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Batch Study Experiments And Column Analysis For Finding Out A Suitable Biosorbent For The Removal Of Heavy Metals From Electroplating Industry Effluent

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ABSTRACT

To solve the environment pollution problem by toxic heavy metal contamination resulting from human technological activities has for long presented a challenge. Electroplating industries poses a major contribution to heavy metal pollution to environment. Since the process of biosorption has many attractive features compared to the conventional effluent treatment methods in electroplating industries, a study has been conducted to find out a cost effective and environment friendly biosorbent from a selected list. The result reveal that Bengal gtram husk (Cicer arientinum), a locally available milling agro waste is a best biosorbent to remove heavy metals as well general pollutants from effluents of electroplating industries.

1. INTRODUCTION

1.1. GENERAL

Earth our home planet, is a beautiful blue and white ball when seen from space. Earth is the only planet known to support life and to have liquid water at the surface. The abundance of water on water on Earth is a unique feature that distinguishes the "Blue Planet" from others in the solar system.

Biosphere is the outermost part of the planet's shell- including air, land, surface rocks and water- within which life occurs, and which biotic processes in turn alter or transform. From the broadest geo physiological point of view, the biosphere is the global ecological system integrating all living beings and their relationships, including their interaction with the elements of the lithosphere (rocks), hydrosphere (water), and atmosphere) air) basic needs of all living beings and plant life, to carry on their life functions .Environment creates favorable conditions for the existence and development of living organism. It has never been constant or static, but always been changing slowly and some times rapidly or drastically. Thus, like other organisms, man is also affected by his environment and these changes in environment may benefit or harm the man or other organisms living in it.

Since the very beginning of human civilization, some thousand years ago man started interfering with the environment. After the scientific and industrial revolution in the recent past, there has been immense impact of man on his environment. Man has failed to realize that any new factor upsets the balance of the ecosystem as a whole. All the devastating effects of man's effort to control nature have occurred because he has upset the balance relationship of the organisms that make up the environment. Huge industrial installations and large crowded cities are the main outcome of the modern civilization. These and a large number of many others are contributing to environmental pollution. If we do not do something soon the arrest the decline in environment at all levels, there is no future for the human race itself. Today numerous issues like quality of environment, ecological imbalance, and disruption of earth's natural ecosystem, environmental degradation, and depletion of protective ozone umbrella chlorofluorocarbons, ozone hole, global warming and sick environment have been raised. No doubt man is now awakened towards environmental problems and the public interest concerning the quality of environment.

There are two main categories of polluting materials or pollutants-biodegradable and non- degradable. Biodegradable materials, such as sewage, that rapidly decomposes by natural processes. Non-degradable pollutants are materials that do not decompose or decompose slowly in the natural environment.

Once contamination occurs it is difficult or impossible to remove these pollutants from the environment. Because humans are at the top of the food chain, they are particularly vulnerable to the effects of non degradable pollutants. It has been established beyond any doubt that heavy metals are most dangerous non degradable pollutants poses serious health hazard. (Sharma, 2000)

Heavy metals are metals with density above 5gm/cm3. They are a group of elements between Copper and Bismuth on the periodic table of elements. They are having a specific gravity above4. The toxic effect of this substance is a wide spread concern. The most often poisoning heavy metals are nickel, chromium lead, mercury, arsenic, zinc, copper, manganese, iron and cadmium. (Nriagu Jo, 1996)

Electroplating industries are one of the major sources, which discharge toxic heavy metals in to the environment. The concentrations of heavy metals in the effluents of electroplating industries are comparatively very high.

1.2 STANDARD LIMITS FOR ELECTROPLATING INDUSTRY EFFLUENTS

The KERALA STATE POLLUTION CONTROL BOARD has stipulated standards for electroplating industrial effluents as per E(p) Rules Schi - ISO 393(E).16.4.87.

TABLE.1. PARAMENTERS OF ELECTROPLATING INDUSRY EFFLUENT

Sl.No.	Parameters	Unit	Limit
1	pH		6 to 9
2	Suspended solids	Mg/1	100
3	Oil; and grease	"	10
4	Cyanides (CN)	"	02
5	Total residual chlorine(Cl)	"	1
6	Cadmium (cd)	"	2
7	Nickel (Ni)	"	3
8	Zinc(Zn)	"	5
9	Chromium (Cr)	"	2
10	Copper (Cu)	"	3
11	Lead (pb)	"	0.1
12	Iron(Fe)	"	3

The commonly used procedure for removing heavy metals from effluents of electroplating industries include chemical precipitation, lime coagulation, ion exchange, reserve osmosis and solvent extraction. The disadvantages like incomplete metal removal, high reagent and energy requirement, generation of toxic chemical sludge or other waste products that requires careful disposal has made it imperative for a cost effective treatment method that is capable of removing heavy metals from effluents.

The search for new technologies involving the removal of toxic metals from wastewaters has directed attention to bio sorption, based on metal binding capacities of various biological materials. (Ahalya et, al.2005).

Considering all the above aspects it was decide to find out an environment friendly and cost effective bio sorbent to remove heavy metals from effluents of electroplating industries.

The objectives of the study are,

1. Evaluation of the characteristics of a selected electroplating industry.
2. To analyze and find out a most performing bio sorbent from a selected list of adsorbents.
3. Column analysis with the selected bio sorbents
4. Evaluation of characteristics of treated effluent
5. Cost comparison of bio sorption with lime coagulation.
6. To verify the applicability of the selected bio sorbent for the removal of other pollutants in addition to heavy metals.
7. To suggest bios option as an environment friendly & economic effluent treatment method for electroplating industries.

