Application of Orange Peel Powder as an Adsorbent for Assessment of Industrial Wastewater

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Abstract - *A continuous adsorption study in a fixed-bed column is carried out by using orange peel powder as an adsorbent for the removal of Cr (VI) & harmful metals from effluent of metallurgic industry. Adsorption is one of the effective & efficient method for the removal of heavy metals with a suitable low cost adsorbent.At present Fixed bed continuous column experiments are conducted to determine percentage of efficiency of removal of metals from effluent. From this, effect of various parameters such as pH, rate of flow, bed depth, contact time & amount of dosage for the process of Cr (VI) & actual effluent on orange peel powder is investigated. Maximum removal efficiency for Cr (VI) achieved at pH 1, 4ml/min rate of flow, 5mg/lit. Amount of dosage, 25cm bed depth & 75 min. Contact time. Maximum removal efficiency for actual effluent achieved at pH 5, 4ml/min rate of flow, 25cm bed depth & 75 min. Contact time.*

Key Words: Orange peel powder, Adsorption, *Cr (VI)*, Effluent, Fixed bed column, Column model.

1.INTRODUCTION

The presence of heavy metals in the environment causes adverse effects on environment. On useful solution for the elimination of harmful metals from environment is the treatment of effluent comes from metallurgic industry using an efficient method I.e. adsorption before being discharged to outstream station. The adsorption technique is quite popular due to its simplicity as well as the availability of a wide range of adsorbent present in nature & it is proved to be an effective & attractive process for removal of non-biodegradable pollutants from industrial effluent.Orange peel is one of the most effective & widely used adsorbent due to its chemical properties & speed of availability. It also has very good property to act as an oxidant.As orange peel is a byproduct & does not require any special expensive additional treatment & can be used as an adsorbent having cost cost.

In the present work, Cr (VI) I.e. potassium dichromate is selected as standard solution for evaluating the potential percentage of removal from waste water. Previously, several researchers has proved that several low cost materials such as sugarcane bagasse, rice husk, phoenix tree leaf powder, neem leaf powder, activated carbon, sawdust for removal of harmful contents from industrial effluent. As all these byproducts are very cheap & can be used for the replacement of harmful chemicals.

1.1 Necessity

Water pollution is one of the serious issue world is facing today, in which wastewater contains heavy metals and continuously released to environment. After some years, there is drastically increasing the ecological and global public health fear connected with these harmful contaminants. there are so many metals present on earth from all those metals Ni, Co, Mn, Zn, Cu, Cr, are main prime concern as per WHO. These metals are available from earth's crust in very low concentration and found in their metallic, elemental form or chemical bounded with other inorganic materials like carbonate, sulphate, oxide or rock. Heavy metals may affect on human body's nervous system, damage various body organs such as liver, kidney, lungs, heart, brain, blood etc. Therefore it is high time to deal with such hazard before it destroy nature, environment, universe. Following are the permissible limits as per standard laid by Ministry of Environment, Forest & Climate Change, India for ETP as per, Environmental Protection rules 1986:

Table 1 Permissible limit as per MOEFG, India

SR NO	NAME OF PROPERTY	LIMIT
1	pH	5.5-9
2	BOD	<100
3	COD	<200
4	TDS	<2100
5	SS	<100
6	Fluoride	<600
7	Iron	<10
8	Sulphate	<1000
9	Temperature	<40
10	Chromium	<2
11	Lead	<1
12	Zinc	<15

13	Copper	<3
14	Lead	<1
15	Cadmium	<1
16	Mercury	<0.01
17	Nitrogen	<50
18	Oil & base	<10

1.2 Adsorption process

It is surface phenomenon when two phases are brought together into contact with each other, one phase or some constituent gets accumulated more at the interface than in bulk. This phenomenon of accumulation at interface is bonding between two phases is called adsorption. The attachment of solid, liquid & gaseous molecules to the surface of adsorbent by physical or chemical bond.

