Available online at www.journalijmrr.com

INTERNATIONAL JOURNAL OF MODERN RESEARCH AND REVIEWS

Int. J. Modn. Res. Revs.

Volume 3, Issue 1, pp 54-58, January, 2015

ISSN: 2347-8314

COMPARATIVE STUDY OF ADSORPTION DYNAMICS OF CALCIUM USING GOOSEBERRY BARK AND GOOSEBERRY SEEDS

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Article History: *Received 14th January,2015, Accepted 30th Jan,2015, Published 31st January,2015*

ABSTRACT

Comparative study of adsorption dynamics of calcium was done by using Gooseberry bark and Gooseberry seeds. Studies on adsorption dynamics of calcium at varying contact time, adsorbent dosage, pH, adsorbent concentrations were carried out and the results were tabulated and discussed. The observed result with the parameter- concentration of the metal ion and adsorbent was an added advantage. As the metal ion concentration increased, the percentage removal of Ca^{2+} decreased. This concept can be utilized in safe removal of trace excess of calcium from human body using natural adsorbent, powdered gooseberry bark or seed.

Keywords: Hypercalcemia,, Decolorisation, Adsorptio

1.INTRODUCTION

The phenomenon of accumulation of a substance on the surface of a solid or liquid is known as Adsorption. From the early days of using bone charcoal for decolourisation of sugar solution and other foods, to the later implementation of activated carbon for removing nerve gases from the battlefield, to today's thousands of application, the adsorption phenomenon has become a useful tool for purification and separation.

Essential metals like Zn, Cu, Fe, Ca etc., play an important role in the metabolism of human being. But even the essential metals at higher concentration, when they cross permissible limits prove to be harmful. One among them is calcium. Ca is very essential for all organisms used in cell wall, bones and some shells as structural component and involved in blood clotting. But its excess causes Hypercalcemia which leads to heart disease, constipation, reduces ability to absorb Zinc, Iron and also increase the risk of kidney stones. This study involves adsorption of calcium on powdered gooseberry bark and gooseberry seed by chemical adsorption process. Calcium – Adsorption depends upon pH, contact time, Adsorbent dosage and concentration.

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2.MATERIAL AND METHODS:

Batch studies were conducted to evaluate the effect of the above said parameters on Adsorption kinetics.

Experiments for contact time:

Calcium stock solution was prepared by taking 0.25 g of $CaCO_3$ in 1000 ml flask. From the stock solution known concentration ie., 20 mg/L of Ca^{2+} was taken in 200ml flask and made upto the mark with distilled water. The entire solution was poured into 250ml beaker. Known quantity of adsorbent, the powdered gooseberry bark, was added to the beaker. The metal ion (Ca) aqueous solution was kept in contact with adsorbent for a period of 10 min to 300 min. The samples were withdrawn at different time intervals such as 10, 20, 30, 60, 120, 180, 240, 300 min. The sample was filtered into a conical flask. From the filterate Calcium was estimated using standard method. The experiment was repeated by taking powdered gooseberry seed as the adsorbent. The values are tabulated in Table-1.

Table – 1: REMOVAL OF CALCIUM USING GOOSEBERRY BARK AND GOOSEBERRY SEED AT VARIOUS CONTACT TIMES

Adsorbent	Contact Time (min)	Initial Conc. of Ca^{2+} (mg/l)	Final Conc. of Ca^{2+} (mg/l)	Amount of calcium adsorbed	q_e	log c_e	logq_e	K min^{-1}	% removal of Ca^{2+}
Goose berry bark	10	20	8.290	11.702	5.851	0.9189	0.7672	0.0870	58.51
	30	20	6.63	13.360	6.680	0.8220	0.8240	0.0363	66.81
	120	20	4.970	15.020	7.513	0.6967	0.8750	0.0076	75.13
	240	20	4.970	15.026	7.513	0.6967	0.8750	0.0057	75.13
Goose berry seed	10	20	5.642	14.358	7.179	0.7514	0.8560	0.1260	71.79
	30	20	4.642	15.358	7.679	0.6667	0.8853	0.4080	76.79
	120	20	3.983	16.017	8.008	0.6002	0.9035	0.0130	80.08
	240	20	3.983	16.017	8.008	0.6002	0.9035	0.0067	80.08