1.3. HEALTH EFFECTS OF HEAVY METALS

Heavy metals are natural components of the Earth's crust. They cannot be degraded or destroyed. Once liberated in to the environment through the air, drinking water, food or countless human made chemicals and products, heavy metals are taken in to the body via inhalation, ingestion and skin absorption. If heavy metals enter and accumulate in body tissues faster than the body's detoxification pathways can dispose off them, a gradual buildup of these toxins will occur. High concentration exposure is not necessary to produce a state of toxicity in the body, as heavy metals accumulate in body tissues and, over time, can reach toxic concentration level.

The effects of heavy metal toxicity studies confirm that heavy metals can directly influence behavior by impairing mental and neurological function, influencing neurotransmitter production and utilization, and altering numerous metabolic body processes. Systems in which toxic metal elements can induce impairment and dysfunction include the blood and cardiovascular, detoxification pathways (colon, lever, kidneys, skin) endocrine (hormonal) energy production pathways, enzymatic, gastrointestinal, immune, nervous, reproductive and urinary. Heavy meals can also increase the acidity of the blood. The body draws calcium from the bones to help restore the proper blood pH. The constant removal of this important mineral from the bones will lead to brittle bones (0osteoporosis.Children and elderly, whose immune systems are either under developed or age compromised are more vulnerable to toxicity. (Gary Farr, 2004)

2. MAJOR SOURCES OF HEAVY METAL POLLUTION

The anthropogenic sources of heavy metals include wastes from the electroplating and metal finishing industries, metallurgical industries, tannery operations, chemical manufacturing mine drainage, battery manufacturing leather tanning industries, pigment manufacturing industries, and contaminated ground water from hazardous waste sites.(lgwe et al.,2006).

Among the various sources of heavy metal pollution, electroplating industries are of paramount concern. Electroplating is the process of producing a coating on a surface by the action of electric current. The decomposition of a metallic coating on to an object is achieved by putting a negative charge on the object to be coated (cathode) and immersing it into a solution (electrolyte) , which contains a salt of the metal to be deposited. The metal to be deposited is kept as anode of the electrolytic cell. The anode and cathode in the electroplating cell are connected to the external supply of direct current. The anode is connected to the positive terminal and the cathode to the negative terminal. When the electric supply is switched on, the metal anode is oxidized and form cations with a positive charge. These cations associated with the anions in the solutions. The cations are reduced at the cathode to deposit in the metallic state. Figure 1 Shows the schematics of an electrolytic cell for plating metals.

Metals, which commonly used fo electroplating, are chromium, nickel, zinc, copper, silver, lead, gold, cadmium, brass etc.

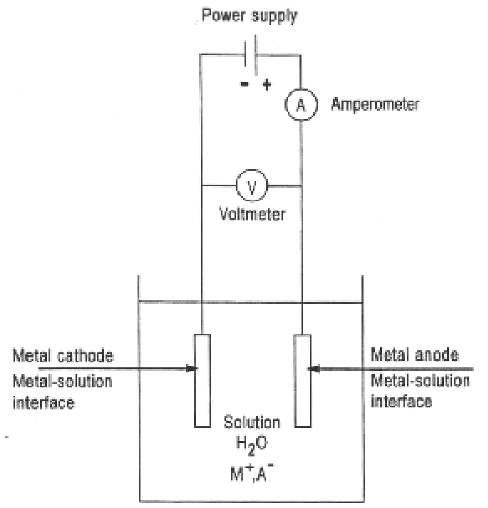

FIGURE 1 SCHEMATICS OF AN ELECTROLYTIC CELL FOR PLATING METALS

2.1. HEAVY METAL GENERATION BY ELECTROPLATING INDUSTRIES

The rinsing process is the primary source of waste generated in metal finishing operations. Rinsing removes plating solutions or cleaners from the work piece. Rinse waters often contain process chemicals carried by the work piece into the rinse (also known as ragout). Metal finishers periodically discharge process baths when they lose their effectiveness because of chemical depletion or contamination. Accidental discharge of these chemicals also can occur. The concentrations of heavy metals in the effluents are normally m,any folds higher than the prescribed standards.Considering the severe health effects of heavy metals on living organisms, stringent limits for heavy metals were stipulate by the regulatory authorities. In order to maintain these parameters within limits, various treatment methods are adopted by the industries.

2.2 CONVENTIONAL METHODS FOR TREATMENT OF EFFLUENTS

The commonly used procedure for removing metal ions from effluents of electroplating industries include chemical precipitation, lime coagulation, ion exchange, reverse osmosis, and solvent extraction. A brief description of each method is presented below.

2.2.1. Reverse osmosis

It is a process in which heavy metals are separated by a semi-permeable membrane at a pressure greater than osmotic pressure caused by the dissolved solids in wastewater. The disadvantage of this method is that it is expensive.

2.2.2. Electrodialvsis

In this process the ionic omponents (heavy metals) are separated througfh the use of semi permeable ion selective membrances. Application of an electrical potential between the two electrodes causes a migration of cations and anions towards respective electrodes. Because of the alternate spacing of cation and anion permeable membranes, cells of concentrated and diloute salts are formed. The disadvantage is the formation of metal bydroxide, which clog the membrane and it is expensive also.

2.2.3. **Ultrafiltration**

They are pressure driven membrane operations that use porous membranes for the removal of heavy metals. The main disadvantage of this process is the generation of heavy metal sludge.

2.2.4. **Ion exchange**

In this process metal ions from dilute solutions are exchanged with ions held by electrostatic forces on the exchange resin. The disadvantages are high cost and partial removal of certain ions.

