"REMOVAL OF HEAVY METALS BY ADSORPTION USING MAGNETITE NANOPARTICLES COATED SAND"

A Thesis

Submitted in partial fulfillment of the requirements for the award of the degree of

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Under the supervision of

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to

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CERTIFICATE

This is to certify that the work which is being presented in the thesis titled **“Removal Of Heavy Metals By Adsorption Using Magnetite Nanoparticles Coated Sand”** in partial fulfillment of the requirements for the award of the degree of Master of Technology in Civil Engineering with specialization in “**Environmental Engineering”** and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by SahilLakhanpal (Enrolment No. 152755)during a period from June 2016 to May 2017 under the supervision of Dr. Rajiv Ganguly Associate Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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ABSTRACT

As we know that day by day pollution is increasing in our surroundings, Lethal substantial metal particles get acquainted with the sea-going streams by methods for different industrial exercises viz. pharmaceutical, mining, refining metals, manure ventures, tanneries, batteries, paper enterprises, pesticides and so forth and have a genuine danger to human beings and environment. In this thesis study we focuses on the removal of heavy metal (chromium) from the wastewater stream of the industries (pharmaceutical) by Adsorption using magnetite coated sand. So in this study we saw the removal efficiency of the heavy metal ion with the suitable amount of adsorbent dosage and also the affects of contact time on the removal efficiency of the heavy metal ion. At last we learn about the Freundlich and Langmuir isotherm. And also find the constants for them.

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CHAPTER-1

INTRODUCTION

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Toxic heavy metal ions get acquainted with the sea-going streams by methods for different mechanical exercises viz. Mining, refining minerals, compost ventures, tanneries, batteries, paper businesses, pesticides and so on and have a genuine danger to environment. The major poisonous metal particles perilous to people and also different types of life are Cr, Fe, Se, V, Cu, Co, Ni, Cd, Hg, As, Pb, Zn and so on. These heavy metals are of particular worry because of their harmfulness, bio-amassing inclination and persistency in nature. A few past disasters because of the pollution of substantial metals in oceanic streams are Minamata disaster in Japan because of methyl mercury defilement and "Itai-Itai" because of sullying of cadmium in Jintsu waterway of japan.Various administrative bodies have set the most extreme recommended limits for the release of poisonous overwhelming metals in the amphibian frameworks. However the metal particles are being added to the water stream at a considerably higher fixation than as far as possible by modern exercises, in this manner leading to ecological degradation.and natural debasement.

Nanoscience and nanotechnology are progressively creating fields of logical enthusiasm for the whole world and have as of now wind up plainly key R&D (innovative work) needs in Europe and Since the 1990s there has been an exceptionally quick increment in the execution of nanotechnologies. Accomplishments around there find viable applications in many fields of industry and everyday life, e.g. In solution – from helpful and indicative prescription to surgery.). In 2004, yearly generation of nanomaterials added up to around 1000 tons. It is assessed that there are now more than 800 items in light of nanotechnologies in ordinary utilize and numerous new nanoproducts are relied upon to show up available inside the following couple of years. As per the patent databases Espacenet and USPTO, saw in December 2007, we can evaluate that there are a couple of thousand licenses depicting diverse strategies for blend of nanoparticles and more than 1600 as per the 27th Report of Royal Commission on Environmental Pollution.

1.2 NEED OF THE STUDY

Discharge of industrial, domestic and agriculture waste in rivers and lakes cause deposit of pollutants in sediments. Such pollutants include heavy metals, which danger for human health after being incorporated in food chain. Heavy metals cannot be destroyed through biological degradation, as is the case with most organic pollutants.

Incidence of heavy metals accumulation in fish, oysters, mussels, sediments and other components of aquatic ecosystems have been reported from all over the world. The problem of metal pollution in water and aquatic organisms including fish, needs continuous monitoring and surveillance as these elements do not degrade and tend to biomagnified in man through food chain

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1.3 OBJECTIVES OF THE STUDY

1. To prepare magnetite coated nanoparticle sand by doing the preparation procedure for magnetite formation.
2. To prepare a artificial heavy metal solution as by taking a chromium compound (Chromium(III)sulphate) which can be dissolved in water or alcohol and then do the batch studies for the adsorption isotherms (Freundlich and Langmuir).
3. Collect the samples from the industry producing heavy metals (chromium compounds) as there effluent waste and then do the batch studies for the adsorption isotherms (Freundlich and Langmuir).

1.4SCOPE OF THE STUDY

The thesis study focuses on developing a effluent treatment system for removal of heavy metals from industries. As earlier the other adsorbents are used for removal of heavy metals and with the advancement in the technologies I am using magnetite coated nanoparticle sand for removal of the heavy metals like (chromium, cadmium, lead etc.) from industrial effluent waste. As this method can be used for other heavy metal removal also. I am expecting better results this time from this research work. Study for removal of heavy metal can be done with other methods like Membrane filtration, Electro dialysis etc.

1.5 TECHNOLOGIES AND METHODS AVAILABLE FOR HEAVY METAL REMOVAL

In the few past years, heavy metal contamination in the waste water streams from the industries(like pharmaceutical, leather etc.) producing heavy metal compounds has become a global issue due to its toxicological and carcinogenic effects on humans as well as on the environment. Figure 1. Shows theexisting technologies for heavy metal removal.

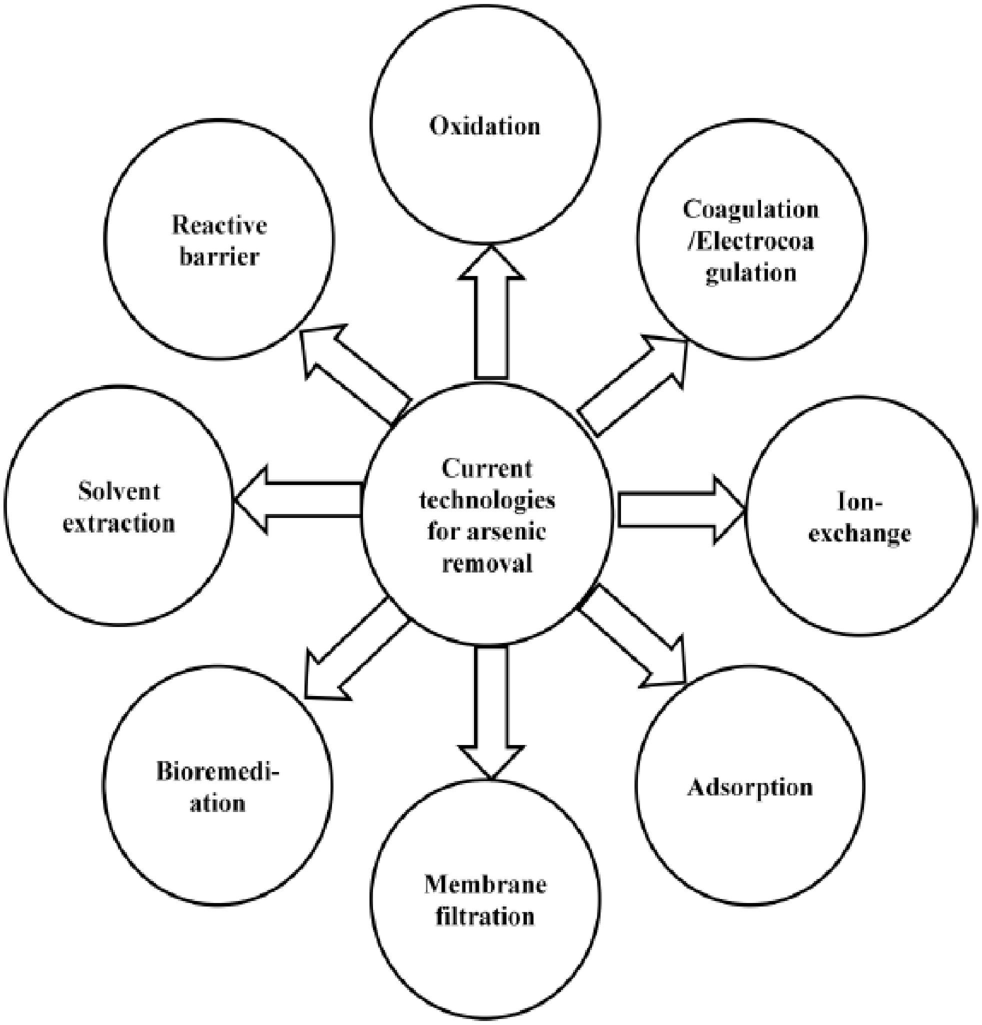

Figure 1 -Schematic of various existing technologies for heavy metal removal.

1.5.1 Adsorption

The main principle behind adsorption is that it involves interphase accumulation or concentration of substance at the surface or the interphase. The process can occur between any two phases such as liquid-liquid, gas-liquid or liquid-solid interphase. The material being concentrated or adsorbed is known as adsorbate and the adsorbing phase is known as adsorbent. It is a surface phenomenon.

1.5.2 Adsorption Isotherm

They give information about the behavior of different adsorbants (like silica gel). Any numerical relationship which shows the relationship between the:

1. Quantity of solute adsorbed,
2. Solute concentration,

At a fixed temperature is known as adsorption isotherm. Adsorption equations based on experimental data have been proposed by Langmuir and Freundlich methods. Langmuir and Freundlich methods are the most common methods of studying adsorption isotherms.

1.5.3 Langmuir Isotherm

It is based on the assumption that maximum adsorption corresponds to a saturated monolayer of solute molecules on the adsorbent surface that the energy of adsorption is positive and there is no migration of the adsorbate the surface.

The Langmuir equation is represented as:

$$\frac{\boldsymbol{C}}{\left(\frac{\boldsymbol{X}}{\boldsymbol{m}}\right)} = \frac{\mathbf{1}}{\boldsymbol{ab}} + \frac{\mathbf{1}}{\boldsymbol{a}} \times \boldsymbol{c}$$

Where:….equation 1.

1. X/m = Amount adsorbed per unit weight of adsorbent.
2. C = Concentration of adsorbate in solution after adsorption.
3. a,b = Empirical constants where: a= Number of moles of solute adsorbed per unit weight of adsorbent in forming a complete monolayer at the surface andb = constant related to energy of adsorption.

1.5.4 Freundlich Isotherm

The general form of Freundlich isotherm is represented as:

$$\log(\frac{X}{m}) = \log k + \frac{1}{n} \times \log C$$

……… equation 2.

Where:

1. X/m = Amount adsorbed per unit weight of adsorbent.
2. k,n = Constants for the particular system.
3. C = equilibrium concentration of adsorbate in solution after adsorption.

1.6 MAGNETITE NANOPARTICLES

1.6.1 Synthesis Of Magnetite Nanoparticles

There are a few strategies mentioned in the literature for the synthesisof magnetite nanoparticles. Figure 2. shows some of the generally used strategies, for example, co-precipitation, sol-gel, aqueous, micro emulsion, warm decay, sonochemical and electrochemical and so forth for magnetite nanoparticles. We have taken co-precipitation technique for the synthesis of magnetite nanoparticles on sand surface.