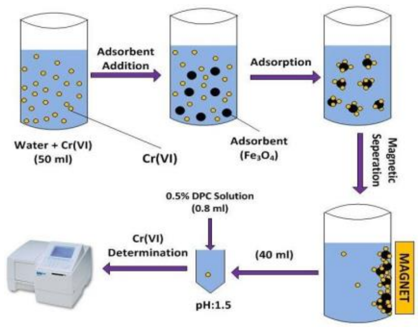


Fig.1 Schematic dig. Of Adsorption process
(Source: www.sciencemedia.com)

2. MATERIALS AND METHOD

2.1 Adsorbent

orange peel is an excellent adsorbent for the removal of heavy metals from their aqueous solutions. The small variation in the adsorption capacity of the adsorbent is due to the variation in affinity of the adsorbent for different metal ions. In recent times Adsorption is one of the most effective technique for removal of heavy metals from wastewater. Agricultural waste is a better choice, as they has unique property of stabilizing. Biosorbent are very low in cost and also easily available. So many researcher around the world has been reported that orange peel has so perfect quality of stabilizer for removal of heavy metals from waste water. Orange peel mainly consist hemicellulose, cellulose, pectin substances, chlorophyll pigments & other low molecular weight compounds like limonene. Hydroxyl & carboxyl are thefunctional groups of cellulose which are active binding sites for metals.

Table 2 Chemical Characteristics of Orange peel
(Source- www.mscstudies.in)

SR NO	NAME	CHARACTERISTICS	VALUES (%)
1	Oxocalcium	CaO	1.42
2	Potassium oxide	K_2O	0.18
3	Sulfur trioxide	SO_3	0.14
4	Magnesium oxide	MgO	0.12
5	Iron oxide	Fe_2O_3	0.11
6	Silicon dioxide	SiO_2	0.08
7	Phosphorus pentoxide	P_2O_5	0.05
8	Barium oxide	BaO	0.02
9	Strontium oxide	SrO	0.01
10	Aluminium oxide	Al_2O_3	0.01
11	Nitrogen oxide	NiO	0.01
12	Tungsten dioxide	WO_3	NA
13	Zinc oxide	ZnO	NA
14	Manganese	Mn	NA
15	Ornanic substance	ORGANIC MATTER	97.83

2.2 List of Instruments & Equipment

Following instruments & euipements which are used while doing overall experiment for all purposes.

Table 3 list of Instruments & Equipment

SR NO	NAME	COMPANY
1	UV1800Spectrophotometer	SHIMADZU
2	Digital weighing balance	CHEMLINE
3	FTIR	SHIMADZU
4	pH meter	CHEMLINE

For environmental purpose basic euipements like beaker, jar, test tube, burrette, pippete, conical flask, stirring rod, etc. Are used.

2.3 Flowchart

Following is the process in schematic way (actual step by step process).

