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BIOREMEDIATION OF WASTE WATER BY USING STRYCHNOS POTATORUM SEEDS (CLEARING NUTS) AS BIO ADSORBENT AND NATURAL COAGULANT FOR REMOVAL OF FLUORIDE AND CHROMIUM

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ABSTRACT

The present study explores the Biosorption potential of Strychnos potatorum seed powder to remove Cr (VI) and Fluoride from aqueous solution. The effect of various parameters such as effect of pH, biosorbent dose, contact time, initial metal ion concentrations and temperature was investigated under batch experimental conditions. The pseudo-first-order, pseudo-second-order and intraparticle diffusion models were used to describe the kinetic behavior and to evaluate rate constants. The best correlation (R^2 = 0.999) was provided by the pseudo-second-order model for the removal of chromium and Pseudo second order for the removal of fluoride. The experimental data were analyzed using two isotherm models namely Langmuir and Freundlich. Langmuir isotherm model better fitted the experimental data than the Freundlich isotherm model. The seeds of Strychnos potatorum used as coagulant for the removal of chromium from industrial waste water.

KEYWORDS: Batch Adsorption, Langmuir isotherm, Freundlich isotherm, Bio adsorption, Strychnos potatorum seeds and kinetic models.

INTRODUCTION

In recent year water is polluting due to discharging of untreated waste water from industries into water bodies, rapid growth of urbanization and fast growth of industrialization may causing several water pollution (Kapoor et al., 1984). Discharging of untreated waste water not only polluting surface water it may shows effect on ground water pollution and soil pollution. The paint manufacturing industry is contains large amount of chromium and fluoride in their effluent. This may shows effect on plant, human and other living organisms. Several methods are available for the removal of chromium and fluoride from industrial effluents such as evaporation distillation, filtration and electrochemical techniques (Alinsafi et al., 2005) etc. Adsorption and coagulation methods are best methods for the removal of water pollutants (Panswed & Wongchaisuwan, 1986). Using of plant based material for adsorption and coagulation studies are the most popular and widely used method because of high adsorption efficiency and eco friendly too.

The extent of adsorption depends on the porosity and surface area of the adsorbent. The porous structure plays a major role in the increase of adsorption rate. These seeds also contains some coagulant proteins which having poly electrolytes. These poly electrolytes will play a major role in the formation of coagulants. The objective of the present research work is to study the adsorption kinetics and thermodynamics of adsorption of fluoride and chromium at different temperatures. The same water samples were treated with coagulation method by taking Strychnos potatorum seed powder as natural coagulant for the removal of chromium.

MATERIALS & METHODS

Selection of adsorbent:

Strychnos potatorum also known as Clearing-Nut Tree (Hindi: Nirmali Burmese) is a deciduous tree which has height up to 40 feet (12 meters).The seeds of the tree are commonly used in traditional medicine as well as purifying water in India and Myanmar. Clearing is used for the removal of Chromium and Fluoride. These seeds are used in South India, rural area especial in Godavari district to remove the turbidity of water. A common tree of medicinal importance in India popularly used to purify water for drinking. According to Ayurveda, seeds are acrid, alexipharmic, lithotriptic and cure strangury, urinary discharges, head diseases etc. Roots cure Leucoderma whereas fruits are useful in eye diseases, thirst, poisoning and hallucinations. The fruits are emetic, diaphoretic alexiteric etc, seeds are bitter, astringent to bowels, aphrodisiac, tonic, diuretic and good for liver, kidney complaints, gonorrhea, colic etc. seeds are used to purify for drinking water. Seeds are rich source of polysaccharide gum suitable for use in paper and textile industries. It belongs to Loganiaceae family. It consists of alkanoids, flavonoids, glycosides, ligins, phenols, saponins, steroids, and tannins. It is used for various ailments such as inflammation, diabetics etc. In the present study, Strychnos potatorum is used as adsorbent and natural coagulant for the removal of chromium and fluoride from waters. These seeds are brought from local supermarket and introduced into the solutions of chromium and fluoride to check its efficiency for removal of chromium and fluoride.

Batch adsorption Experiments for the removal of fluoride:

Batch adsorption studies were carried out by using pre-weighted amounts of adsorbents to reach equilibrium with fluoride solution of various initial concentrations (1 – 4 mg/L) at 273, 313, 333, and 353 K. At the end of equilibrium period (60 min), the contents of the bottles were filtered, and then the supernatant samples were subsequently analyzed for removal percentage of fluoride bu using UV/Vis Spectrophotometer at wavelength 570 nm. The amount of percentage removal is calculated by using the following equation (Gandhi et al., 2012).

$$\% \text{ Removal} = \frac{\text{initial concentration} - \text{Final concentration}}{\text{Initial concentration}} \times 100$$

Batch adsorption Experiments for the removal of Chromium:

Preparation of Cr (VI) solution:

A stock solution of Cr (VI) (0.35g/100ml) was prepared by dissolving appropriate quantity of AR grade $K_2Cr_2O_7$ in 100 ml of distilled water from Millipore purification unit. The stock solution was further diluted with distilled water to desired concentration for obtaining the test solutions. The initial metal ion concentrations ranged from 10 mg to 85 mg/ml were prepared. Final residual metal (Cr VI) concentration after adsorption was directly measured by spectrophotometer (Gandhi et al., 2013).

Effect of Contact time between Chromium and Strychnos potatorum Seed.

The initial and final concentration is determined at regular intervals of time i.e. 5,10,20,30 and 45 minutes. The results are given in Figure-2

Effect of initial Cr (VI) Concentration:

Different concentrations of aqueous solution of chromium are mixed with fixed amount of adsorbent. The experiments are carried out with contact time is fixed depending upon contact time experiments. The results are given in Figure-4.

Effect of Strychnos potatorum Seed Dosage:

Definite concentration of aqueous solution of chromium is made to pass through different amounts of adsorbent dosages i.e. 0.2 gms, 0.4 gms, 0.6 gms, and 0.8 gms respectively. The experiments are carried out with the contact time of one hour is maintained.

Effect of pH:

The effect of pH was carried out for the initial chromium (VI) and fluoride concentration with 10 mg/L and 5 mg/L. The Chromium and fluoride solution was adjusted to various pH (3, 4, 5, 6, 7, 8 and 9) and 1g of Strychnos potatorum seed was added and batch adsorption experiments were conducted at room temperature. Each experiment was repeated three times in order to get accurate results. The samples were drawn for analysis after equilibrium.

Non-linear regression analysis:

In this experimental study, a non-linear regression analysis was conducted to determine the isotherm and kinetic constants and statistical comparison values such as determination coefficient (R^2) and residual sum of squares (RSS). The batch adsorption data was evaluated using Graphpad scientific software. As regression models were solved, they were automatically sorted according to the goodness-of-fit system into a graphical interface. To determine the statistical significance of the predicted results 95% confidence was used in the non-linear regression analysis.

