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Removal of Heavy metals from Waste Water using Tomato Peel

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Abstract: Heavy metal ions and dissolved organic compounds in waste water are known to adversely affect human health, aquatic life and the overall ecosystem. Naturally abundant tomato peels or other bio membranes are used as an efficient biomaterial to remove toxic metal ions and organic pollutants from aqueous solution. Tomato is the second most consumed vegetable in the world, with approximately 30 per cent consumed as processed products. The disposal of the tomato skin and its other fibrous materials is an economic waste for many food processing industries. This studied the structure of the tomato peels to assess their efficiency as biomaterials to remove toxic metal ions and organic pollutants from water. In addition, factors such as the pH, nature and amount of adsorbent used for extraction were considered to establish the optimum conditions under which tomato peel could remove various pollutants from water. This study revealed that tomato peels can effectively remove different contaminants in water, including dissolved organic and inorganic chemicals, dyes and pesticides, and they can also be used in large scale applications.
Keywords: heavy metals, tomato peel, bio material

1. Introduction

Based on different environmental issues, pollution by heavy metals of surface water, ground water and soil in urban areas are the major environmental problems, which adversely affects all living organism. Some of the pollutants like lead (Pb), arsenic (As), mercury (Hg), chromium (Cr), nickel (Ni), barium (Ba), cadmium (Cd), cobalt (Co), selenium (Se), Vanadium (V), oils and grease, pesticides etc. are very harmful and poisonous even if present in very small amounts like ppb (parts per billion range). The bio-toxic effects of heavy metals refer to the harmful effects of heavy metals to the body when consumed above bio-recommended limits. Some of the general symptoms associated with cadmium, lead, arsenic, mercury, zinc, copper and aluminium poisoning are gastrointestinal (GI) disorders, diarrhoea, stomatitis, tumour, haemoglobineria causing a rust red colour to stool, ataxia, paralysis, vomiting and convulsion depression and pneumonia when volatile vapour and fumes are inhaled Many water purification methods have been developed such as chemical coagulation, flocculation, membrane separation, activated sludge formation, trickling filtration, photo degradation and ion exchange to remove such pollutants. But there is no ideal material or method that can eliminate all pollutants from drinking water. Among water purification techniques, active adsorption has been a promising method of treating effluents, offering advantages over conventional processes. Desirable qualities such as low cost, simplicity of design, availability in large amounts and ability to treat pollutants in a more concentrated form, made the design and synthesis of new adsorption materials of particular interest. Activated carbon was considered to be a suitable adsorbent for most of the pollutants, but it suffers from limitations such as poor regeneration, low surface area and disposal of used contaminated carbon. Many natural polymers, such as pectin, cellulose, hemicelluloses, protein, chitosan and chitin have functional groups to bind different pollutants. In addition, natural polymers are biodegradable, non-toxic and readily available. Several studies have been reported during recent years to investigate the pollutant binding efficiency of several bio sorbents (e.g. fungus, chitosan and silk worm).Utilization of bio waste (e.g. almond shell, wheat shell, coconut husk and coir pith) and bio membranes (e.g. orange peel, banana peel, rice husk, lemon peel) for the extraction of heavy metal ions, pesticides and organic dyes offers an alternative low cost option for water purification for economically poor countries. Often, people living in poor countries depend on the contaminated ground water or local rivers for their daily water needs. Here we show a low cost and highly efficient method of using materials that are easily accessible in rural areas for water purification. Tomato peel is an efficient biomaterial for the adsorption of heavy metals in waste water. Naturally abundant tomato peels or other bio membranes are used as an efficient biomaterial to remove toxic metal ions and organic pollutants from aqueous solution.

1.2 Adsorption

Among the unit operations in water and wastewater treatment adsorption occupies an important position. Adsorption operations exploit the ability of certain solids preferentially to accumulate specific substances from solution onto their surfaces. Sorption includes selective transfer to the surface, and for into the bulk of liquid. In a general adsorption process, the adsorbed solutes are referred to as adsorbate and the

adsorbing agent is the adsorbent. Theoretically, the adsorption of solute on to solid particles normally takes four essential steps:
a) Solutes diffuses through the fluid to an area near the solid particle surface,
b) Solute diffuses to the external surface of the particle,
c) Solute diffuses to the pore wall,
d) Solute adsorbs to the internal surfaces of the pore wall.

