

“Modelling of Copper adsorption from aqueous solution on Jamun seed using Artificial Neural Network”

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Abstract— Artificial neural network was employed to develop prediction models for Copper removal efficiency on Jamun seed Powder. This adsorbent was characterized by FT-IR. Batch adsorption studies were carried out for adsorption of Cu by using natural cheap agro waste such as Jamun seed Powder for removal of copper from aqueous solution. The effects of initial metal concentration, Dose, pH, contact time on the removal on Cu have been studied. Results indicate that contact time of 360 min is sufficient to achieve equilibrium at different concentrations. Determination of Cu was done using Atomic absorption spectrophotometer. The peak percentage adsorption of Cu was attained at pH 7.0. These operating variables were used as the inputs to the constructed neural network to predict the copper uptake at any time as output. The model was developed using multilayer feedforward backpropagation network with levenberg marquardt training algorithm. A comparison between simulated and experimental results shows that the model is able to predict the concentration of residual copper in the solution.

Index Terms— AAS, Adsorption, Artificial Neural Network, Removal efficiency, Jamun seed Powder

I. INTRODUCTION

Water supports all forms of life on earth. The availability of clean water to the human population is of paramount importance. As the world population increases, water consumption also increases. Water pollution is a major problem in the global context and has even been suggested to be the leading cause of death and disease worldwide. The major contributor for this rise in the concentration level is in the extensive development of heavy & manufacturing industries that use metals & related compounds. Therefore there is an urgent need that all possible sources of agro-based inexpensive adsorbents should be explored and their feasibility for the removal of heavy metals should be studied. Copper is a toxic metal. It causes a disease named Wilson's disease. It causes harmful biochemical effects, toxicity and hazards in flora, fauna and human beings. Intake of copper through air, water, and food beyond its permissible limits causes disease. Copper toxicity leads to serve mucosal irritation, corrosion, widespread capillary damage hepatic and renal damage, central nervous system irritation followed by depression. Over the last few decades, several methods have been devised for the treatment and removal of heavy metals. The objective of this study to evaluate the feasibility of using the Syzygium Cumini L seed powder for the removal of copper, optimize of the different operating parameters such as pH, adsorbent dose, contact time and initial copper concentration were studied, to find the equilibrium values, in order to get maximum efficiency study the comparison of Adsorption capacity of locally available adsorbent. Validating the results in terms of copper removal efficiency and Adsorption Capacity by comparison between experimental and predicted data using artificial neural network.

II. PROCEDURE

A. Material for Adsorbent

Syzygium Cumini L is an evergreen tropical tree in the flowering plant family Myrtaceae, native to India and Indonesia. Seeds were locally collected from Syzygium Cumini L tree located in Nasik. Flesh of the fruit was removed. The seeds were separated from the Syzygium Cumini L fruits by eating and seed was washed with the distilled water. The seeds were dried in shade and stored at 25°C. The dried seed was ground and screened to uniform powder by using 150 microns sieve. Thus Jamun seed powder is stored in an air tight container for further usage. Submit your manuscript electronically for review.

B. Reagents and Equipments

Prepare a series of standard metal solutions in the optimum concentration range by appropriate dilution of the following stock metal solutions with water containing 1.5ml conc. (HNO₃)/l. Thoroughly, dry reagents before use. In general use reagents of the highest purity.

Copper

Dissolve 1.00g copper metal in 15ml of 1+1 HNO₃ and dilute to 1000ml with water;

$$1.00\text{ml} = 1.000\text{mg Cu}$$

Air, cleaned and dried through a suitable filter to remove oil, water and other foreign substances, use metal free water for preparing all reagents and calibration standards and as dilution water. Acetylene standard commercial grade acetone. When you submit your final version, after your paper has been accepted, prepare it in Single column format, including figures and tables.