Coagulation Experiments:

Preparation of coagulant:

The purchased Strychnos potatorum were grounded into fine powder and sieved and the powder was stored in a plastic bags. This powder is used as natural coagulant for the removal of chromium and fluoride from the drinking and synthetic waste water.

RESULTS & DISCUSSION:

Batch adsorption Experiments for the removal of Fluoride and Chromium:
Effect of contact time on the removal fluoride and Chromium:

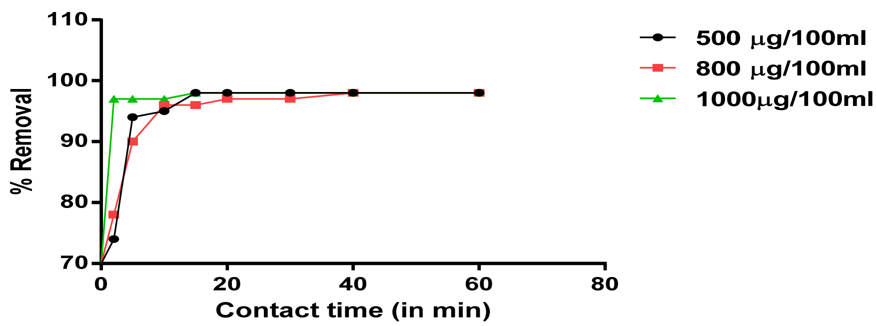

Figure-1: Variation of Contact time on Fluoride

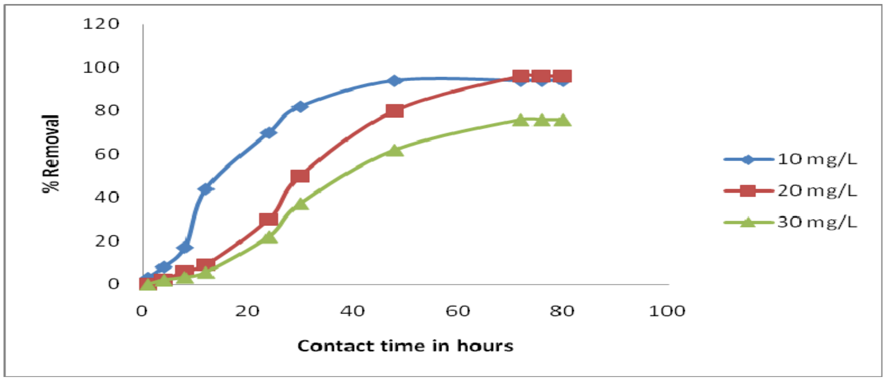

Figure-2: Variation of Contact time on Chromium

Batch adsorption studies are carried out to check the effect of contact time on the removal of fluoride and chromium from synthetic waste water. The adsorption of Chromium and fluoride from synthetic waste water by using Strychnos potatorum is increasing with increase in contact time (Gandhi et al., 2012). From the figure-1 and figure-2 it was observed that the adsorption of fluoride is high when comparing to adsorption of chromium. The graphs showing a smooth curve the initial steep in the curves is due to existence of free valences on the surface of Strychnos potatorum seeds. After the establishment of equilibrium the lines in the figure-1 and figure-2 become parallel to time axis, this can be explained on the basis of reaching saturation point (Gandhi et al., 2013). The equilibrium time taken for the removal of chromium by Strychnos potatorum is 70 hours; the initial adsorption showed a very slow approach to equilibrium and the optimum time for the removal fluoride is 15 to 20 min at different concentrations. The adsorption rate and percentage removal of chromium and fluoride is high at all different concentrations (Sujana et al., 2009).

Effect of initial concentration on adsorbent:

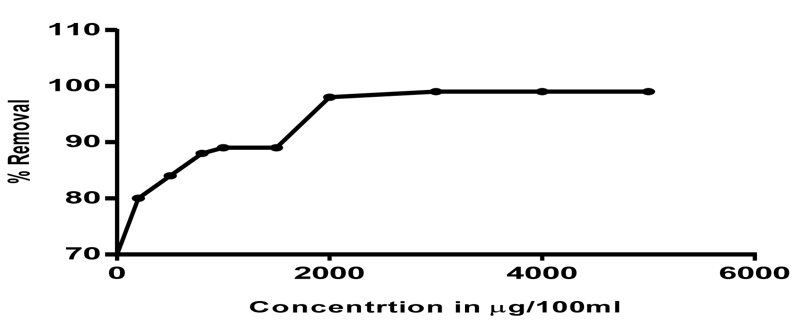

Figure- 3: Effect of initial fluoride concentration on adsorbent

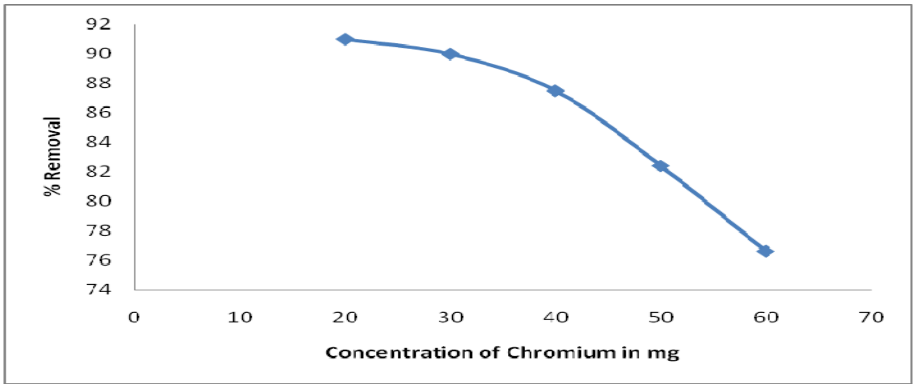

Figure -4: Effect of Initial Chromium concentration on adsorbent

The removal chromium(VI) by using Strychnos potatorum seeds was shown to increase with time and attained a maximum value at 70- 72 hours. The removal of fluoride Strychnos potatorum seed was also shown the percentage removal is increased with increase in time and attained a maximum value at 15-20 minutes. On changing of initial concentrations of Chromium and fluoride from the range 20 mg/L – 60 mg/L chromium and 0.2 µg/100 ml to 5 mg/100 ml of fluoride respectively. The batch adsorption studies were performed at room temperature for the removal of chromium and fluoride from synthetic waste water by using Strychnos potatorum seeds (Sirisha et al., 2012). From the figure-3 and figure-4 it was observed that the percentage removal of fluoride is increasing with increase in fluoride concentration and it became parallel to the concentration axis at 1 mg/100 ml of fluoride concentration. It indicates that the 1 gm/100 ml Strychnos potatorum seeds have the capacity to remove 1 mg/100 ml fluoride. The percentage removal is very low at initial lower concentration compare to higher concentration but in case of chromium the percentage removal is decreasing with increase in concentration of chromium. The percentage removal is high at lower concentration (Sumanjit & Prasad, 2001).