2.2.5. Chemical precipitation

Precipitation of metals is achieved by the additions of coagulants such as alum, lime, iron salts and other organic polymers. The large amount of sludge containing toxic compounds during process is the main disadvanr5age. The disadvantages like incomplete metal removal , high reagent and energy requirements, generation of toxic sludge or other waste sludge or other waste product the requires careful disposal has made it imperative for a cost effective treatment method that is capable of removing heavy metals from electroplating industry effluents.(George E. Pataki,2001).

2.3 BIOSORPTION

The search for new technologies involving the removal of toxic metals from wastewater has directed attention to bio sorption, based on metal binding capacities of various biological materials. Bio sorption can be defined as the ability of biological materials to accumulate heavy metals from wastewater through metabolically medicated or physico chemical pathways of uptake.Various biosorbnents have been tried, which includes seal weeds, moulds, yeast, bacteria, crab shell, agricultural products such as wool, rice bran, rice hulls, soyabean hull, cotton seed hull and saw dust.(Ahalya et.al.2003).

3.EXPERIMENTAL STUDY

3.1. **Field of study**

CANARA Electroplating works ,Edapally in Ernakulam district has been selected for this study. The industry is mainly engaged in plating of Zinc, Copper,Nickel and Chromium.Rinse water from each plating section, periodically discharged process baths and wash water were combined together and collected in a tank for further treatment (Conventional chemical precipitation is being practiced in the industry) . Thus the influent is a composite one which contains more than one heavy metal

(Zinc,Copper,Nickel,Chromium and iron) with high concentrations. The industry was visited , and samples of influent has been collected for the study. Various plating processes and finished products are shown in Figure. 2 to 6. Effluent collection point and the collected sample are shown in Figures 7 & 8

3.1.1. Plating in pictures

FIGURE.2.ZINC PLATING

FIGURE.3 COPPER PLATING

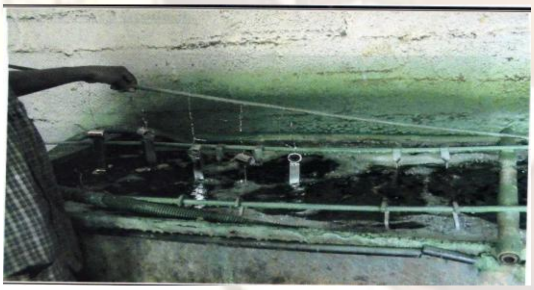

FIGURE.4.NICKEL PLATING

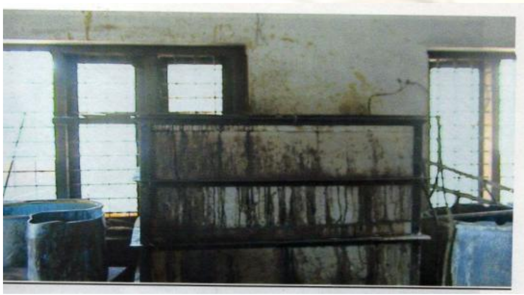

FIGURE.5 CHROMIUML PLATING

3.1.2. Finished products

FIGURE.5 FINISHED PRODUCTS

3.1.3. Sample collection

FIG.6. EFFLUENT DISCHARGE

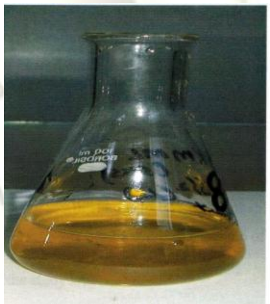

FIGURE.7. COLLECTED SAMPLE

4. AIM AND SCOPE OF THE STUDY

In kerala around 200nos of electroplating industries are functioning. Most of them are small scale industrial units and are located in the nooks and corners of every district. Even though the quantities of wastewater generated and comparatively less, they are extremely toxic and harmful to the atmosphere. A number of cases have been noticed that the wastewater is being discharged into the near by drainage/land or water bodies without proper treatment. The entrepreneurs or the employees may not be aware of the severity of the situation or eluding from adopting proper treatment methods so as to reduce the running cost. Nowadays the regulatory authorities are more concerned about this and made it compulsory to treat the effluents before discharge.

In this circumstance, it is essential to adopt an economically viable treatment method to remove the toxic heavy metals from the discharging effluents of electroplating industries. Considering the disadvantages of the conventional treatment systems, it is decided to develop a cost effective and environment friendly treatment method. Citing previous literatures on the subject, it is observed that bio sorbents are highly effective to remove heavy metals from aqueous solutions. Most of the electroplating industries are engaged in plating of different metals. The effluent from each plating sections are not being segregated and are collectively stored for treatment. It has been noticed that most of the previous studies are intended to find out a bio sorbent to remove only one particular metal ion. Hence the aim is to find out a suitable bio sorbent, which can remove various heavy metals from a composite sample of effluent.

The objectives of the study are,

1. Evaluation of the characteristics of a selected electroplating industry effluent
2. To analyze and find out a most performing bio sorbent from a selected list of adsorbents.
3. Column analysis with the selected bio sorbents.
4. Evaluation of characteristics of treated effluent.
5. Cost comparison of adsorption with lime coagulation.
6. To verify the applicability of the selected bio sorbent for the removal of other pollutants in addition to heavy metals.
7. To suggest bio sorption as an environment friendly & economic effluent treatment method for electroplating industries.

5.MATERIALS AND METHODS

5.1. ANALYSIS OF SAMPLES

Composite effluent sample was collected from the selected industry for analysis. The characteristics of the sample were analyzed using standard procedure. The metal concentrations were measured by Atomic Adsorption Spectrophotometer (Figure.8).

