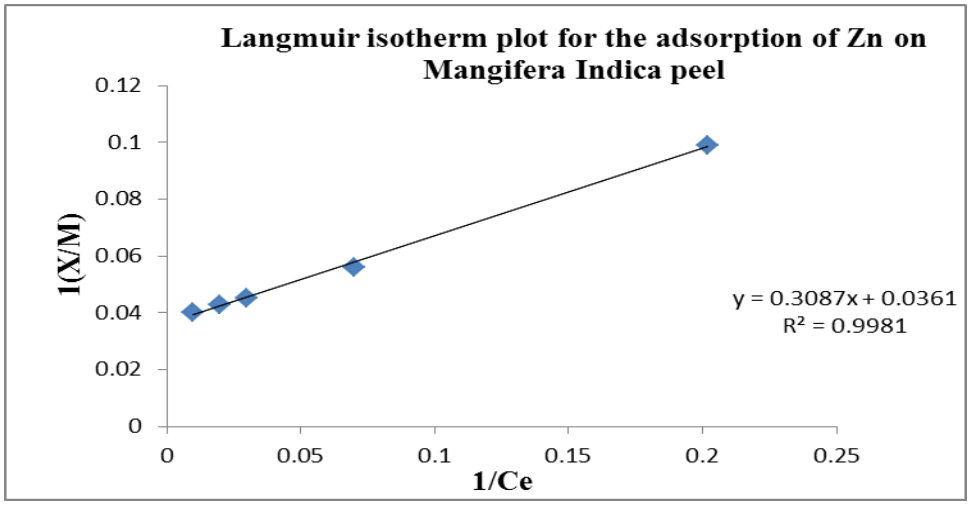

Fig:10. Langmuir isotherm plot for the adsorption of Zn(II) – Mangifera indica peel

(Langmuir constants value a=0.117, b=27.7)

5.CONCLUSION:

The batch study was investigated in the removal of Zn(II) by using mangifera indica peel.

The results of the study are discussed below.

- Batch studies on zinc removal showed significant effects of the variations of pH, dosage, contact time and concentration. The investigation has proved to be effective in the removal of Zn(II) from wastewater for different operating conditions.
- The electrostatic change in the wastewater has been identified by finding the pH value. The maximum removal efficiency for Zn(II) was 59.42% at a pH 4.
- The dosage of adsorbent at 2.5g/500ml was identified with a maximum removal efficiency as 67.50%.
- The time of contact was varied with 15 minute intervals and identified the effective contact time as 90 min for maximum percentage removal of 70.10%.
- Initial concentration of the metal solution was varied from 25mg/l to 125mg/l, giving aneffective percentage removal of 70.38% for 50mg/l.
- The adsorption capacities (K_f) and adsorption intensity has been identified from the Freundlich adsorption isotherm are6.31mg/g and 3.04.
- From Langmuir adsorption isotherm, the empirical constants (a, b) for zinc were found to be (0.117, 27.7).
- From the data identified the Langmuir adsorption isotherm is the best fit .

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