1.3 Adsorbents

Adsorbents are available as irregular granules, extruded pellets and formed pellets. The size reflect the need to pack as much surface area as possible into a given volume of bed and at the same time minimize pressure drop for flow through the bed. Size up to 6 mm is common. The adsorbent must have following features;

- It should have large surface area.
- The area should be accessible through pore enough to admit the molecule to be adsorbed. It is a bonus if the pores are also small enough to exclude molecules which it is not desired to adsorb.
- It should be easily regenerated.
- The adsorbent should not age rapidly, that it loses its adsorptive capacity through continuous recycling.

2. Methodology

2.1 Materials

2.1.1 Tomato

Tomato (Lycopersicon esculentum) is the second most consumed (37 million tonnes/year) vegetable in the world. Tomato peel is the material used as an adsorbent for the removal of Chromium (VI) and lead. Tomato peel is an attractive and economic alternative for the removal of metal ions from waste water. Tomato peels are excellent for the skin. Most of people waste tomato peels because lack of knowledge about benefits of peels. Tomato peel contains pectin, carotene and phenolic compounds with functional groups such as –NH2, –OH and –COOH. These functional groups act as potential adsorption sites for various pollutants, especially for cationic pollutants.

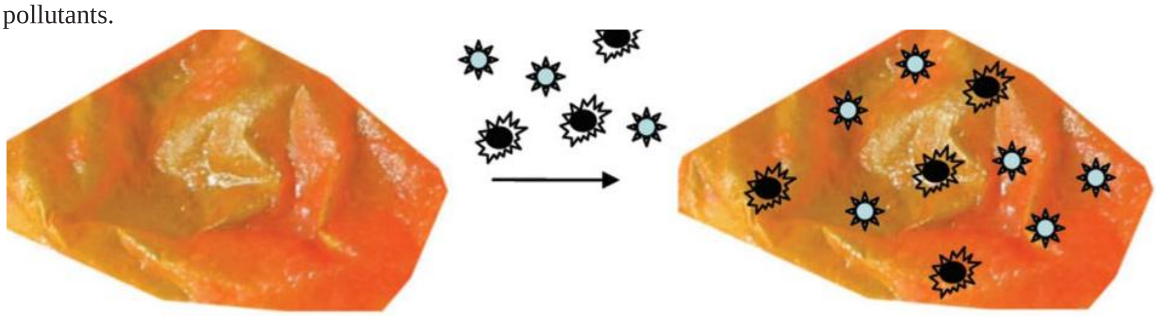

Figure 1: Schematic representation of pollutant extraction using tomato peel. Different dots indicate different classes of pollutants in water.(1)

2.1.2 Stock chromium solution

Add 2.8287g potassium dichromate into 1000ml distilled water. 1 L of this solution contains 100mg Cr(VI).

Chromium standard solution: measure exactly 10 ml of the solution, and add 1 drop of sodium hydroxide solution and water to make exactly 1000ml, 1ml of this solution contains 2.5 µg of chromium and water to make exactly 1000ml. Prepare freshly before use.

2.1.3 Stock lead solution

Dissolve 0.1598 g lead nitrate Pb(NO3)2 in a minimum amount of 1+1 HNO3,add 10 mL concentrated HNO3 and dilute to 1000 mLwith water;1.00 mL=100 µg Pb.

Lead Standard Solution: Measure exactly 10 ml of Lead Standard Stock Solution, and add water to make exactly 100 ml. One ml of this solution contains 10 µg of lead (Pb). Prepare freshly before use.

2.2 Methods

2.2.1 Preparation Of tomato peel adsorbent

Tomatoes collected from local super market . Tomatoes boiled for 10 min in water. The outer layer was carefully peeled off and cut into small pieces. The peels were washed with ethanol to remove anthocynins, followed by water. The thoroughly washed peels were dried and stored for further characterization. Stock solutions of Cr^{6+} and Pb^{2+} were prepared by dissolving stoichiometric amounts of $K_2Cr_2O_7$and $Pb(NO_3)_2$ in distilled water, respectively. HCl (0.1 mol /L) and NaOH (0.1 mol /L) were used to adjust the pH.