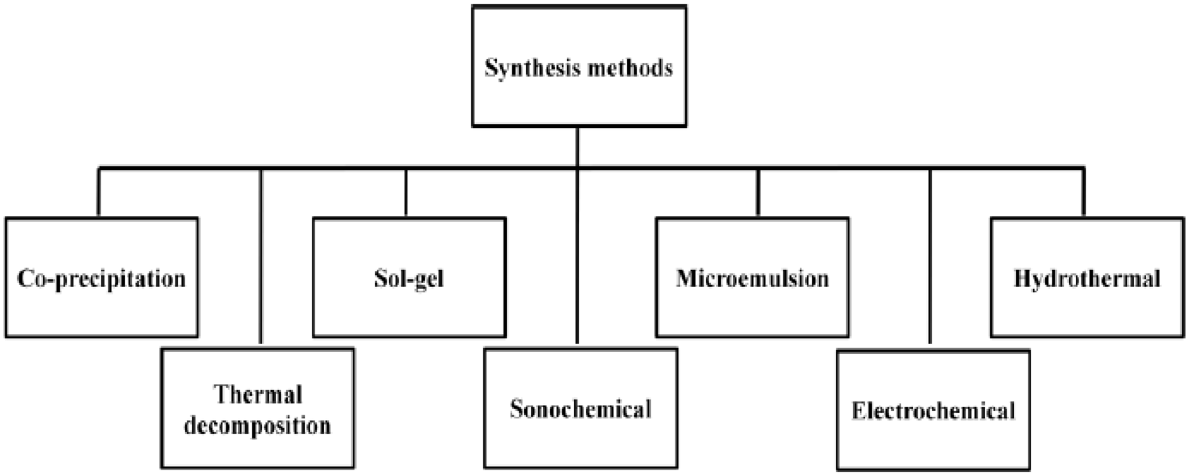

Figure 2 -Methods for synthesis of magnetite nanoparticles.

1.6.2 Factors Affecting Arsenic Removal Efficiency

Effect of contact time– The contact time amongst adsorbate and adsorbent is likewise an imperative component which impacts adsorption forms. Numerous examiners have concentrated the impact of contact time on substantial metal expulsion effectiveness by utilizing distinctive magnetite nanosystems and announced diverse balance time. The balance time is the time after which no more adsorption of overwhelming metal happens on adsorbent surface. The balance at various contact times have been accomplished because of various nature of the frameworks utilized.**Effect of adsorbent dose** – It is vital to know the base measure of adsorbent required to diminish the substantial metal fixation underneath MCLS esteem set by WHO i.e. 0.05 mg/L (shown in Table 1.). Along these lines adsorbent dosage is additionally a vital parameter examined by different scientists in adsorption forms. They watched that with increment in adsorbent fixation, the measure of the substantial metal adsorbed alongside the rate of adsorption increments accomplishing an ideal adsorbent dosage. This is because of the way that expanded adsorbent dosage gives huge number of surface restricting destinations for overwhelming metal adsorption. In the wake of accomplishing ideal measurements, additionally increment in adsorbent dosage does not bring about noteworthy change in overwhelming metal evacuation productivity because of lacking substantial metal particles show in arrangement concerning accessible surface destinations.

Heavy Metal	Atomic Number	MCLS(mg/l)
Copper	29	0.25
Arsenic	33	0.050
Cadmium	48	0.01
Lead	82	0.006
Nickel	28	0.20
Chromium	24	0.05
Fluoride	09	1.5

Table 1 – The maximum contamination limit standards (MCLS).

CHAPTER – 2

LITERATURE REVIEW

CHAPTER 2: LITERATURE REVIEW

2.1 CASE STUDY: “METHOD OF EXTRACTING HEAVY METALS FROM INDUSTRIAL WASTE WATERS” [1]

A technique is accommodated extricating metal polluting influences from waste water to which ferrous particles are added to give no less than two times the measure of ferrous particles on the mol premise to the measure of metal particles introduce, 'the subsequent arrangement containing corrosive radicals, a base being added to the Solution to fraise the ph to shape a suspension of metal hydroxides, taking after which an, oxidizing gas is risen in answer for frame precious stones containing ferric particles and further containing the metal particles initially in arrangement, the encouraged gems being from there on isolated to give clean water.

2.2 CASE STUDY: “AGRICULTURAL WASTE MATERIAL AS POTENTIAL ADSORBENT FOR SEQUESTERING HEAVY METAL IONS FROM AQUEOUS SOLUTIONS” [2]

Heavy metal remediation of watery streams is of uncommon worry because of refractory and persistency of substantial metals in condition. Ordinary treatment advances for the evacuation of these dangerous overwhelming metals are not efficient and additionally produce enormous amount of lethal synthetic slime. Biosorption is developing as a potential contrasting option to the current ordinary advancements for the expulsion as well as recuperation of metal particles from fluid arrangements. The significant favorable circumstances of biosorption over regular treatment strategies include: ease, high proficiency, and minimization of concoction or organic slop, recovery of biosorbents and probability of metal recuperation. Cellulosic horticultural waste materials are a plenteous hotspot for huge metal biosorption. The utilitarian gatherings introduce in horticultural waste biomass viz. Acetamido, alcoholic, carbonyl, phenolic, amide, amino, sulfhydryl bunches and so forth have liking for substantial metal particles to frame metal edifices or chelates. The component of biosorption process incorporates chemisorption, complexation, adsorption on surface, dissemination through pores and particle trade and so on. The motivation behind this survey article is to give the scattered accessible data on different parts of usage of the farming waste materials for overwhelming metal evacuation. Horticultural waste material being very effective, ease and inexhaustible wellspring of biomass can be misused for substantial metal remediation. Encourage these biosorbents can be altered for better proficiency and various reuses to upgrade their materialness at mechanical scale.

2.3 CASE STUDY: “LOW-COST MAGNETIC ADSORBENT FOR AS(III) REMOVAL FROM WATER: ADSORPTION KINETICS AND ISOTHERMS” [3]

Magnetite nanoparticles as adsorbent for arsenic (As) were covered on sand particles. The covered sand was utilized for the expulsion of very dangerous component "As(III)" from drinking water. Here, clump investigations were performed with the variety of arrangement ph, adsorbent dosage, contact time and beginning arsenic focus. The adsorbent indicated huge expulsion productivity around 99.6%for As(III). Investigation of adsorption energy uncovered that the adsorbent takes after pseudo second-arrange energy display indicating R2 = 0.999, though for pseudo-first-arrange energy demonstrate, the estimation of R2 was 0.978. On account of adsorption harmony, the information is very much fitted with Langmuir adsorption isotherm demonstrate (R2 > 0.99), showing monolayer adsorption of As(III) on the surface of adsorbent. The presence of ordinarily present particles in water impacts the evacuation effectiveness of As(III) minutely in the accompanying request PO43−>HCO3−>Cl−>SO42−. The got adsorbent can be utilized to conquer the issue of water filtration in rustic territories. Besides, as the nano-magnetite is covered on the sand, it maintains a strategic distance from the issue of extraction of nanoparticles from treated water and can without much of a stretch be evacuated by a basic filtration handle.

2.4 CASE STUDY: “MAGNETITE NANOPARTICLES COATED SAND FOR ARSENIC REMOVAL FROM DRINKING WATER” [4]

In this paper, interestingly we depict the expulsion of noxious component 'arsenic (V)' from drinking water by nanoscale magnetite covered sand. The expulsion effectiveness of recently framed adsorbent was considered by differing different parameters, for instance, contact time, pH, adsorbent dose and introductory As(V) focus. Additionally, the trials were performed within the sight of coinciding cations (Zn2? Cd2? Pb2? Ni2? Mg2? Cr3? What’s more, Fe3?). To concentrate their impact on As(V) expulsion proficiency. The adsorption energy information fitted well in both the pseudo-first request and pseudo-second-arrange energy with high connection coefficients (R2 [0.99). Adsorption isotherm information are fitted in Langmuir and Freundlich isotherm models. It is watched that in this manner framed adsorbent shows huge As(V) evacuation effectiveness, and decreases the As(V) fixation beneath 5 lg/L from 6700 lg/L, which is a great deal not as much as the most extreme contaminant level set by WHO (10 lg/L). Here, the existing together cations don't demonstrate any huge impact on As(V) expulsion proficiency. The watched Freundlich adsorption limit of 2.06 mg/g for As(V) expulsion is similar with certain different adsorbents.

2.5 CASE STUDY: “MAGNETIC POLYMER NANOCOMPOSITES FOR ENVIRONMENTAL AND BIOMEDICAL APPLICATIONS” [5]

Cross breed nanomaterials have gotten voluminous enthusiasm because of the mix of remarkable properties of natural and inorganic segment in one material. In this class, attractive polymer nanocomposites are specifically noteworthy on account of the blend of amazing attractive properties, steadiness, and great biocompatibility. Organic–inorganic attractive nanocomposites can be set up by in situ, ex situ, microwave reflux, co-precipitation, liquefy mixing, and ceramic–glass preparing and plasma polymerization systems. These nanocomposites have been misused for in vivo imaging, as super paramagnetic or negative complexity specialists, sedate transporters, substantial metal adsorbents, and attractively recoverable photograph impetuses for debasement of natural poisons. This audit article is chiefly centered around manufacture of attractive polymer nanocomposites and their applications. Diverse sorts of attractive nanoparticles, strategies for their blend, properties, and applications have likewise been checked on quickly. The survey additionally gives point by point knowledge into different sorts of attractive nanocomposites and their blend. Various utilizations of attractive nanocomposites including natural and biomedical uses have been examined.

2.6 CASE STUDY: “ADSORPTION OF HEAVY METAL IONS FROM AQUEOUS SOLUTIONS BY ACTIVATED CARBON PREPARED FROM APRICOT STONE” [6]

Apricot stones were carbonized and actuated after treatment with sulphuric corrosive (1:1) at 200 C for 24 h. The capacity of the initiated carbon to evacuate Ni(II), Co(II), Cd(II), Cu(II), Pb(II), Cr(III) and Cr(VI) particles from fluid arrangements by adsorption was researched. Clump adsorption trials were led to watch the impact of ph (1–6) on the enacted carbon. The adsorptions of these metals were observed to be reliant on arrangement ph. Most astounding adsorption happened at 1–2 for Cr(VI) and 3–6 for the rest of the metal particles, individually. Adsorption capacities with regards to the metal particles were acquired in the sliding request of Cr(VI) > Cd(II) > Co(II) > Cr(III) > Ni(II) > Cu(II) >Pb(II) for the enacted carbon arranged from apricot stone (ASAC).

2.7 CASE STUDY: “REMOVAL OF HEAVY METALS FROM WASTEWATER BY ADSORPTION ON COIR PITH ACTIVATED CARBON” [7]

The initiated carbon arranged from coconut coir substance by potassium hydroxide initiation was found to display wonderful adsorption limit for cadmium, copper, and zinc. Group balance tests appeared that the degree of metal expulsion was observed to be subject to introductory focus, contact time, ph, and carbon measurement. It was found that at ph values beneath 3, the adsorption of metal particles was less and was powerful above ph 6. The metal particle sorption was found to take after the Freundlich display. The energy of adsorption of metal particles took after Ist arrange. The agglomerated coir substance carbon was assessed for the impact of stream rate and bed profundity in section tests. Direct connections between bed profundity and administration time were acquired for all the metal particles by performing bed-profundity benefit time (BDST) examination. The adsorbed metal particles could be quantitatively recuperated by utilizing 1.0 M hcl, and the limit of carbon stayed unaffected when put to rehashed use for the expulsion of metal particles from watery arrangements. The effectiveness of carbon when connected to modern effluents was observed to be unrivaled in expulsion of metal particles contrasted and the business ones.

2.8 CASE STUDY:“HEAVY METALS REMOVAL FROM WASTEWATER BY ADSORPTION PROCESS: A REVIEW” [8]

Substantial metals are harmful and impeding water contamination. Their nearness influences people as well as creatures and vegetation due to their portability in watery environment, danger and non-biodegradability. Expulsion of overwhelming metals from the profluent is one of the significant research completed by scientists in the field of condition. Albeit diverse strategies, for example, Ion trade, precipitation, dissipation, layer filtration and adsorption are utilized for overwhelming metals evacuation, adsorption handle has pulled in consideration of numerous analysts due to minimal effort, outline adaptability, and high productivity. The present survey is centered around the overwhelming metals evacuation in view of the execution of different adsorbents, for example, normal materials, modern side effect, agrarian and organic waste, biopolymers and hydrogels. The goal of this review is to contribute in the look for ease adsorbents and examine the parameters that impact the adsorption of substantial metals on adsorbents.

