

Reduction of Iron from Ground Water Using Eco-Friendly Adsorbents

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering in
Civil Engineering
by

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DEPARTMENT OF CIVIL ENGINEERING

SCHOOL OF BUILDING AND ENVIRONMENT

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

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JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

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DEPARTMENT OF CIVIL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Pema Dechin (39200033)** and **Tenali Alekhya (39200039)**, who carried out the project entitled "**Reduction of Iron from Ground Water Using Eco-Friendly Adsorbents**" under my supervision from October 2022 to April 2023.

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Submitted for Viva voce Examination held on **20.04.2023**

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DECLARATION

We, **Pema Dechin (39200033)** and **Tenali Alekhya (39200039)** hereby declare that the Project Report entitled “**Reduction of Iron from Ground Water Using Eco-Friendly Adsorbents**” done by us under the guidance of **Mrs. S. Vanitha** is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering in Civil Engineering.

DATE 13.04.2023

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SIGNATURE OF THE CANDIDATES

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ABSTRACT

Water is very essential material to all living things for their survival. Good health condition depends on purity of water. Water may be exposed to various activities such as industrial, agricultural, domestic etc which leads to the deterioration of water quality. Water quality problem typically associated with high concentration of iron content. Ground water in the study area i.e., Porur contains more than 5mg/l. According to WHO, the normal drinking water contains permissible limit of iron concentration 0.3mg/l. This study tries to introduce low-cost adsorbents coconut coir (COC) and Tulasi powder (TP) for the reduction of iron from water. The parameters such as effect of pH, adsorbent dosage, contact time, initial concentration, etc., were studied. The highest percentage removal of total iron was observed at Coconut coir (97%) compared than Tulasi leaves (50%).

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Ground water has played a significant role in the maintenance of India's economy, environment and standard of living. According to British Geological survey, India (2005) almost 70% of the water in India has become polluted due to the discharge of sewage and industrial effluents in normal water resources such as rivers, streams as well as lake, about 95% rural population living in India depends on ground water for domestic use. Rapid urbanization and increased industrial activities have resulted in the degeneration of ground water quality.

Recent trends show that our world is moving towards the greatest problem due to deficiency of quality and quantity of water. As a consequence, the research on quality and quantity of groundwater is in alarming stage.

Heavy metal pollution is a common environmental problem facing many places worldwide with the rapid development of technology and industries. Heavy metals cause serious health effects, including reduced growth and development, cancer, organ damage, nervous system damage, and in extreme cases, death. Iron is one of the earth's most plentiful resources making up about 5% of the earth crust. Iron is one of the major impurities that is commonly found in many sources of water. Water quality problem typically associated with high level concentration of iron. Iron removal from groundwater is therefore, a major concern for most scientific researchers.

In rural ground water supply iron is the common problem. It's concentration ranges from 0 to 50mg/l, while WHO recommended level is <0.3mg/l.

This study is trying to introduce some natural adsorbents such as coconut coir (COC) and Tulasi powder (TP) for the reduction of iron from ground water.

Coconut coir activated carbons having good porosity and high surface area. The adsorption properties of coconut shell are due to the presence of some functional

groups, such as carboxylic, hydroxyl and lactone, which have a high affinity for metal ions.

The scientific name of Tulsi is *Ocimum Tenuiflorum*, Holy basil or *Ocimum Sanctum* Linn. Leaves are dropped in drinking water for purification and for medication. In all Hindu temples, water mixed with Tulsi leaves are offered to devotees every day since the herbal plant is an excellent medicinal plant found all over India and is considered sacred. The leaves, seeds and root of this plant have been used in ayurvedic medicine. Chemical composition is highly complex, containing many nutrients and other biological active compounds. It can remove fluoride levels in drinking water. Recently it's used have been found in fighting fluorosis.

1.2 AFFECTS OF IRON

Iron dissolved in groundwater is in the reduced iron II form. This form is soluble and normally does not cause any problems by itself. Iron II is oxidised to iron III on contact with oxygen in the air or by the action of iron related bacteria. Iron III forms insoluble hydroxides in water. These are rusty red and cause staining and blockage of screens, pumps, pipes, reticulation systems etc. If the iron hydroxide deposits are produced by iron bacteria, then they are also sticky and the problems of stain and blockage are many times worse. The presence of iron bacteria may be indicated by rusty slime inside headwork's, reduced water flow from the bore and unpleasant odour from water pumped from the bore, slimy deposits blocking main and lateral lines.

1.3 HARM AGAINST HEALTH

While uncommon, too much iron in the body can lead to a variety of physical health issues, including joint pain, liver disease, and osteoporosis. It can also cause damage to healthy skin, resulting in premature wrinkles.

1.4 BIOLOGICAL IRON REMOVAL

Biological iron removal is a means of removing iron from groundwater within water filters. Microbiologists have known for many years that certain bacteria are capable of oxidizing and immobilizing iron. The bacteria responsible for the process appear to be natural inhabitants of the well environment.

CHAPTER 2

LITERATURE SURVEY

2.1 GENERAL

In this the review is done about the journals based on ground water, natural adsorbents and purification processes discussed.

2.2 LITERATURE REVIEW

Ankit a. jinturkar et al (2017) In this work removal iron is done using neem leaf as adsorbent with varying contact time and its concentration. Now-a-days, nanotechnology offers the possibility of an efficient removal of water pollutants including metals, organic dyes, bacteria, parasites etc. Nanomaterials of Neem leaf powder are very promising materials used in water decontamination particularly for heavy metals. The maximum iron removed was 94.8364% at contact time of 180 minutes and 200mg/l amount of adsorbent.

Ashoka and Inamdar (2010) studied Adsorption removed of methyl red from aqueous solution with treated sugarcane bagasse and activated carbon. Paper reported that methyl red dye removed by sugarcane bagasse, an agro industry waste from the waste water. In this process, sugarcane bagasse treated with formaldehyde and sulphuric acid. The adsorption capacities of both treated bagasse were examined at varying pH. initial dye concentration, adsorbent dosage, contact time and temperature and compare the treated bagasse with commercially available powdered activated carbon. The effect of pH. adsorbent dosage, initial dye conc., and temperature on removal of dye was examined for different times. It was observed that adsorption efficiency of sulphuric acid treated bagasse was higher than formaldehyde treated bagasse.

Ai Phing Lim, Ahmad Zaharin Aris(2013) This work helps to determine the potential quality of low cost materials in the application for water and wastewater treatment. Wide ranges of low-cost adsorbents were used to remove heavy metal in aqueous solution and wastewater. The low-cost adsorbents were usually

collected from agricultural waste, seafood waste, food waste, industrial by-product and soil. These adsorbents are readily available in a copious amount. Besides, the pre-treatment is not complicated to be conducted on the raw products, which is economically sound for an alternative treatment. The previous studies have provided much evidence of low-cost adsorbents' efficiency in removing metal ions from aqueous solution or wastewater. In this review, several low-cost adsorbents in the recent literature have been studied. The maximum adsorption capacity, affecting factors such as pH, contact times, temperature, initial concentration and modified materials were revised and summarized in this review for further reference. Comparisons of the adsorbent between the modified and natural products were also demonstrated to provide a clear understanding on the kinetic uptake of the selected adsorbents. Some of the natural adsorbents appeared as good heavy metal removal, while some were not and require further modifications and improvements to enhance the adsorption capacity.