Effect of adsorbent dosage:

The adsorption of Chromium and fluoride on Strychnos potatorum seeds were studied by changing the quantity of adsorbent (1-6 gm/L in case of fluoride and 1-8 gm/L in case of chromium). The percentage removal checked for all samples after equilibrium time (60 minutes for fluoride and 72 hours for chromium). The results are given in figure-5 and figure-6. From the figures 5 & 6 it was observed that the percent of adsorption increased with increasing adsorbent dose in both cases. The increase in the percent removal of chromium and fluoride with the increase in adsorbent dosage is due to the availability of larger surface area with more active functional groups (Manjusha et al., 2012).

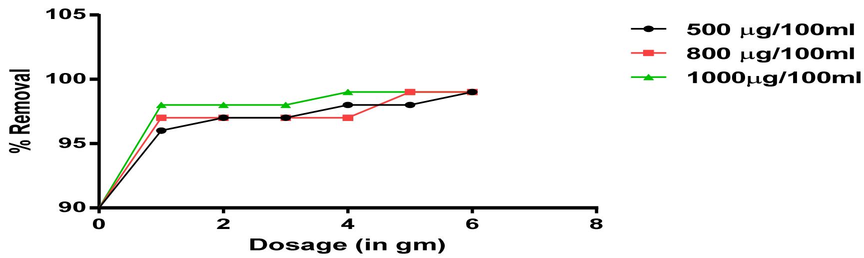

Figure-5: Effect of adsorbent dosage on fluoride removal

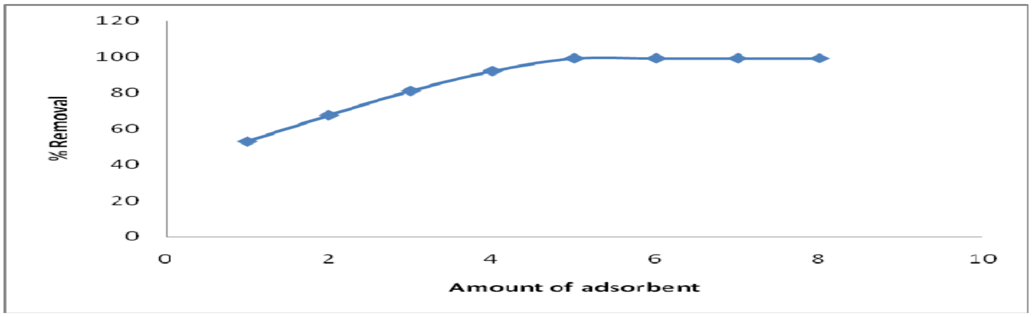

Figure-6: Effect of adsorbent dosage on Chromium removal

Kinetic Studies:

In order to investigate the mechanism of adsorption several kinetic models were tested including the pseudo first order kinetic model, the Elovich model, pseudo second order kinetic model and intra particular diffusion model for batch adsorption process.

Pseudo first order kinetic model:

Lagergren model or pseudo first order kinetic equation expressed as (Lagergren, 1898)

$$\log (q_e - q_t) = \log q_e - \frac{K_1}{2.303} X t$$

Where q_e is the amount of fluoride and chromium adsorbed at equilibrium, q_t is the amount of fluoride and chromium adsorbed at time t and K_1 is the rate constant for pseudo first order adsorption per minute, the values are given in table-1. From the table -1 & 2, figure- 7 and figure- 8, it was observed that the removal of fluoride by Strychnos potatorum seeds is does not following pseudo first order kinetic model but the r^2 values are high for adsorption of chromium by Strychnos potatorum seeds compare to fluoride adsorption. This statement concludes that the adsorption of chromium by Strychnos potatorum seeds is following pseudo first order kinetic model (Raffiea Baseri et al., 2012). The plots of log (q_e-q_t) versus t should give a straight line with slope of $-k_1/2.303$ and intercept log q_e which allows calculation of adsorption rate constant k_1 and equilibrium adsorption capacity q_e.

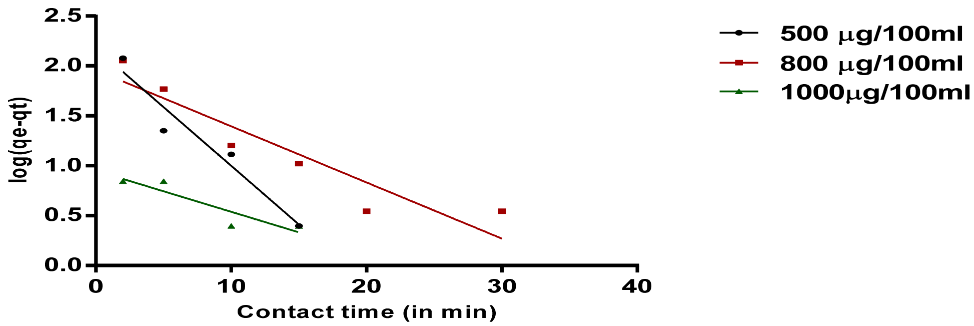

Figure- 7: Pseudo first order kinetic plots for adsorption of Fluoride by Strychnos potatorum seeds

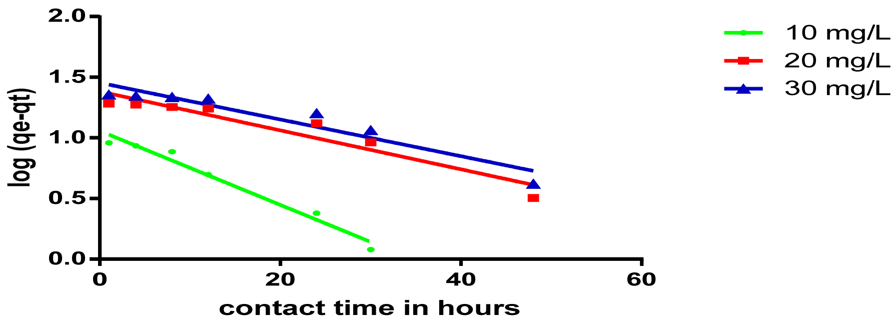

Figure- 8: Pseudo first order kinetic model plots for adsorption of Chromium by Strychnos potatorum seeds

Pseudo Second order kinetic model:

The pseudo second-order adsorption kinetic rate equation is expressed as (Ho, et al., 2000)

$$\frac{dq_t}{d_t} = k_2 (q_e - q_t)^2$$

Where k_2 is the rate constant of pseudo second-order adsorption (g·mg-1·min-1). For the boundary conditions t = 0 to t = t and q_t = 0 to $q_t = q_t$, the integrated form of above equation becomes (Erhan et al., 2004).

$$\frac{1}{(q_e - q_t)} = \frac{1}{q_e} + k\,t$$

The linear form of pseudo second order kinetic equation expressed as (Navine Kamal Amin, 2008).