Table – 2: REMOVAL OF CALCIUM USING GOOSEBERRY BARK AND GOOSEBERRY SEED AT VARIOUS ADSORBENT DOSAGES

Adsorbent	Adsorbent dosage (g)	Initial conc. Of Ca^{2+} (mg/l)	Final Conc. Of Ca^{2+} (mg/l)	Amount Of calcium adsorbed	q_e	log C_e	Log q_e	K min^{-1}	% removal Of Ca^{2+}
Goose berry bark	0.4	30	9.95	20.05	50.125	0.9978	1.700	0.0118	66.83
	0.8	30	7.63	22.36	27.95	0.8827	1.446	0.022	74.55
	1.2	30	6.63	23.36	19.46	0.8220	1.289	0.025	77.87
	1.6	30	5.97	24.02	15.015	0.776	1.1765	0.026	80.08
	2	30	4.97	25.02	12.51	0.6967	1.097	0.029	83.42
Goose berry seed	0.4	30	9.29	20.71	51.77	0.968	1.714	0.019	69.03
	0.8	30	4.642	25.35	31.68	0.666	1.500	0.030	84.5
	1.2	30	3.319	26.68	22.23	0.521	1.347	0.036	88.93
	1.6	30	2.65	27.34	17.08	0.424	1.232	0.040	91.13
	2	30	1.659	28.34	14.17	0.219	1.515	0.048	94.47

Table – 3: REMOVAL OF CALCIUM USING GOOSEBERRY BARK AND GOOSEBERRY SEED AT VARIOUS pH VALUES

Adsorbent	pH	Initial Conc. Of Ca^{2+} (mg/l)	Final Conc. Of Ca^{2+} (mg/l)	Amount of calcium adsorbed	q_e	log C_e	log q_e	Kmin^{-1}	% removal of Ca^{2+}
Goose berry bark	2	10	4.978	5.022	2.511	0.697	0.399	0.023	50.22
	3	10	4.314	5.686	2.843	0.634	0.453	0.027	56.86
	4	10	3.319	6.681	3.340	0.521	0.523	0.036	66.81
	5	10	5.310	4.689	2.344	0.725	0.369	0.020	46.89
	6	10	5.970	4.025	2.012	0.776	0.303	0.017	40.89
Goose berry seed	2	10	3.31	6.681	3.340	0.521	0.5238	0.036	66.89
	3	10	2.655	7.345	3.672	0.424	0.564	0.043	73.45
	4	10	1.65	8.341	4.170	0.219	0.6201	0.059	83.41
	5	10	4.314	5.686	2.843	0.634	0.453	0.027	56.86
	6	10	4.97	5.022	2.511	0.697	0.399	0.023	50.22

Table – 4: REMOVAL OF CALCIUM USING GOOSEBERRY BARK AND GOOSEBERRY SEED AT VARIOUS CONCENTRATIONS

Adsorbent	Initial Conc. of Ca^{2+} (mg/l)	Final Conc. of Ca^{2+} (mg/l)	Amount of calcium adsorbed	q_e	log C_e	log q_e	K min^{-1}	% removal of Ca^{2+}
Goose berry bark	10	1.659	8.34	4.170	0.220	0.620	0.059	83.40
	20	3.651	16.34	8.174	0.562	0.912	0.056	81.74
	30	6.306	23.69	11.840	0.799	1.073	0.051	78.98
	40	9.950	30.05	15.020	0.997	1.176	0.045	75.12
	50	13.94	36.06	18.030	1.144	1.255	0.042	72.12
Goose berry Seed	10	1.32	8.673	4.33	0.122	0.637	0.066	86.73
	20	2.98	17.013	8.50	0.475	0.929	0.062	85.06
	30	5.64	24.350	12.17	0.751	1.085	0.055	81.19
	40	8.29	31.700	15.85	1.501	1.200	0.051	79.29
	50	12.94	37.060	18.53	1.568	1.111	0.044	74.12

Experiments for Adsorbent dosage:

From the stock solution known concentration ie., 300 mg/L of Ca was taken in 200 ml flask and made upto the mark with distilled water. The entire solution was distributed in five beakers to which different quantities (0.4, 0.8, 1.2, 1.6, 2 g) of adsorbent-powdered gooseberry bark was added and left for a period of 60 min. Then the solutions were filtered separately and the filterate was estimated for 'Ca' using standard method. The same procedure was repeated for the adsorbent-powdered gooseberry seed. Table -2 shows the calculated results of percentage removal of 'Ca' at various Adsorbent dosages

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Experiments for pH:

From the stock solution known concentration ie., 10 mg/L of Ca was taken in 200ml flask and made upto the mark with distilled water. The entire solution was poured into five 50 ml beakers. pH was adjusted using hydrochloric acid. The known quantity of adsorbent powdered gooseberry bark was added to the beakers.

The metal ion (Ca^{2+}) solution was kept in contact with adsorbent for a period of 30 mins. After the filteration, the filterate was estimated for the amount of 'Ca'. The same procedure was repeated with the adsorbent- powdered gooseberry seeds. The values of the results were tabulated in Table -3.

