Removal of Fluoride from synthetic water by using banana as low cost adsorbent

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Abstract:

In villages Groundwater is the primary water source for drinking in south eastern India was listed in the sphere of 1.5 and 5.7 mg/L. As per ground water brochure released by Central Water Board 993 villages in Ananthapuramu district affected by fluoride contamination. This leads to many health problems like dental, skeletal fluorosis and some chronic diseases also. It necessity to removal fluoride using an adsorbent which is highly abundant, low price and highly efficient in adsorption technique and it should be easy and safe for the domestic and community usage purpose.

The present study concentrates on effective extraction of fluoride using natural low-cost adsorbents like banana peel. Banana peel was washed with tap randomly with double distilled water, and dried for 12 hours at 450for one day. This adsorbents well grounded using motor and pestle, it is sieved to gain the desired fractions 250(µm). The pH, initial concentration, contact time, and adsorbent dose are the property of operating constants and fluoride removal efficiency will be analyzed using UV spectroscopy. The adsorbent isotherm has to be drawn for total adsorbents and compare the results and will suggest suitable adsorbents for removal enough fluoride from ground water.

Key words: Defluoridation, adsorption process, banana peel, Flouride, Concentration.

2. INTRODUCTION

Fluoride is a constant mineral that is originate in many foods and in all waters and ruin waters [1], when the fluoride presence is high, it can act as a health hazards The negative charged fluoride particle is exceedingly pulled in by positive charged particles, similar to calcium particles, of bones and teeth, which brings about dental, more skeletal fluorosis [2, 3]. Likewise it drives sporadic arrangement of collagen, which fills in as a noteworthy auxiliary part of skin, tendons, ligaments, muscles, cartilage, bones and teeth. Most proof shows that fluoride can meddle with DNA amalgamation [4]. High fluoride concentrations in Wastewater contains ceramic also glass manufactures, coal burning power stations, electroplating, beryllium extraction plants, semiconductor manufacturing, brick along with iron works, and aluminum shelters. The natural water contains fluoride concentration of ten to thousand times lower than the industrial effluents [5].

As per the World Health Organization (WHO) the most extreme suitable centralization of fluoride is 1.5mg L^{-1} [6]. Thus, the removal of the high fluoride from waters and wastewaters is imperative as far as assurance of general wellbeing and condition. Defluoridation of drinking water is the main practicable approach to conquer the issue of over the top fluoride in drinking water. A few treatment advances, in light of the standard of particle trade [7], precipitation-coagulation [8], film procedures, for example, invert osmosis [9], Donnan dialysis [10], electro dialyses [11], nano-filtration [12] and adsorption [13] have been created for the expulsion of fluoride from waters and wastewaters. The primary point in an adsorption procedure is to choose an adsorbent with high limit and quick energy for contaminant expulsion from water a few adsorbents, for example, enacted alumina. Numerous normal adsorbent materials were attempted in the past to discover effective and financially feasible Defluoridation specialists, for example, enacted alumina, alumina-gibbsite, initiated carbon, calcite, clay, zeolite, initiated charcoal, bleaching earth, red mud, brick powder, sugarcane charcoal, waste tea ash and rice husk ash [14]. Different parameters have been concentrated such as contact time, dosage, concentration, pH to control the effectiveness of fluoride in wastewater by batch and kinetic, isotherms studies.

3. EXPERIMENTAL PROCEDURE

3.1. Adsorbent sample preparation

XRD analysis was done to know the crystallite size and structure of any unknown sample. 1gram of adsorbent sample from banana peel particles was placed under XRD sample holder. XRD analysis is used to find the nature of crystal structures that includes measurement of length or angle that defines the size and shape of the unit cell of a crystal lattice, identifying of unspecified matter or substances, consistency of substances, stresses in a solid metal, crystal coordinate system, and others. The crystallite size can be calculated as a function of peak width (referred as full – width at half maximum peak intensity (FWHM), β), peak position and wavelength.

3.2 Preparation of stock solution of sodium fluoride on synthetic solution

1gm of 99% of NaF (sodium fluoride) was dissolved in 1L of distilled water to prepare 100mg/l of sodium fluoride stock solution.100ppm of solution will be prepared. An amount of synthetic solution different concentration solutions were prepared from stock solution (2mg/l, 4mg/l, 6mg/l, 8mg/l, and 10mg/l) by diluting the stock solution. Standard curve will be drawn for required ppm of stock solution of sodium fluoride on synthetic solution.

3.3. Preparation of adsorbent banana peel powder

Banana peels (Musa paradisiaca) is gathered from neighborhood natural product, rinsed with tap water arbitrarily and afterward rinsed with distilled water. This particle is left to dry under sun for 12 h and taken after by drying at 45o c for 24 h. using mortar and pestle One-third of peels will be cut and grounded well .

3.4. Effects of Various Parameters on % Removal of fluoride

Sodium fluoride stock solution was prepared for 100 mg/l. Different parameter study on by using adsorption in banana peel powder capacities of banana peel powder ions are carried out. In this trail various consequences are contact time, pH, dosage, concentration are determined by adsorption technique using banana peel powder adsorbent.

3.5.1 Effect of contact time

10mg/l of aqueous solution is taken in 250ml of conical flask add1gm of banana peel powder of average diameter about 130 micro meters. These conical flasks will be placed on orbital shaker. These samples are withdrawn separately at regular intervals of time (10, 20, 30, 40, 50, and 60, up to 120 min) by using filter paper. This solution is kept in UV spectroscopy to analyze the adsorption capacity of sodium fluoride.

$$\%R=\frac{c_i-c_f}{c_f}\ \boldsymbol{X}\ 100\ldots\ldots\ldots\ldots\ldots(1)$$

Finally graph will be drawn for contact time and percentage removal of fluoride.