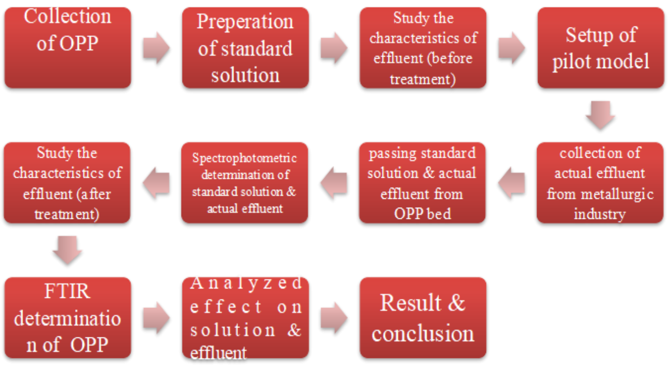


Fig.2 Experimental working steps

2.4 Pilot Model

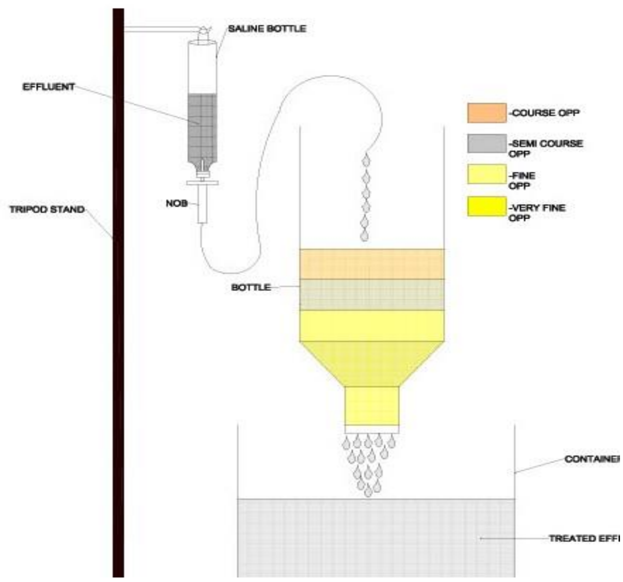


Fig.3 Experimental setup

3. EXPERIMENTAL ANALYSIS

This chapter gives information about preparation of adsorbent, standard solution and all other actual process, Column adsorption studies had conducted during experiment to analyze various effects of parameters like pH, contact time, amount of dosage, bed depth rate of flow.

3.1 Preparation of Adsorbent

Orange peel powder is chosen as adsorbent, as its easily available and eco-friendly. After selecting the adsorbent they are cleaned by distilled water.Then it is sun dried near about for week and powdered with the help of home grinder.It was sieved using a sieve to know the perfect range of particle. Powder pass through some sieve and then particles below size 500 μm selected for further process. This was stored in a plastic container prior to use for adsorption studies. No physical or chemical process has performed on adsorbent.

Fig.4 Process of making OPP

3.2 Preparation of standard solution

Synthetic solution is prepared by dissolving 1.5gm Cr (VI) in 1 ltr. distilled water. Keep it stable for 24 hrs. in dark room so that no sunlight will passed through it. After that standard solution is used in 5 intervals 5mg/lit. To 25mg/lit..

3.3 Spectrophotometric determination for Standard solution & Actual adsorbent

Chromium ions are detected using spectrophotometer. Basic principle used in this is that each compound adsorbs or transmits light over a certain range of wavelength. Different concentrations of potassium dichromate and actual effluent were tested in the spectrophotometer and final optimum concentration of removal is found out.

Fig.5 UV- 1800 Spectrophotometer

3.4 FTIR determination for structure of Orange peel

The basic theory at work is that the bonds between different elements absorb light at different frequencies. The light is measured using an infrared spectrometer which produces the output of an infrared spectrum Typically, interpreting FTIR spectra starts at the high frequency end to identify the functional groups present. The fingerprint regions are then studied to positively identify the compound.Following graph represent the final structure plots of OPP before and after are found. As per this results orange peel can be used as an adsorbent as it has high power of stabilizer. Because of this power the graph shows the ups and downs which consumes that after treatment as OPP contains high moisture content.

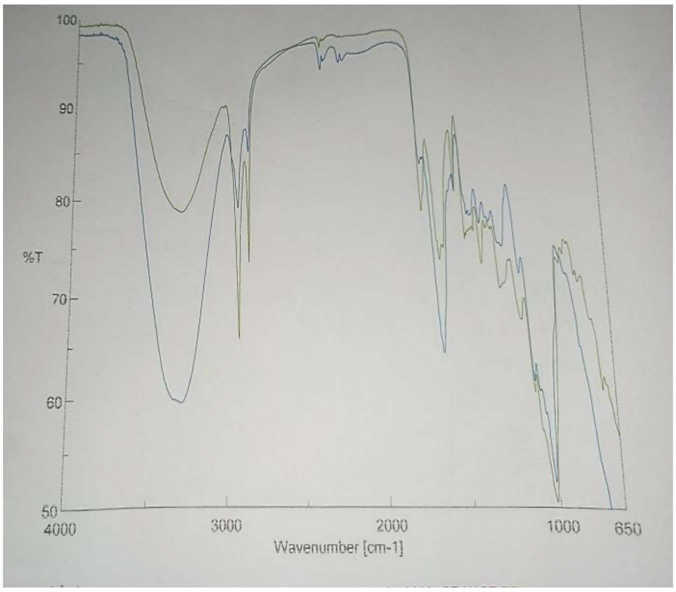


Fig.6 FTIR graphical representation of OPP (comparison between before and after testing)