Ajmal (2002) studied adsorption on rice husk: removal and recovery of Cd (II) from waste water. Here phosphate-treated rice husk (PRH) showed that adsorption of Ni (II) and Cd (II) was greater when PRH was used as an adsorbent. Sorption of Cd (II) was dependent on contact time, concentration, temperature, adsorbent doses and pH of the solution. The Langmuir constants and thermodynamic parameters have been calculated at different temperatures. It was found that recovery of Cd (II) from synthetic wastewater by column operation was better than a batch process.

Balaji.R et al (2014) Has studied that the Sustainability of good health depends upon the purity of water. However, groundwater may be exposed towards to contamination by various anthropogenic activities such as agricultural, domestic and industrial. Groundwater quality problem are typically associated with high level of iron concentration in West Mugapair, Chennai. The normal drinking water contains permissible limit of iron concentration 0.3mg/l but the West Mugapair Groundwater contains 17mg/L of iron concentration. In the present study sugarcane bagasse (SCB) and Coconut coir (COC) from agricultural waste have been selected as solid phase extractor for removal total iron. Sugarcane bagasse, Coconut coir exhibits remarkable binding characteristics for removal total iron, so special interest was devoted for optimizing its uptake and studying its selectivity properties under

static and dynamic conditions. The parameters such as effect of pH, adsorbent dosage, contact time, initial concentration, etc., were studied. Maximum removal of total iron was observed in the pH range of 4-5. The highest percentage removal of total iron was observed at Coconut coir (96%) compared than sugarcane bagasse (93%).

Bishnu Joshi (2011), This study reviews the disinfection of Drinking Water in Rural Area Using Natural Herbs. Here Tulasi leaf and neem leaf used for purify of water and check 3 coli form reduction in water samples by Aqueous leaf extract, Alcoholic leaf extract and Fresh leaf juice.

Baharudin F et al (2017) This study was conducted to measure and compare the concentration of iron, manganese and hardness of the river and groundwater and to determine the effectiveness of iron and manganese removal by using natural biosorbent which is banana peels. The samples of river and groundwater were collected at riverbank filtration site at Jenderam Hilir, Dengkil. Based on the water quality investigation, the concentration of iron and manganese in the samples of groundwater have exceeded the drinking water quality standard which are 0.3 mg/L for iron and 0.1 mg/L for manganese. The removal process of the iron and manganese in the groundwater was done by using 2, 4 and 8 grams of banana peels activated carbon. It is found that with higher amount of activated banana peels, the removal of iron and manganese is more effective. The ranges of percentage of iron and manganese removal are between 82.25% to 90.84% and 98.79% to 99.43% respectively. From the result, banana peels activated carbon can be concluded as a one of the most effective low-cost adsorbent for groundwater treatment.

Bhattacharjee (January 2013), studied Disinfection of Drinking Water in Rural Area Using Natural Herbs. Here tulasi leaf and neem leaf used for purify of water and check coliform reduction in water samples by Aqueous leaf extract, Alcoholic leaf extract and Fresh leaf juice.

C.A.J. Appelo and W.W.J.M. de Vet (2003) Here the principles of in situ iron removal from groundwater were explained in simple terms, based on the reaction of sorbed ferrous iron in the aquifer. The efficiency of an in-situ iron removal system was defined as the ratio of the volume of groundwater pumped to the volume of

oxygenated water injected. A relatively high sorption capacity of the freshly precipitated ferrihydrite suggests that the precipitate in the aquifer is a mixed solid of Fe, P and C, rather than a neat iron-oxyhydroxide to which Fe^{2+} and other elements are sorbed.

Danka Barloková et al (2009) Found more efficient and cost-effective materials and technologies used in water treatment. The goal of this study is to compare activated natural zeolite-clinoptilolite with activated filtration sand and the imported material Birm (from the Clack Corporation, USA) in removal of iron and manganese from water. Obtained results carried out in the water treatment plant in Holíč prove that Klinopur-Mn is suitable for removal of iron and manganese from water and is comparable with other imported materials. Natural or synthetic zeolite can be used as a filtration material for removal of iron and manganese from water. Birm, Greensand, Pyrolox, and MTM are the most frequently used materials in filtration quietly used materials in filtration. Birm is a granulated filter medium (imported from the USA) used for iron and manganese removal from water. It is a specially developed material containing MnO_2 film on the surface (catalyst). It is recommended to use Birm for lower iron concentrations (to Fe^{2+} concentration of $6.0 \text{ mg}\cdot\text{l}^{-1}$ and Mn^{2+} about $3.0 \text{ mg}\cdot\text{l}^{-1}$) and for household water treatment. It can also be used in gravity or pressure filters.

Deepika B.V; Pradeep Kumar K J (2016) Has studied that clean water is being a primary importance in developing countries. Contaminated water will affect the life of people to the greater extent. Efficient and low-cost water purification systems are being utilized and being tried to be accessed worldwide for purification of water. About one-fifth of the population on earth lack the access to safe drinking water, a condition that resulted in the death of 2 million people in 2004, as per the records of United Nations. In this work an attempt was made to develop a “Low-Cost Water Purification Technique” to remove iron from drinking water using the basic ideas of glass filter, some locally available filter material like Rice Husk and Sugarcane bagasse. Adsorption technique was used for removal of iron from ground water. Among all the low-cost materials used, the ash produced from rice husk was proved to give the best result in removal of iron and also available in local area having the cheapest material cost. Locally collected Sugarcane bagasse and Rice husk were combined which also proved to be effective for removal of iron.

Dipankar Thakuria et al (2016) Worked on Removal of iron and fluoride from groundwater using the process of adsorption. The experiments were performed on various parameters like dosage of adsorbent, pH, temperature and contact time to check their influence on adsorption. Adsorbent dosage of 4.7 g/50 ml at pH 5, temperature of 20°C and contact time of 420 minutes were considered as optimum. The adsorbents were prepared and cleaned before using as adsorbent. They were kept in contact with 0.1 N HCl at 20°C at 120 rpm for 24 hours in an orbital shaking machine. After 24 hours they were filtered and dried in an oven at 105°C again for 24 hours.

Dipankar Thakuria, Buddharatna. J. Godbole (2016) In this paper an attempt has been made to study the iron and fluoride contamination, their effects to health and environment and removal from groundwater using the process of adsorption and adsorptive filtration.