Fig 2: tomato peel and dried small pieces of tomato peel

2.2.2 Effect of agitation time

Tomato peel (2 g) was added to solutions (200 mL) of different concentrations of pollutants. All adsorption experiments were carried at 30 ^{o} C using an jar test apparatus at 100 rpm. The residual concentrations of pollutants were analysed after a pre determined time interval.

2.2.3 Effect of solution pH

The effect of solution pH on pollutant removal was studied by varying the pH from 2 to 12, where the pH was adjusted by adding either 0.01 M HCl or 0.01 M NaOH. The initial Concentrations used were 100 mg /L.Other parameters such as adsorbent dosage, agitation speed and solution temperature remained constant. The percentage Removal of pollutant was calculated as:

Removal %=(Ci-Cf)/100

Where Ci and Cf (mg /L) are the initial and final concentrations of the pollutants in the water.

3. Results and Discussions

3.1 test for chromium

3.1.1 Initial chromium content determination

For the preparation of calibration curve different concentrations of stock solutions were analyzed (10ppm, 20ppm, 30ppm, 40ppm, 50ppm) in the spectrophotometer. The absorbance readings were obtained at 560nm and they are noted as shown in the table below. Using these values calibration curve was plotted.

Table 1: Absorbance readings

Sl. no	concentration (mg/l)	Absorbance (ABS)
1	10	0.09
2	20	0.17
3	30	0.26
4	40	0.4
5	50	0.81

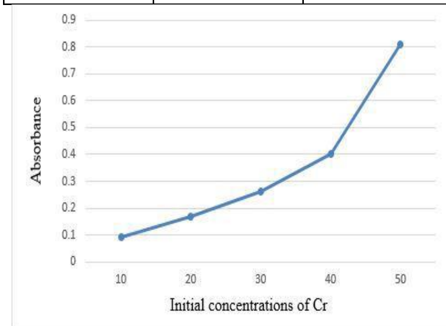

Fig 3: Calibration Curve

3.1.2 Effect of agitation time

The adsorption uptake versus the adsorption time for different pollutants at 30° C is shown in Fig. The amount of pollutant adsorbed (mg /g) increased with increasing time. The experiment is carried out at different agitation time of 1hr, 2hr, 3hr, 4hr and 5hr. Operating conditions for the experiment is shown in the table.

Table 2: operating conditions for effect of agitation time

Operating condition	
pH	4
Initial concentration	20,40,60,80,100mg/L
Temperature	30° C (room temperature)

Table3: Effect of agitation time for 20mg/L concentration of chromium

Sl. no	Agitation time (hr)	Initial concentration (mg/l)	Final concentration (mg/l)	% Removal of Cr
1	1	20	3.2	84
2	2	20	2.8	86
3	3	20	2.3	88
4	4	20	2	90
5	5	20	1.6	92

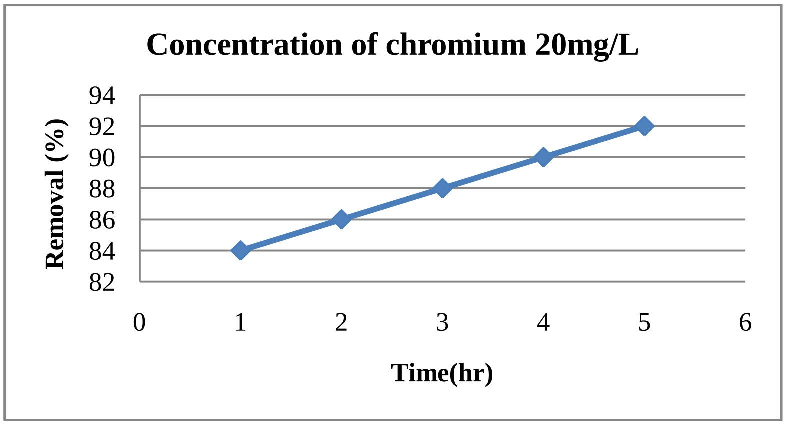

Fig 4: Effect of agitation time for 20 mg/l of chromium

Effect of agitation time for 20mg/L of chromium concentration is shown in the fig. The removal of Cr ions increases with agitation time. Maximum removal efficiency of 92% is achieved at an agitation time of 5hr.