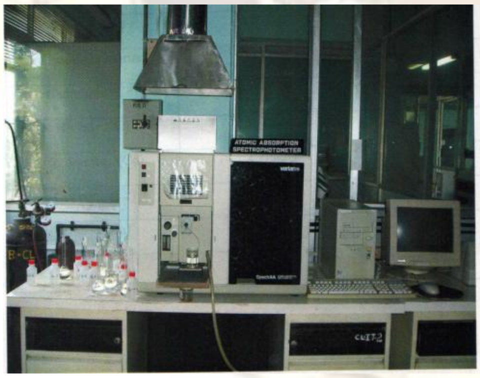

FIGURE.8. ATOMIC ADSORPTION SPECTROPHOTOMETER

5.2. CHARACTERISTICS OF THE SAMPLE ANALYZED

Parameters	KSPCB limit	Parameters of sample (mg/1)
pH	06-Sep	3.76
Suspended solids (S.S.)	100(mg/1)	64
Oil & Grease	10(mg/l)	8.8
Total residual chlorine (Cl)	1(mg/l)	26.63
Cadmium (Cd)	2(mg/l)	0.06
Nickel (Ni)	3(mg/l)	209.375
Chromium (Cd)	2(mg/l)	216.2
Copper (Cr)	3(mg/l)	378.4
Zinc(Zn)	5(mg/l)	662.625
Iron (Fe)	3(mg/l)	625

TABLE.1. ANALYSIS RESULT OF SAMPLE COLLECTED

5.3.BATCH STUDY EXPERIMENT

Batch study experiments with a selected list of adsorbents were conducted using jar test apparatus (Figure.9)

FIGURE.9. JAR TEST APPARATUS

5.3.1. Set Parameters For Batch Study

Quantity of effluent	-	100ml
Quantity of adsorbent	-	1gm
pH	-	pH of sample (3.76)
Contact time	-	120 minutes
Revolutions per minute	-	120

5.3.2. Adsorbents used

1. Saw dust saw dust of size 500 microns
2. Straw: grinded straw of size 500 microns
3. Bengal gram husk : grinded (bgh) to 500 microns size
4. Green leaf : Chopped green leaf of mangifera indica
5. Burnt coconut husk: grinded and sieved to 500 micron size
6. Alkali treated straw: Grinded to 1-mm size and treated with NaOH solution, kept overnight and dried.
7. Treated Bengal gram husk: Bengal gram husk washed, dried and grinded to a size of 500 microns.

8. Treated Black gram husk: Black gram husk washed, dried and grinded to a size of 500 microns.
9. Treated ground nut hull: Ground nut hull washed, dried and grinded to a size of 500 microns.
10. Chitosan:Dried Chitiosan of 2-mmsize
11. Bean hull: Grinded to a size of 500 mcrons.
12. Activated carbon: Grinded to a size of 500 microns.
13. Paddy husk ash: Grinded to a size of 500 microns.

FIGURE.10. ALKALI TREATED STRAW, TREATED BENGAL GRAM HUSK, TREATED GROUND NUT HULL

FIGURE.11. CHITOSAN, GREEN LEAF ,TREATED BLACK GRAM HUSK, BEAN HULL

FIGURE.12.DRIED STRAW, GROUND NUT BENGAL GRAM, BEAN HULL, GREEN LEAF

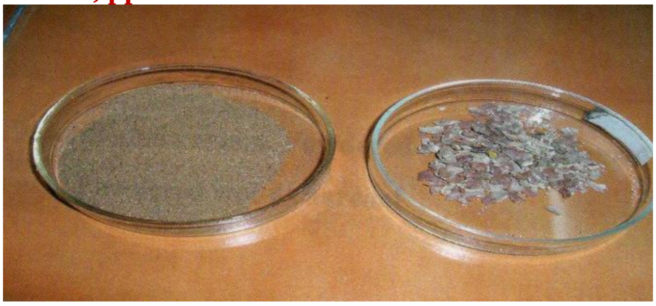

FIGURE.13. SAW DUST, BENGAL GRAM HULL

FIGURE.14. ALKALI TREATED STRAW

FIGURE.15. ACTIVATED CARBON, POWDERED COCONUT CHARCOAL, POWDERED PADDY HUSK ASH, POWDERED GOOD CHARCOAL

5.3.3. Batch study result

TABLE.2 % CONCENTRATION REDUCTION OF DIFFERENT ADSORBENTS

Parameter	Saw dust	Straw	Raw Bengal gram husk	Green leaf	Burnt Coconut husk	Alkali Treated Straw	Treated Bengal Gram Husk	Treated Black gram husk	Treated ground nut Husk	Chitosan	Bean hull	Activated Carbon
Cr	33	33	57	44	30	68	78	91	66	87	60	90
Ni	75	75	50	76	99	82	87	86	85	98	76	78
Zn	`36	35	36	54	90	62	75	73	84	99	40	82
Cu	97	95	97	99	90	96	99	99	99	76	97	91
Fe	99	99	99	99	100	99	100	100	99	100	99	100

The batch study results showed that % concentration reductions fo heavy metals are maximum for Bengal gram and Black gram husk. Hence they were selected for column analysis.