C. Batch Adsorption study

Batch experiments were carried out in 250mL glass jar with 250 mL test solution at room temperature (29±2°C). The jar, along with known volume of test solution of fixed concentration at neutral pH, was shaken in Jar test apparatus at 100 rpm to study the equilibration time for maximum adsorption of copper. The effect of pH on copper was studied by adjusting the pH of test solution using 1N HCl or 1N NaOH on fixed quantity of adsorbent. At the end of the desired contact time, the samples were filtered using Whatman no. 42 filter paper and the filtrate was analyzed for residual copper concentration by Atomic Absorption spectrophotometer: Model No. AA-200, PERKIN described in the standard methods of examination of water and wastewater. The batch study was performed to determine the optimum condition and to study the effect of pH, adsorbent dose, contact time and initial copper concentration on the test solution.

The efficiency and copper adsorption capacity from the residual copper concentration was calculated by the following equations.

The percent removal efficiency of the copper was calculated as follow,

$$\% \text{ Removal} = \frac{C_i - C_e}{C_i} \times 100 \quad (1)$$

Where, C_i is the initial copper concentration (mg.L⁻¹), C_e is the equilibrium concentration of copper solution (mg.L⁻¹).

$$\text{Adsorption capacity (q}_e) = \frac{(C_i - C_e) \cdot V}{m} \quad (2)$$

Where, C_i is the initial copper concentration (mg.L⁻¹), C_e is the equilibrium concentration of copper solution (mg.L⁻¹), V is the volume of solution used in the batch (lit.), m is mass of adsorbent (g), q_e is adsorption capacity (mg of copper removed/ g of adsorbent).

III. Results and Discussions

3.1 Effect of Adsorbent dose on percentage copper removal

One of the parameters that strongly affect the adsorption process in an aqueous solution is the adsorbent dose. This is an important parameter, because it determines the capacity of an adsorbent for a given initial concentration of the adsorbate. More specifically, the increase rate of this parameter was high for higher adsorbent doses, due to the greater availability of active sites on the surface of the materials, and low for lower adsorbent doses, due to the progressive saturation of these active sites. However, the amount of Cu (II) adsorbed per adsorbent mass unit decreased considerably as the adsorbent dose increased. This can be attributed to adsorption sites remaining unsaturated during the adsorption reaction. In addition, it could also be noticed that the majority of the tested materials, steady state was reached for an adsorbent dose value 0.1g/l. Therefore, the optimum adsorbent dose of 0.1 g/L was selected in all the subsequent experiment.

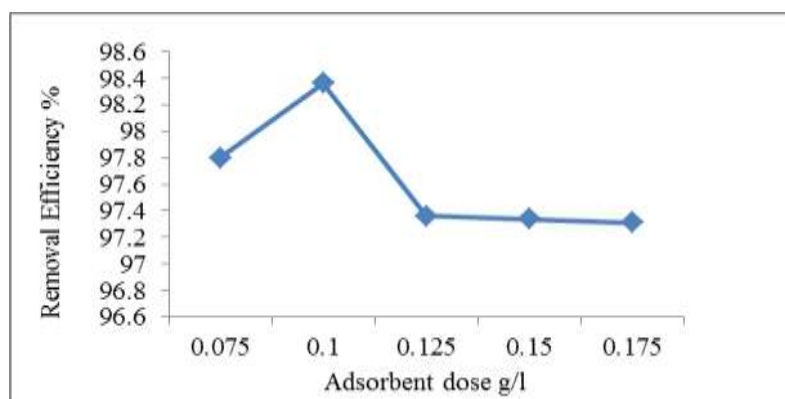


Figure 1: Graph for effect of Adsorbent dose on copper removal

3.2 Effect of Initial metal concentration on percentage copper removal

The mechanism of metal adsorption from an aqueous solution is particularly dependent on the initial metal concentration in the solution. According to the results increasing the initial Cu(II) concentration caused an increase in the amount of Cu(II) adsorbed per adsorbent mass unit. This was due to the increase in the driving force for mass transfer, which is the concentration gradient. In addition, a decrease in the Cu (II) removal could be noticed as the initial Cu (II) concentration in the solution increased, due to the saturation of the active sites in the solution (El-Ashtoukhy et al., 2008). These findings agree with previous studies (Aydin et al., 2008; El-Ashtoukhy et al., 2008; Zheng et al., 2008).