Table 4: Effect of agitation time for 30mg/L concentration of chromium

Sl. no	Agitation time (hr)	Initial concentration (mg/l)	Final concentration (mg/l)	% Removal of Cr
1	1	30	4	80
2	2	30	3.6	82
3	3	30	3.1	84.5
4	4	30	2.4	88
5	5	30	2	90

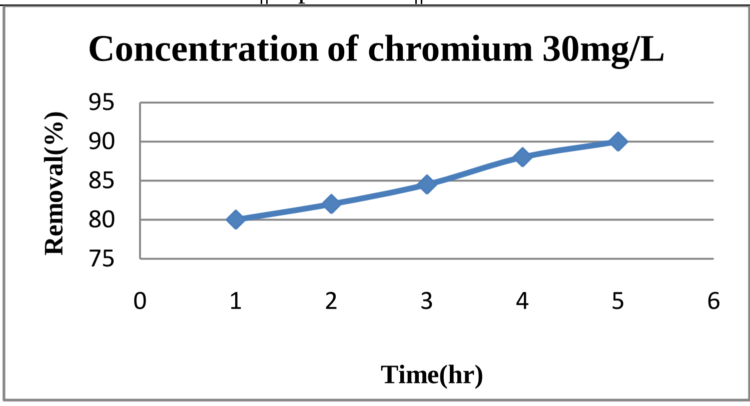

Fig 5: Effect of agitation time for 30 mg/l of chromium

Effect of agitation time for 30mg/L of chromium concentration is shown in the fig. The removal of Cr ions increases with agitation time. Maximum removal efficiency of 90% is achieved at an agitation time of 5hr.

Table 5: Effect of agitation time for 40mg/L concentration of chromium

Sl. no	Agitation time (hr)	Initial concentration (mg/l)	Final concentration (mg/l)	% Removal of Cr
1	1	40	6.1	85
2	2	40	5.8	85.5
3	3	40	5.5	86
4	4	40	5.2	87
5	5	40	4.8	88

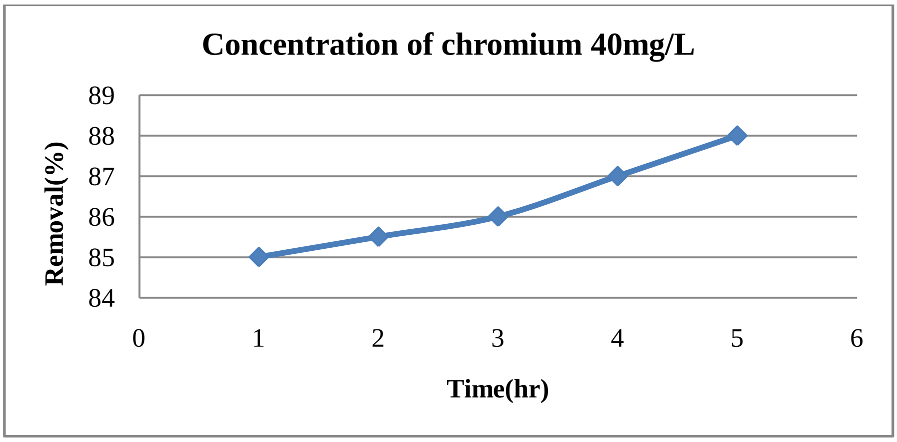

Fig 6: Effect of agitation time for 40 mg/l of chromium

Effect of agitation time for 40mg/L of chromium concentration is shown in the fig. The removal of Cr ions increases with agitation time. Maximum removal efficiency of 88% is achieved at an agitation time of 5hr

4.1.3 Effect of solution pH

The removal percentages of chromium with varying pH are presented in Fig.One of the parameters that strongly affect the sorption capacity is the pH. The experiment is carried out in different pH 2,4,7,10,12. Operating conditions for the experiment is shown in the table.