Daifulla (2002) studied Utilization of agro-residues (rice husk) in small waste water treatment plans. Rice husk can be made into sorbent materials which are used in environmental remediation. This study characterized and evaluated two types of sorbents made from rice husk. The efficiency of both sorbents in the removal of the complex matrix containing six heavy metals was c100%. These metals are Fe, Mn, Zn, Cu, Cd and Pb., which are found in the drain containing the agriculture and sewage wastewater at El-Menofiya Governorate, Egypt. The two sorbent materials were prepared according to the scheme presented. The two sorbents made from the rice husk have considerable potential for adsorption of metals of environmental concern.

Euras, et al. (2006) studied Removal of cadmium from aqueous solution by adsorption on to sugarcane bagasse. In this paper, cadmium removed by sugarcane bagasse from aqueous solution. Process for removal cd, investigated through batch experiments. First experiment of preparation of synthesis waste water and adsorbent and adsorption experiment. The adsorption processes were relatively fast and equilibrium was achieved after some duration. The optimum adsorption of cd occurred at ph. range 5-7. The kinetic process of cd adsorption on to sugarcane bagasse was tested by applying pseudo first order, second order and intrapeptide

diffusion rate equation. The equilibrium data fitted the Langmuir isotherm model & maximum adsorption capacity determined.

Grace K Mikhayel (2018) This review says how to develop a “Low-cost water purification technique” using plastic bottles and locally available herbal materials like Neem leaf powder and Tulasi leaf powder. Main focus was removal of iron and chromium from pharmaceutical waste water. Filtration is the simplest and cheapest technique for the removal of metal components from waste water. The initial concentration of iron and chromium is 0.536 mg/L and 0.289 mg/L respectively. Neem with aluminium hydroxide is more efficient in removing iron content from waste water with efficiency of removal is 60.075%. Tulsi with aluminium hydroxide is more efficient in removing chromium from waste water with efficiency of removal is 93.77%. Thus it is below than the permissible limit and can be used for drinking and irrigation purpose.

G.K. Khadse, V.W. Lande, S.P. Andey and P.K. Labhasetwar (2013) It is done for performance of up-flow roughing biofilter in iron removal from groundwater. The performances of the IRPs were evaluated during pre-monsoon and post-monsoon seasons. Water samples were collected and analysed for physico-chemical, heavy metals, biological and bacteriological parameters to assess the water quality of raw and treated water as per standard methods. Lacky's microsect drop method was used for qualitative estimation of phytoplankton and organisms were expressed as number per millilitre. Quantitative estimation of zooplankton was carried out with the help of Sedgwick-Rafter cell.

Ghanshyam Pandhare, Nikhilesh Trivedi, Nitin Kanse and S.D. Dawande (2013) They aimed to utilize the commonly available waste material Neem leaves. In this project the materials have been converted to the activated carbon by chemical activation. This activated carbon was utilized for the adsorption of colour from the prepared solution. Various amount of the sample was taken and the adsorption study was carried out. It was seen that the amount of sample is increased the percentage adsorption also increases. Thus, from the studies carried out it can be concluded that the prepared activated carbon can be used effectively to adsorb colour. There is a tremendous potential in these materials to be explored as industrial low cost-effective adsorbents.

Ganvir, et al. (2011) studied the removal of fluoride from groundwater by aluminium hydroxide coated Rice husk ash [12, 13]. Activated aluminium hydroxide has been used for activating the RHA surface which forms a complex with fluoride ion in water and accelerates the process of removal. RHA was obtained by controlled burning of dry and crushed rice husk and treating with hydrochloric acid before activation.

Ioannis A. Katsoyiannis, Anastasios I. Zouboulis (2006), In this paper the biological oxidation of iron and manganese has been reviewed and recent findings regarding the removal of iron have been summarized. Iron can be removed efficiently from a wide range of initial concentrations with practically limited operational cost.

John.S, Ahammed.M (2006) The results of the laboratory study indicated that a combination of potassium permanganate and candle filter can be used effectively for the household removal of iron in the rural areas of developing countries. Batch testing using potassium permanganate, ceramic candle filter or a combination of twain removing iron from an iron skipped tap water.

Khadase.G. K et al (2005) This paper has the goal of improving water treatment efficiency and reducing water treatment cost based on comparative studies and can improve water treatment efficiency, reduce water treatment cost, lower water treatment expense, and implement effective communication.

Khalid Z. Ekwakeel et al (2015) Has explained how to pre-treat the natural adsorbents before converting them to activated carbon. The Activated carbon was prepared from sugarcane bagasse impregnated with phosphoric acid at 500°C activation temperature and 2 h activation time, resulting in the carbon yield of 27.13%. The prepared activated carbon has high BET surface area (671.54 m² /g) and the maximum adsorption of iodine is 602.23 mg/g. The adsorption characteristics of the obtained carbon towards both Fe (II) and Mn (II) at different experimental conditions were conducted by means of batch and column methods. The adsorbent showed high affinity for the removal of both Fe (II) or Mn (II) from aqueous medium, where an uptake values of 7.01 and 5.40 mg/g were reported for Fe (II) and Mn (II), respectively, at 25°C. Various parameters such as pH, agitation time and speed, adsorbent dose, metal ion concentration, temperature, and ionic

strength had been studied. The kinetic and thermodynamic behaviour of the adsorption reaction was defined, these data indicated pseudo-second-order model and the adsorption is endothermic in nature and mainly physical. Breakthrough curves for the removal of Fe (II) or Mn (II) were studied. Regeneration and durability of the loaded carbon toward the successive cycles were clarified. The adsorbed Fe (II) or Mn (II) was eluted from the column effectively using 0.5 M hydrochloric acid.

Lin, K., Lind, S., Boe-Hansen, R., Smets, B. F., & Albrechtsen, H-J. (2012)

In this paper biological removal of manganese and iron in rapid sand filters has been done. The assay allows testing the effect of various parameters as well as distinguishing between biological and non-biological removal processes. The general tendency through the depth of a filter was that the manganese removal rate was highest in the top of the filter and decreased throughout the depth. Biological manganese removal could be detected, but the nonbiological removal had a large role in removal performance as well. The interaction between nitrification, manganese and iron removal was investigated and showed that ammonium had a positive effect on manganese removal whereas iron had a negative effect on manganese removal and even caused an increase of manganese. These conclusions are based on preliminary results. Further studies will aim at verifying the preliminary results and identify the most important controlling parameters on biological manganese and iron removal and their effect.

Megha N S (2019) Has studied that the Adsorption method for removal of iron from drinking water is more economical and effective in rural villages. Amla Tree Bark (ATB), Sugarcane bagasse (SCB) and Banana Peel (BP) have been using as a natural low cost adsorbent for the removal of Iron from drinking water. A batch adsorption study was conducted to check the efficiency of ATB, SCB and BP and the studies were conducted to investigate the effect of various operational parameters such as Adsorbent dose, pH, Contact time and Initial iron concentration on the treatment efficiency. The maximum removal efficiency of iron from synthetic water was observed in the pH range 4-6 by the adsorbents. The study of Freundlich and Langmuir adsorption isotherms were carried out. Amla tree bark and Sugarcane Bagasse shows higher iron removal efficiency than the Banana peel.