5.4. COLUMN ANALYSIS

The batch study results showed that % concentration reductions of heavy metals are maximum for Bengal gram and Black gram husk. Hence they were selected for column analysis. Figures 16 & 17 shows raw Bengal gram and black gram

FIGURE.16 BENGAL GRAM

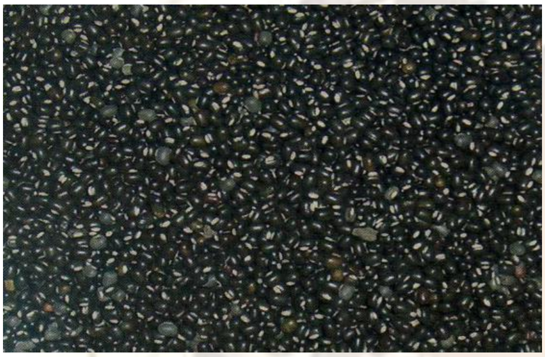

FIGURE.17 BLACK GRAM

A glass column of internal diameter 1.5cm has been selected for column analysis. Trial experiments were conducted with various flow rate, pH and depth of adsorbent.

4.4.1. Preparation of husk

5kg of Bengal gram (Cicer arientinum) was soaked and the husk (bgh) were peeled out. The bgh was extensively washed in running tap water to remove dirt and other particulate matter. Washing and boiling in distilled water repeatedly to remove color followed this. The washed and boiled bgh was oven dried at 105^{o} C for 24 hrs. The oven dried bgh was ground and sieved through 500 micron size and stored in desiccators for bio sorption studies.The stages of bgh adsorbent preparation are shown Figures 18 to 21

FIGURE.18.PEELED HUSK

FIGURE.19.BOILING

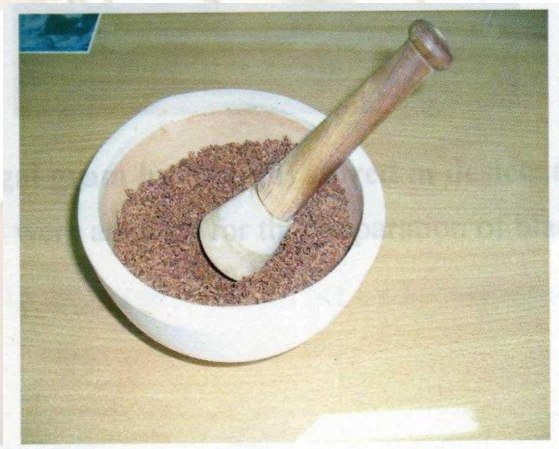

FIGURE.20.GRINDING

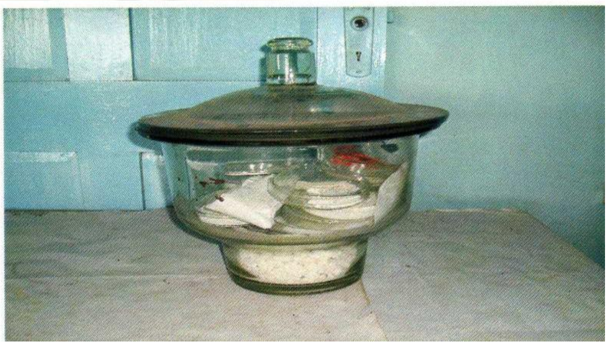

FIGURE.21BENGAL GRAM HUSK STORED DESICCATORS

4.4.2. Experimental Set Up

Experimental set up for column analysis is shown in Figure.. 22.

FIGURE.22.EXPERIMENTAL SETUP FOR COLUMN ANALYSIS

4.4.3. Short term analysis

On a trial basis adsorbent was filled in the column for 20cm. and the effluent stored in an over head can as passed through the column with a flow rate of 0.125ml/min. Figure.23shows the adsorption of heavy metals during column analysis. The color change clearly indicates the uptake of heavy metal at the top portion of the adsorbent column.

FIGURE.23 ADSORPTION IN PROGRESS

Sample was collected after adsorption and analyzed for heavy metal concentration in Atomic Adsorption Spectrophotometer. The result shows that the percentage removal of heavy metal concentration was 99.9. The result showing the % reduction of heavy metal concentration is shown in column test result table -4.3.

5. COMPARISON OF INFLUENT AND TREATED EFFLUENT

Figure.24 shows a comparison of effluent before and after adsorption.

FIGURE.24 COMPARISON OF RAW AND TREATED EFFLUENT

Column analysis was repeated with different depth of adsorbent, pH and effluent flow rate. After getting an optimum depth of adsorbent, pH, and rate of flow, long term analysis was carried out.

6. LONG TERM ANALYSIS

Long term analysis was conducted with Bengal gram and black gram. It was observed that the column with black gram gets clogged in a short duration. Hence Bengal gram was selected for further studies.

Long term tests were conducted with the optimum adsorbent depth of 20 cm. and flow rate of 2.46 ml/min. Breakthrough curve was prepared. In order to increase the life of adsorbent column. The pH of the sample was raised to the optimum level of 5 and the long term test was repeated. The precipitate formed was settled out and the supernatant has been taken for further analysis. The break through curve was prepared and it could be observed that the life of the column was much improved..

The effect due to pH variation is shown in figures 25 to 27.