Table 6 : Operating conditions for effect of pH

Operating condition	
Agitation time	1hr
Initial concentration	20 mg/l
Temperature	30°C(room temperature

Table7: Effect of pH

Sl. no	PH	Initial concentration (mg/l)	Final concentration (mg/l)	% Removal of Cr
1	2	20	9.1	54.5
2	4	20	2	90
3	7	20	14	30
4	10	20	16	20
5	12	20	17	15

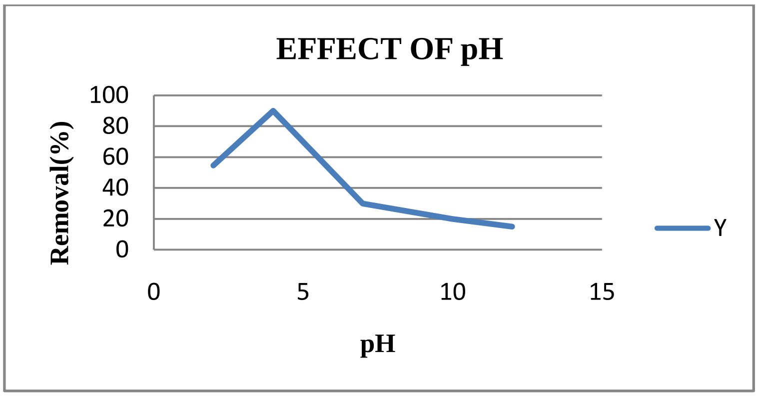

Fig 7: Effect of pH

3.2 TESTS FOR LEAD

3.2.1 Initial lead content determination

The technique makes use of absorption spectrometry to assess the concentration of an analyte in a sample. It requires standards with known analyte content to establish the relation between the measured absorbance and the analyte concentration and relies therefore on the Beer-Lambert Law.

Table 8: Absorbance readings of standard lead solution

Standard lead solution (ppm)	**Absorbance (%)**
1	0.022
2	0.042

Table 9: Absorbance reading of stock lead solution

Sample (ml)	**Absorbance (%)**	**Concentration(ppm)**
1	0.024	1.0

initial lead content in sample = 1.0 x 100 = 100 ppm

3.2.2 Effect of agitation time

Table 10 Effect of agitation time for 20mg/L concentration of Lead

Sl. no	Agitation time (hr)	Initial concentration (mg/l)	Final concentration (mg/l)	% Removal of Pb
1	1	20	1.6	92
2	2	20	1.4	93
3	3	20	1.1	94
4	4	20	0.9	95
5	5	20	0.7	96.5

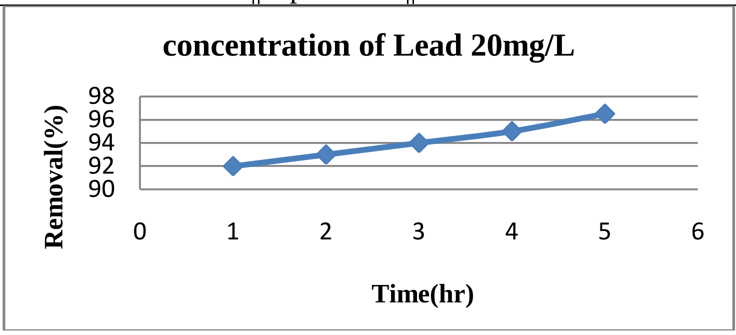

Fig 8: Effect of agitation time for 20 mg/l of lead

Table 11 Effect of agitation time for 30mg/L concentration of Lead

Sl. no	Agitation time (hr)	Initial concentration (mg/l)	Final concentration (mg/l)	% Removal of Cr
1	1	30	3.1	84.5
2	2	30	2.7	91
3	3	30	2.5	91.6
4	4	30	2	93
5	5	30	1.8	94