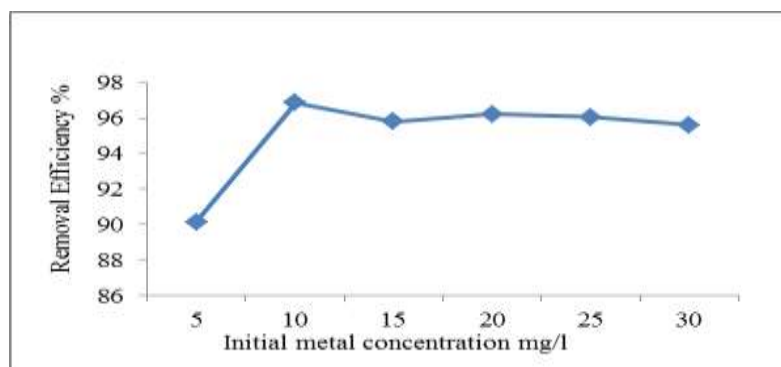


Figure 2: Graph for effect of Initial metal Concentration on copper removal

3.3 Effect of pH on percentage copper removal

The pH of an aqueous solution is one of the most important controlling parameters in the heavy metal adsorption process. It affects the surface charge of the adsorbent and the degree of ionization and speciation of the heavy metal in the solution. This study was carried out in a pH range 2-11 since copper starts to precipitate above pH 7. The optimum Cu (II) uptake of 97.16%, by *Syzygium Cumini L* respectively, was observed at pH 7.

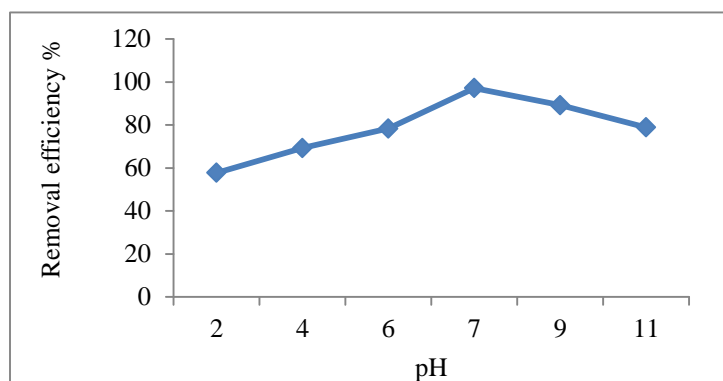


Figure 3: Graph for effect of pH on copper removal

3.4 Effect of Contact Time on percentage copper removal

By increasing contact time, an increase in both the amount of Cu (II) adsorbed per adsorbent mass unit and the Cu(II) removal was obtained. In most cases, the quick initial rate of adsorption during the first few minutes of contact was followed by a slower one, until equilibrium state was reached. This was due to the existence of abundant vacant active *Syzygium Cumini L* sites, whereas as adsorption continued a progressive saturation of

these active sites with time occurred. In addition, the required time to reach equilibrium was about 6 h, since an increase of contact time to 24h did not have any significant effects.