2.9 CASE STUDY: “HEAVY METALS REMOVAL USING ACTIVATED CARBON, SILICA AND SILICA ACTIVATED CARBON COMPOSITE” [9]

Substantial metal contamination has turned out to be a standout amongst the most genuine ecological issues these days. The evacuation of substantial metals from the earth is of exceptional worry because of their constancy. Clump analyses were directed to test the capacity of enacted carbon for the evacuation of lead, cadmium, nickel, chromium and zinc from water. The Langmuir and Freundlich adsorption isotherms were utilized to confirm the adsorption execution. Nickel demonstrated the most noteworthy expulsion rates by enacted carbon at all fixations and the expulsion rates diminished as the grouping of overwhelming metal expanded. The gotten connection coefficient (R2) for various adsorbents recommended poor fitting of the trial information to Langmuir isotherm for Cd, Pb, Ni, and Zn, while R2 got utilizing Freundlich show for various adsorbents demonstrated that it fitted the test information well. Silica/initiated carbon (2:3) composite was more productive in the expulsion of nickel particles than enacted carbon and silica nanoparticles. SEM pictures were taken for the three particles under test.

2.10 CASE STUDY: “HEAVY METAL REMOVAL FROM WASTEWATER USING LOW COST ADSORBENTS” [10]

With the onset of industrialization humankind has seen different natural issues in the general public. This industrialization has brought advancement and flourishing as well as in the long run aggravated the biological system. One of the effects is obvious, in type of water contamination. In the present review overwhelming metal defilement of water bodies has been examined. Effluents from expansive number of ventures viz., electroplating, calfskin, tannery, material, color and colors, paint, wood preparing, oil refining, photographic film generation and so on., contains noteworthy sum of substantial metals in their wastewater. The regular strategies for treatment of overwhelming metal tainting incorporates synthetic precipitation, compound oxidation, particle trade, layer partition, turn around osmosis, electro dialysis and so on. These strategies are expensive, vitality escalated and frequently connected with era of dangerous repercussions. In this way,adsorption has been explored as a financially savvy technique for expulsion of substantial metals from wastewater. In the present review different minimal effort adsorbent has been surveyed as a decrease of overwhelming metal contamination from wastewater. These adsorbent incorporates materials of common source like zeolites, earth, peat greenery and chitin are found tobe a successful operator for expulsion of poisonous overwhelming metals like Pb, Cd, Zn, Cu, Ni, Hg, Cr and so forth. Aside from these different farming squanders like rice husk, neem bark, dark gram, squander tea; Turkish espresso, walnut shell and so forth were too built up as an intense adsorbent for substantial metal evacuation. Next to that minimal effort modern by items like fly fiery debris, impact heater slime, squander slurry, lignin, press (III) hydroxide and red mud, espresso husks, Areca squander, tea manufacturing plant squander, sugar beet mash, battery industry squander, ocean knob deposit and grape stalk squanders have been investigated for their specialized practicality to expel lethal overwhelming metals from debased water.

2.11 CASE STUDY: “METAL IONS REMOVAL FROM WASTEWATER BY ADSORPTION” [11]

Three diverse carbonaceous adsorbents comprising of (i) financially accessible lignin (L); (ii) carbon residue created by circular segment vanishing of graphite bars (AC); and (iii) industrially accessible carbon (RC) were utilized for the evacuation of hexavalent and trivalent chromium, and the cations of lead and zinc. Air conditioning carbon was found to specifically adsorb just the hexavalent type of chromium which exists as a number of anionic species in the water. Inconsequential metal cation adsorption was seen with AC. Be that as it may, lignin is found to adsorb all the metal particles utilized in the review. RC utilized as a part of this examination adsorbs just the metal cations and does not evacuate the hexavalent type of chromium utilized. Harmonyand also active information acquired are dissected in light of a numerical model created which accept that the general metal expulsion rate is controlled by the rate of mass transport of solute from mass to the surface of the adsorbent.

2.12 CASE STUDY: “REMOVAL OF HEAVY METALS PB2+, CU2+, ZN2+, CD2+, NI2+, CO2+ AND FE3+ FROM AQUEOUS SOLUTIONS BY USING XANTHIUM PENSYLVANICUM” [12]

The unsafe sick impact of overwhelming metals on nature and open wellbeing involves genuine concern. Biosorption is developing as an economical powerful innovation. Overwhelming metals in water assets are a standout amongst the mostvital natural issues of nations. The heightening of modern action and ecological anxiety incredibly adds to the critical ascent of overwhelming metal contamination in water assets making dangers on earthbound and amphibian life. The poisonous quality of metal contamination is moderate and wearisome, as these metal particles are non bio-degradable. The adsorption limit of Xanthium Pensylvanicum towards metal particles, for example, Pb2+, Cu2+, Zn2+, Cd2+, Ni2+, Co2+ and Fe3+, was examined. The adsorption limit was performed by cluster tries as an element of process parameters, (for example, sorption time and ph). Exploratory outcomes demonstrated that the evacuation rates expanding of metal particles at ph=4, starting grouping of metal particles 10 mg/L, and after 90 min of shaking was: Zn2+ < Cd2+ < Cu2+ < Pb2+ < Ni2+ < Fe3+ < Co2+.

2.13 CASE STUDY: “REMOVAL OF SOME HEAVY METALS FROM WASTEWATER BY USING OF FAVA BEANS” [13]

The fava beans were utilized as a part of this work as minimal effort adsorbent material for expulsion of pb(ii), cd(ii) also, zn(ii) particles from fluid arrangements. The specimens were set up without more remote treatment also, sorted by the particles measurement by standard sifters 250 - 500 µm. Cluster adsorption tests were done to concentrate the adsorption procedure, a few parameters, for example, initial ph of adsorbent, impact of contact time, impact of adsorbent sum and impact of metal fixation were led in these examinations. The impacts of any of those beforehand specified parameters on the adsorption limit were considered while alternate parameters were kept steady. It was found that the got most extreme adsorption limits of fave beans for the evacuation of chose overwhelming metals were high. This give us to utilize fava beans as a low drift adsorbent material to tidy up the water in the earth from harmful overwhelming metals, for example, pb(ii), cd(ii) and zn(ii) particles.

2.14 CASE STUDY: “NEW TRENDS IN REMOVING HEAVY METALS FROM INDUSTRIAL WASTEWATER” [14]

Inventive procedures for treating mechanical wastewater containing substantial metals regularly include advances for diminishment of danger keeping in mind the end goal to meet innovation based treatment principles.This article audits the current advancements and specialized pertinence of different medications for the expulsion of substantial metals from mechanical wastewater. A specific concentration is given to inventive physico-compound expulsion procedures, for example, adsorption on new adsorbents, film filtration, electro dialysis, and photo catalysis. Their points of interest and impediments in application are assessed. The principle working conditions, for example, ph and treatment execution are exhibited. Distributed investigations of 94 referred to references (1999–2008) are checked on. It is obvious from review that new adsorbents and film filtration are the most as often as possible contemplated what's more, broadly connected for the treatment of metal-defiled wastewater. In any case, in the close future, the most encouraging techniques to treat such complex frameworks will be the photocatalytic ones which expend shabby photons from the UV-close obvious area. They initiate both corruption of natural contaminations and recuperation of metals in one-pot frameworks. Then again, from the regular forms, lime precipitation has been found as a standout amongst the best intends to treat inorganic gushing with a metal grouping of >1000 mg/L. Note that the general treatment cost of metal-sullied water changes, contingent upon the procedure utilized and the nearby conditions. All in all, the specialized relevance, plant effortlessness and cost-adequacy are the key calculates choosing the most appropriate treatment for inorganic gushing.

2.15 CASE STUDY: "REMOVAL OF HEAVY METALS FROM WASTEWATER USING AGRICULTURAL AND INDUSTRIAL WASTES AS ADSORBENTS" [15]

Adsorption procedures are as a rule generally utilized by different scientists for the expulsion of overwhelming metals from waste streams and actuated carbon has been often utilized as an adsorbent. In spite of its broad use in water and wastewater treatment businesses, initiated carbon remains a costly material. As of late, the requirement for sheltered and conservative techniques for the end of overwhelming metals from defiled waters has required research enthusiasm toward the generation of minimal effort contrasting options to monetarily accessible enacted carbon. Hence, there is a pressing require that every single conceivable wellspring of agro-based reasonable adsorbents ought to be investigated and their practicality for the expulsion of substantial metals ought to be contemplated in detail. The target of this examination is to concentrate the use potential outcomes of more affordable adsorbents for the end of substantial metals from wastewater. Farming and modern waste by-items, for example, rice husk and fly fiery remains have be utilized for the disposal of overwhelming metals from wastewater for the treatment of the EL-AHLIA Company wastewater for electroplating businesses as a real contextual investigation. Comes about demonstrated that ease adsorbents can be productively utilized for the expulsion of overwhelming metals with a focus scope of 20–60 mg/l additionally, utilizing genuine wastewater demonstrated that rice husk was viable in the concurrent expulsion of Fe, Pb and Ni, where fly fiery debris was successful in the evacuation of Cd and C.

2.16CASE STUDY: “REMOVAL OF HEAVY METAL IONS FROM INDUSTRIAL WASTEWATER BY SCOLECITE” [16]

It is a vital target now to reuse treated mechanical waste water for washing, water system and so forth., to effectively oversee what's more, amplify Sudanese's water assets. The point of the present work was to concentrate the execution of common zeolite (scolecite) for expelling substantial metals from modern waste water. Normal zeolite store test was gathered from Bayooda betray. Regular zeolite utilized (scolecite) was described by XRD, XRF, SEM and FTIR instruments. The physical properties (ph, EC, TDS, COD, BOD, add up to hardness) and substance properties (Ni2+, Pb2+, Zn2+, Cd2+, Fe3+, Cr3+) of the gathered mechanical waste water tests were researched. Zeolite sorbed around 95.8, 88.1, 48, 50, 19.7 and 99.9% of Ni2+, Pb2+, Zn2+, Cd2+, Fe3+ and Cr3+ metal fixations separately. As per the rate sorption values, the selectivity arrangement of considered metals by common zeolite can be given as Cr3+>Ni2+<Pb2+<Cd2+<Zn2+>Fe3+. These outcomes demonstrate that characteristic zeolites hold awesome potential to expel cationic overwhelming metal species from modern wastewater.

CHAPTER- 3

RESEARCH METHODOLOGY

CHAPTER- 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

The heavy metal contamination in groundwater, runoffs, and wastewater streams has resulted in human poisoning and death. It causes skin, cardiovascular, neurological, and respiratory infection and additionally lung, bladder and kidney growth. Harmful substantial metal particles get acquainted with the oceanic streams by methods for different mechanical exercises viz. Mining, refining metals, manure businesses, tanneries, batteries, paper ventures, pesticides and so on. Also, have a genuine danger to condition. The major lethal metal particles dangerous to people and additionally different types of life are Cr, Fe, Se, V, Cu, Co, Ni, Cd, Hg, As, Pb, Zn and so on. These overwhelming metals are of particular worry because of their lethality, bio-aggregation inclination and persistency in nature. A few past calamities because of the defilement of substantial metals in oceanic streams are Minamata disaster in Japan because of methyl mercury pollution and "Itai-Itai" because of tainting of cadmium in Jintsu waterway of Japan. Different administrative bodies have set the most extreme endorsed limits for the release of harmful substantial metals in the oceanic frameworks (shown in Table1). However the metal particles are being added to the water stream at a significantly higher fixation than as far as possible by mechanical exercises, therefore prompting the wellbeing dangers and ecological corruption. WHO has published there last edition in 1993, WHO reduced maximum acceptable concentration level of chromium from 0.05 mg/L in the waste water streams.