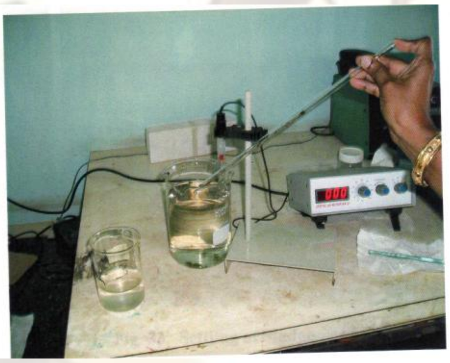

FIGURE.25. ADDITION OF ALKALI TO RAISE PH

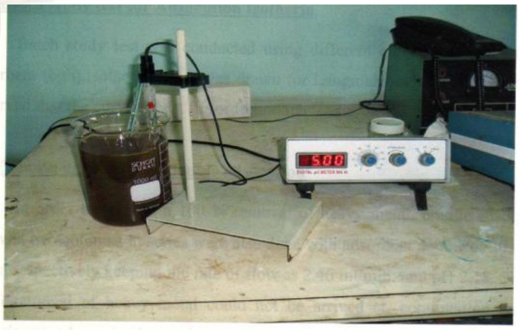

FIGURE.26.PH AT 5

FIGURE.27. SETTLING OF SLUDGE

6.1. BATCH STUDY TEST FOR ADSORPTION ISOTHERM

Batch study test was conducted using different quantity of the selected adsorbent (bgh).Isotherm curve was drawn for Langmuir and Freundlich . It was observed that the curve is best fit for freundlich isotherm.

6.2 COLUMN ANALYSIS WITH DOUBLE ADSORPTION

In order to achieve a 100 % removal of heavy metal, double adsorption test with two columns in series were also done with adsorbent depths of 20cm & 10cm respectively keeping the rate of flow as 2.46 ml/min. and pH 2.18.Since a 100% removed of heavy metal could not be arrived at, continuation on this analysis procedure was dropped.

6.3. PRESENCE OF OTHER POLLUTANTS AFTER BIO SORPTION

Analysis was conducted to determine the effectiveness in reducing the concentration of other pollutants after the bio sorption process. The results showed that Bengal gram husk could effectively remove the entire pollutants to a non- detectable level. It is evident from the comparison figure 30 that the treated effluent was crystal clear compared to the deep yellow color of sample. Hence it is proved that Bengal gram husk can be most suitable for the removal of heavy metals as well as other pollutants of electroplating industrial effluents.

7.RESULT AND DISCUSSIONS

7.1. SHORT TERM TEST RESULT

Short term test results of samples (pH of 3.76 & 2.18) taken on two occasions were carried out on trial basis with rate of flow at 0.125 ml/min. and depth of adsorbent at 20cm. The results are shown in table 5.1. & 5.2.The results show a percentage reduction of heavy metals around 99.9%.

7.1.1. Column test result of sample taken on first occasion.

DEPTH OF ADSORBENT – 20 CM
INFLUENT FLOW RATE – 0.125ML/MIN
(BENGAL GRAM HUSK)

TABLE.3 COLUMN TEST RESULT OF SAMPLE TAKEN ON FIRST OCCASION

NAME OF PARAMETERS	PRESCRIBED LIMITS OF KSPCB(MG/1)	INFLUENT	EFFLUENT	% REDUCTION
PH	6-9	3.76	3.1	-
Cr(mg/L)	2	216.2	0.432	99.8%
Ni(mg/L)	3	209.375	0.166	99.92%
Zn(mg/L)	5	662.625	0.9972	99.85%
Cu(mg/L)	3	378.4	0.058	99.98%
Fe(mg/L)	3	625.62	0.187	99.97%

7.1.2. COLLUMN TEST ANALYSIS RESULT OF SAMPLE TAKEN ON SECOND OCCASION

DEPTH OF ADSORBENT – 20 CM
INFLUENT FLOW RATE – 0.125ML/MIN
(BENGAL GRAM HUSK)

TABLE.4. COLUMN TEST RESULT OF SAMPLE TAKEN ON FIRST OCCASION

NAME OF PARAMETERS	PRESCRIBED LIMITS OF KSPCB(MG/1)	INFLUENT	EFFLUENT	% REDUCTION
PH	6-9	2.18	2.18	-
Cr(mg/L)	2	11.1	0.365	97
Ni(mg/L)	3	31.5	0.33	99
Zn(mg/L)	5	13.55	1.4	93
Cu(mg/L)	3	7.25	0.064	99.1
Fe(mg/L)	3	14.2	0.043	99.6

7.1.3. Selection of optimum depth, rate of flow and pH

In order to find out an optimum depth of adsorbent,pH and rate of flow, the short-term test was carried out with different depth of adsorbent , pH and rate of flow.

Selection of optimum depth of adsorbent

To find out an optimum depth of adsorbent in use, short term tests were conducted with depths of 10cm, 15cm & 25cm keeping the flow rate as 0.125 ml/min. The results are shown in table 5,6 & 7

TABLE.5.COLUMN ANALYSIS RESULT WITH ADSORBENT DEPTH OF 10CM

NAME OF PARAMETERS	PRESCRIBED LIMITS OF KSPCB (MG/1)	INFLUENT	EFFLUENT	% REDUCTION
PH	6-9	2.18	2.18	-
Cr	2(PPM)	11.1	0.467	95
Ni	3(PPM)	31.5	0.43	98
Zn	5(PPM)	13.55	1.69	87
Cu	3(PPM)	7.25	0.039	99.5
Fe	3(PPM)	14.2	0.8	94

TABLE.6.COLUMN ANALYSIS RESULT WITH ADSORBENT DEPTH OF 15CM

NAME OF PARAMETERS	PRESCRIBED LIMITS OF KSPCB(MG/1)	INFLUENT	EFFLUENT	% REDUCTION
PH	6-9	2.18	2.18	-
Cr(mg/L)	2	11.1	0.14	99
Ni(mg/L)	3	31.5	0.41	99
Zn(mg/L)	5	13.55	BDL	100
Cu(mg/L)	3	7.25	0.017	99.7
Fe(mg/L)	3	14.2	0.839	94