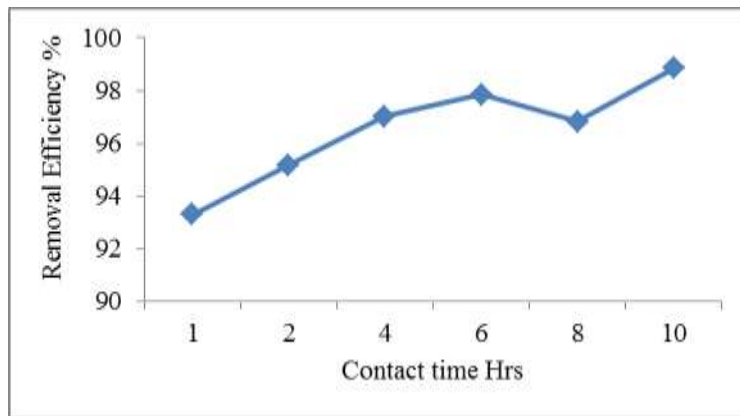


Figure 4: Graph for effect of Contact time on copper removal

IV. HELPFUL HINTS

A.Validation of results using Artificial Neural Network

Table 1. Total data for Ann Modelling

Sr no.	Input1	Input2	Input3	Input4	Input5	Actual 1	Actual 2	Predicted 1	Predicted 2
1	10	0.025	7	720	100	97	97	96.775	84.7362
2	10	0.05	7	720	100	98.18	49.09	96.7641	49.0097
3	10	0.1	7	720	100	98.78	24.70	96.7423	15.2291
4	10	0.2	7	720	100	99.27	12.41	96.6983	1.9052
5	10	0.4	7	720	100	99.68	6.23	96.6085	0.75697
6	10	0.8	7	720	100	99.52	3.11	96.4219	0.75
7	10	1.6	7	720	100	98.72	1.54	96.0188	0.75
8	10	3.2	7	720	100	96.63	0.75	95.0827	0.75
9	20	0.025	7	720	100	97.35	194.70	97.5645	3.5424
10	20	0.05	7	720	100	99.54	99.54	97.5563	0.76691
11	20	0.1	7	720	100	99.84	49.84	97.5398	0.75

12	20	0.2	7	720	100	99.04	24.76	97.5064	192.022
13	20	0.4	7	720	100	98.15	12.27	97.4383	75.1179
14	20	0.8	7	720	100	97.90	6.12	97.2965	0.75
15	20	1.6	7	720	100	96.20	3.01	96.989	0.75
16	20	3.2	7	720	100	95.13	1.49	96.2685	0.75
17	30	0.025	7	720	100	97.86	293.57	98.1594	364.9938
18	30	0.05	7	720	100	98.39	147.59	98.1532	148.858
19	30	0.1	7	720	100	99.80	74.85	98.1409	0.84945
20	30	0.2	7	720	100	99.62	37.36	98.1158	0.75
21	30	0.4	7	720	100	98.93	18.55	98.0647	0.75
22	30	0.8	7	720	100	98.58	9.24	97.9582	428.176
23	30	1.6	7	720	100	98.21	4.60	97.7264	37.7696
24	30	3.2	7	720	100	97.90	2.29	97.1797	0.75001
25	40	0.025	7	720	100	96.85	387.40	98.6036	34.4382
26	40	0.05	7	720	100	97.93	195.85	98.599	19.1311
27	40	0.1	7	720	100	98.60	98.60	98.5898	10.6275
28	40	0.2	7	720	100	98.79	49.40	98.5712	6.0137
29	40	0.4	7	720	100	99.18	24.79	98.5331	34.4382
30	40	0.8	7	720	100	99.28	12.41	98.4537	51.2655
31	40	1.6	7	720	100	99.54	6.22	98.2806	75.1179
32	40	3.2	7	720	100	98.73	3.09	97.8702	34.5867
33	50	0.025	7	720	100	97.48	487.40	98.933	34.5272
34	50	0.05	7	720	100	98.83	247.09	98.9296	34.4679
35	50	0.1	7	720	100	99.68	124.60	98.9228	47.986

36	50	0.2	7	720	100	99.15	61.97	98.909	46.5768
37	50	0.4	7	720	100	98.74	30.86	98.8808	1.2833
38	50	0.8	7	720	100	98.09	15.33	98.822	0.75011
39	50	1.6	7	720	100	97.75	7.64	98.6936	0.75
40	50	3.2	7	720	100	97.26	3.80	98.3881	0.75
41	20	0.075	7	720	100	97.80	65.20	97.5481	47.2402