$$t/q_t = \frac{1}{k_2 q_e^2} + t/q_e$$

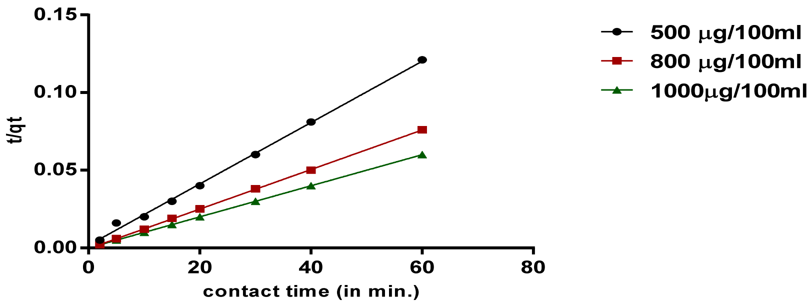

Figure-9: Pseudo Second order kinetic model for adsorption of fluoride by Strychnos potatorum seeds

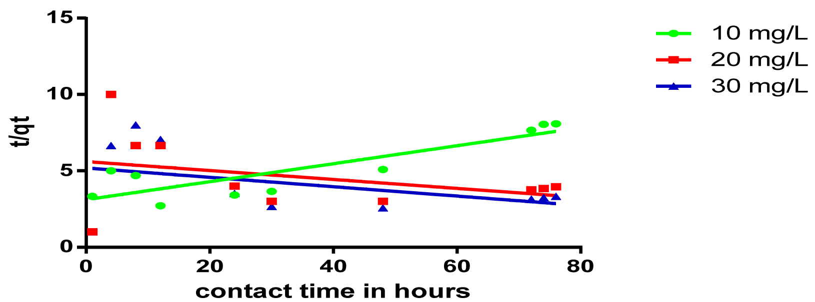

Figure-10: Pseudo Second order kinetic model for adsorption of Chromium by Strychnos potatorum seeds.

Figure- 9 & 10 shows the pseudo second order kinetic model plots for adsorption of fluoride and chromium at various contact time and different concentrations of fluoride and chromium at room temperature. When the pseudo second order kinetic model is applicable the plot of t/q_t against t should give a linear relationship. From the relationship k_2 and q_e can be determined from the intercept and slope of the plot. From the figure-9 & 10 it was observed that the adsorption of fluoride by Strychnos potatorum seeds is following pseudo second order. The r^2 values and correlation coefficient values are higher than pseudo first order kinetic model. The adsorption of chromium is does not following pseudo second order kinetic model. The r^2 values and correlation coefficient values are very lower than pseudo first order kinetic model (Raffiea Baseri et al., 2012).

Elovich Model:

The Elovich model equation is generally expressed as (Chein and Clayton, 1980; Spark, 1986):

$$\frac{dq}{dt} = \alpha e^{-\beta q_t}$$

Where α is the initial adsorption rate (mg/g min) and β is the desorption constant which is related to the extent of surface coverage.

If the adsorption of fluoride and chromium by Strychnos potatorum seeds fits to the Elovich model the plot of ln (t) versus q_t should give linear relationship with a slope of $1/\beta$ and intercept of $(1/\beta) \ln (\alpha\beta)$. The results of adsorption of fluoride and chromium are given in figure-11 & figure-12. From the figure-11 and table-1 it was observed that adsorption of fluoride is not fits into Elovich model. The r^2 value for the adsorption is low compare to other kinetic models. From the figure-12 and table-1 & 2, it was proved statistically and graphically that the adsorption of chromium by Strychnos potatorum seeds were following Elovich model and the r^2 values are good compare to Elovich model of adsorption of fluoride.

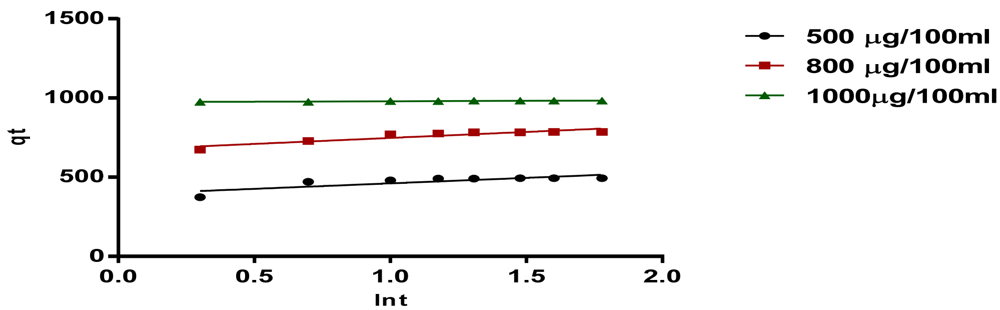

Figure-11: Elovich model plots of adsorption of fluoride by by Strychnos potatorum seeds

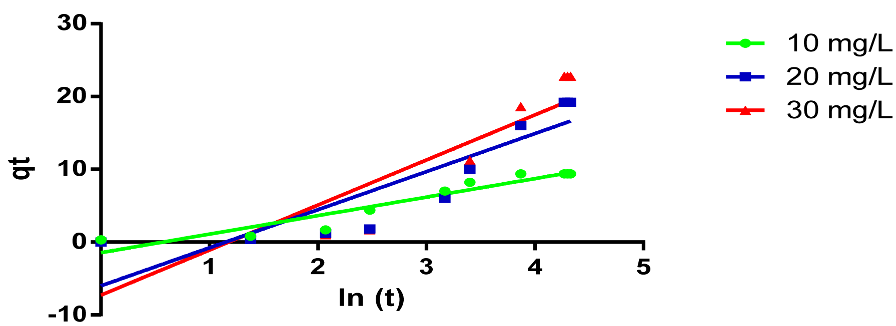

Figure-12: Elovich model plots of adsorption of fluoride by Strychnos potatorum seeds

Intra particle diffusion model:

The intraparticle diffusion model is expressed as (Weber & Morris, 1963; Srivastava et al., 1989):

$$R = k_{id} (t)^a$$

A linearised form of the equation is followed by

$$\log R = \log k_{id} + a\log(t)$$

Where:

R is the per cent Cr (VI) and fluoride adsorbed

t is the contact time (h)

a is the gradient of linear plots

k_{id} is the intraparticle diffusion rate constant (h-1)

a depicts the adsorption mechanism

k_{id} may be taken as a rate factor, i.e., per cent Cr(VI) and fluoride adsorbed per unit time.