As to remove toxic heavy metals from wastewater, USEPA evaluated various treatment technologies such as, “bioremediation, ion exchange, coagulation and filtration, reverse osmosis, electro-coagulation, adsorption etc.” Most of these methods has several disadvantages such as requirement of expensive equipments, sludge production, time consuming and complexity. Among these adsorption and coagulation are believed to be the cost effective methods, however coagulation needs skilled operator and shows more effectiveness only on some specific iron and aluminium salts. However, “the adsorption method due to its low cost, simplicity in design, sludge free operation, ease of operation and potential of regeneration has gained popularity.” However, if the adsorbent is chosen carefully and experiments are conducted in appropriate conditions then the adsorption based methods are capable of removing heavy metal to a much lower level than any other method. There are many types of adsorbents such as activated alumina (AA), iron based adsorbents (IBS), chitosan based adsorbents, graphene oxide composites, magnetic nanochains etc.

From all the various adsorbents iron oxide adsorbents are widely investigated to remove heavy metal ions solutions due to strong affinity of iron oxides towards the heavy metal ions. In the few past years, the use of nano particles in environmental protection techniques is increased due to there high surface area and small size. As doing different studies among all the different iron oxide nanoparticles, a magnetite (Fe_3O_4) nanoparticle has been proved to be suitable adsorbents owing to their strong adsorption capacity for heavy metal removal.

In this chapter we described the synthesis of adsorbent by coating magnetite nanoparticles on the sand surface with the help of the co-precipitation method. After this with the help of the chromium compounds (Chromium (III) sulphate) dissolved in water or alcohol, an artificial sample is made. Then batch experiments are performed to analyze the influence of adsorbent dose and contact time on heavy metal removal efficiency. Then we do the Langmuir and Freundlich isotherm studies respectively. Then at last collect the samples from the industry producing chromium as there waste and do the studies for the industrial samples.

3.2 SYNTHESIS AND CHARACTERIZATION OF MAGNETITE NANOPARTICLES COATED SAND

As in this chapter we study about the synthesis of adsorbent by coating magnetite nanoparticles on the sand surface. In this chapter we do the characterizations of the adsorbent (magnetite nanoparticles coated sand) to confirm the coating of magnetite nanoparticles on the sand surface.

3.2.1 Materials

Every one of the chemicals utilized as a part of this study were of investigative review and acquired from Sigma Aldrich. The chemicals were utilized as gotten without further cleansing. The arrangements were set up in milli-Q water. Milli-Q water was set up by utilizing milli-Q water cleansing framework (BiocellMilli-Q Millipore, Elix). For the synthesis of (Fe_3O_4) nanoparticles Iron (III) chloride hexahydrate ($fecl_3.6H_2O$), Iron (II) chloride ($fecl_2$) and ammonia water (NH_4OH) are used**. The substrate sand is taken from Beas river in Mandi district, Himachal Pradesh, India.** The substrate is then sieve analyzed and it is **73.2%** by weight and it is medium **coarse sand (2.00-0.425mm)**. Then the substrate (sand) is cleaned by using hydrochloric acid (hcl) and engrave by aquaregia (HNO_3 :hcl) solution in 1:3 ratio, respectively before use. To adjust the ph we use standard acid (0.1 M HNO_3) and base (0.1 M naoh) solutions and then it is measured with the help of an Oakton ph meter (ph 700 Benchtop Meter).

3.2.2 METHODS (COATING OF MAGNETITE NANOPARTICLES ON SAND SURFACE)

Take 200g sand is sieved with 600 microns' sieve in the lab. Then clean 100g of sieved sand withHCL (HCL wash). As the sand is to be dipped in hcl for 24 hours or 1 day (shown in Figure 3) . Then thoroughly 4-5 times wash the sand with distilled water until sand is cleaned. Then put the washed sand in the oven for its drying. At $70C^0$ sand is to be put into oven for 1 day. Artificial heavy metal solution is formed by dissolving Chromium (III) sulphate in water. Then take about 10-20g of sand in a heating container. Then the obtained clean sand was added to a stock solution of $Fecl_3$ and $Fecl_2$ in 2:1 ratio. Then the mixture was stirred for 30 mins at $70C^0$ temperature under **Argon** gas flow. Then for co precipitation reaction the base NH_4 OH solution was added drop wise until a ph close to 10.0 was attained. Also, the addition of NH_4 OH solution resulted in black color of the mixture due to co precipitation of Fe^{2+} and $Fe^{3+.}$ After the completion of reaction, the mixture was sealed in a vessel and aged for 2 days at room temperature. Then this mixture is filtered and after filtration was dried at around $85C^0$ temperature under **Argon** gas flow. In this process the magnetite nanoparticles were coated on sand surface. Then the magnetite nanoparticles coated sand was washed with distilled water until run off was clear. Then it was again dried at $85C^0$ for 3 hours in **Argon** gas environment. Finally, magnetite nanoparticles coated sand was cooled to room temperature and stored in (PVC) bottles for further use.

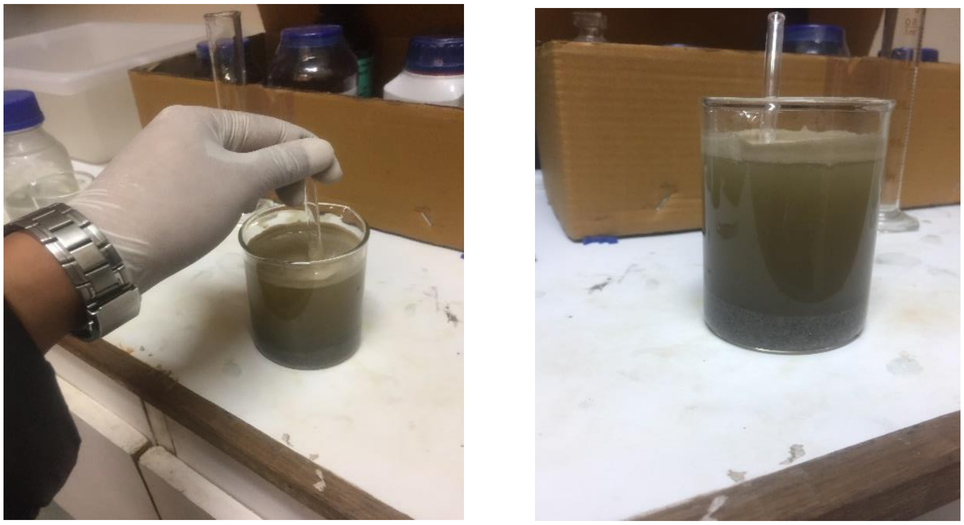

Figure 3(a) **Figure3(b)**

Figure 3(a,b) – HCL sand wash.

3.3 CHARACTERIZATION OF THE ADSORBENT

3.3.1 Physical Characterization

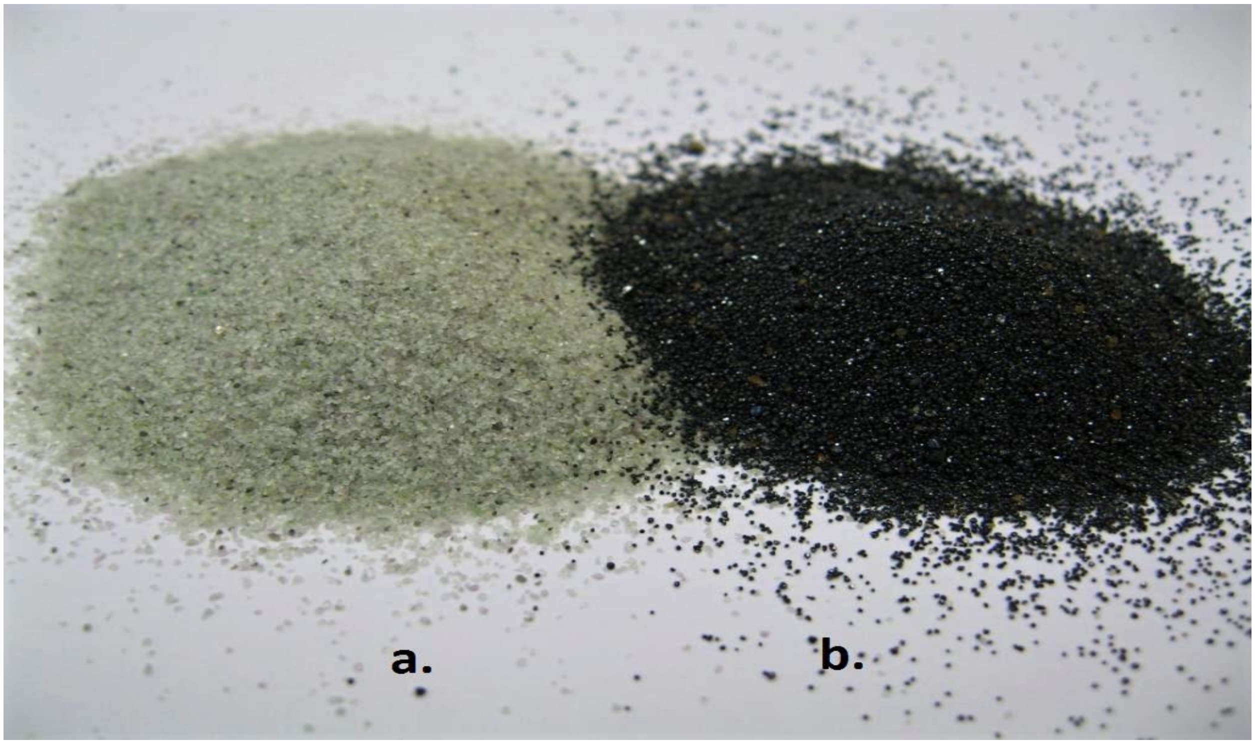

Figure 4 -(a) Bare sand particles before coating and (b) Fe3O4 coated sand particles.

As the Figure 4(a) and 4(b) shows the bare sand particles before coating and the (Fe3O4) coated sand particles. Before coating the sand particles appear grayish white in color and after coating it appears black, which indicates (Fe3O4) coating on the sand surface.

3.3.2 Magnetic Property

Figure 5(a) demonstrates that the uncovered sand particles are not pulled in by attractive globule, though magnetite nanoparticles covered sand is pulled in by the attractive dot (Figure 5(b)). This is on the grounds that the uncovered sand particles are non-attractive and magnetite nanoparticles are attractive in nature. Accordingly, the magnetite nanoparticles covered sand particles are pulled in by attractive globule affirming the arrangement of attractive material on sand surface.