Milind R. Giddel et al (2013) has studied that the standard methods of disinfection include initial filtration of various sorts, and Ultraviolet treatment is sometimes employed in special situations; but reliance is mainly placed on chemical treatment species such as Chlorine and Chlorine dioxide. There are certain disadvantages associated with conventional methods of disinfecting water; either they are costly or unskilled labour to handle the chemicals leads to the formation of unwanted by-products obtained from chemical disinfectants which have got the potential to cause hemolytic anaemia, cancer risk, nervous system disruption. In both the oral and written traditions, knowledge of alternative methods of water treatment is still available. According to traditional belief Tulsi leaves (*Ocimum sanctum*) & Neem leaves (*Azadirachta indica*) have the capacity to purify water. This is virtually cost less way to render contaminated water fit for human consumption.

Nitasha khatri et al (2017) the dumping of domestic and industrial wastes in the water bodies is responsible for elevated levels of iron in the water. The continuous consumption of such water with high iron content may lead to various health problems. 7 Bad odour, unpleasant taste, red colour of water and stains on laundry and plumbing fixtures are also some of the issues related with high iron content in water. A variety of techniques have been adapted for the remediation of iron from different water sources. This review summarizes the different approaches used worldwide till date for the removal of high iron content from water. These methods have been classified into 4 different categories: conventional strategies, biological strategies, membrane technology-based strategies and nanotechnology-based strategies. The conventional strategies involve 11 different remediation techniques for removing iron from water, which have different iron removal efficiencies. The review also classifies the diverse types of iron available in water based on its mineral form, solubility and chemical nature.

M A Hossain, F. Ishaque, M A R Sarker, S P Ritu and S Rashid (2016) In this paper they have evaluated low-cost filter column to remove iron from drinking water. This study was conducted to investigate the effectiveness and performance of different low-cost filter media in the removal for iron from drinking water. Three water samples were collected from Tilagor area.

Pandhare and Dawande (2010) This journal reviews about Neem leaves powder as low-cost adsorbent and its characteristics. Adsorption has been used successfully in the removal of impurities from effluents. He was developed the Neem leaves powder activated using chemical treatment as low-cost adsorbent.

Ranjit N. Patil (2017) This review focused on the different used adsorbents for the removal of iron by using method of adsorption. Utility of different material of various plants, agro-wastes, other bio-masses as bioadsorbents are over viewed with its different parameter. . Determination of iron is very important in explorations of new water supplies, particularly from bore well and other surface water sources. The drinking water can be rejected only on the basis of excess iron present in it. Iron can be toxic to freshwater aquatic life above 1 mg/l and may interfere with fish uptake of oxygen through their gills above 0.3 mg/l. Therefore pre-concentration or removal of iron from aqueous solutions is a matter of great concern in analytical and environmental works. Many of the researchers work on the removal of iron from water

Salwa A. Ahmed et al (2015) has studied that The potential to remove or reduce the risk of Mn(II) from ground water through adsorption using Sugar Cane Bagasse (SCB) and Beet Pulp (BP) as a low cost natural wastes was investigated. The SCB and BP were characterized using Fourier transform infrared spectra (FT-IR) and Scanning Electron Microscope (SEM). The adsorption was taken in batch experiments under 8 different parameters such as pH (2.0-10.0), weight of phase (0.25-2.5 g), contact times (10-180 min), initial concentration (2.0-10.0 ppm). Under the optimum conditions, the percentage removals of Mn (II) using SCB and BP were 62.5 and 86.36%, respectively. The rate limiting step of the adsorption was studied using different kinetic models such as pseudo-first-order, pseudo-second-order adsorption equation, elovich equation and the intra particle diffusion model. Kinetics data was best fitted with the pseudo-secondorder type. This method has been successfully applied for reduce the risk of Mn (II) from ground water samples.

Saroj K. Sharma (2005) has studied Different mechanisms (physicochemical and biological) may contribute to iron removal in filters but the dominant mechanism depends on the physical and chemical characteristics of the water and process conditions applied. Nowadays, there are increasing numbers of

publications on methods of biological iron removal which are reported to be much more efficient and cost effective than conventional physicochemical iron removal. This paper reviews the theoretical background of biologically mediated iron removal, the process conditions required, the advantages and limitations of the method and a few case studies. A literature review revealed that biological iron removal is not suitable when pH and oxygen concentrations are high. Physicochemical removal mechanisms can achieve the same removal efficiency under the conditions that are reported to be favorable for biological iron removal.

Sharma and Bhattacharyya (2004) studied Adsorption of Chromium (VI) on Neem Leaf Powder. He developed a novel adsorbent from mature leaves of the Neem tree for removing metal ions from water. The adsorbent, in the form of fine powder, was found to be very effective in removing chromium (VI) from aqueous solution.

S. Vanitha, Dr. N. K. Rajan (2018), This paper deals with the traditional method of iron removal from ground water by using coconut shell charcoal, rice husk ash and banana ash. These are commonly available natural and low-cost adsorbents for removal of iron. The coconut shell charcoal has been found to be a good adsorbent to remove the iron in drinking water and optimum concentration was found to be 500 ppm. MnO₂ incorporated coconut shell charcoal is very effective to remove the iron content in water below 0.3-0.4 ppm without increasing the pH. Rice husk ash with coconut shell charcoal also proved to be a good adsorbent in removal of iron. Banana ash with coconut shell charcoal has been proved to be effective enough for removal of iron ion when compared to other coagulant used in the present study and being the low-cost material used in the experiment. The production of banana ash is also very cost-effective where it is only burned by controlled combustion at 500° for 4 hours.

Sheena K.N and Bhavia K.K (2017) This paper is done for removal of iron content using natural adsorbent. This study tries to introduce low-cost adsorbents sugarcane bagasse (SCB), coconut coir (COC) and neem leaves (NL) for the removal of iron from water. Effect of parameters like contact time, pH and adsorbent dosage on iron removal were determined using each of these adsorbents. This study shows that the three adsorbents have significant effect on iron removal. On

comparing the three adsorbents the iron removal for coconut coir is higher than that of neem leaves and sugarcane bagasse. Since sugarcane bagasse, neem leaves, coconut coir are easily available and eco-friendly it can be used for the removal of iron from water.

Thomas et al. (2009) studied about the bio sorption of heavy metal ions from aqueous solutions using a biomaterial. The aim of this work is to study the removal of toxic heavy metal ions by Neem leaves from synthetic waste water and to offer this bio sorbent as local replacement for existing commercial adsorbent materials.

Venkateswarlu et al. (2007) Department of Chemical engineering; Andhra University, Visakhpathanam (India) studied Removal of chromium from an aqueous solution using Neem leaf powder as an adsorbent. He was investigated; Neem leaf powder is used as an adsorbent for the removal of chromium from aqueous solution.