Figure- 13 & figure-14 shows the plots of q_t versus $(t)^{1/2}$ for adsorption of fluoride and chromium by Strychnos potatorum seeds respectively. The adsorption of fluoride showing non linear relation with lower r^2 values compare to intraparticle diffusion of chromium. The adsorption of chromium fits into intraparticle diffusion model. The values of k_{id} were calculated from the slope of the plot for both adsorption of fluoride and chromium and results are given in table-1. The r^2 values led to the conclusion that the intraparticle diffusion process is the rate-limiting step. Higher values of k_{id} illustrate an enhancement in the rate of adsorption, whereas larger k_{id} values illustrate a better adsorption mechanism, which is related to an improved bonding between Cr (VI) ions and the adsorbent particles (Erhan et al., 2004).

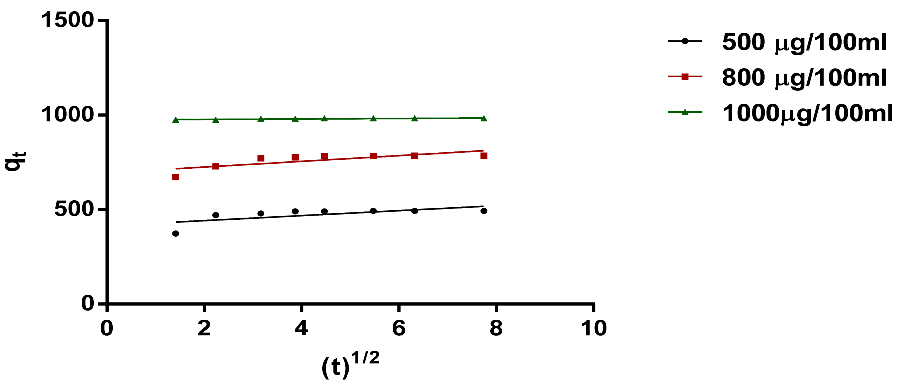

Figure-13: Intra particle diffusion plots for adsorption of fluoride Strychnos potatorum seeds

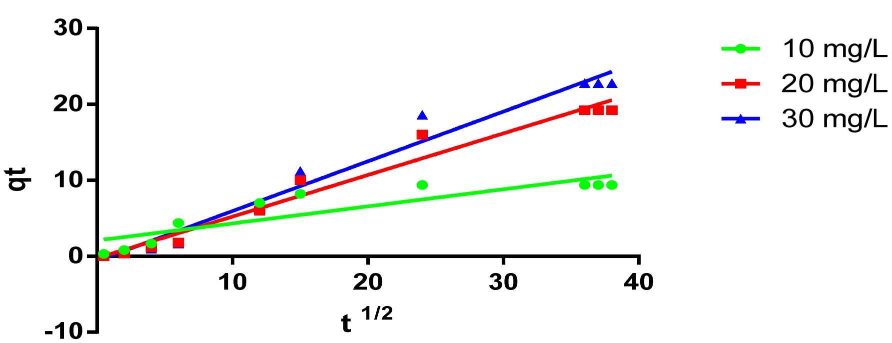

Figure-14: Intra particle diffusion plots for adsorption of Chromium Strychnos potatorum seeds

Effect of pH:

The removal of fluoride and chromium from synthetic waste water using

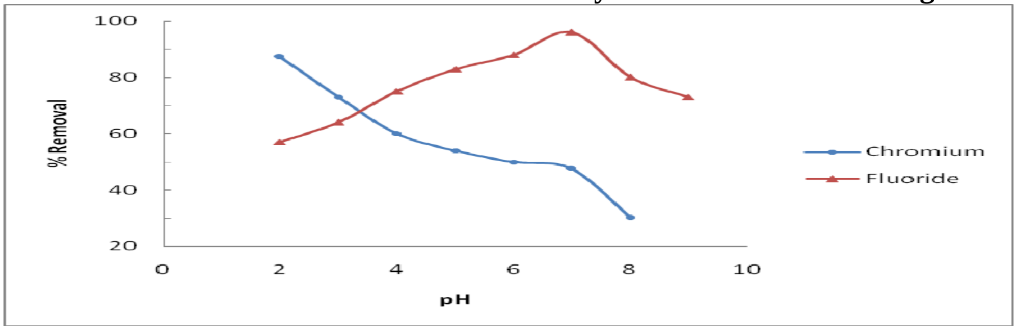

Figure-15: Effect of pH on removal of Chromium and fluoride.

Effect of pH using Strychnos potatorum seeds were studied and results were shown in Figure-15 and it was observed that the percentage removal of chromium was maximum at pH 2.0 and was found to be 88% and the percentage removal of fluoride was maximum at pH 7.0 and was found to be 96% respectively (Volsky & Holan, 1995).

Effect of temperature:

Temperature has an important effect on the process of adsorption. The percentage of chromium and fluoride adsorption is studied as a function of temperature. The results obtained are presented in figure-16 and figure-17 at temperatures of 0^{o}C, 40^{o}C, 60^{o}C, 80^{o}C and 100^{o}C. The increase in percentage of adsorption with rise in temperature may be due to activation of functional groups present in seeds caused by an increase in the available thermal energy. Higher temperature induces higher mobility of the adsorbate causing desorption (Pandey et al., 2010).

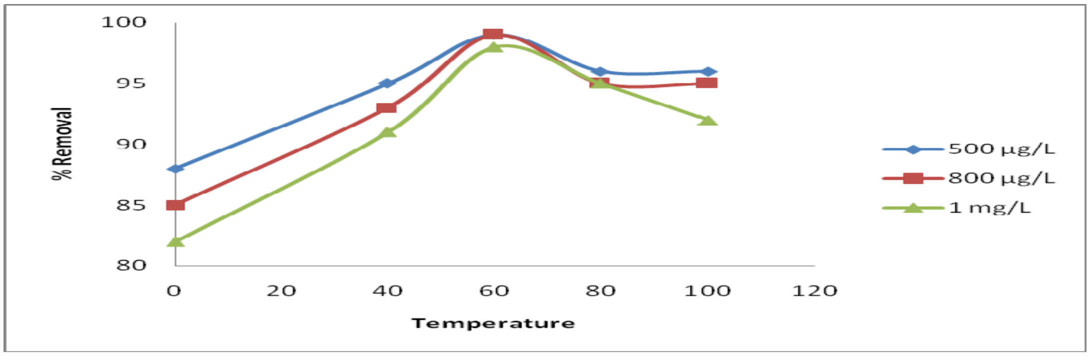

Figure-16: Effect of temperature on removal of fluoride by Strychnos potatorum seeds.