3.5.2 Effect of adsorbent dosage

10mg/l of aqueous solution is taken in three 250ml of conical flasks and add different dosages of banana peel powder of average diameter about 130 micro meters separately (2gm, 4gm, 6gm, 8gm). These conical flasks will be placed on orbital shaker. These samples are withdrawn separately at regular intervals of time (10, 20, 30, 40, 50, 60, 70, 80, 90,100,110&120 min). This solution is kept in UV spectroscopy to analyze the adsorption capacity of sodium fluoride.Finally graph will be drawn for contact time and percentage removal of fluoride for different dosages (2gm, 4gm, 6gm and 8gm).

3.5.3 Effect of initial concentration

10mg/l of aqueous solution is taken in three 250ml of conical flasks and add different dosages of banana peel powder of average diameter about 130 micro meters at different concentrations and add constant dosage of banana peel powder separately. These conical flasks are placed on orbital shaker at regular intervals about (10, 20, 30, 40, 50, 60, 70, 80, 90,100,110&120 min) 2 hr. These samples are filtered separately by using filter paper. Filtered solution is kept in UV spectroscopy to analyze the adsorption capacity of sodium fluoride. Finally graph will be drawn contact time and percentage removal of lead for different concentrations (1mg/L, 2mg/L, 3mg/L, and 4mg/L).

3.5.4 Effect of pH

The effect of a pH was studied at different PHs (2, 4, 6, 8, 10, 11, and 12) to find maximum adsorption of fluoride from an aqueous solution. The adsorption capacities are shown in graph. Sometimes it may be increases or decreases based on influence of pH. The influence of aqueous phase pH on the uptake of fluoride ions was investigated by using a banana peel powder experiment was carried out by varying pH. Finally the graph will be drawn contact time vs. pH.

4.RESULTS AND DISCUSSION

4.1 Particle analysis of adsorbent

XRD analysis carried from local fruit market area Anantapur in AP .From the XRD analysis we conclude it is amorphous state.

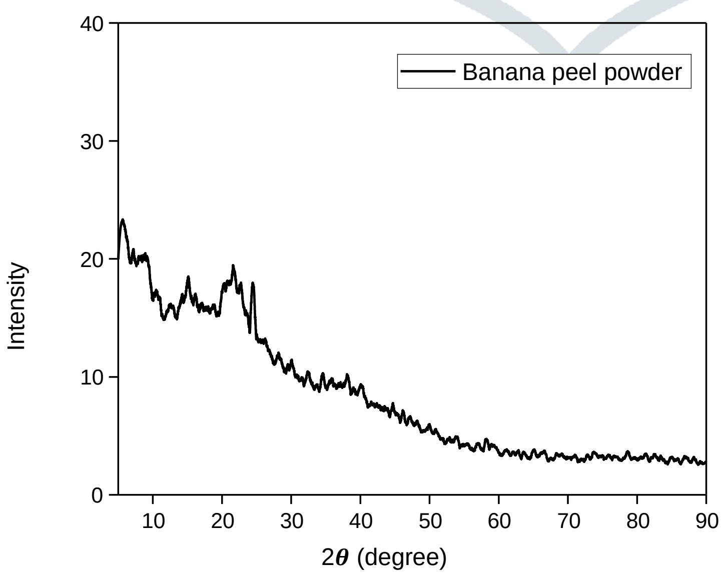


Figure 4.1 XRD analysis of banana peel powder

4.2 Synthetic Stock Solution of Sodium Fluoride

1gm of 99% of NaF (sodium fluoride) was dissolved in 1L of distilled water to prepare 100mg/l of sodium fluoride stock solution.100ppm of solution will be prepared. An amount of synthetic solution different concentration solutions were prepared from stock solution (2mg/L, 4mg/L, 6mg/L, 8mg/L, and 10mg/L) by diluting the stock solution. Standard curve will be drawn for required ppm of stock solution of sodium fluoride on synthetic solution.

Table 4.1Standard Calibration curve

Concentration of Solution (Mg/L)	Absorbance
1	0.008
2	0.001
3	0.257
4	0.353
5	0.435
6	0.521
7	0.632
8	0.740
9	0.859

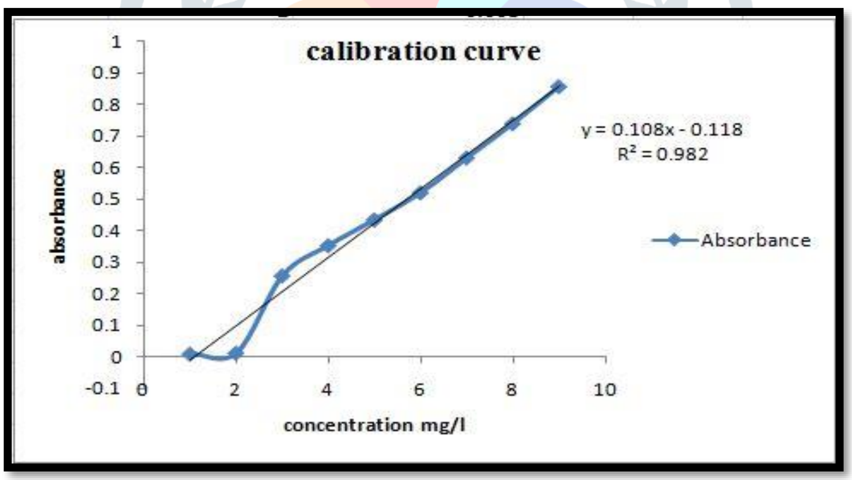


Figure 4.2 Standard Calibration curve

4.3 Effects of Various Parameters on Percentage Removal of fluoride:

Sodium fluoride stock solution will be prepared for 100 mg/l. Various parameters have been studied by using batch adsorption technique. Adsorption capacities of banana peel powder ions are carried out. In this trail various consequences are contact time, pH, dosage, concentration are determined by adsorption technique using banana peel powder adsorbent. These consequences are explained in stepwise manner.