CHAPTER 3

AIM AND SCOPE OF THE EXPERIMENTAL WORK

3.1 AIM

To reduce the iron content in ground water using natural adsorbents like Coconut coir (COC) and Tulasi powder (TP) to the maximum extent.

3.2 SCOPE OF WORK

- To study various natural adsorbents used for identification of water purification.
- To study the existing water filtration methods.
- To design a low-cost water filter using eco-friendly adsorbents.
- To make a suitable method for reduction of iron.
- The objective of this project is to focus on reduction of iron from ground water by adsorption technique and to analyse the physio-chemical properties of ground water.

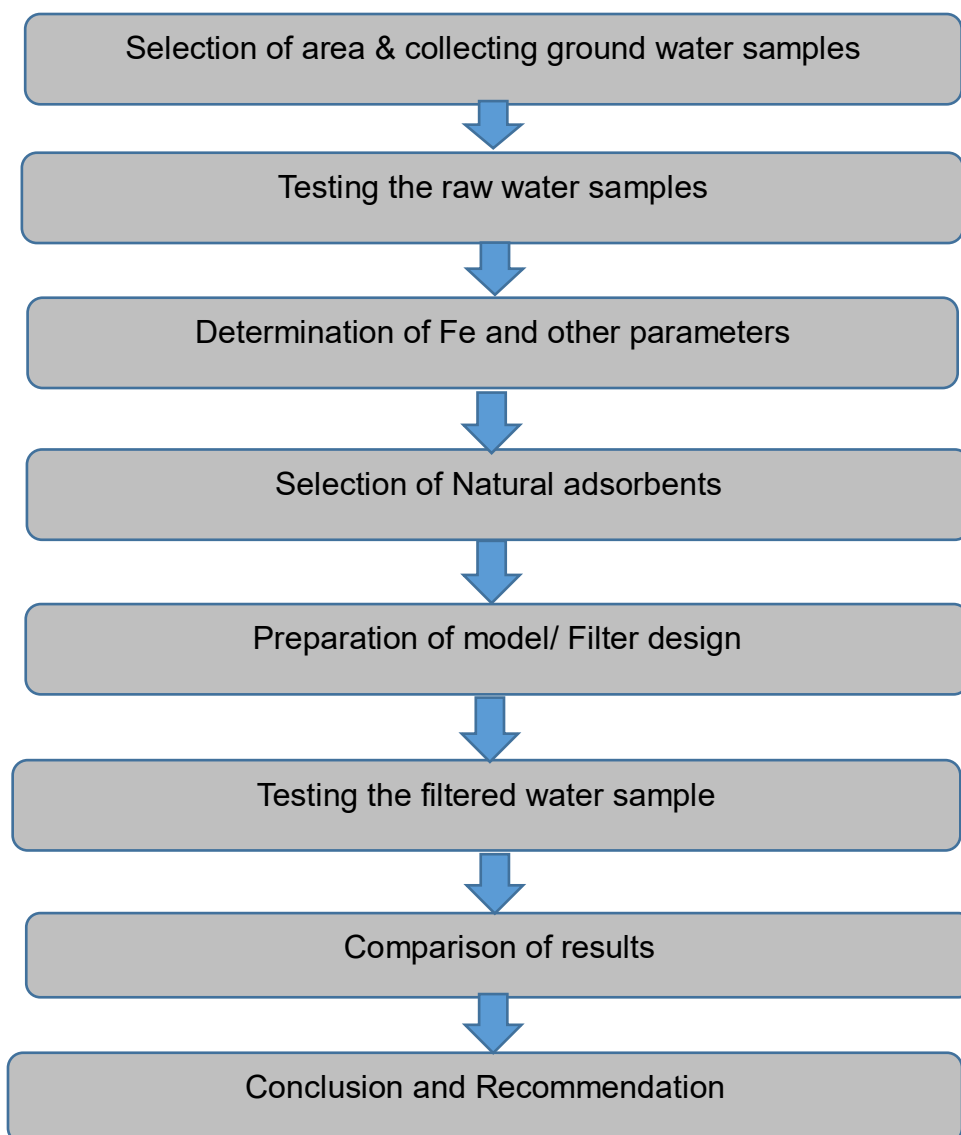
CHAPTER 4

EXPERIMENTAL WORK

4.1 METHODOLOGY

The steps involved in the process of the reduction of iron from the ground water which was collected from Porur West where the iron concentration is more than 3mg/l using Natural adsorbents like coconut coir and Tulasi powder is discussed in the methodology frame work as shown in fig 4.1. The process involved in testing the ground water for both physical and chemical parameters and the preparation of the low-cost filtration model using the Natural adsorbents is discussed. The below flow chart is showing the project process in reduction of iron content from ground water.

Fig 4.1: Methodological frame work



4.2 COLLECTION OF WATER SAMPLES

- Water samples have been collected where the iron content is more in Chennai according to the Chennai Corporation.
- In the western part of Chennai, there is a limited amount of alluvium under the topsoil, followed by clay. Areas like Valasaravakkam, Virugambakkam, Anna Nagar and Porur have clayey soil. The groundwater found in these areas is rich in iron, making it unfit for domestic consumption.
- Samples are collected from Porur in 5 areas.