TABLE.7. COLUMN ANALYSIS RESULT WITH ADSORBENT DEPTH OF 25CM

NAME OF PARAMETERS	PRESCRIBED LIMITS OF KSPCB(MG/1)	INFLUENT	EFFLUENT	% REDUCTION
PH	6-9	2.18	2.18	-
Cr(mg/L)	2	11.1	0.1	99
Ni(mg/L)	3	31.5	0.28	99
Zn(mg/L)	5	13.55	BDL	100
Cu(mg/L)	3	7.25	0.012	99.8
Fe(mg/L)	3	14.2	0.5	96

On analyzing the results, it was observed that a 99% removal of heavy metals was achieved in all the above tests. However on long term test, the life of the column with adsorbent depths of 10 & 15cm were comparatively less. Results with column depth of 20 and 25cms, were almost the same and hence to minimize the use of adsorbent quantity, further tests were carried out with 20cm column depth.

Selection of optimum rate of flow

Short term analysis was carried out with different rate of flow such as 0.125, 0.535, 2.46, 3.4, 15.8 and 22.4 ml/min. The results are shown in Table. 8.

TABLE.8. ANALYSIS RESULT WITH INFLUENT OF DIFFERENT FLOW RATE

PARAMETERS	KSPCB	FLOW RATE (ml/min)					
	LIMITS (mg/i)	0.125	0.533	2.46	3.4	15.8	22.4
Cr	2	0.36	1.3	1.52	6.3	9.8	10
Ni	3	0.33	0.48	0.72	3.4	7	7.8
Zn	5	1.47	1.83	2.37	3.8	4.6	5
Cu	3	0.064	0.23	0.34	3.13	7.1	7
Fe	3	0.21	2.3	2.81	5.2	14	14.1

An optimum value is obtained for 2.46 ml/min.

Selection of optimum pH

Short term analysis was carried out with different pH values of samples such as 2,3,4 and 5. The results are shown in Table .9

TABLE.9 ANALYSIS RESULT WITH INFLUENT OF DIFFERENT PH

PARAMETERS	KSPCB	PH			
	LIMITS (mg/i)	2	3	4	5
Cr	2	0.365	0.133	0.222	0.131
Ni	3	0.33	0.027	0.048	0.0
Zn	5	1.47	0.1321	0.2154	00.1488
Cu	3	0.064	0.013	0.034	0.012
Fe	3	0.043	0.288	1.45	0.545

The result shows an optimum value for pH at 5. .

7.2. LONG TERM TEST RESULT

Long term tests were carried out with optimum values of rate of flow, column depth and without variation in the pH of influent (2.18), so as to avoid the use of chemicals. The tests results are shown in Table.10.

The breakthrough curve was prepared for each parameter and are shown in fig 48 to 52.On analyzing the graphs it can be observed that the curve breaks after 21 hrs. of operation.

TABLE.10 LONG TERM TEST RESULT WITH PH 2.18

PARAMETERS	INITIAL CONCENTRATION (mg/1)	Ist 7hrs	2nd 7hrs	3rd 7hrs	4th 7hrs	5th 7hrs	6th 7hrs	7th 7hrs
Cr. Limit-2	11.1	0.13	0.25	0.38	1.4	4.58	10	11
Ni. Limit-3	31.5	0.054	0.0.82	0.21	0.48	12	28	28
Zn. Limit-5	13.5	0.266	0.373	1.82	2.1	6.2	12.5	12.5
Cu. Limit-3	7.25	0.018	0.027	0.108	0.156	6.1	6.8	7
Fe Limit-3	14.2	0.64	1.021	3.1	6.3	8.1	8	9

Long term test result with pH raised to 5

In order to increase the life of column (saturation period),pH raised to the optimum value of 5, Long test was carried out and the results are shown in Table.11.

TABLE.11 LONG TERM TEST RESULT WHEN PH RAISED TO 5

Parameters (ppm)	Ist 7hrs	2nd 7hrs	3rd 7hrs	4th 7hrs	5th 7hrs	6th 7hrs	7th 7hrs	8th 7hrs	9th 7hrs`	10th 7hrs
Cr. Limit-2	0.045	0.048	0.053	0.064	0.074	0.18	1.74	2.9	3.7	5.8
Ni. Limit-3	0.04	0.071	0.083	0.097	0.13	0.27	0.48	2.81	5.7	8.01
Zn Limit-5	0.132	0.24	0.27	0.28	0.59	0.63	0.79	1.53	2.51	3.12
Cu. Limit-5	0.132	0.24	0.27	0.28	0.59	0.63	0.79	1.53	2.51	3.12
Cu. Limit-3	0.007	0.007	0.011	0.018	0.019	0.09	0.35	0.78	1.51	2.93
Fe Limit-3	ND	ND	ND	ND	5.5	6.1	6.8	7.5	7.9	8.2

ND-Non detectable

This analysis showed that when pH was raised, the life of column was increased considerably. The breakthrough curve of each parameter is shown in fig. 53 to 56.It can be noticed that the breakthrough point has been shifted from 21 hrs to 42 hrs.

7.3. BATCH STUDY TEST RESULT FOR ADSORPTION ISOTHERM

Batch study test was carried out with different adsorbent quantity keeping influent quantity as 100-ml,rpm-120 and contact time -120min. The test result is shown in Table.12.