4.3.1 Effect of contact time:

The percentage removal of fluoride increases with the increase of dosage contact time with constant concentration and dosage. Finally it gives conclusion that, if the contact time increases more amount of adsorption of fluoride gets adsorbed on to the surface of the adsorbent. The maximum % removal of fluoride is obtained after 2hr is about 87%. The % removal of fluoride becomes almost constant after 2hr. It is calculated by using following equation.

$$\%R = \frac{c_i - c_f}{c_f} \, \boldsymbol{X} \, 100$$

Finally graph will be drawn for contact time and percentage removal of fluoride.

Table 4.2 Effect of contact time on Percentage removal of fluoride

TIME(min)	ABSORBANCE	$\%R = \frac{c_i - c_f}{c_f} \, X \, 100$
10	0.432	49.1
20	0.321	59.4
30	0.302	61.2
40	0.276	63.6
50	0.253	65.7
60	0.179	72.5
70	0.153	75
80	0.131	77
90	0.103	79.6
100	0.072	82.5
110	0.046	84.9
120	0.023	87

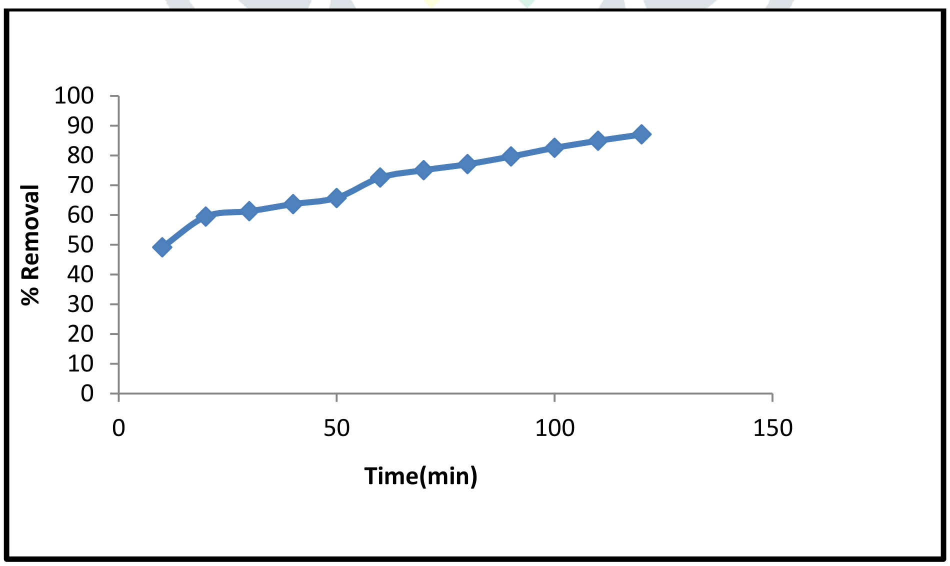


Figure 4.3 Effect of contact time

4.3.2 Effect of adsorbent dosage

The percentage removal of fluoride increases with the increase of dosage volume with constant concentration by varying dosage. For an adsorbent dosage of 2gm, the adsorption of fluoride ion varies from 49.1% to 87%. For an adsorbent dosage of 4gm the fluoride ion adsorption varies from 50.6% to 87.4%. For an adsorbent dosage of 6gm the lead ion adsorption varies from 51.8% to 88.2%.For an adsorbent dosage of 8gm the fluoride ion adsorption gives efficiency up to 90%. Finally it gives conclusion that, if the adsorbent dosage increases more amount of adsorption of fluoride gets adsorbed on to the surface of the adsorbent. The maximum % removal of lead is obtained after 2hr is about 90%. The % removal of fluoride becomes almost constant after 2hr. Finally graph will be drawn for contact time and percentage removal of fluoride for different dosages (2gm, 4gm, 6gm and 8gm).

Table 4.3 Effect of dosage2gm on Percentage removal of fluoride

TIME(min)	ABSORBANCE	%R= $\frac{c_i-c_f}{c_f}$ $\boldsymbol{X}$ 100
10	0.432	49.1
20	0.321	59.4
30	0.302	61.2
40	0.276	63.6
50	0.253	65.7
60	0.179	72.5
70	0.153	75
80	0.131	77
90	0.103	79.6
100	0.072	82.5
110	0.046	84.9
120	0.023	87

Table 4.4 Effect of dosage 4gm on Percentage removal of fluoride

TIME(min)	ABSORBANCE	%R= $\frac{c_i-c_f}{c_f}$ $\boldsymbol{X}$ 100
10	0.416	50.6
20	0.303	61.1
30	0.296	61.7
40	0.255	65.5
50	0.247	66.3
60	0.163	74
70	0.147	75.5
80	0.123	77.7
90	0.096	80.2
100	0.069	82.7
110	0.035	85.9
120	0.019	87.4

Table 4.5 Effect of dosage 6gm on Percentage removal of fluoride

TIME(min)	ABSORBANCE	%R= $\frac{c_i - c_f}{c_f}$ $\boldsymbol{X}$ 100
10	0.403	51.8
20	0.297	61.6
30	0.283	62.9
40	0.245	66.4
50	0.231	67.7
60	0.153	75
70	0.136	76.5
80	0.115	78.5
90	0.091	80.7
100	0.053	84.2
110	0.028	86.5
120	0.010	88.2