4. RESULT & DISCUSSION

4.1 Effect of pH

At different pH of the contact solution, the adsorption process occurs by ion exchange and at different pH; i.e., it is physical. The variation in readings demonstrates that adsorption occurs spontaneously. The process was also observed to occur at parameters to occur maximum efficiency. The infra-particle diffusion coefficient depends on pH, which can modify the shape and concentrations of the hydrated metal complexes in solutions, thus affecting the adsorption process. Following graph shows the result of comparison between removal efficiency due to OPP for standard solution at different concentration and same for the actual effluent. From all below five intervals of pH for Cr (VI) it came to know that as pH increases rate of removal decreases. at pH 1, 8ml/min. Rate of flow, 5cm depth, 30min. Time, 93.18% removal efficiency is recorded for 5mg/lit, 93.43% for 10mg/lit., 92.29% for 15mg/lit., 92.45% for 20mg/lit., 92.66% for 25mg/lit. By taking all these parameters for actual effluent 88.88% optimum efficiency has been recorded at 5 pH, 8ml/min rate of flow, 5cm bed depth & 75 min. Time for actual effluent. For actual effluent it came to know that pH, bed depth & time is directly proportional to adsorption and rate of flow is inversely proportional to adsorption. As Standard solution contains only one metal i.e. Cr (VI), but in actual effluent there are lots of metals present in unknown amount therefore its % of removal is less and fluctuations are occurred.

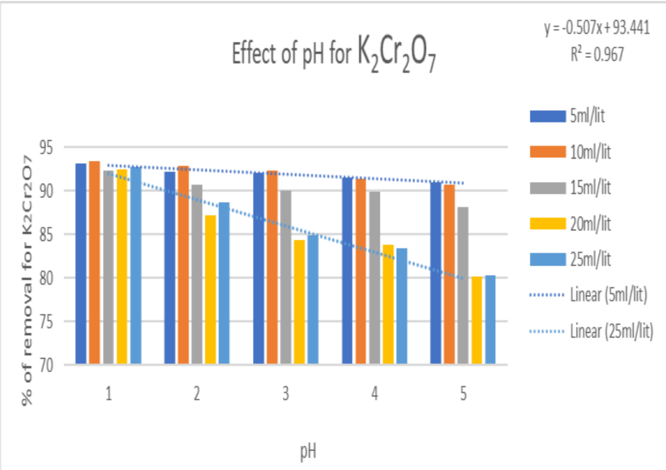


Fig.7 Effect of pH for Cr (VI)

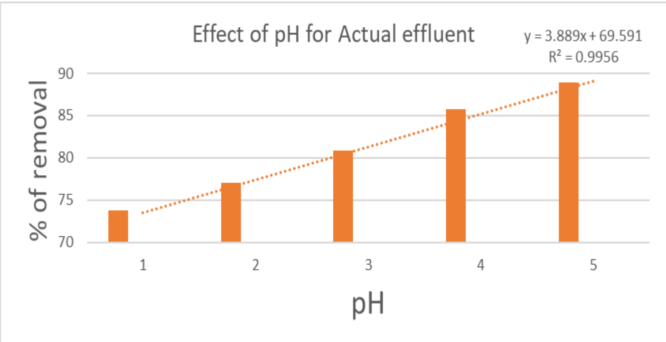
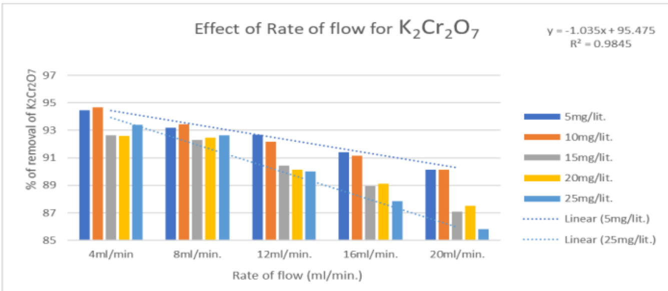