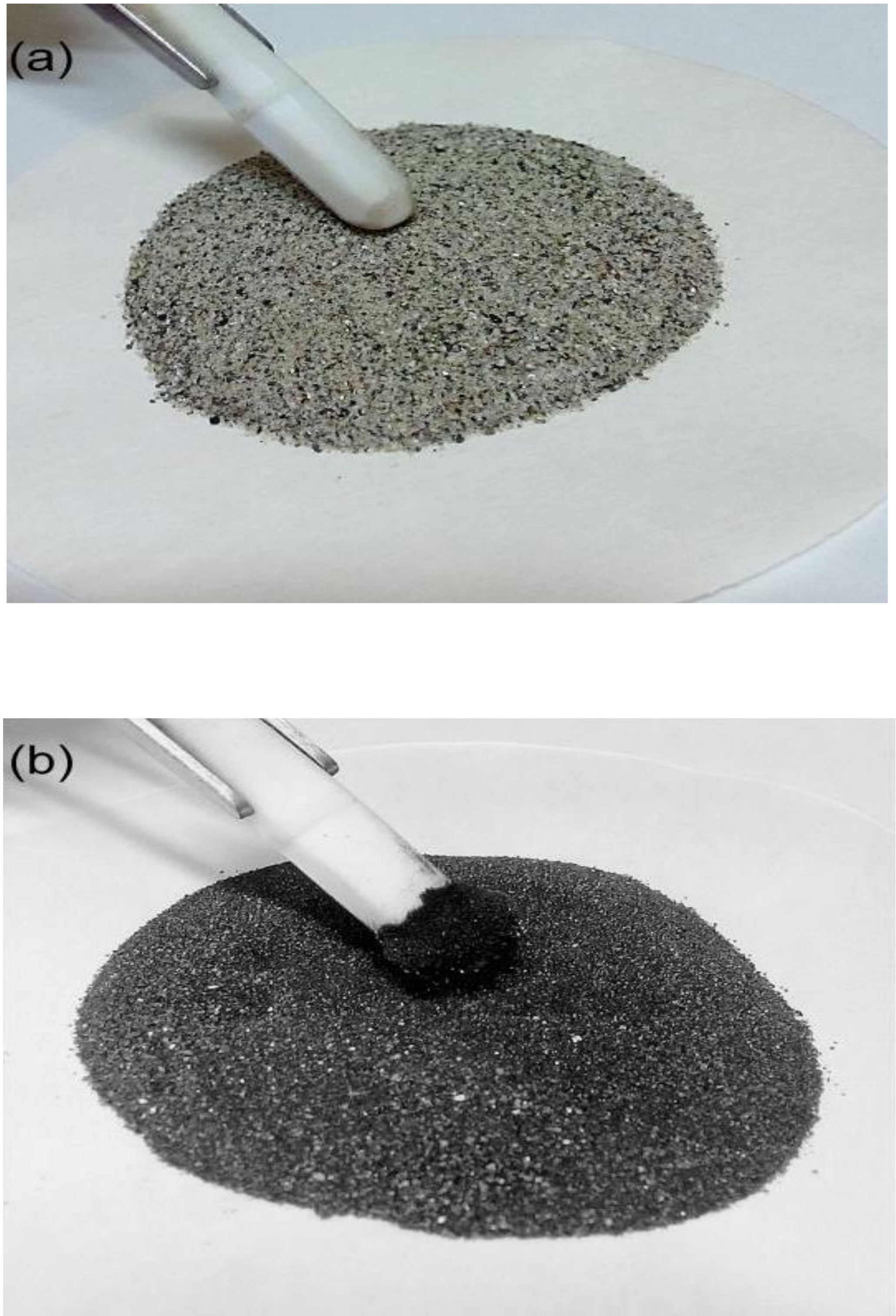

Figure 5 - Photographs of response of (a) bare and (b) Fe3O4 coated sand particles to magnetic bead.

3.3.3 Field Emission Scanning Electron Microscopy (FESEM)

The morphology of Fe3O4 nanoparticles was inspected by Field Emission Scanning Electron Microscopy (FESEM**)**, **Hitachi S-4700** (shown in Figure 6).

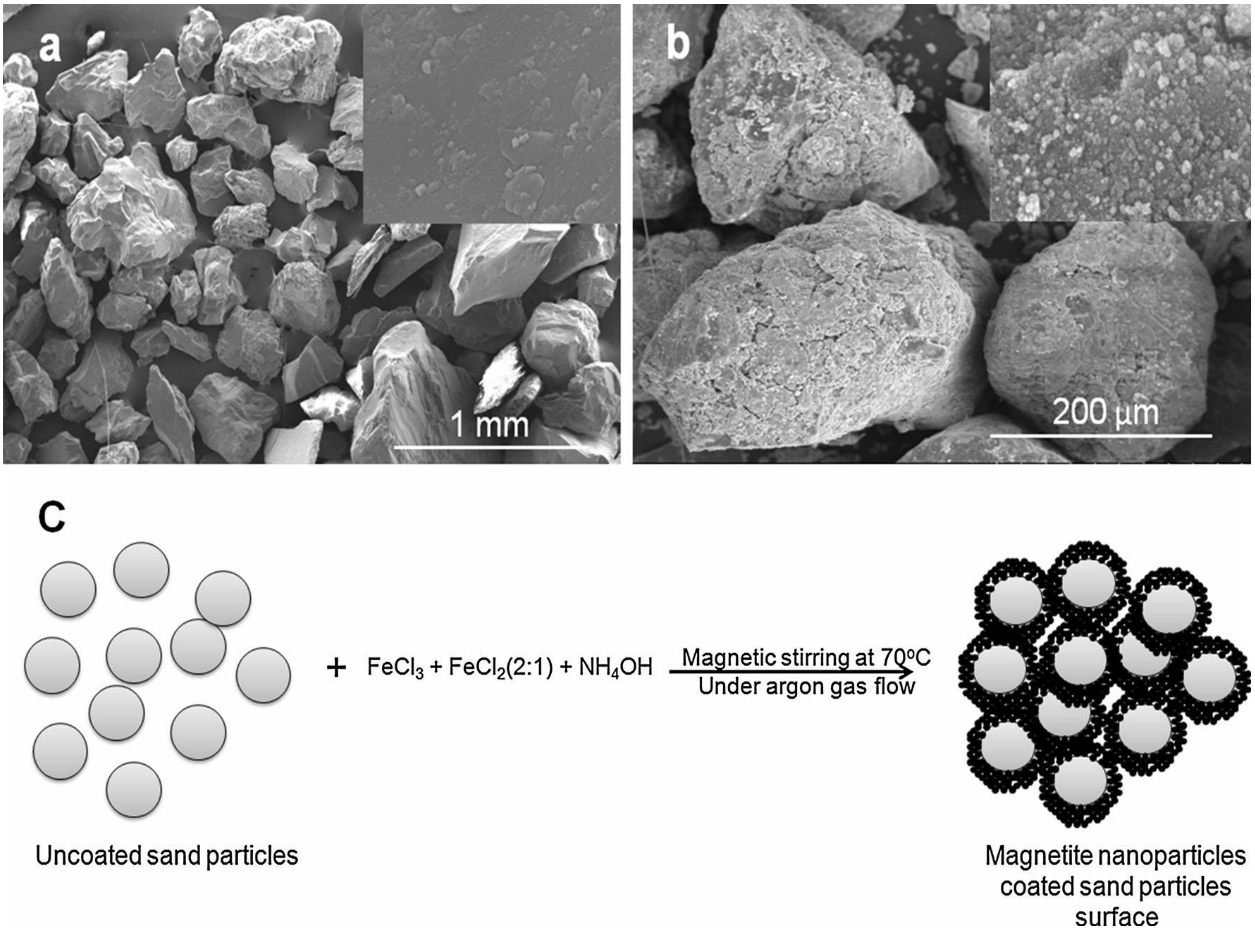

Figure 6 –**(a)**FESEM images of a uncoated sand, (**b)** magnetite nanoparticles coated sand and (**c)**schematic of magnetite nanoparticles coating on sand particles.

3.4 BATCH ADSORPTION EXPERIMENTS

To determine the kinetics and equilibrium data the batch adsorption experiments are carried out. The effect of various parameters like contact time, adsorbent dose, initial Chromium (III) sulphate on Chromium (III) sulphate removal efficiency and adsorption capacity are investigated by the batch adsorption experiments. Every one of the examination are performed at room temperature in a incubator shaker at a fomentation speed of 200rpm (shown in Figure 7).

To study the effect of contact time on Chromium (III) sulphate adsorption the contact time varied between 30 – 180 minutes, using 25g $Fe3O4$ coated sand at initial Chromium (III) sulphate concentration of 1mg/L at room temperature. Then to study the adsorbent dose effect it can be done by varying the adsorbent dose from 5g-30g and keeping other parameters fixed. When we get the required agitation the above solutions are then filtered using 0.45 µmdurapore filter paper, acidified with 1 % $HNO3$ and then finally after the filtration of the solution is done then the residual Chromium (III) sulphate is analyzed using **Inductively Coupled Plasma Mass Spectrometer (ICP-MS).** This study is to be done for both synthetic and industrial samples.

1. Synthetic samples – By suitable means artificially prepared Chromium (III) sulphate solution is formed having initial concentration of 1mg/L.
2. Industrial samples - EFT processed samples are taken from pharmaceutical industry (Austro Labs Ltd. Ludhiana, Punjab.) Having initial concentration of 0.05mg/L.

Figure 7 – Incubator Shaker.

3.4.1 Chromium (iii) Sulphate Removal Efficiency Of Fe3o4 Nanoparticles Coated Sand Was Calculated By Using The Formula:

$$\%\mathbf{RemovalEfficiency} = \frac{\mathbf{C_o - C_e}}{\mathbf{C_o}} \times \mathbf{100}$$

…… equation 3.

And The Amount Of Chromium(iii) SulphateAdsorbed (mg) Per Unit Mass Of Adsorbent (g) I.E. *qe*Was Determined By Using The Formula:

$$\boldsymbol{qe} = \frac{\mathbf{C_o - C_e}}{\mathbf{M}} \times \boldsymbol{V}$$

……… equation 4.

Where:

Where, ***Co***and ***Ce***are initial and final **Chromium (iii) Sulphate** concentrations (mg/L), respectively**,** ***V***is the volume of solution in liters and ***M***is the mass of the adsorbent in grams.

CHAPTER – 4

RESULTS AND ANALYSIS

CHAPTER 4: RESULTS AND ANALYSIS

4.1 BATCH STUDIES FOR CHROMIUM REMOVAL BY USING MAGNETITE NANOPARTICLES COATED SAND

4.1.1 Effect Of Contact Time On Chromium (III) SulphateRemoval:

Batch 1 (Synthetic Samples): As in this batch adsorbent dosage remains constant which is 25g, contact time varies between 30-180 mins, initial concentration of the samples is 1mg/L and volume of the sample taken is 0.1L (shown in Table 2). The % removal and chromium adsorbed per unit mass of adsorbent can be calculated by using equation 3 and 4.

Serial no.	Contact time (t) mins	Initial concentration (Co) mg/L	Final concentration (Ce) mg/L	% Chromium (III) sulphate removal	Chromium (III) sulphate adsorbed (mg) per unit mass of adsorbent (g) i.e. (*qe*) mg/g
1.	30	1	0.172	82.2	0.0032
2.	60	1	0.121	87.9	0.0035
3.	90	1	0.088	91.2	0.0036
4.	120	1	0.047	95.3	0.0038
5.	150	1	0.033	96.7	0.0038
6.	180	1	0.029	97.1	0.0038

Table 2 –Shows data for contact time vs. % removal.

Batch 1 (Graph): Contact Time Vs. % Removal

Figure 8. Shows the effect of contact time on % Chromium (III) Sulphate removal efficiency. We have observed that the Chromium (III) Sulphate removal takes place in two phases i.e. Fast and slower adsorption phase. Initially within 30 min of contact time rapid removal (**82.2 % of Chromium (III) Sulphate was removed**) of Chromium (III) Sulphate occurred and after that the chromium removal rate decreased.