Table 4.6 Effect of dosage 8gm on Percentage removal of fluoride

TIME(min)	ABSORBANCE	%R= $\frac{c_i - c_f}{c_f}$ $\boldsymbol{X}$ 100
10	0.397	52.4
20	0.236	67.3
30	0.274	63.8
40	0.236	67.3
50	0.228	68
60	0.147	75.5
70	0.129	77.2
80	0.107	79.2
90	0.089	80.9
100	0.046	84.9
110	0.019	87.4
120	0.007	88.5

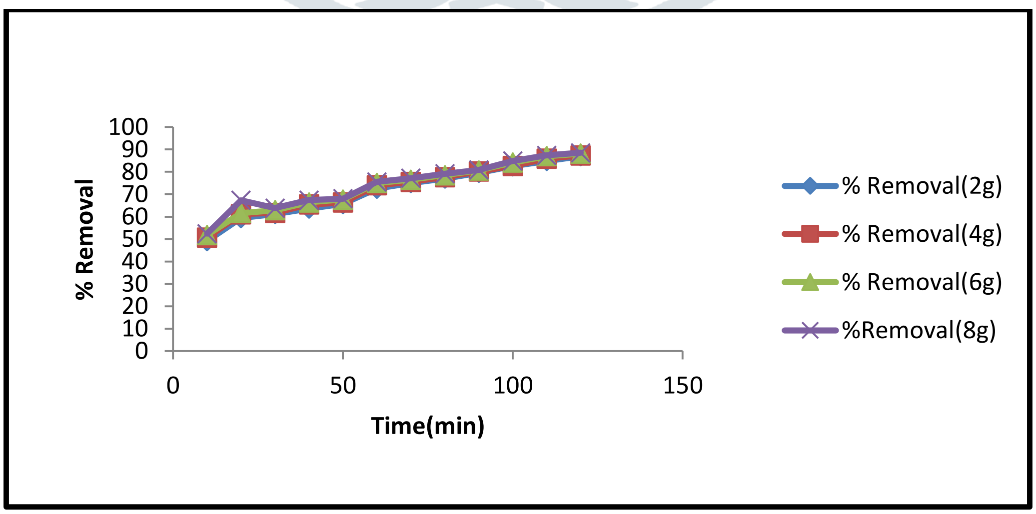


Figure 4.4 Effect of dosage on Percentage removal of fluoride

4.3.3 Effect of initial concentration

The percentage removal of fluoride decreases with the increase of concentration with constant dosage. For the concentration of 1mg/l with constant adsorbent dosage the adsorption of fluoride ion varies from 49.1% to 87%. For concentration of 2mg/l the adsorption of fluoride varies from 48.5% to 88%. For concentration of 3mg/l the adsorption of fluoride varies from 48.1% to 85%. For concentration of 4mg/l the adsorption of fluoride varies from 47.2% to 84.2%. Finally it concluded that if the concentration increases less amount of adsorption of fluoride gets adsorbed on to the surface of the adsorbent. The maximum % removal of fluoride is obtained after 2hr is about 87% for 10ppm concentration. Finally graph will be drawn contact time and percentage removal of lead for different concentrations (1mg/L, 2mg/L, 3mg/L, and 4mg/L).

Table 4.7 Effect of initial concentration 1mg/L on Percentage removal of fluoride

TIME(min)	ABSORBANCE	%R= $\frac{c_i - c_f}{c_f}$ $\boldsymbol{X}$ 100
10	0.432	49.1
20	0.321	59.4
30	0.302	61.2
40	0.276	63.6
50	0.253	65.7
60	0.179	72.5
70	0.153	75
80	0.131	77
90	0.103	79.6
100	0.072	82.5
110	0.046	84.9
120	0.023	87

Table 4.8Effect of concentration 2mg/L, on Percentage removal of fluoride

TIME(min)	ABSORBANCE	%R= $\frac{c_i - c_f}{c_f}$ $\boldsymbol{X}$ 100
10	0.439	48.5
20	0.336	58
30	0.311	60.3
40	0.283	62.9
50	0.259	65.1
60	0.183	72.2
70	0.162	74.1
80	0.143	75.9
90	0.114	78.6
100	0.081	81.6
110	0.057	83.8
120	0.034	86

Table 4.9 Effect of concentration 3mg/L, on Percentage removal of fluoride

TIME	ABSORBANCE	$\%R=\frac{c_i-c_f}{c_f}\ X\ 100$
10	0.443	48.1
20	0.347	57
30	0.321	59.4
40	0.292	62.1
50	0.266	64.5
60	0.197	70.9
70	0.174	73
80	0.156	74.7
90	0.127	77.4
100	0.096	80.2
110	0.068	82.8
120	0.045	85

Table 4.10 Effect of concentration 4mg/L, on Percentage removal of fluoride

TIME(min)	ABSORBANCE	$\%R=\frac{c_i-c_f}{c_f}\ X\ 100$
10	0.453	47.2
20	0.351	56.6
30	0.337	57.9
40	0.313	60.1
50	0.274	63.8
60	0.213	69.4
70	0.186	71.9
80	0.167	73.7
90	0.135	76.6
100	0.103	79.6
110	0.075	82.2
120	0.053	84.2