Fig.8 Effect of pH for actual effluent

4.2 Effect of Rate of flow

The flow rate of a liquid is how much fluid passes through an area in a particular time. Flow rate can be in either in terms of velocity and cross-sectional area, or time and volume.As this experiment based on column model rate of flow is one of the important factor. As flow rate gives this experiment the perfect meaning.A flow rate increase is systematically accompanied by a small increase of the amount adsorbed. This phenomenon is consistent with the influence of the pressure on the equilibrium constant of adsorption due to the difference between the partial molar volumes of the solute and the adsorbate. The larger average pressure along the column that is required to achieve a larger flow rate causes a larger amount of solute to be adsorbed on the column at equilibrium. The larger average pressure along the column that is required to achieve a larger flow rate causes a larger amount of solute to be adsorbed on the column at equilibrium. Following graph shows the result of comparison between removal efficiency due to OPP for standard solution at different concentration and same for the actual effluent. From all below five intervals of rate of flow for *Cr (VI)* it came to know that as rate of flow increases rate of removal decreases. at pH 1, 5cm depth, 30min. Time, 94.44% removal efficiency is recorded for 5mg/lit, 94.66% for 10mg/lit., 92.62% for 15mg/lit., 92.59% for 20mg/lit., 93.42% for 25mg/lit. By taking all these parameters for actual effluent 93.33% optimum efficiency has been recorded at 5 pH, 4ml/min rate of flow, 5cm bed depth & 30 min. Time for actual effluent. For actual effluent it came to know that pH, bed depth & time is directly proportional to adsorption and rate of flow is inversely proportional to adsorption. As Standard solution contains only one metal i.e. *Cr (VI)*, but in actual effluent there are lots of metals present in unknown amount therefore its % of removal is less and fluctuations are



occurred.

Fig. 9 Effect of rate of flow for Cr (VI)

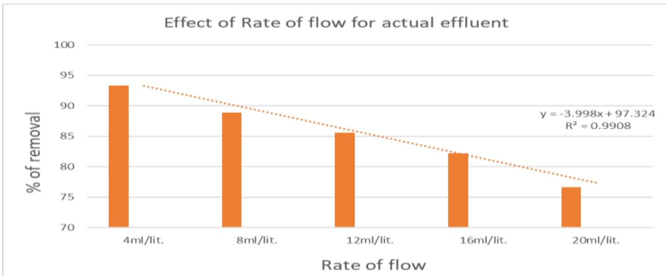


Fig. 10 Effect of Rate of flow for actual effluent

4.3 Effect of amount of dosage

Under the process of adsorption amount of dosage is one of the important factor which might be considered by other researcher, because higher dosage amount can affect the whole adsorption process. As amount of dosage in standard solution increases another reaction with adsorbent may occur which affect the result & efficiency of removal. It also react in different way by adding higher amount of dosage may also impact on the test and gives excellent result. Following graph shows the result of comparison between removal efficiency due to OPP for standard solution at different concentration. From this graph it is shown that as concentration is high rate of adsorption low.