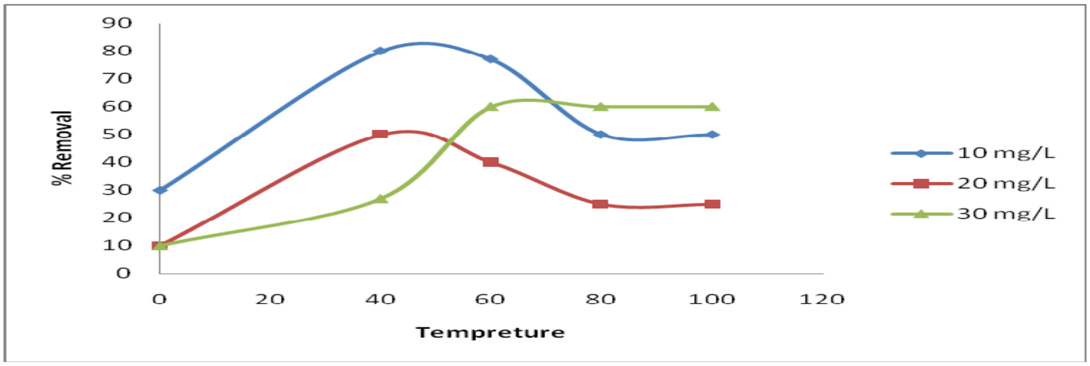

Figure-17: Effect of temperature on removal of Chromium by Strychnos potatorum seeds.

Adsorption isotherm studies:

Isotherm models are used to express the surface properties and affinity of the biosorbent. The equilibrium data of adsorption of chromium and fluoride by Strychnos potatorum seeds was evaluated with the Temkin, Langmuir and Freundlich models.

Temkin isotherm:

Temkin isotherm equation is based on the assumption that adsorption take place through the characterization of uniform distribution in binding energies up to a certain level and the adsorption energy decrease linearly as the coverage of adsorbent increases (Hameed & Daud, 2008). The linear form of Temkin equation is

$$q_e = \frac{RT}{b_T} \ln a_T + \frac{RT}{b_T} \ln C_e$$

Where b_T is the Temkin constant related to heat of sorption, a_T is the Temkin isotherm constant, R is the gas constant with the value of 8.314 J/mol/K and T is the absolute temperature in Kelvin. The values of constants a_T and b_T are calculated from the intercept and slope of the plot qe versus C_e (Raffiea Baseri et al., 2012). The r^2 values for Temkin plot and correlation coefficient values are showing linear relationship for adsorption of fluoride by Strychnos potatorum seeds and chromium removal is does not fit for temkin isotherm. The results are shown in table-2 and figure-18 & 19.

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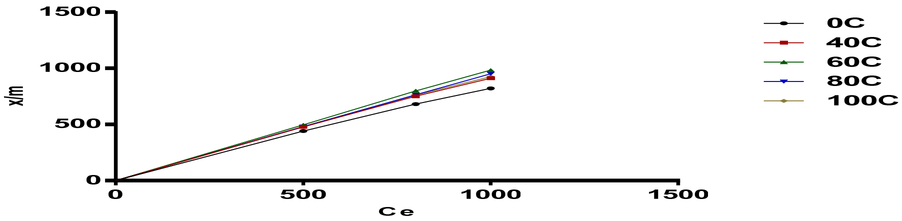

Figure-18: Temkin adsorption isotherm plots for removal of fluoride by Strychnos potatorum seeds

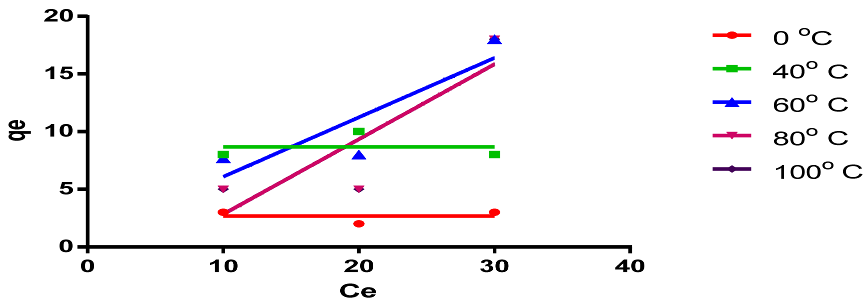

Figure-19: Temkin adsorption isotherm plots for removal of Chromium by Strychnos potatorum seeds

Freundlich adsorption isotherm:

The Freundlich model assumes a heterogeneous sorption surface and is expressed as (Freundlich, 1906)

$\log q_e = \log k_f + 1/n (\log C_e)$

Where Kf is a constant relating the biosorption capacity and 1/n is an empirical parameter relating the biosorption intensity. The values of Langmuir and Freundlich constants K_f and 1/n were obtained from plots of $1/q_e$ vs. $1/C_e$ and log C_e vs. log q_e representing. The values are included in Table 2. If the adsorption of fluoride and chromium by Strychnos potatorum seeds follows the Freundlich adsorption isotherm the plots 1og q_e versus log C_e has to show a linear relationship. The figure-20 showing the adsorption of fluoride by Strychnos potatorum seeds is perfectly fits into Freundlich adsorption isotherm.

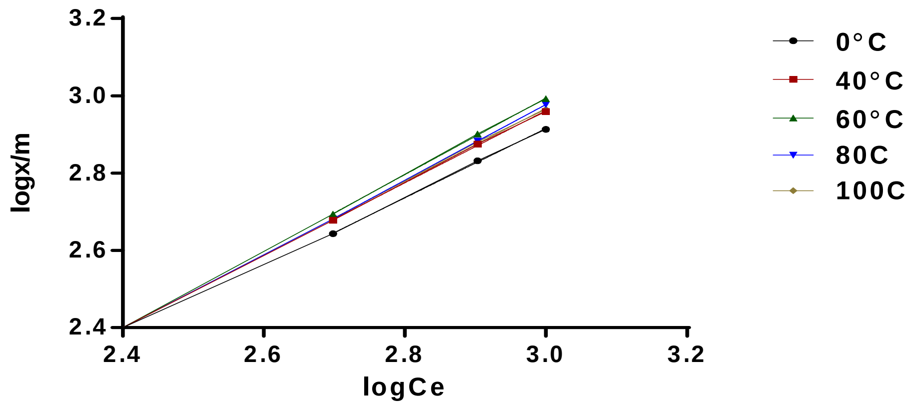

Figure-20: Freundlich adsorption isotherm plots for removal of fluoride by Strychnos potatorum seeds.

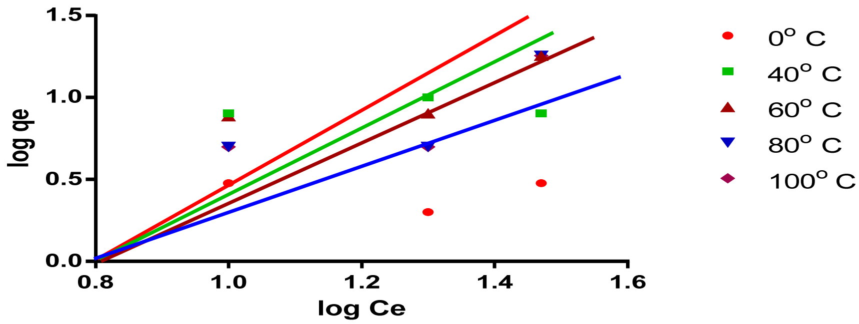

Figure-21: Freundlich adsorption isotherm plots for removal of Chromium by Strychnos potatorum seeds.