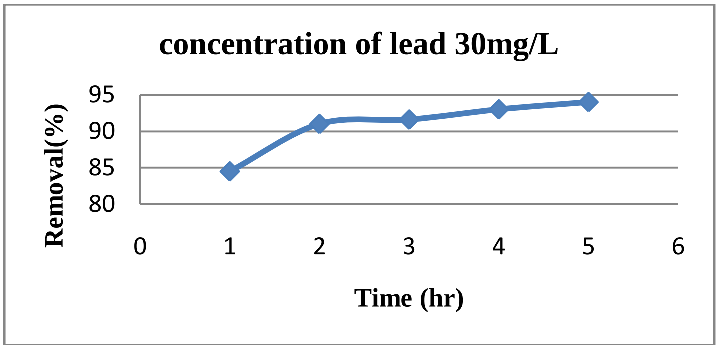

Fig 9: Effect of agitation time for 30 mg/l of lead

Table 12 Effect of agitation time for 40mg/L concentration of Lead

Sl. no	Agitation time (hr)	Initial concentration (mg/l)	Final concentration (mg/l)	% Removal of Cr
1	1	40	5.6	86
2	2	40	5	87.5
3	3	40	4.6	88.5
4	4	40	4.1	89
5	5	40	3.5	91

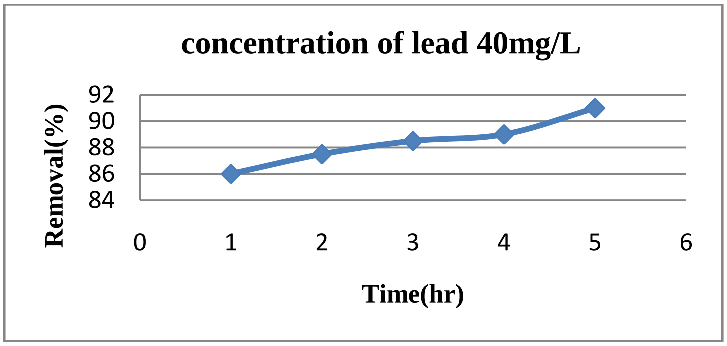

Fig 10. Effect of agitation time for 40 mg/l of lead

These results indicate that the tomato peel tends to bind cationic pollutants more favourably than anionic pollutants. This may be due to the presence of a higher percentage of acid and alcoholic functional groups on the surface of the tomato peel.

3.2.3 Effect of solution pH

Table 13 Operating conditions for effect of pH

Operating condition	
Agitation time	1hr
Initial concentration	100 mg/l
Temperature	30° C(room temperature

Table 14 Effect of pH

Sl. no	PH	Initial concentration (mg/l)	Final concentration (mg/l)	% Removal of pb
1	2	100	46	54.5
2	4	100	30	70
3	7	100	4	96
4	10	100	27	73
5	12	100	19	81

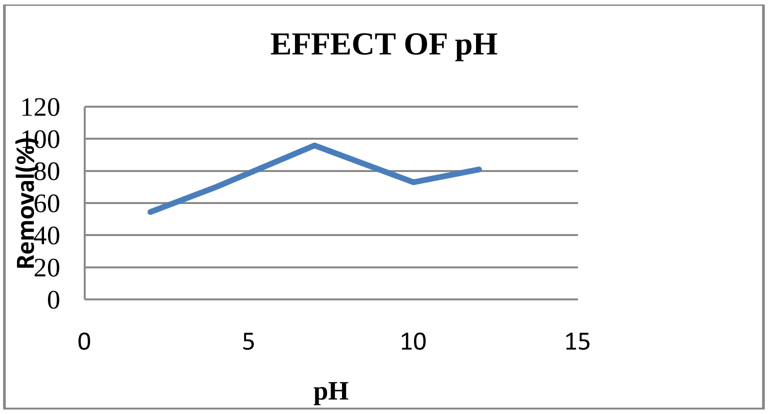

Fig 11 Effect of pH

The removal of Pb2+ was found to increase as the pH increases. It is assumed that ionic interactions are involved in the adsorption process. For cationic pollutants, the lower adsorption at acidic pH was due to the presence of excess H+ ions competing with the pollutant cations for the adsorption sites. At higher pH, the acidic functional groups on the surface of the peels get ionised, which enhances the adsorption of positively charged cations through electrostatic attraction. In the case of anionic pollutant (Cr6+) the lower pH resulted in a higher adsorption as the positively charged surface of the peels could absorb negatively charged pollutants. Adsorption of chromium (VI) was higher at acidic pH, owing to electrostatic attraction between the positively charged peel and the anions.