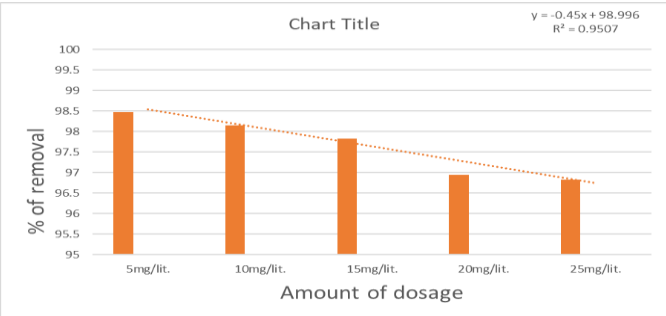


Fig.11 Effect of Amount of dosage for Cr (VI)

4.4 Effect of bed depth

Bed depth is main factor in adsorption process. Whole process is depend upon the bed depth variation. In pilot model we take bed depth from 5cm to 25 cm in five intervals to catch the maximum efficiency. Because of study of effect of bed depth on adsorption process, amount of maximum efficiency may calculated. Following graph shows the result of comparison between removal efficiency due to OPP for standard solution at different concentration and same for the actual effluent. From all below five intervals of bed depth for Cr (VI) it came to know that as rate of flow increases rate of removal decreases. at pH 1, 4ml/min. Rate of flow, , 30min. Time, 96.96% removal efficiency is recorded for 5mg/lit, 97.33% for 10mg/lit., 95.81% for 15mg/lit., 94.92% for 20mg/lit., 94.94% for 25mg/lit. By taking all these parameters for actual effluent 98.669% optimum efficiency has been recorded at 5 pH, 4ml/min rate of flow, 5cm bed depth & 30 min. Time for actual effluent. For actual effluent it came to know that pH, bed depth & time is directly proportional to adsorption and rate of flow is inversely proportional to adsorption. As Standard solution contains only one metal i.e. *Cr (VI)*, but in actual effluent there are lots of metals present in unknown amount therefore its % of removal is less and fluctuations are occurred.

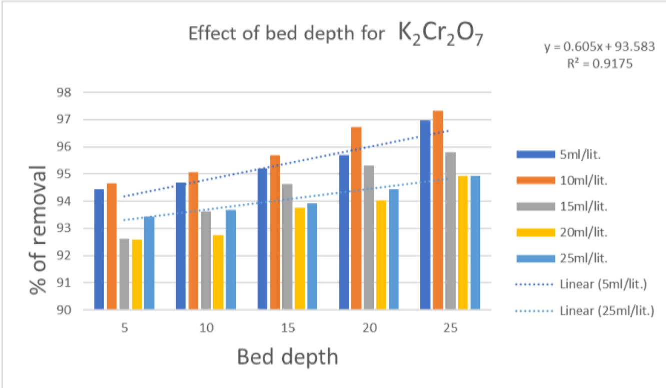


Fig.12 Effect of bed depth for Cr (VI)

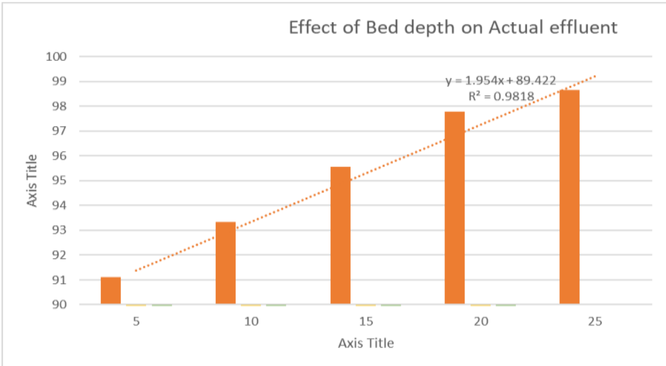


Fig.13 Effect of bed depth for Cr (VI)