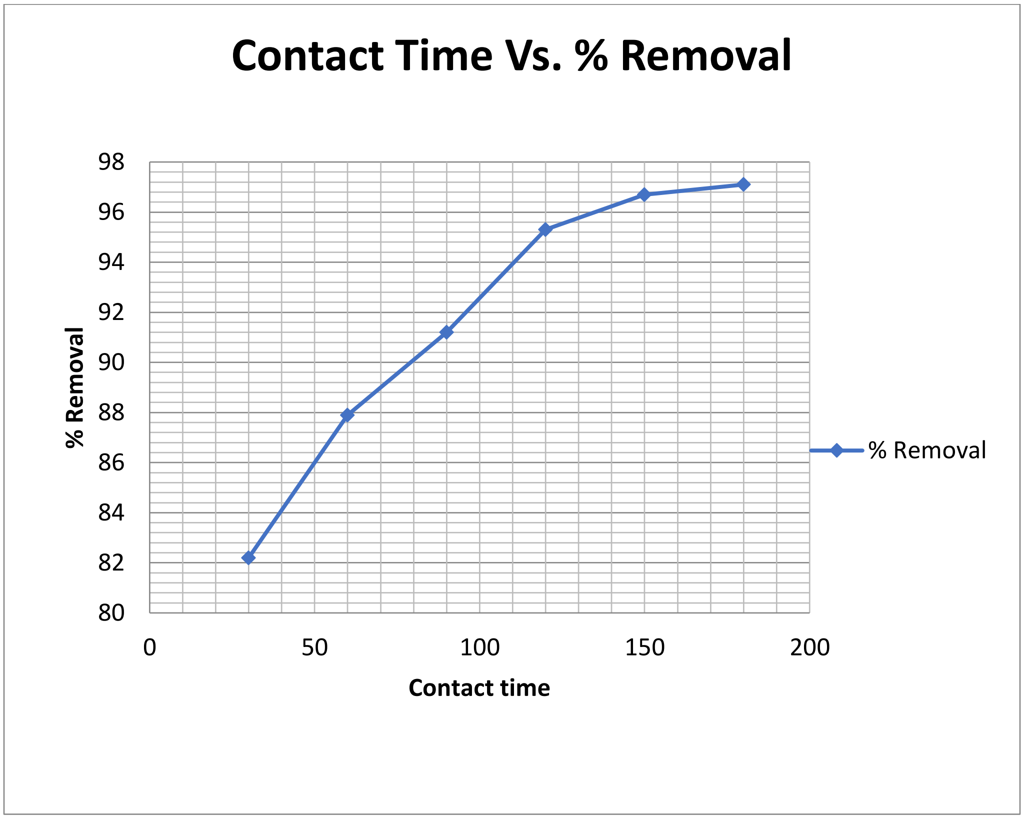

Figure 8 - Shows that the effect of contact time on the % removal of chromium.

Batch 2 (Industrial Samples): As in this batch adsorbent dosage remains constant which is 25g, contact time varies between 30-180 mins, initial concentration of the samples is 0.05mg/L and volume of the sample taken is 0.1L (shown in Table 3). The % removal and chromium adsorbed per unit mass of adsorbent can be calculated by using equation 3 and 4.

Serial no.	Contact time (t) mins	Initial concentration (Co) mg/L	Final concentration (Ce) mg/L	% Chromium (III) sulphate removal	Chromium (III) sulphate adsorbed (mg) per unit mass of adsorbent (g) i.e. (*qe*) mg/g
1.	30	0.05	0.0073	85.4	0.00017
2.	60	0.05	0.0033	93.4	0.00017
3.	90	0.05	0.0027	94.6	0.00018
4.	120	0.05	0.0021	95.8	0.00019
5.	150	0.05	0.0011	96.4	0.00019
6.	180	0.05	0.0014	97.2	0.00019

Table 3 – Shows data for contact time vs. % removal.

Batch 2 (Graph): Contact Time Vs. % Removal

Figure 9. Shows the effect of contact time on % chromium (iii) sulphate removal efficiency. We have observed that the chromium (iii) sulphate removal takes place in two phases i.e. Fast and slower adsorption phase. Initially within 30 min of contact time rapid removal (**85.4 % of chromium (iii) sulphate was removed**) of chromium (iii) sulphate occurred and after that the chromium removal rate decreased.

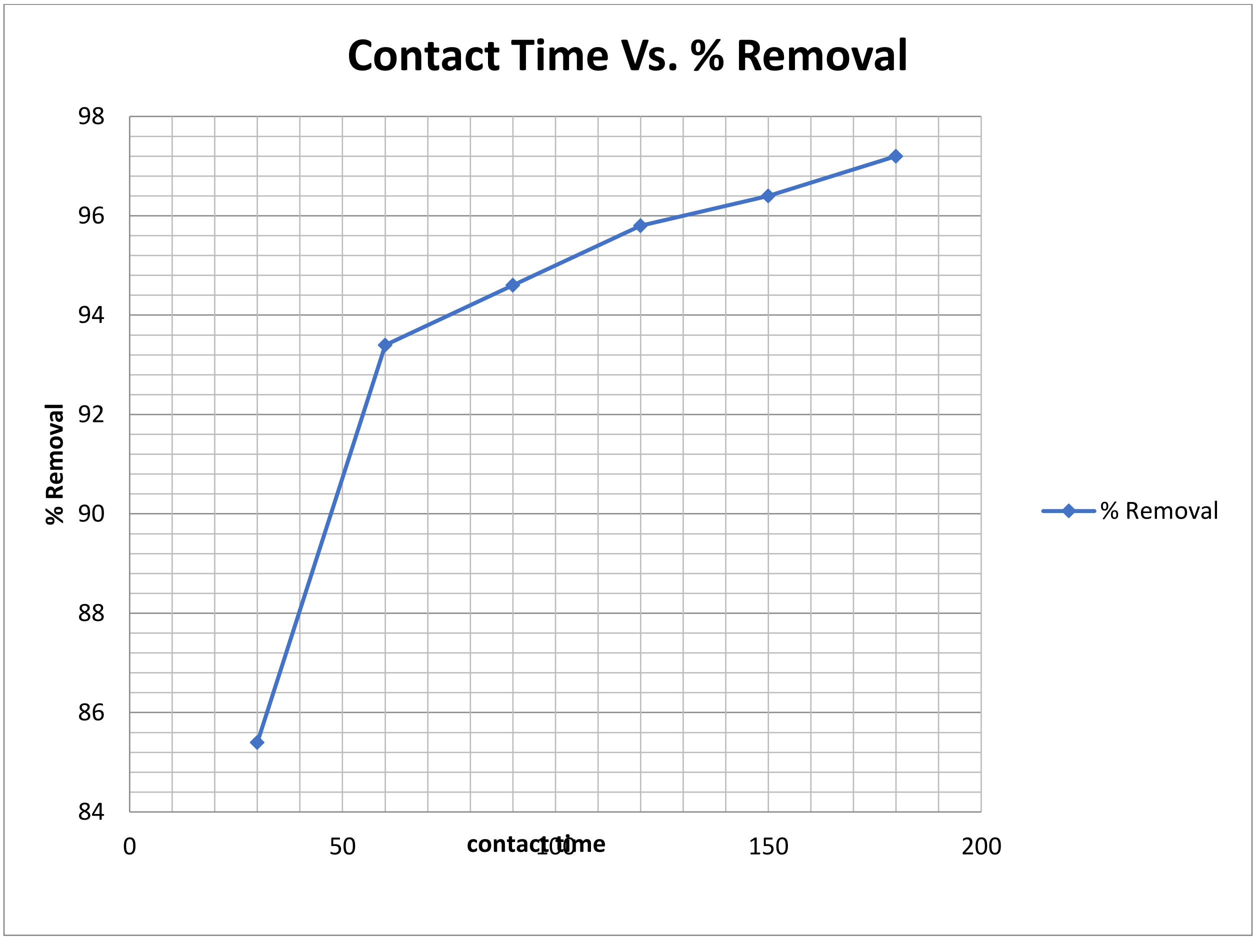

Figure 9 - Shows that the effect of contact time on the % removal of chromium.

4.1.2 Effect Of Adsorbent Dose On Chromium (III) SulphateRemoval:

Batch 3 (Synthetic Samples): As in this batch contact time remains constant which is 30 mins, adsorbent dose varies between 5-30g, initial concentration of the samples is 1mg/L and volume of the sample taken is 0.1L (shown in Table 4). The % removal and chromium adsorbed per unit mass of adsorbent can be calculated by using equation 3 and 4.

Serial no.	Adsorbent dosage (g)	Initial concentration (Co) mg/L	Final concentration (Ce) mg/L	% Chromium (III) sulphate removal	Chromium (III) sulphate adsorbed (mg) per unit mass of adsorbent (g) i.E. (*qe*) mg/g
1.	5	1	0.419	58.1	0.0116
2.	10	1	0.321	67.9	0.0067
3.	15	1	0.247	75.3	0.0050
4.	20	1	0.188	81.2	0.0040
5.	25	1	0.171	82.9	0.0033
6.	30	1	0.168	83.2	0.0027

Table 4 –Shows data for adsorbent dose vs. % removal.

Batch 3 (Graph): Adsorbent DoseVs. % Removal

Figure 10. Shows the effect of adsorbent dose on % chromium (iii) sulphate removal efficiency and adsorption capacity (*q*e= mg/g) at fixed initial chromium (iii) sulphate concentration of 1 mg/L. It has been observed that with an increase in adsorbent dose from 5g to 30g, the chromium (iii) sulphate removal efficiency increases from **58.1 % to 83.2 %**, which is obvious due to available more active sites at higher concentrations of the adsorbent. However, beyond 25 g/L dose, no significant change in chromium (iii) sulphate removal efficiency was observed.

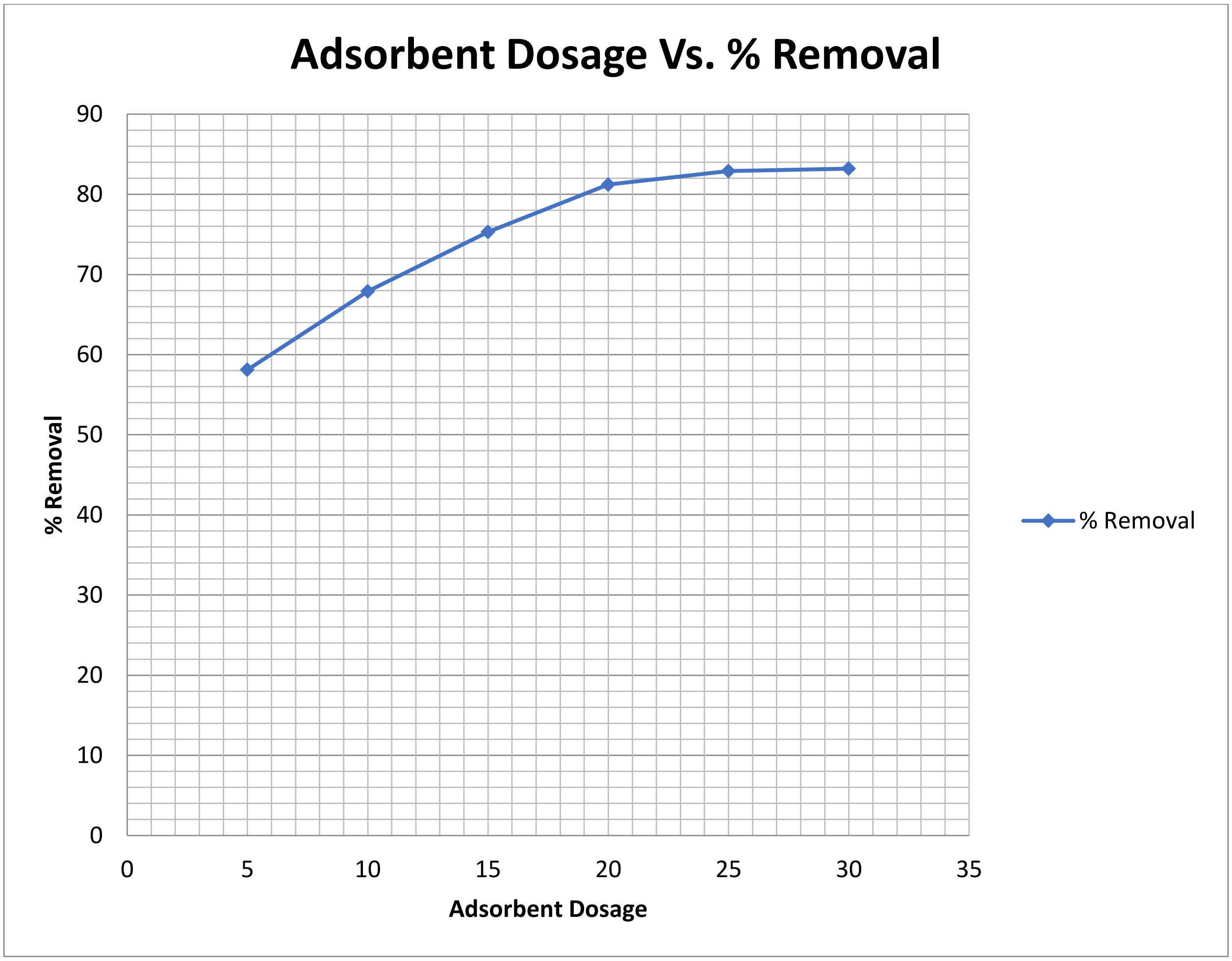

Figure 10 - Shows that the effect of adsorbent dosage on the % removal of chromium.