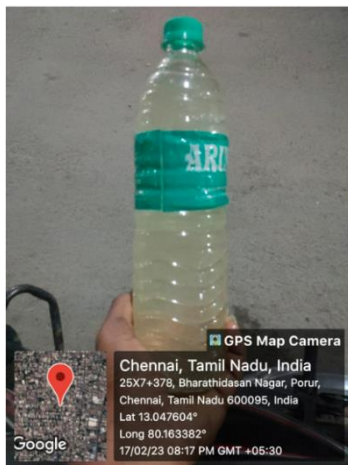


Fig 4.21

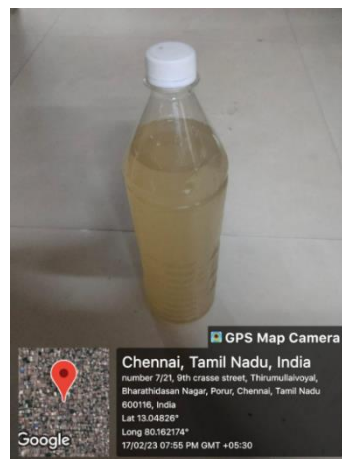


Fig 4.22

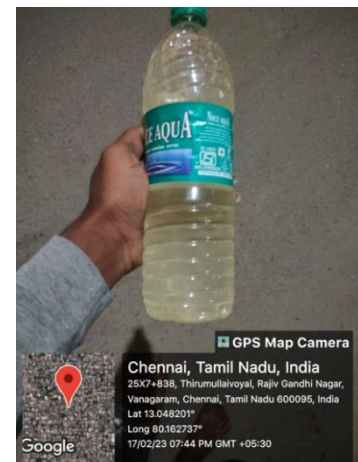


Fig 4.23



Fig 4.24

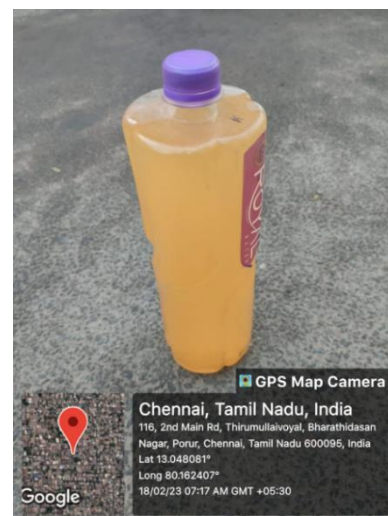


Fig 4.25

4.3 RAW WATER SAMPLES COLLECTED FROM FOLLOWING LOCATIONS

Table 1: Locations

S. No	Code for Samples	Area	Latitude	Longitude
1.	A	25X7+378, Bharathidasan Nagar	13.047604°	80.163382°
2.	B	9 th crasse street	13.04826°	80.162174°
3.	C	25X7+838, Thirumullaivoyal	13.048201°	80.162737°
4.	D	12 th St, Porur Garden	13.045707°	80.152887°
5.	E	2 nd Main Rd	13.0480081°	80.162407°

4.4 TESTING RAW WATER SAMPLES

Raw water samples have been tested for the following parameters to know the physio-chemical properties of the samples collected from five different places in study area i.e., Porur are

- pH
- Total Dissolved Solids
- Total Hardness
- Alkalinity
- Iron

4.4.1 pH

pH stands for the “power of hydrogen”. pH is a determined value based on a defined scale, similar to temperature. It is a figure between 0 and 14 defining how acidic or basic a body of water is along a logarithmic scale.

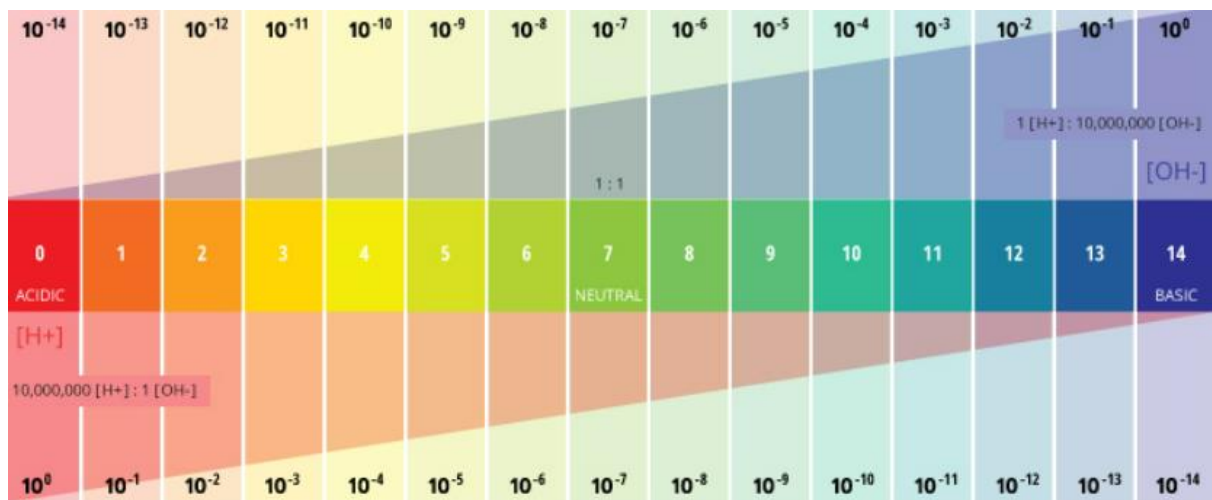


Fig 4.41: pH scale

4.4.2 Total Dissolved Solids

Total Dissolved Solids (TDS) are all the good and bad elements in water. These can be organic and inorganic substances such as minerals, salts, metals, cations, or anions dissolved in water. The TDS level is measured in parts per million (PPM) and milligrams per litre (mg/L). The higher the TDS, the more minerals are dissolved in the water.

Organic substances:

- Algae
- Bacteria
- Disinfectants
- Hair
- Herbicides
- Pesticides

Non-organic substances:

- Aluminum
- Ammonium
- Arsenic
- Bicarbonate
- Barium
- Calcium
- Chloride

4.4.3 Total Hardness

All waters contain two forms of hardness, i.e., temporary (or carbonate) hardness and permanent (noncarbonate) hardness. The combination of the two is referred to as total hardness. Total hardness is the sum of the calcium and magnesium concentrations, both expressed as calcium carbonate, in milligrams per liter (mg/L).

$$\text{Total Hardness, mg/L as CaCO}_3 = \frac{V_1 \times N \times 100 \times 1000}{V}$$

V= Volume of the sample taken, ml

V₁= Volume of titrant used for sample, ml

N= normality of EDTA

4.4.4 Alkalinity

Alkalinity is a chemical measurement of a water's ability to neutralize acids. Alkalinity is also a measure of a water's buffering capacity or its ability to resist changes in pH upon the addition of acids or bases and expressed in mg/L. Alkalinity of natural waters is due primarily to the presence of weak acid salts although strong bases may also contribute (i.e., OH⁻) in extreme environments. Bicarbonates represent the major form of alkalinity in natural waters; its source being the partitioning of CO₂ from the atmosphere and the weathering of carbonate minerals in rocks and soil.

$$\text{Alkalinity} = \text{HCO}_3^- + 2\text{CO}_3^{2-} + \text{OH}^- + \text{H}^+$$

4.4.5 Iron

Making up at least 5% of earth's crust, iron is one of the earth's most plentiful resources. Rainwater as it infiltrates the soil and underlying geologic formations dissolves iron, causing it to seep into aquifers that serve as source of groundwater. Iron is seldom found at concentrations greater than 0.3mg/L and can cause water to turn reddish brown color.

Table 2: WHO Standards for Water Quality

Parameters	Minimum Limit	Maximum Limit	Desired Range
pH	5	9.7	6.5
Total Dissolved solids (mg/L)	200	2500	1000
Alkalinity (mg/L)	200	600	500
Total Hardness (mg/L)	100	1000	500
Iron (mg/L)	0.2	1	0.3
Chlorine (mg/L)	600	1200	250

Table 3: Test Results of Raw water Samples

Code of Samples	pH	Alkalinity (mg/L)	Total Hardness (mg/L)	Total Dissolved solids (mg/L)	Iron (mg/L)
A	6.80	420	400	1443	18.97
B	6.98	428	360	1513	15.60
C	6.56	324	700	1899	11.26
D	7.03	440	520	1677	3.69
E	6.90	240	330	1107	4.20

From the above table, it is clear that all the parameters (pH, Alkalinity, Total Hardness, Total Dissolved solids) except Iron are in permissible limits of WHO standards.