4.5 Effect of contact time

Time is one of the important factor in column study experiment. Contact time inevitably a fundamental parameter in all transfer phenomena such as adsorption. Consequently it is important to study the effect its effect on removal capacity for OPP. Adsorption rate gives crucial information for the design of adsoprtion system. Since the adsorption is a time dependent process. It is clear from the readings and graph that rate of adsorption increases as increasing in time, more contact time, more rate of adsoption. After certain amount of time all the active parts of adsorbent will be either filled with metal ions or the solution itself is unsaturated.Following graph shows the result of comparison between removal efficiency due to OPP for standard solution at different concentration and same for the actual effluent. From all below five intervals of rate of flow for $K_2Cr_2O_7$ it came to know that as contact time increases rate of removal increases. at pH 1, 4ml/min. Rate of flow, 25cm bed depth, 98.48% removal efficiency is recorded for 5mg/lit, 98.15% for 10mg/lit., 97.82% for 15mg/lit., 96.95% for 20mg/lit., 96.83% for 25mg/lit. By taking all these parameters for actual effluent 99.33%

optimum efficiency has been recorded at 5 pH, 4ml/min rate of flow, 25cm bed depth & 75 min. Time for actual effluent. For actual effluent it came to know that pH, bed depth & time is directly proportional to adsorption and rate of flow is inversely proportional to adsorption. As Standard solution contains only one metal i.e. $K_2Cr_2O_7$, but in actual effluent there are lots of metals present in unknown amount therefore its % of removal is less and fluctuations are occurred.

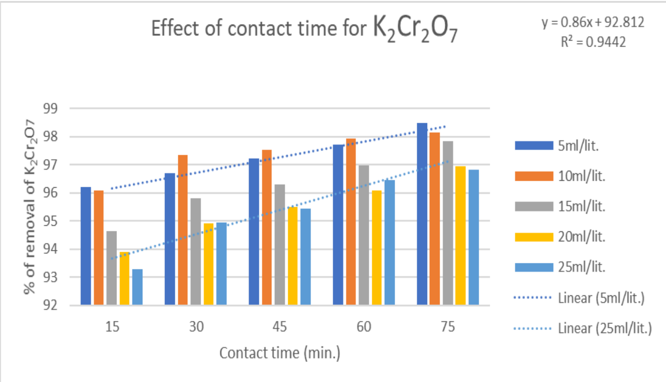


Fig.14 Effect of Contact time for Cr (VI)

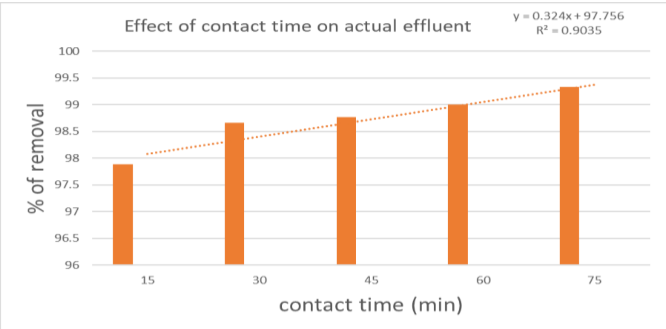


Fig.15 Effect of contact time on actual effluent

5. CONCLUSIONS

Column adsorption study is conducted for removal of heavy metals from industrial effluent using orange peel powder and following conclusions were made.

- The column adsorption was performed using various parameters such as pH, rate of flow, bed depth, contact time & amount of dosage.
- From all these parameters it came to know that adsorption process is spontaneous. It takes ups and downs by variations in parameters.
- As orange peel powder is a good organic replacement as adsorbent rather than using highly economical & harmful chemicals for effluent treatment.
- From all parameters, it also found that efficiency of removal for column adsorption is increases as it reaches to parameters, 1 pH, 4ml/min rate of flow, 25cm bed depth, 75 min contact time for standard solution and for actual effluent it reaches at 5 pH, 4ml/min rate of flow,25cm bed depth,75 min. Time.
- For FTIR process it came to know that orange peel has tremendous percentage of stabilization as it contains high amount of citric acid, which helps to stabilizes harmful contents I.e. various metals present in effluent.
- This research proves that this method is eco-friendly and easy in use without any special skills and supervision.
- Although process is time taking, needs high amount of adsorbent but for saving this nature steps should be taken.

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