Batch 4 (Industrial Samples): As in this batch contact time remains constant which is 30 mins, adsorbent dose varies between 5-30g, initial concentration of the samples is 0.05mg/L and volume of the sample taken is 0.1L (shown in Table 5). The % removal and chromium adsorbed per unit mass of adsorbent can be calculated by using equation 3 and 4.

Serial no.	**Adsorbent dosage (g)**	**Initial concentration (Co) mg/L**	**Final concentration (Ce) mg/L**	**% Chromium (III) sulphate removal**	**Chromium (III) sulphate adsorbed (mg) per unit mass of adsorbent (g) i.E. (*qe*) mg/g**
1.	5	0.05	0.0157	68.6	0.00068
2.	10	0.05	0.0133	73.4	0.00036
3.	15	0.05	0.0109	78.2	0.00026
4.	20	0.05	0.0085	83.0	0.00020
5.	25	0.05	0.0071	85.8	0.00017
6.	30	0.05	0.0068	86.4	0.00014

Table 5 –Shows data for adsorbent dose vs. % removal.

Batch 4 (Graph): Adsorbent DoseVs. % Removal

Figure 11. Shows the effect of adsorbent dose on % chromium (iii) sulphate removal efficiency and adsorption capacity (*q*e= mg/g) at fixed initial chromium (iii) sulphate concentration of 1 mg/L. It has been observed that with an increase in adsorbent dose from 5g to 30g, the chromium (iii) sulphate removal efficiency increases from **68.6 % to 86.4 %**, which is obvious due to available more active sites at higher concentrations of the adsorbent. However, beyond 25 g/L dose, no significant change in chromium (iii) sulphate removal efficiency was observed.

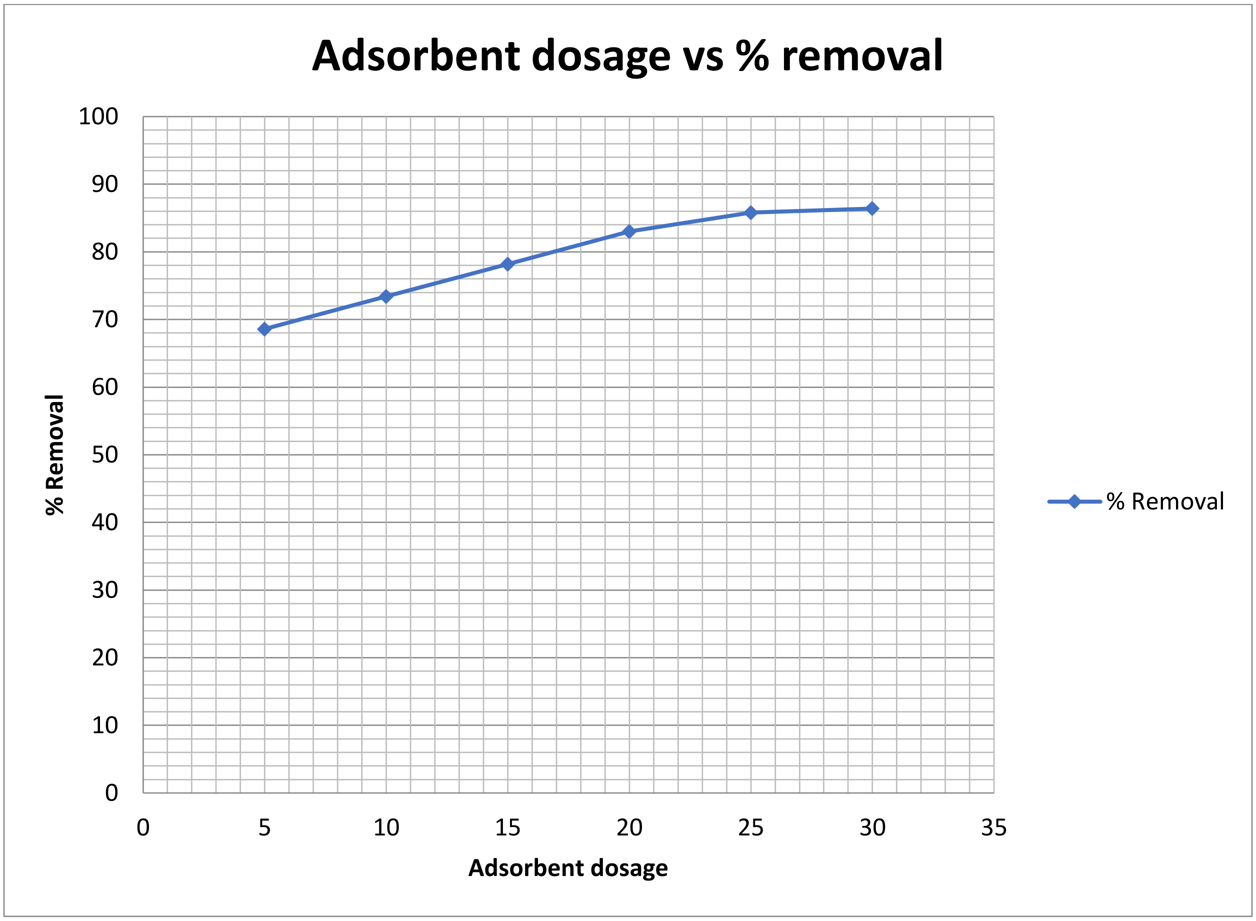

Figure 11 - Shows that the effect of adsorbent dosage on the % removal of chromium.

4.2 STUDIES FOR FREUNDLICH AND LANGMUIR ISOTHERMS

Batch 3 (Synthetic Samples): As in this batch contact time remains constant which is 30 mins, adsorbent dose varies between 5-30g, initial concentration of the samples is 1mg/L and volume of the sample taken is 0.1L (shown in Table 6).As for the study of **Freundlich isotherm** we have to plot the graph between Log (x\m) Vs. Log(C).

Flask no.	Adsorbent dosage (g)	Concentration Of adsorbate in soln after adsorption mg/l (C)	Amount adsorbed per unit weight of adsorbent mg/g (x\m)	Log(C)	Log(x\m)
1.	5	0.419	0.0116	-1.935	-0.377
2.	10	0.321	0.0067	-2.174	-0.493
3.	15	0.247	0.0050	-2.301	-0.607
4.	20	0.188	0.0040	-2.398	-0.726
5.	25	0.171	0.0033	-2.481	-0.767
6.	30	0.168	0.0027	-2.568	-0.774

Table 6 –Shows data for Log (x\m) Vs. Log(C).

Batch 3 (Graph): Log (x\m) Vs. Log(C)

Figure 12. Shows the graph between Log (x\m) Vs. Log(C) and by using equation 2 we find the values for k and n). In this case the value **of k= -1.45 & n= 0.7215**.

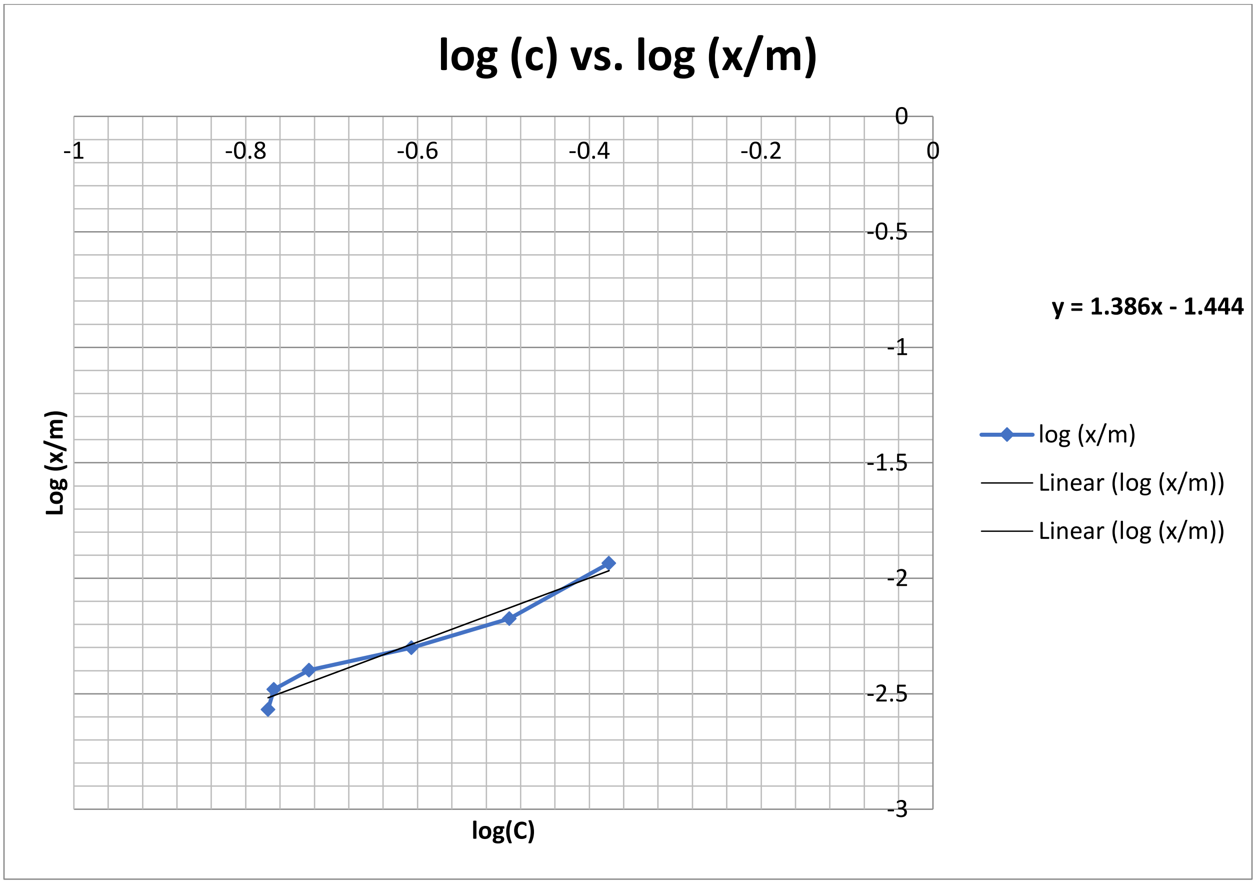

Figure 12 - As this represent the graph between log (c) Vs. Log (x/m). In this case the value of **k= -1.45 & n= 0.7215**.

Batch 3 (Synthetic Samples): As in this batch contact time remains constant which is 30 mins, adsorbent dose varies between 5-30g, initial concentration of the samples is 1mg/L and volume of the sample taken is 0.1L (shown in Table 7). As for the study of **Langmuir isotherm** we have to plot the graph between (c) Vs. C/(x/m).

Flask no.	**Adsorbent dosage (g)**	**Concentration Of adsorbate in soln after adsorption mg/l (C)**	**Amount adsorbed per unit weight of adsorbent mg/g (x\m)**	**C\(x\m)**
1.	5	0.419	0.0116	36.12
2.	10	0.321	0.0067	47.97
3.	15	0.247	0.0050	49.4
4.	20	0.188	0.0040	47
5.	25	0.171	0.0033	51.81
6.	30	0.168	0.0027	62.28

Table 7 – Shows data for (c) Vs. C/(x/m).