Langmuir adsorption isotherm:

The linear form of Langmuir isotherm is represented as (Langmuir, 1916).

$$\frac{1}{q_e} = \frac{1}{q_m b}(1/C_e) + 1/q_m$$

Where qe is the equilibrium metal ion concentration on the sorbent (mg/g), Ce is the equilibrium metal ion concentration in the solution (mg/L), qm is the maximum monolayer biosorption capacity of the biosorbent (mg/g), and b is the Langmuir constant (L/mg) related with the free energy of sorption. If the adsorption of chromium and fluoride by Strychnos potatorum seeds at different temperature were follows Langmuir adsorption isotherm mechanism the plot of Ce versus Ce/q_e has to show linear relationship. But from the figure-22 it was observed that the removal of fluoride by Strychnos potatorum seeds was not fit for Langmuir adsorption isotherm. The figure-23 is showing a linear fit for the adsorption of chromium by Strychnos potatorum seeds.

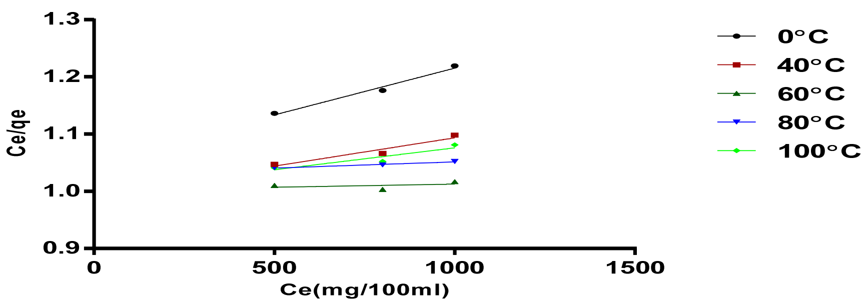

Figure-22: Langmuir adsorption isotherm plots for the removal fluoride by Strychnos potatorum seeds.

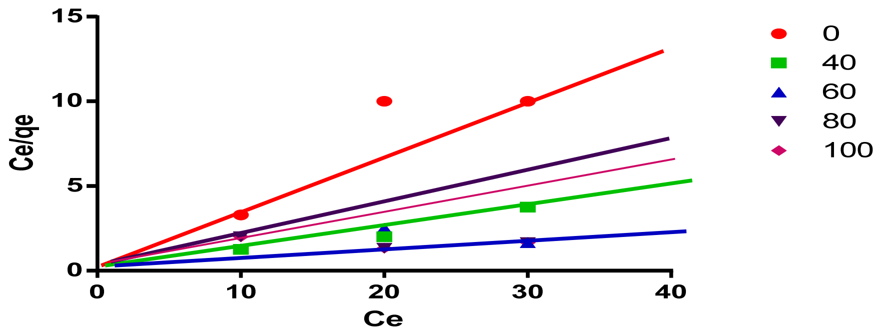

Figure-23: Langmuir adsorption isotherm plots for the removal fluoride by Strychnos potatorum seeds.

Table-1: Kinetic parameters for adsorption of fluoride by Strychnos potatorum seeds.

S.No	Parameters	Fluoride concentration (0.5 mg/L)	Fluoride concentration (0.8 mg/L)	Fluoride concentration (1.0 mg/L)
	Pseudo first order kinetic model			
01	R^2	0.9392	0.8686	0.8265
	ASS	0.08779	0.2553	0.03482
	K_1	4.3259	3.8953	3.9789
	Pseudo Second order kinetic model			
02	R^2	0.9975	0.9999	1.000
	ASS	2.692	5.115	0
	K_2	6.1232	7.5649	4.1531
	Elovich model			
03	R^2	0.6803	0.8403	0.8670
	ASS	3794	1823	8.698
	A			
	B			
	Intraparticle diffusion model			
04	R^2	0.4599	0.6261	0.7508
	ASS	6409	4269	16.29
	k_{id}	5.829	4.757	0.2939
	I	27.80	22.69	1.402

Table-2: Kinetic parameters for adsorption of Chromium by Strychnos potatorum seeds.

S.No	Parameters	Chromium concentration (10 mg/L)	Chromium concentration (20 mg/L)	Chromium concentration (30 mg/L)
	Pseudo first order kinetic model			
01	R^2	0.9733	0.9129	0.9079
	ASS	0.01693	0.04181	0.03949
	K_1	4.5950×10^{-2}	3.1666×10^{-2}	4.9470×10^{-2}
	Pseudo Second order kinetic model			
02	R^2	0.7544	0.1222	0.1656
	ASS	9.302	50.73	39.21
	K_2	1.0235	0.3752	0.4739
	Elovich model			
03	R^2	0.9131	0.8026	0.7891
	ASS	11.53	125.9	191.6
	A			

	B			
	Intraparticle diffusion model			
04	R^2	0.7857	0.9706	0.9747
	ASS	28.43	18.75	22.96
	k_{id}	0.04149	0.03369	0.03728
	I	0.9378	0.7616	0.8426
	SEE			

Table-3: Isotherm kinetics for adsorption of fluoride by Strychnos potatorum seeds

S.No	Parameters	**Temperature °C**				
		0	40	60	80	100
	Temkin Adsorption Isotherm					
01	R^2	0.9995	0.9994	0.9997	1.000	0.9994
	a_T	0.2204	0.1561	0.02307	0.03463	0.1324
	b_T	0.8984	0.9352	0.9903	0.9809	0.9451
	Langmuir Adsorption Isotherm					
02	R^2	0.9817	0.9334	0.1579	0.9722	0 .8698
	Q_0	1.052	0.9945	1.002	1.030	0 .9993
	b_L	0.02578	0.05642	0.0857	0.1298	0.1324
	Freundlich Adsorption Isotherm					
03	R^2	0.9995	0.9994	0.9997	1.000	0.9994
	k_f	1.6611	1.4177	1.0545	1.08300	1.35643
	N	1.1130	1.0692	1.0097	1.000019	1.05808

Table-4: Isotherm kinetics for adsorption of Chromium by Strychnos potatorum seeds

S.No	Parameters	**Temperature °C**				
		0	40	60	80	100
	Temkin Adsorption Isotherm					
01	R^2	-1.554e-015	7.772e-016	0.7718	0.7500	0.7500
	ASS	0.6667	2.667	15.68	28.17	28.17
	a_T	1.247	2.496	6.049	8.107	8.107
	b_T	0.05773	0.1158	0.2800	0.3753	0.3753
	Langmuir Adsorption Isotherm					
02	R^2	0.7500	0.9494	0.08903	0.2575	0.2575
	ASS	7.482	0.1667	0.7004	0.1667	0.1667
	Q_0	4.178	0.6236	1.278	0.6236	0.6236
	b_L	0.1934	0.02887	0.05918	0.02887	0.02887
	Freundlich Adsorption Isotherm					
03	R^2	0.02487	0.02487	0.6423	0.6027	0.6027
	ASS	0.02014	0.006117	0.03105	0.08217	0.08217
	k_f	3.4371	1.9746	4.6312	12.105	12.105
	N	2.3719	4.3029	1.9102	1.1739	1.1739