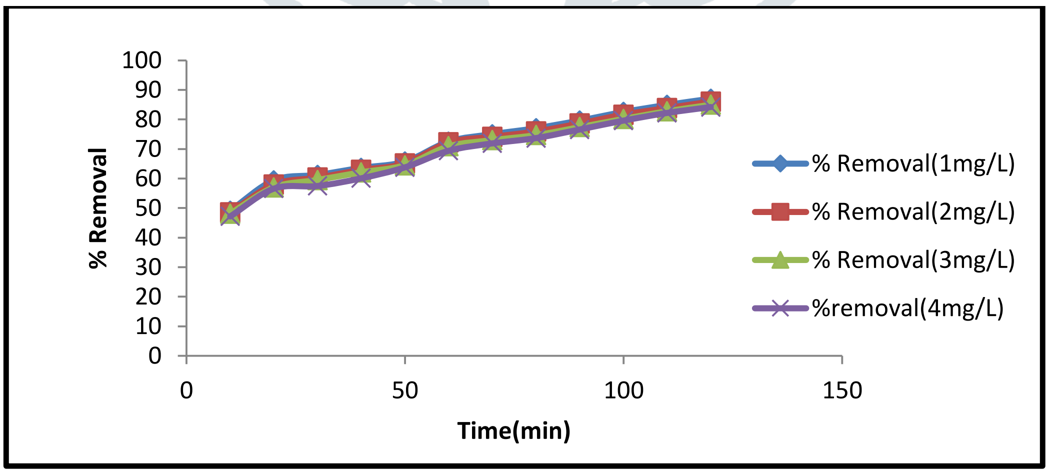


Figure 4.5Effect of concentration on percentage removal of fluoride

4.3.4 Effect of pH:

The percentage removal of fluoride varies for different pH values (4, 6, 8, and 10). For the pH values of (4- 6) the fluoride ion adsorption varies from 49.1% to 87%. The adsorption of fluoride lead ion for pH value 6 is about 87.5%. The pH value of fluoride ion adsorption from 4 to 6 it increases. For the pH value (8) the adsorption of fluoride varies from 50.7% to 88.2%. For the pH value (10) the adsorption of fluoride varies from 52.4% to 88%.The pH value of fluoride ion adsorption decreases with an increase of pH value. The maximum % removal of fluoride is obtained after 2hr. It is calculated by using following equation2.

$$\%R= \frac{c_i - c_f}{c_f}\ \boldsymbol{X}\ 100\ldots\ldots\ldots\ldots(2)$$

Table 4.11 Effect of pH 4 on Percentage removal of fluoride

TIME(min)	ABSORBANCE	$\%R= \frac{c_i - c_f}{c_f}\ \boldsymbol{X}\ 100$
10	0.432	49.1
20	0.321	59.4
30	0.302	61.2
40	0.276	63.6
50	0.253	65.7
60	0.179	72.5
70	0.153	75
80	0.131	77
90	0.103	79.6
100	0.072	82.5
110	0.046	84.9
120	0.023	87

Table 4.12 Effect of pH 6 on Percentage removal of fluoride

TIME(min)	ABSORBANCE	$\%R= \frac{c_i - c_f}{c_f}\ \boldsymbol{X}\ 100$
10	0.423	50
20	0.317	59.8
30	0.296	61.7
40	0.255	65.5
50	0.246	66.3
60	0.163	74
70	0.146	75.6
80	0.121	77.9
90	0.097	80.1
100	0.063	83.3
110	0.034	86
120	0.017	87.5

Table 4.13 Effect of pH 8 on Percentage removal of fluoride

TIME(min)	ABSORBANCE	%R= $\frac{c_i - c_f}{c_f}$ $\boldsymbol{X}$ 100
10	0.415	50.7
20	0.303	61.1
30	0.287	62.5
40	0.243	66.6
50	0.239	67
60	0.154	74.9
70	0.137	76.4
80	0.114	78.6
90	0.085	81.3
100	0.051	84.4
110	0.023	87
120	0.010	88.2

Table 4.14 Effect of pH 10 on Percentage removal of fluoride

TIME(min)	ABSORBANCE	%R= $\frac{c_i - c_f}{c_f}$ $\boldsymbol{X}$ 100
10	0.397	52.4
20	0.296	61.7
30	0.278	63.4
40	0.235	67.4
50	0.228	68
60	0.147	75.5
70	0.129	77.2
80	0.107	79.2
90	0.079	81.8
100	0.043	85.1
110	0.017	87.5
120	0.006	88.6