TABLE.12 TEST RESULT OF BATCH STUDY FOR ISOTHERM CALCULATION

PARAMETERS (PPM)	0.5gm	1gm	1.5gm	2gm
Cr	10	9.7	5.1	3.4
Ni	26	22	12	10
Zn	12	11	8	5
Cu	5	3	2.9	1.592
Fe	4.8	4.7	3.6	3.2

Langmuir and Freundlich Isotherm curve were drawn for nickel and chromium . The isotherms are shown in figures 44 of 47.It was obsereved that the curve is best fit for freundlich isotherm. The adsorbent required for particular treatment efficiency can be calculated from the isotherm.

7.4. TEST RESULT OF DOUBLE ADSORPTION

In order to achieve a 100% removed of heavy metal, double adsorption test with two columns in series were also done with adsorbent depths of 20cm & 10cm respectively, keeping the rate of flow as 2.46 ml/min and pH 2.18.The test result are shown in Table.13

TABLE.13TEST RESULT OF DOUBLE ADSORPTION

PARAMETERS& LIMIT IN PPM	CONC BEFORE TREATEMT (PPM)	CONC. AFTER TREATEMENT (PPM)	CON.AFTER DOUBLE ADSORPTION AT 10CM DEPTH
Cr.2	11.1	0.365	0.364
Ni-3	31.1	0.33	0.04
Zn-5	13.5	1.4	0.1
Cu-3	7.25	0.064	0.02
Fe-3	14.2	0.043	0.038

Since 100% removal of heavy metal could not be arrived at , continuation on this analysis procedure was dropped.

5.5. PRESENCE OF OTHER POLLUTANTS AFTER BIOSORPTION

Analysis were conducted to determine the effectiveness in reducing the concentration of other pollutants after the biosorption process. The results showed that Bengal gran husk could effectively remove the entire

TABLE.14. VARIATION IN CONCENTRATION OF PARAMETERS OTHER THAN HEAVY METAL

PARAMETERS	RAW SAMPLE	TREATED SAMPLE
TOTAL RESIDUAL CHLORINE (LIMIT-1)	0.1(MG/1)	ND
SUSPENDE SOLID (LIMIT – 100)	30(MG/1)	ND
OIL & GREASE (LIMIT -10)	6(mg/1)	ND

pollutants to a non- detectable level. Hence it is evident that Bengal gfram husk can be used for the removal of heavy metals as well as other pollutants from the electroplating industrial effluents. The test results are shown in Table.14.

8.COST COMPARISON

8.1 A SAMPLE CALCULATION FOR COST EFFECTIVENESS OF BIOSORPTION Vs CONVENTIONAL EFFLUENT TREATMENT

Considering a small scale industry discharging 2000 liters of effluent per day.As per the study the optimum rate of flow is 2.46ml/min. Long term study shows that for an optimum column depth of 20cm, the adsorbent required is 5mg for 35 hrs and the corresponding effluent treated is 5166ml (2.46mlx60minx35hrs) approximately 5000ml (5lits). Thus for treating 1000 lits of effluent, adsorbent required is 5 kg. Cost analysis for treating 1000 lits of effluent (as per date obtained from the industry)

TABLE.14EFFECTIVENESS OF BIOSORPTION VS CONVENTIONAL EFFLUENT TREATMENT

CONVENTIONAL (CHEMICAL ADDITION)	BIOSORBENT
COST OF CHEMICAL – 150	COST OF ADSORBENT – NIL
TRANSPORTATION- 150	COLLECTION & TRANSPORTATION- Rs.50
LABOUR – Rs.300 POWER- Rs.200	LABOUR- RS.300 POWER- 50
TOTAL- Rs.800	TOTAL- Rs- 400

The sample calculation shows (Table.14) that by adopting the method of bio sorption a cost reductio9n of 50% can be achieved. Over and above, all the environment pollution could be averted completely.

9. CONCLUSION

Heavy metal pollution by electroplating industries is an environmental problem of wide concern. Remediation of this problem with economic, environment friendly and convenient methods are highly desirable rather than conventional treatment methods. Based on metal binding capacities of various biological materials, removal of toxic metals from wastewaters has directed attention of bio sorption. All the referred previous bio sorbents studies were aimed at the removal of a particular heavy metal from the effluent. However in the present study, analysis with column depth of 20cm Bengal gram husk as bio sorbent showed optimum result for an effluent with flow rate of 2.46ml/min. and at a PH of 5. Thus it is proved that among the various bio sorbents analyzed, Bengal gram husk is the most effective bio sorbent for the removal of various heavy metals as well as other general pollutants from a complex effluent. It is observed that decolourization of the effluent can also be achieved during this process. With a slight pH variation, the life of the adsorbent can be raised to a countable period and there by the economic feasibility can be ensured. Thus this treatment system can be suggested as more advantageous to small scale units. Thus it is concluded that,

- ❖ Bio sorption is an environment friendly alternative to conventional treatment systems for the removal of heavy metals from electroplating industrial effluents.
- ❖ It is proved that Bengal gram husk can be used for the removal of hazardous heavy metal as well as total treatment of electroplating industrial effluent.
- ❖ Bengal gram husk is cost effective, high efficient and it minimizes hazardous sludge formation.

10. SCOPE FOR FURTHER STUDIES

Being an environment friendly and economically viable treatment method, the possibility of implementing bio sorption using Bengal gram husk as an alternative to the present conventional treatment system may be suggested by the regulatory authorities. A detailed study be conducted to explore the possibility of valuable heavy metal recovery from the bio sorbents. Further studies can also be done for the regeneration of bio sorbent and to arrive at a treatment method free of chemical addition at any stages. Surface characteristics of the bio sorbents can be analyzed and its applications in various other fields may be explored.

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