Coagulation Studies for the Removal of Chromium:

The Strychnos potatorum seeds were showing coagulation characteristics due to presence of coagulating proteins. Taking that factor into consideration the seed powder used as natural coagulant for the removal of chromium. The experimental procedure is done by using jar apparatus at standard rpm of 100 for 5 minutes and 40 rpm for 30 minutes. To allow the formed floccs settle down the sample were kept for 30 minutes without any disturbance. The coagulation experiments are carried out with respect to coagulant dosage, initial concentration, effect of pH and the effect of coagulant on other parameters of paint manufacturing industry waste water along with chromium.

Effect of coagulant dosage on chromium removal:

The coagulation experiments were done to check the effect of coagulant dosage on percentage removal of chromium at a different amount of coagulant and standard initial concentration of chromium i.e. 20 mg/L. the results are given in figure. From the figure-24 it was observed that the percentage removal of chromium is increasing with increase in coagulant dosage and it became constant at 3gm/ 20 mg/L.

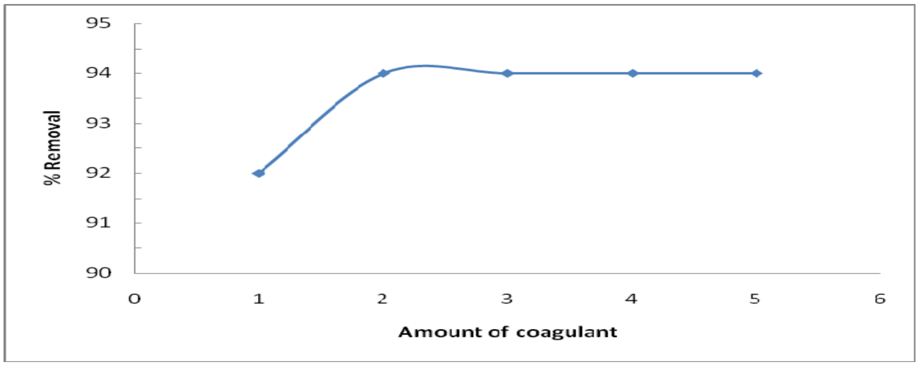

Figure-24: Effect of coagulant dosage on chromium removal

Effect of initial chromium concentration on coagulant:

The coagulation experiments were carried out to check the effect of initial chromium metal concentration on Strychnos potatorum seeds at different chromium concentration. The results are shown in figure. From the figure-25 it was observed that the removal of chromium is decreased with increase in concentration of chromium, reason for this is the protein content present in seeds were saturated with all chromium metal present in waste water. At higher concentration the available protein level will be low, due to this reason the removal of chromium is low at higher concentration.

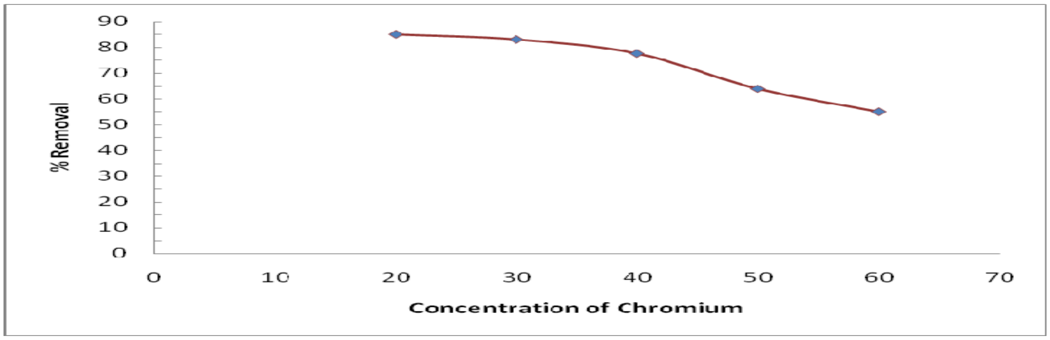

Figure-25: Effect of chromium initial concentration on percentage removal

Effect of pH:

The coagulation studies were done at room temperature by taking standard amount of coagulant (3 gm/L) and standard concentration (20 mg/L) of chromium at different pH to check the effect of pH on removal pH. The results are given in figure. From the figure-26 it was observed that the removal of chromium is high at pH 7.0 showing 93% removal.

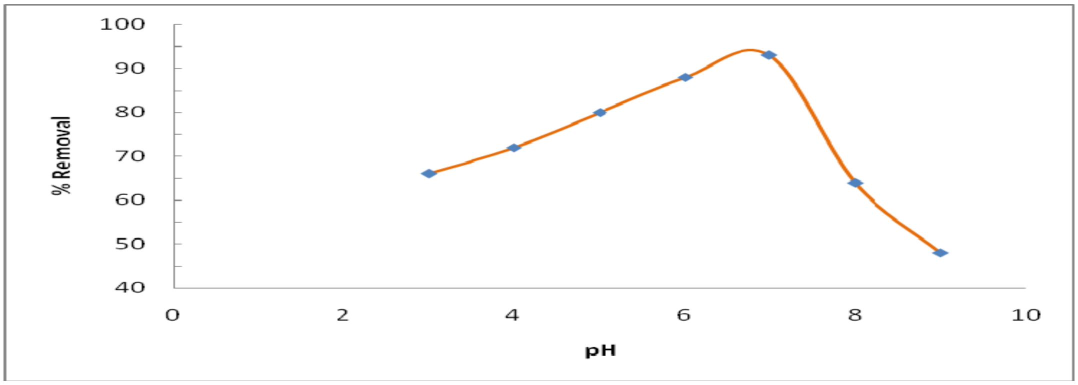

Figure-26: Effect of pH on chromium removal

CONCLUSION

It is necessary for the environmental researcher to control the ill effects caused by water pollution for the survival of the mankind. So the present research work might be help to control the water pollution caused by fluoride and chromium. The adsorptive removal of chromium by Strychnos potatorum seeds is showing higher percentage removal at an equilibrium time 72 hours, at a adsorbent dosage of 5 gm/L, but it is showing higher percentage removal in coagulation at a dosage of 3 gm/L. from the above experiment it was concluded that for the removal of chromium, coagulation techniques is advisable compare to adsorption. Even it is also concluding that Strychnos potatorum seeds have the capacity to remove fluoride. The present study provides economic solution for cleaning up water pollution and it is advisable for industries for the treatment of waste water and industrial effluents before they are discharging.

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