4.5 LIST OF ADSORBENTS

Following are the list of adsorbents used for removal of iron from the journals referred

- Neem Leaves powder
- Rice Husk
- Coconut Coir
- Tulasi Leaves powder
- Natural zeolite
- Banana leaves ash
- Wood Charcoal

In this project, Tulasi leaves powder and Coconut coir are used as adsorbents for removing the iron content from the raw water samples.

4.6 MATERIALS USED

Over the years number of scientists and environmentalists had investigated the possibility and efficiency of utilization of the natural adsorbents for heavy metal adsorption in polluted water. Following materials were used in removal of iron from water discussed below.

4.6.1 Coconut coir as adsorbent

Coconut coir have beneficial properties such as structural stability, high absorptivity, porous structure that make them excellent bio-adsorbent for waste water contaminants. Coir is extracted from the coconut husk. Coir is an organic and versatile natural fibre, called the golden fibre because of its colour. Coconut coir was function as the main filter to screen out large solids such as algae. This material can withstand suspended solids due to the physical characteristics of the fibre solids capable of withstanding large. This material is as a substitute for the existing filter material on the market. Pollutant will be absorbed during the treatment process.

Preparation

Coconut coir was collected from the vendor. Washed thoroughly with distilled water to remove dirt. Sundried for two days. Crushed into small pieces for convenient usage.



Fig 4.61



Fig 4.62

4.6.2 Tulasi powder as adsorbent

The scientific name of Tulasi *Ocimum Sanctum* Linn. Leaves are dropped in drinking water for purification and for medication. In all Hindu temples, water mixed with Tulsi leaves are offered to devotees every day since the herbal plant is an excellent medicinal plant found all over India and is considered sacred. The leaves, seeds and root of this plant have been used in ayurvedic medicine. Chemical composition is highly complex, containing many nutrients and other biological active compounds. It has antimicrobial property. It has been reported to have radio protective and anti carcinogenic property. Chemical composition is highly complex, containing many nutrients and other biological active compounds that can remove iron. It contains phytochemicals working together these compounds process antioxidant, antibacterial and immune enhancing properties that maintain good health status. It is *Ocimum sanctum* or Tulsi is a traditionally and clinically proved medicinal herb for both its application and efficacy.



Fig 4.63

4.6.3 Plain sand

Fine sand is naturally occurring glacial deposits high in silica content and low in soluble calcium, magnesium and iron compounds are very useful in sedimentation removal. But here the media is used for iron removal from drinking water. Here for the experimentation plain sand is washed it thoroughly with tap water followed by distilled water (DW). Sand being the cheapest adsorbing surface is very effective in removal of dissolved iron from drinking water and the rate of filtration is also very high. The only demerit is subsequent development of bacterial layer due to rigorous use. Again, back washing is needed time to time.



Fig 4.64

4.6.4 Gravel chips

Gravel filters were found to be very effective for the removal of sediment and heavy metals under all water level regimes even as the system clogged over time. Despite the sediment particle size distribution being much smaller than the filter media pore size, sediment and its time associated pollutants were effectively trapped in the top of the gravel filter.



Fig 4.65

4.6.5 Filtration model development

Here, we have prepared a simple cylindrical filtration bottle as shown in Fig4.6.5 with the following dimensions

Lower Container Dimension

Length = 30cm

Diameter = 24cm

Upper Container Dimension

Length = 25cm

Diameter = 15cm

Materials used for preparing filter

- Gravel
- Fine Sand
- Filter paper
- Cotton pads
- Plastic Bottle
- Plastic Container
- Plastic Tap
- Coconut Coir
- Tulasi Powder



Fig 4.66

4.7 FILTRATION PROCESS

For removal of iron the natural materials had been used in the experiments i.e., Tulasi powder and Coconut coir has been adopted. The following adsorption media were tested in this study to remove iron from a sample of collected raw water.

- Take two different containers. Place the smaller one at the top for raw water collection and place the large container at the bottom for filtered water.
- Make holes at the bottom and top of a plastic container that will serve to place the adsorbent medium.
- In the adsorbent medium, place filter paper, cotton pads, adsorbents, gravel, and sand.
- To the bottom container, the plastic tap is fixed.
- Place a container with the adsorbent media inside.
- Pour the water to be filtered.

4.7.1 Coconut coir

The coconut coir, sand, gravel chips, and cotton pads are used for the filtration process. The plastic bottle is used as filter media and at the bottom and top layers cotton pads and filter paper are placed. Where the coconut coir in a specific amount of 20 grams, 50 grams, 100 grams is placed above the filter paper that is placed at the bottom, followed by sand and gravel chips.



Fig 4.71



Fig 4.72

The adsorbent media is placed in between plastic containers. The raw water sample with known concentration was passed through adsorbent media, and the filtrate water was collected. The filtrate water was then given for testing and the test result is shown in Table 4.



Fig 4.73

4.7.2 Tulasi powder

The tulasi powder, sand, gravel chips, and cotton pads are used for the filtration process. The plastic bottle is used as filter media. The top and bottom layers are placed with cotton pads and filter paper. Where the tulasi powder in a specific amount of 20 grams, 50 grams, 100 grams is placed above the filter paper that is placed at the bottom, followed by sand and gravel chips.



Fig 4.74

The adsorbent media is placed in between plastic containers. The raw water sample with known concentration is passed through adsorbent media, and the filtrated water is collected. The filtrated water is then given for testing and the test result is shown in fig.



Fig 4.75

CHAPTER 5

RESULTS AND DISCUSSION

5.1 INTRODUCTION

This chapter describes the data and analysis related to the results obtained from testing of samples after filtration using coconut coir and Tulasi powder. Data of the parameters pH, Alkalinity, Total Hardness, Total Dissolved, Iron obtained from testing are shown in tabular and Graphical forms. This data is important for the analysis of results concerning efficiency of the adsorbents.

C₁, C₂, C₃ are the codes for the samples that are filtered with Tulasi powder as adsorbent and C₄, C₅, C₆ are the codes for samples that are filtered with coconut coir as adsorbent.

Table 4: Test Results of Filtered Water

Parameters	Sample C ₁	Sample C ₂	Sample C ₃	Sample C ₄	Sample C ₅	Sample C ₆
pH	6.16	6.77	6.98	7.3	7.21	7.5
Alkalinity (mg/L)	396.13	412.1	400.87	496.8	486.45	441.2
Total hardness (mg/L)	600.5	559.12	500.9	379.76	359.56	320.96
Total Dissolved Solids (mg/L)	1500	1440	1680	1136	1131	1125
Iron	10.86	7.3	5.94	1	0.5	0.34

5.2 COCONUT COIR

The results obtained in removal of iron using coconut coir are mentioned in below tabular and graphical forms.

The initial concentration of the sample considered was 11.26mg/L.