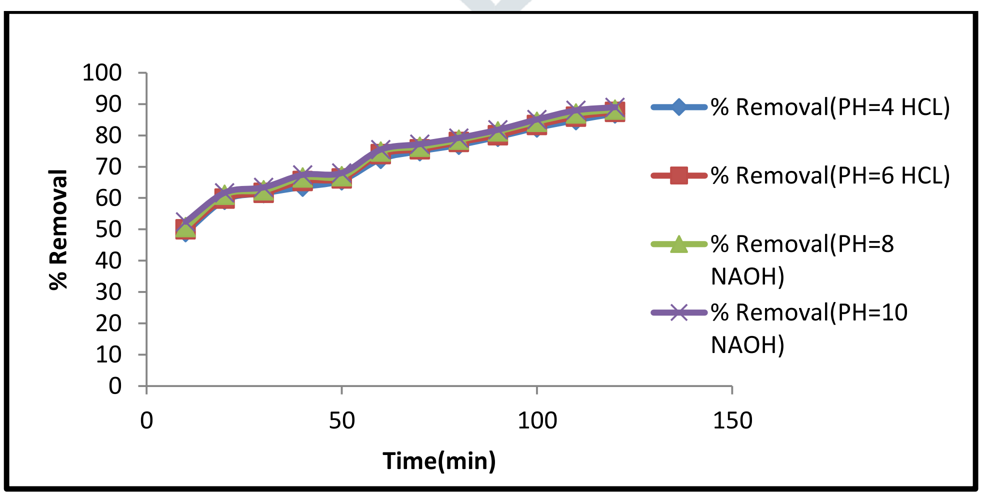


Figure 4.6Effect of pH on Percentage removal of fluoride

4.4 Study of Adsorption Kinetics

100 ml of solution samples with concentration (10mg/L) is to be prepared in a conical flask with adsorbent concentration (1g) and placed in an orbital shaker. The samples were withdrawn at regular intervals of time. Percentage and absorbance values are calculated by using UV spectrophotometer at the wavelength corresponding to maximum absorbance, (λ_{max}=350). These solutions were measured after 10, 20, 30, 40, 50, 60, 70, 80, 90,100,110,120 minutes to reach constant value. A graph was plotted with amount of adsorption (q) Vs time (t). The amount of adsorption was calculated by using following equation3.

$$q= \frac{(c_i-c_f)V}{W} \text{……………..(3)}$$

Where c_i and c_f (mg/L) are the dye initial concentration and the concentration at a given time t (min.) respectively. V is volume of sample taken and W is weight of adsorbent.

Table 4.15 Effect of Time on adsorption

CONTACT TIME (min)	ABSORBANCE	(c_e)	%R= $\frac{c_i-c_f}{c_f}*100$
10	0.432	5.09	49.1
20	0.321	4.06	59.4
30	0.302	3.88	61.2
40	0.276	3.64	63.6
50	0.253	3.43	65.7
60	0.179	2.75	72.5
70	0.153	2.50	75
80	0.131	2.30	77
90	0.103	2.04	79.6
100	0.072	1.75	82.5
110	0.046	1.51	84.9
120	0.023	1.30	87

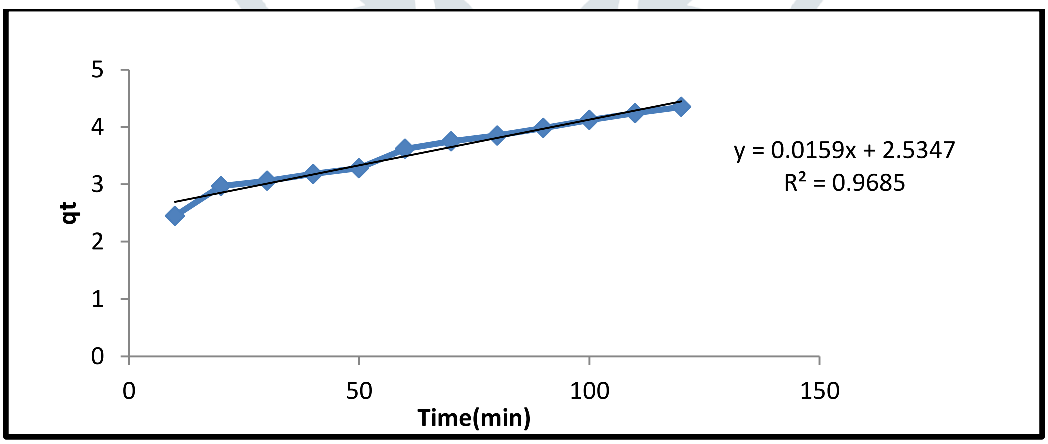


Figure 4.7 Amount of adsorption (q) Vs time (t) curve

When experimental "q_e" is closer to theoretical "q_e" value, we can say adsorption process either Pseudo-first-order kinetic model (or) Pseudo-second-order kinetic model.

10 mg/l of sodium fluoride solution is taken in a 250 ml conical flask and add 100 ml of distilled with an adsorbent dosage of 2gm. The conical flask was put in the orbital shaker up to 2 hr. Samples were collected with different time periods and their corresponding absorbance are calculated using UV spectroscopy (λ_{max}=350). These values are used to calculate q_t (amount of fluoride adsorbed per unit amount of banana peel powder) values at different time, the q_t for equilibrium time (120 min) was taken to be q_e. Thus using equations for pseudo first order and second order kinetic model, we determine the best fitting kinetic model for the system as mentioned in the equations 4. & 5.

Pseudo-first-order kinetic model is given by

$$\frac{dq_t}{dt} = k_1(q_e - q_t) \quad \ldots\ldots\ldots\ldots\ldots\ldots.. (4)$$

After integration we get;

$$\ln (q_e - q_t) = \ln q_e - k_1 t. \quad \ldots\ldots\ldots\ldots\ldots\ldots.. (5)$$

Slope gives k_1 and intercept gives q_e.

Table 4.16 Pseudo first order kinetic model

TIME	ln (q_e - q_t)
10	0.64
20	0.32
30	0.25
40	0.15
50	0.06
60	-0.31
70	-0.51
80	-0.69
90	-0.99
100	-1.46
110	-2.20
120	-2.20