Experiments for concentration:

From the stock solution different concentration ie., 10 mg/L 20 mg/L 30 mg/L 40 mg/L and 50mg/L of Ca was taken in 200ml flask and made upto the mark with distilled water. The entire solution was poured into five 250ml beakers. A known quantity of adsorbent, powdered gooseberry bark was added to the beakers and allowed to remain for 30 mins. The sample was filtered and filterate analysed for 'Ca' amount. The same procedure was repeated for the adsorbent-powdered gooseberry seeds. The values are shown in Table – 4

3.RESULTS AND DISCUSSION

All the experiments were carried out at room temperature. In all the above experiments, the amount of Ca ion adsorbed, qe and percentage removal of Ca were calculated using the formula.

i. Amount of Calcium adsorbed = $C_i - C_e$

Where C_i ⟶ initial concentration of the metal ion

C_e ⟶ remaining concentration of the metal ion after adsorption

ii. $q_e = \frac{\text{Amount of Calcium adsorbed}}{\textit{weight of the adsorbent}}$

iii. Percentage removal of Calcium = $\frac{\text{Amount of Calcium adsorbed}}{\textit{Initial concentration}}$ x 100

1. **Effect of contact time:**

Studies show that the contact time has greater effect on calcium removal. By increasing the contact time, the adsorption also increased and after one hour 'becamen' constant is attained (Fig- 1). This indicates that the equilibrium was obtained in one hour as there was no further significant change in equilibrium concentration upto four hours. The percentage removal of metal ion calcium observed was 75.1 for gooseberry bark whereas it was 80 for gooseberry seeds

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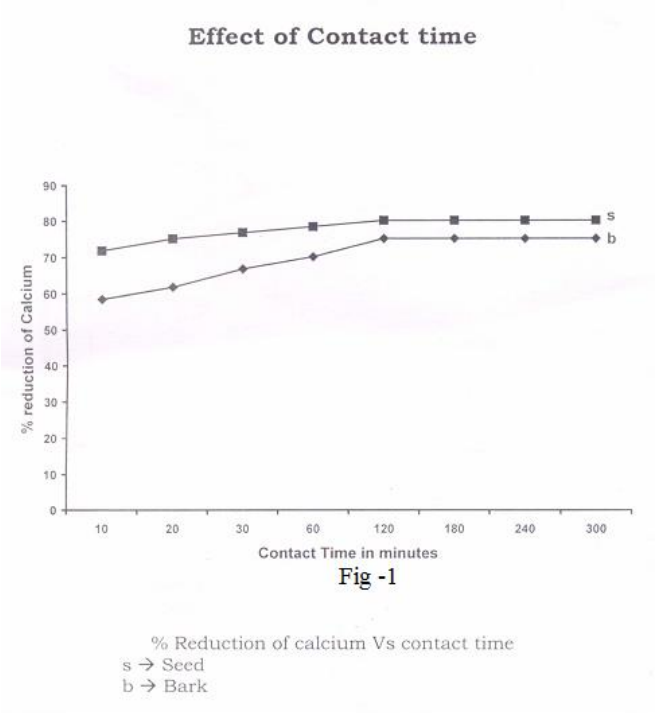

Fig -1

% Reduction of calcium Vs contact time
s → Seed
b → Bark

3.Effect of Adsorbent Dosage:

From the study, as the amount of adsorbent dosage, the powdered gooseberry bark, was increased from 0.4 to 2g, gradually, the percentage removal of Ca ions also increased continuously (Fig -2). A similar observation was made for powdered gooseberry seed when used as adsorbent. The rate of adsorption depends on the driving forces per unit area and in this case since the adsorbent dosage increased the surface area available for adsorption, percentage of 'Ca' removal also increased. For 30 g/L of calcium for a contact time of one hour with a dosage of 2g of powdered gooseberry bark and powdered gooseberry seed were 83.4% of 94.4% respectively.

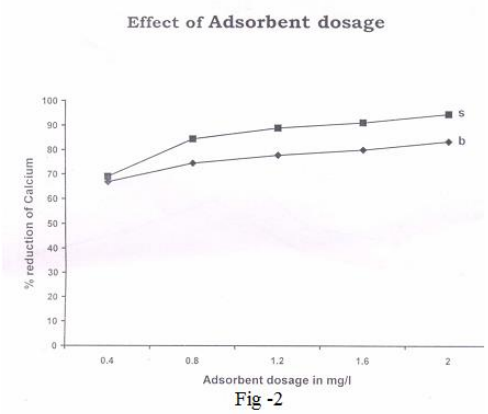

Fig -2

% Reduction of calcium Vs adsorbent dosage
s → Seed
b → Bark

3. Effect of pH :

The percentage removal of metal ion Ca increased with increase in pH. In the case of powdered gooseberry bark, as the pH increased from 2, 3 to 4 the percentage removal increased from 50.2, 56.8, to 66.81. The reverse was observed with high pH ie., percentage removal of 'Ca' decreased from 66.81 to 46.8 (pH=5) and to 40.89 (pH=6) owing to the competition of hydroxyl ion with the metal ions for the adsorption(Fig -3). The increase in hydrogen ion concentration at low pH of 4 may result in neutralisation of negative and positive charges at the surface of the adsorbent, thereby reducing hindrance to diffusion and making more of the active surface of the adsorbent. The similar observation was noticed for powdered gooseberry seed.