Batch 3 (Graph): (c) Vs. C/(x/m)

Figure 13. Shows the graph between (c) Vs. C/(x/m) and by using equation 1 we find the values for a and b. In this case the value of **a= -0.01465 & b= 1.03.**

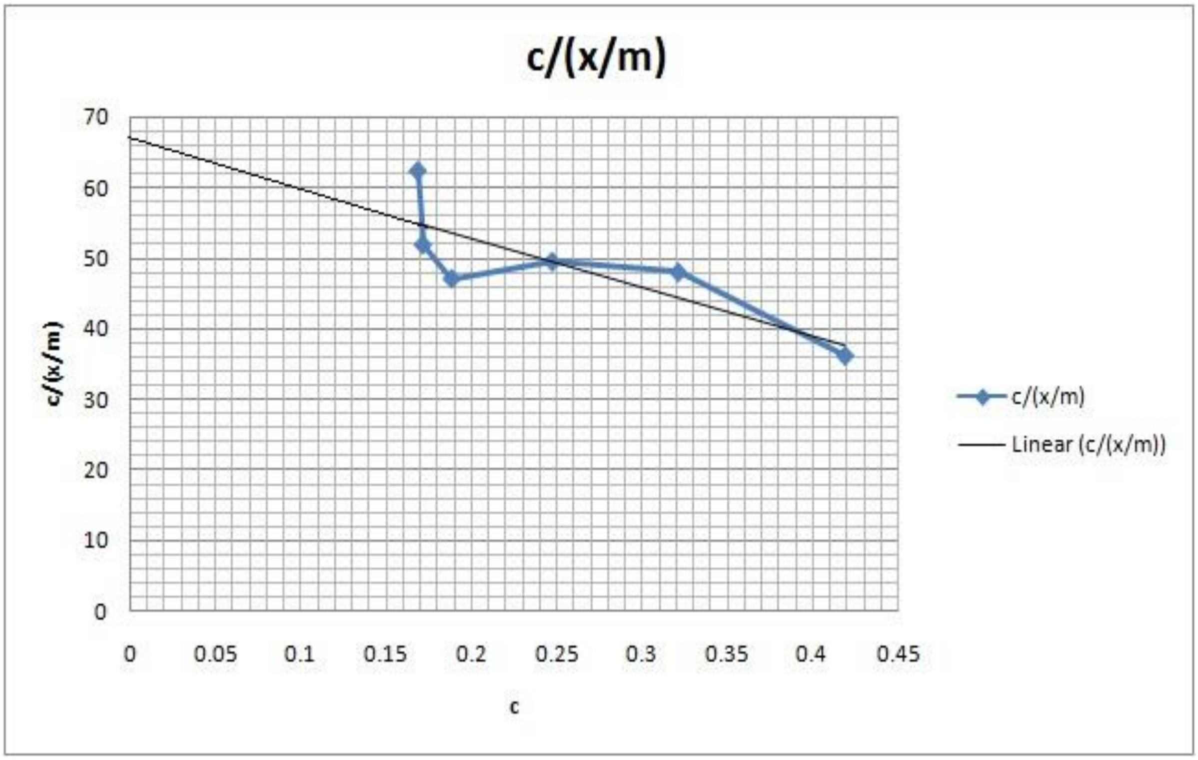

Figure 13 - As this represent the graph between (c) Vs. C/ (x/m). In this case the value of

a= -0.01465 & b= 1.03.

Batch 4 (Industrial Samples): As in this batch contact time remains constant which is 30 mins, adsorbent dose varies between 5-30g, initial concentration of the samples is 0.05mg/L and volume of the sample taken is 0.1L (shown in Table 8).As for the study of **Freundlich isotherm** we have to plot the graph between Log (x\m) Vs. Log(C).

Flask no.	Adsorbent dosage (g)	Concentration Of adsorbate in soln after adsorption mg/l (C)	Amount adsorbed per unit weight of adsorbent mg/g (x\m)	Log(C)	Log(x\m)
1.	5	0.0157	0.00068	-3.167	-1.804
2.	10	0.0133	0.00036	-3.445	-1.876
3.	15	0.0109	0.00026	-3.585	-1.963
4.	20	0.0085	0.00020	-3.698	-2.071
5.	25	0.0071	0.00017	-3.769	-2.148
6.	30	0.0068	0.00014	-3.853	-2.167

Table 8 –Shows data for Log (x\m) Vs. Log(C).

Batch 4 (Graph): Log (x\m) Vs. Log(C)

Figure 14. Shows the graph between Log (x\m) Vs. Log(C) and by using equation 2 we find the values for(k and n). In this case the value of **k= 0.485 & n= 0.613**.

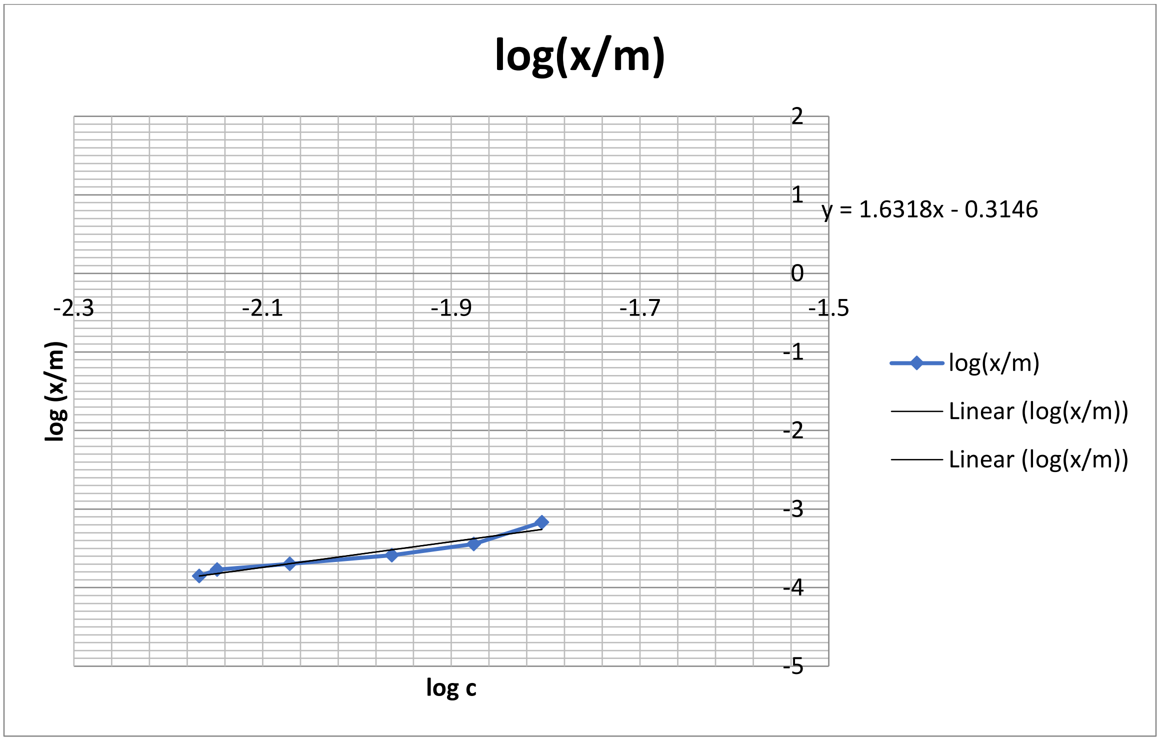

Figure 14 - As this represent the graph between log (c) Vs. log (x/m). In this case the value of

k= 0.485 & n= 0.613.

Batch 3 (Industrial Samples): As in this batch contact time remains constant which is 30 mins, adsorbent dose varies between 5-30g, initial concentration of the samples is 1mg/L and volume of the sample taken is 0.1L (shown in Table 9).As for the study of **Langmuir isotherm** we have to plot the graph between (c) Vs. C/(x/m).

Flask no.	**Adsorbent dosage (g)**	**Concentration Of adsorbate in soln after adsorption mg/l (C)**	**Amount adsorbed per unit weight of adsorbent mg/g (x\m)**	**C\(x\m)**
1.	5	0.0157	0.00068	23.09
2.	10	0.0133	0.00036	36.94
3.	15	0.0109	0.00026	41.9
4.	20	0.0085	0.00020	42.5
5.	25	0.0071	0.00017	41.76
6.	30	0.0068	0.00014	62.28

Table 9 – Shows data for (c) Vs. C/(x/m).

Batch 4 (Graph): (c) Vs. C/(x/m)

Figure 15. Shows the graph between (c) Vs. C/(x/m) and by using equation 1 we find the values for a and b. In this case the value of **a= -0.000461 & b= 42.45.**

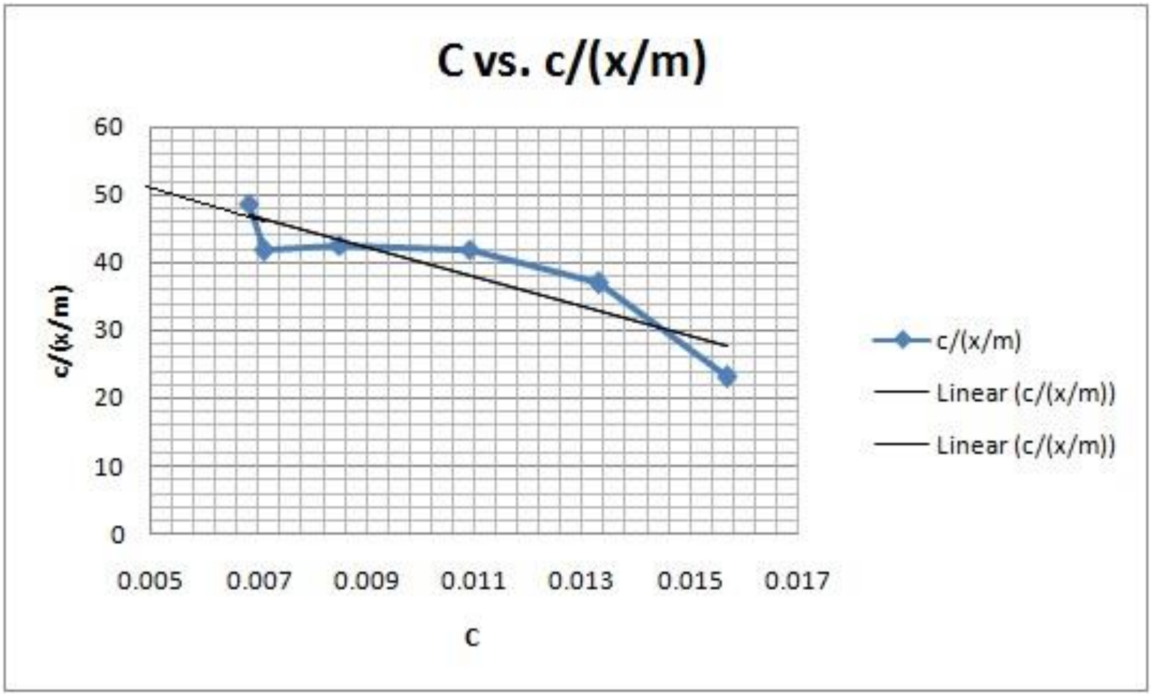

Figure 15 - As this represent the graph between (c) Vs. C/ (x/m). In this case the value of

a= -0.000461 & b= 42.45.

CONCLUSION

As by doing different batch studies we can conclude that sand coated magnetite’s are very effective in adsorbing heavy metals. Effect of contact time and adsorbent dosage plays different roles respectively. So hence this study shows that we can use magnetite’s nanoparticles to remove heavy metals from the industrial waste water and this is also very effective then other adsorbents. In the end we also study the Langmuir and Freundlich isotherms and also found there constants.

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