3.3 Comparsion of Percentage Removal Efficiency of Chromium And Lead

Results showed that Tomato peel is more effective in removing lead than chromium. Percentage removal efficiency of chromium and lead was found to be 92 % and 96.5 %.

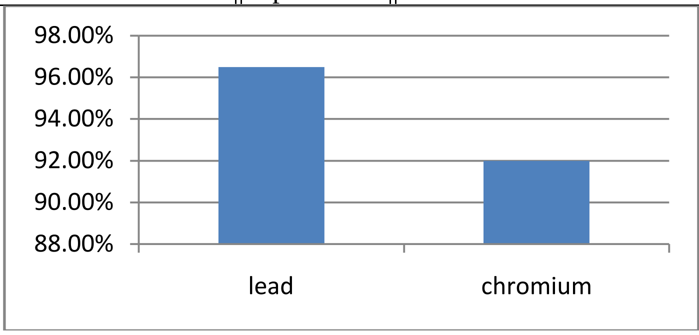

Fig 4.12: Comparison between percentage removal efficiency of metals

3.4 Water Quality Criteria for Irrigation

As per IS 11624-2009, recommended maximum permissible concentration lead in irrigation water is 5 mg/L. Hence the samples after addition of bio sorbent can be used for irrigation purposes.

4. Conclusions

The adsorption of Chromium and lead was evaluated using tomato peel as an adsorbent. Adsorption studies were conducted to understand the adsorption mechanism. Adsorption experiments show that tomato peel can adsorb cationic pollutant (Pb^{2+}) more efficiently than anionic pollutant (Cr^{6+}). Desorption of these cationic pollutants was studied at different pH values (4, 7 and 10) at a constant temperature of 30° C. 96% of pollutants was desorbed at pH 4 . Under acidic conditions, H^+ ions will replace cationic pollutants from the tomato peel surface. Tomato peel showed efficient adsorption towards lead (96.5%) and chromium (92%). Experimental factors such as pH and temperature of the medium also influence the extraction efficiency. The functional groups on tomato peel can be further modified for the extraction of different contaminants in water. It is conceivable that the use of such bio waste is simple, cost effective and an efficient method for water treatment and can be used in large scale applications.

Scope for Further Studies

The use of Tomato peel, natural adsorbent removes the heavy metals of Chromium (VI) and lead from waste water. It can also be used as an adsorbent for the removal of other types of heavy metals like Zn, Cu, Ni, Co, Fe etc. present in the waste water. So the tomato peel can be used as a better adsorbent for the removal of heavy metals from waste water as compared to other adsorbents.

References

[1]. R. Mallampati .et al.,” Application of tomato peel as an efficient adsorbent for water purification-alternative biotechnology? ”, *The Royal Society of Chemistry* 2012. Volume-2, 9914–9920.

[2]. M. Ghaedi, et al.,” Removal of Heavy Metal Ions from Polluted Waters by Using of Low Cost Adsorbents: Review” *Journal of Chemical Health Risks* 3(1): 07-22, 2013

[3]. Dr. N. jain” removal of heavy metal by using different fruit peels, vegetable peels and organic waste - a review ”, *international journal of advanced research* (2015), volume 3, issue 11, 916 – 920

[4]. A. Adam,et al.,” the trends in removal of heavy metal conaminantes from the waste water by using biomaterials”, *International Journal of Development Research* Vol. 5, Issue, 06, pp. 4660-4669, June, 2015”

[5]. L. Agwaramgbo,et al., “Assessing Lead Removal from Contaminated Water Using Solid Biomaterials: Charcoal, Coffee, Tea, Fishbone, and Caffeine”, *Journal of Environmental Protection*, 2013, 4, 741-745

[6]. S. R Popuri et al. (2007); ‘Biosorption of hexavalent chromium using tamarind (*Tamarindus indica*) fruit shell-a comparative study’, *Electronic Journal of Biotechnology*, ISSN: 0717-3458, Vol.10 No.3,

[7]. S. Mandina (2013); ‘Removal of chromium (VI) from aqueous solution using chemically modified orange peel’, *IOSR Journal of Applied Chemistry (IOSR-JAC) e- ISSN: 2278-5736*. Volume 6, Issue 2 (Nov. – Dec. 2013), PP 66-75.