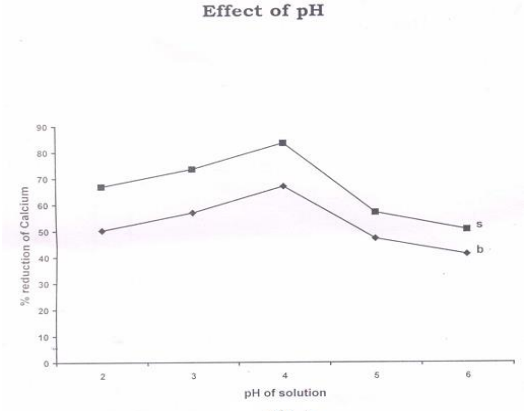

Fig -3

% Reduction of calcium Vs pH
s → Seed
b → Bark

4. Effect of concentration :

The effect of concentration of the adsorbate on the molecular equilibrium adsorption from a solution on a solid is characterized by an ordinary isotherm of adsorption for sufficiently diluted solutions. In present study the initial Ca^{2+} concentration were taken from 10, 20, 30, 40 upto 50 mg/L with adsorbent dosage of 2g/L at a pH of 4 for a contact time of one hour. The percentage removal of calcium gradually decreased from 83.40 81.74, 78.98, 75.12 and 72.12 as the metal ion concentration increased. In the case of powdered gooseberry seed, the percentage removal of calcium decreased as 86.73, 85.06, 81.19, 79.2 and 74.1 with increases in metal ion concentration (Fig -4). Adsorption generally followed first order kinetics. The rate constant for removal of Ca^{2+} with gooseberry bark and seed for varying metal ion concentration were calculated using the equation

$K = 1/t \ \ln C_i / C_e$

t ⟶ contact time

C_i ⟶ initial concentration of the metal ion

C_e ⟶ remaining concentration of the metal ion after adsorption

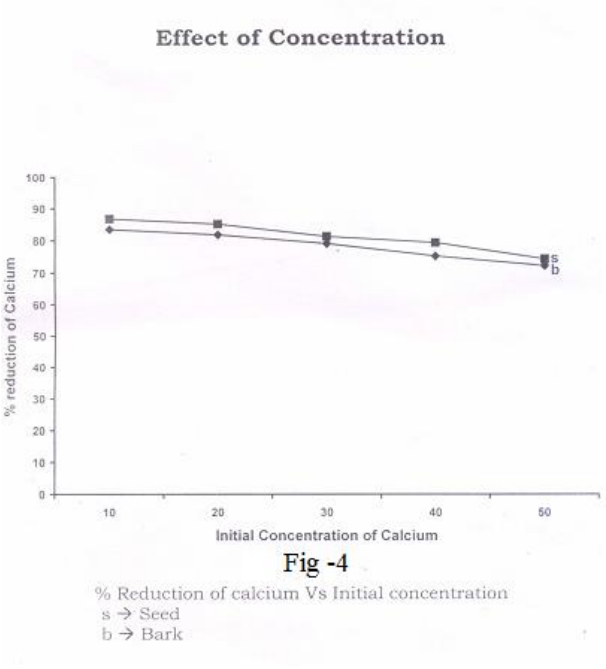

Fig -4

% Reduction of calcium Vs Initial concentration
s → Seed
b → Bark

4.CONCLUSION:

The comparative study of the two adsorbents namely powdered gooseberry bark and gooseberry seeds revealed that, as the contact time of the metal ion (Ca^{2+}) and the adsorbent is increased, there was a gradual increase in the percentage removal of metal ion (Ca^{2+}). Powdered gooseberry seed was found to be more effective than the powdered gooseberry bark. The effect of the parameter pH on the adsorption of Ca^{2+} on powdered gooseberry bark and seed were similar ie., as pH increased from 2 to 4 gradually the removal of Ca^{2+} also increased. Again gooseberry seed (83.4% at pH =4) showed good results when compared with gooseberry bark (66.8 at pH =4).

The observed result with the parameter- concentration of the metal ion and adsorbent was an added advantage. As the metal ion concentration increased, the percentage removal of Ca^{2+} decreased. This concept can be utilized in safe removal of trace excess of calcium from human body using natural adsorbent, powdered gooseberry bark or seed. Further studies on biological activities of adsorbent gooseberry bark and gooseberry seeds are in progress. If succeeded it can be a remedy for Hypercalcemia.

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