Table 2. Abbreviations of variables in ANN modelling

Sr.no	Variables	Meaning of Variables	Unit
1	Input 1	Initial Copper Concentration	mg/l
2	Input 2	Adsorbent Dose	g/l
3	Input 3	pH	-
4	Input 4	Contact Time	Minutes
5	Input 5	Agitation speed	RPM
6	Actual 1	Experimental Copper removal efficiency	%
7	Actual 2	Experimental Copper Adsorption capacity	mg/g
8	Predicted 1	ANN predicted Copper removal efficiency	%
9	Predicted 2	ANN predicted Copper Adsorption capacity	mg/g

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1) paper is to introduce a new measurement technique. Authors should expect to be challenged by reviewers if the results are not supported by adequate data and critical details.

VIII. CONCLUSION

The operational parameters such as pH, adsorbent dose, contact time and initial copper concentration were found to have predominant effect on the adsorption efficiency of *Syzygium Cumini* L seed powder. The uptake of copper ions is possible between pH of 2.0 and 10; however pH of 7.0 gives maximum copper removal for *Syzygium Cumini* L seed powder. The removal efficiency at pH=7 is about 97.16% whereas at pH=6 it is 78.36%. Which are also encouraging and might be improved by optimizing the operating parameters at the pH=7. The percentage of copper removal was found to be a function of adsorbent dose and contact time at a given initial solute concentration. In case of effect of adsorbent dose, equilibrium dosage of 0.1g was found for *Syzygium Cumini* L seed powder after that there is no any significant change on copper removal efficiency with increase in dose. While the maximum efficiency was found to be 99.84%. The increase in copper concentration from 5 to 30mg/L the percentage of copper removal was decreased from 99.54-90.14% and curve gradually attains equilibrium after 720 min for *Syzygium Cumini* L seed powder. As Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

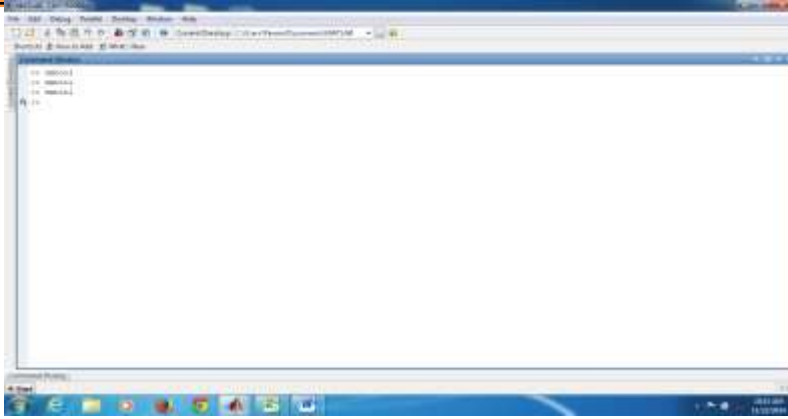


Figure 5: Snapshot of simulation run

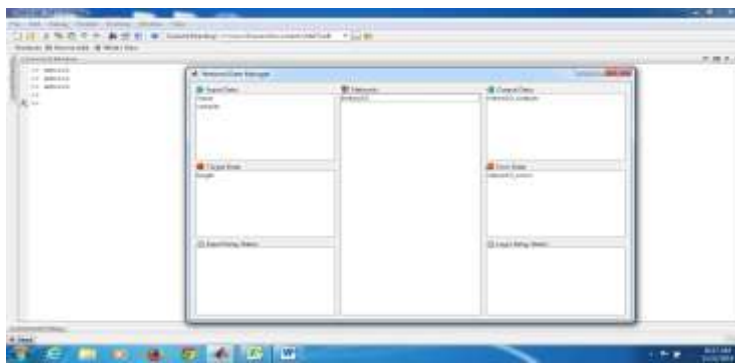


Figure 6: Network data Manager