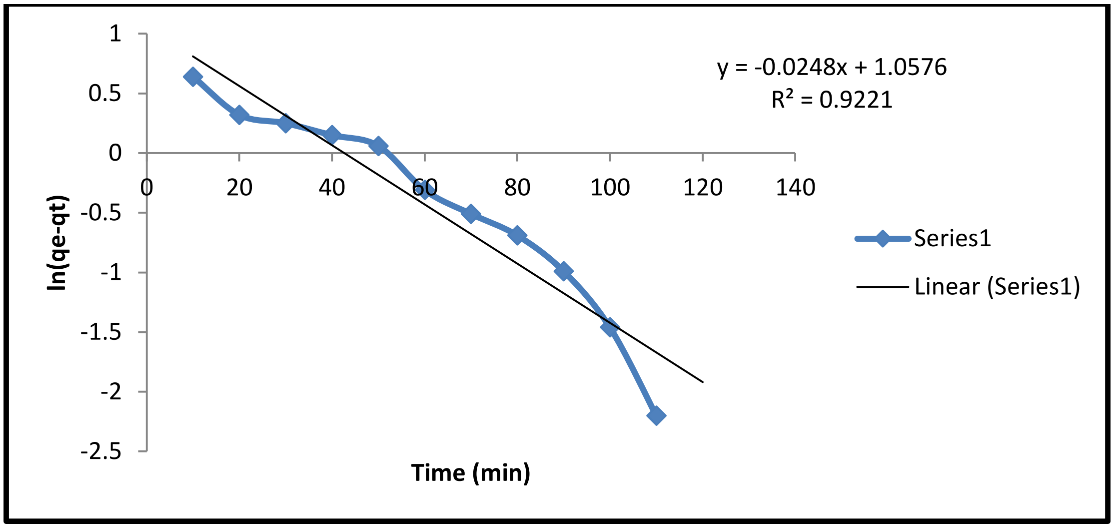


Figure 4.8 Pseudo first order kinetic model

Pseudo-second-order kinetic model is given by

$$\frac{dq_t}{dt} = k_2(q_e - q_t)^2 \qquad \text{................................. (6)}$$

Up on integration,

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e} * t \qquad \text{................................. (7)}$$

Slope gives q_e and intercept gives k_2.

Table 4.17 Pseudo-second-order kinetic model

TIME	t/q_t
10	4.08
20	6.73
30	9.80
40	12.57
50	15.24
60	16.57
70	18.66
80	20.77
90	22.61
100	24.27
110	25.94
120	27.58

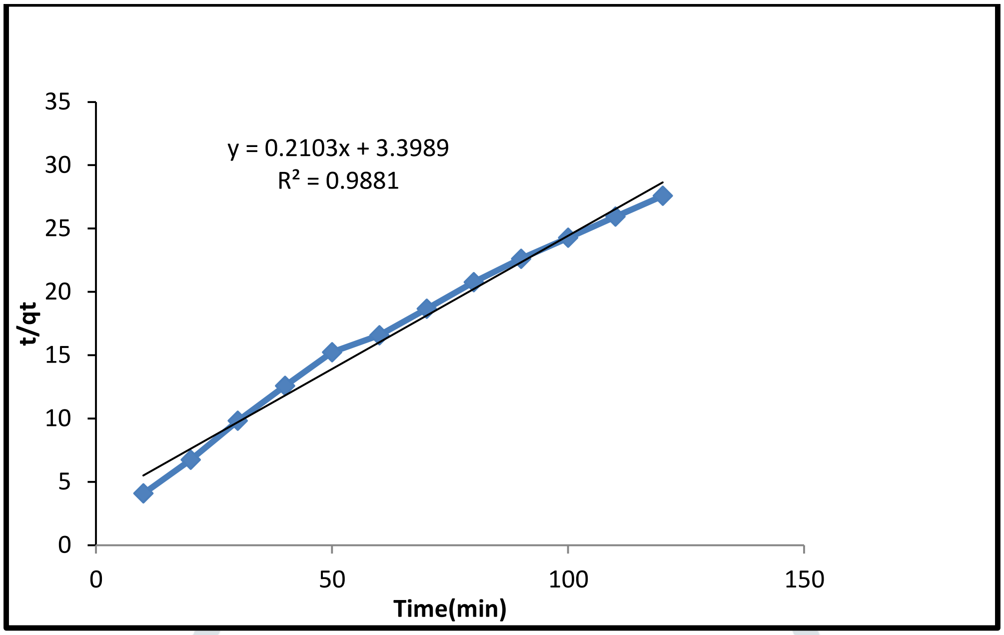


Figure 4.9 Pseudo Second order kinetic model

4.5 Study of Adsorption isotherms

It is the graph between the amounts of adsorb ate(x) adsorbed on the surface of the adsorbent (m).10 mg/l of fluoride solution is taken in a 250 ml conical flask and add 100 ml of distilled with an adsorbent dosage of 2gm and pH value is 4. The conical flask was placed in an orbital shaker for 120 min. Samples are withdrawn at different time periods and absorbance values, percentages are calculated using UV spectroscopy (λ_{max}=350). By using these values we calculate c_f and c_f/q_e values. We can draw the graph for Langmuir isotherm and Freundlich isotherm. In these two isotherm models, we analyse the best fitting model.

Langmuir isotherm model:

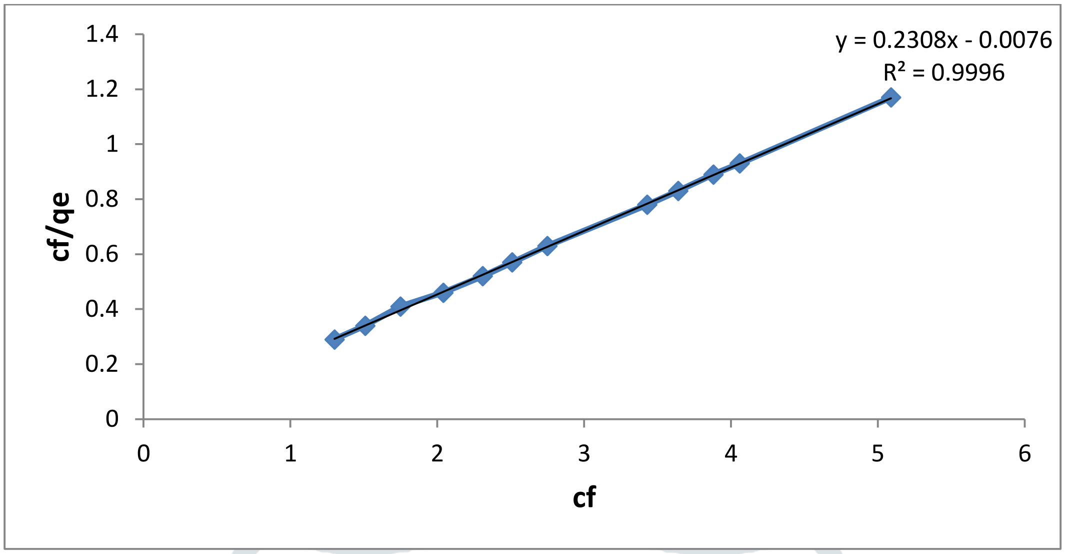
$$\frac{c_f}{q_e} = c_f * \frac{a_l}{k_l} + \frac{1}{k_l} \text{......................} \qquad (8)$$

A curve c_f/q_evs. c_f is plotted, the intercept gives the k_l value and slope gives the a_l/k_l value.

Table 4.18 Langmuir isotherm model

C_f	C_f/q_e
5.09	1.17
4.06	0.93
3.88	0.89
3.64	0.83
3.43	0.78
2.75	0.63
2.50	0.57
2.30	0.52
2.04	0.46
1.75	0.40
1.51	0.34
1.30	0.29

Figure 4.10 Langmuir isotherm model



Freundlich isotherm model:

$$\boldsymbol{lnq_t = \frac{1}{n} * lnc_f + lnk_f} \qquad \text{................................ (9)}$$

A curve ln(q_t) Vs ln(c_f) is plotted , the slope gives 'n' value and intercept gives K_f value.

Table 4.19 Freundlich isotherm model

lnc_f	lnq_t
1.62	0.89
1.40	1.08
1.35	1.11
1.29	1.15
1.23	1.18
1.01	1.28
0.91	1.32
0.83	1.34
0.71	1.38
0.55	1.41
0.41	1.44
0.26	1.47

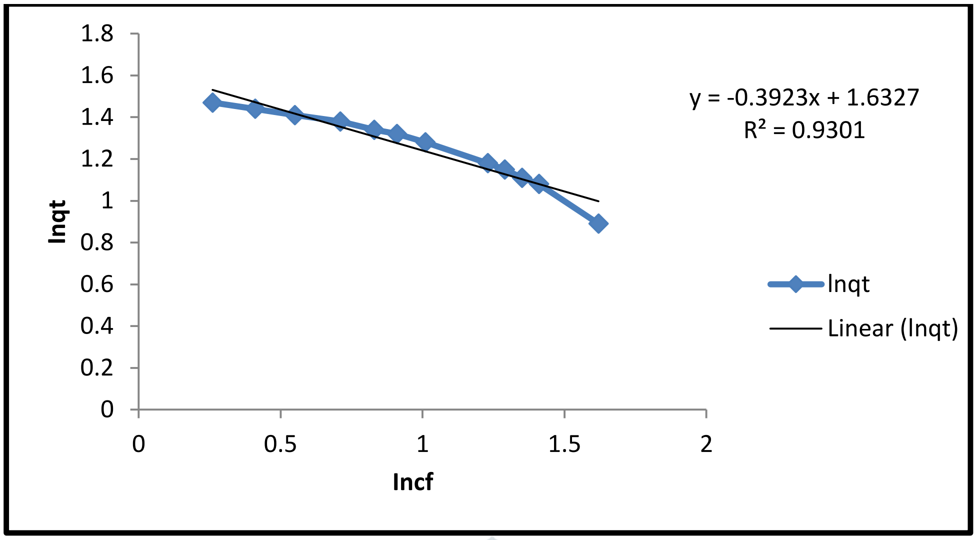


Figure 4.11 Freundlich isotherms

Langmuir Isotherm	a_l	k_l	k_l/a_l	R_L	R^2
	32.85	142.85	4.34	0.00353	0.999
Freundlich Isotherm	k_f	(1/n)	R^2		
	-5.14	0.392	0.930		

It is observed that Langmuir isotherm curve fit well with the adsorption system as their R^2value is equal to value 1.00 compared to the freundlich equation. Therefore, the Langmuir model represents the experimental data better on the basis of values of regression coefficient.

5. Conclusion

- Various parameters have been studied for the removal of fluoride. The percentage removel observed to be 88.5% at adsorbent dosage 8gm/l.
- At pH-10 the adsorption of fluoride is about 88%.
- The particles size analysis was done using XRD analysis. It was found that the banana peel powder was in amorphous.
- When experimental "$_{qe}$" is closer to theoretical "$_{qe}$" value, it was observed to be adsorption process either Pseudo-first-order kinetic model (or) Pseudo-second-order kinetic model.

- For the second order q_e value calculated differs very much from the experimental value. The R^2 value is also very high as compared to the pseudo-first-order model. Thus it is concluded that pseudo-second-order is the best fitting kinetic model.
- Langmuir isotherm can be expressed in terms R_L values within the range $0< R_L<1$ indicate favourable adsorption R_L value of banana peel powder is 0.00353, for the initial concentration of 10 mgL^{-1}. It indicates favourable adsorption of banana peel powder onto them. The R^2 value is also very high as compared to the Freundlich Isotherm model. Thus it is concluded that Langmuir isotherm is the best fitting kinetic model.

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