Table 5: Iron values obtained from report

Sample no	Amount of coconut coir used (g)	Iron concentration obtained (mg/L)
C ₄	20	1
C ₅	50	0.5
C ₆	100	0.34

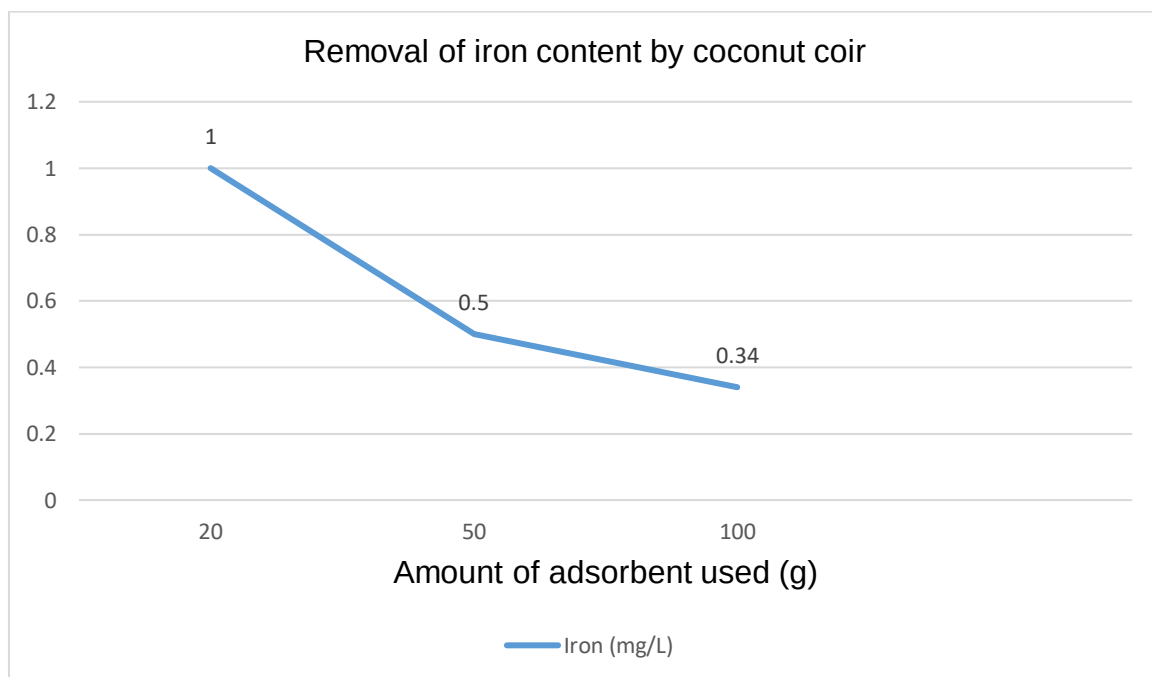


Fig 5.21: Graphical representation of obtained Iron values

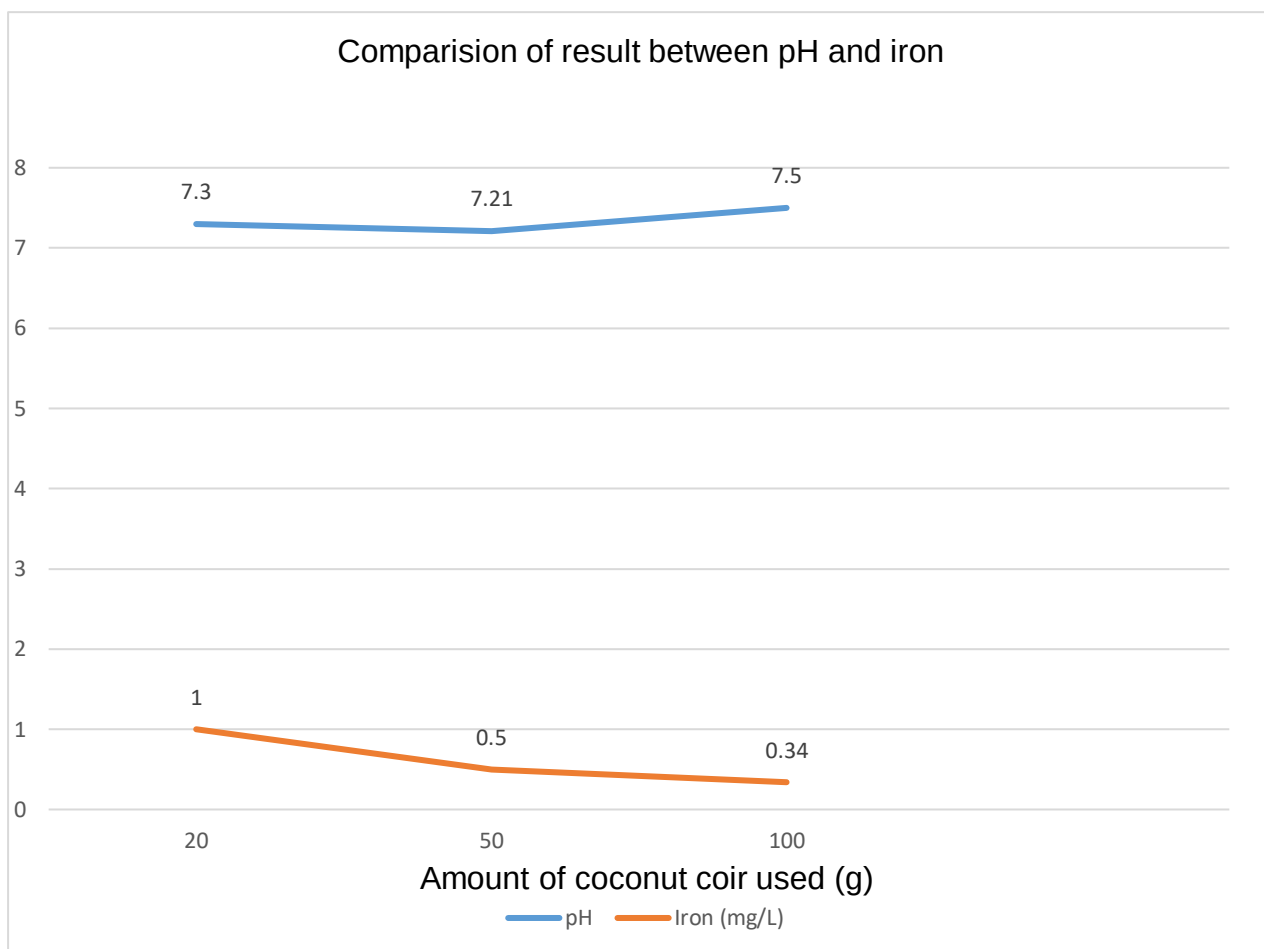


Fig 5.22 Graphical representation of comparison between results

5.3 TULASI POWDER

The results obtained in removal of iron using Tulasi Powder are mentioned in below tabular and graphical forms.

The initial concentration of the sample considered was 11.26mg/L.

Table 6: Iron Values obtained from report

Code for samples	Amount of Tulasi powder used (g)	Iron concentration obtained (mg/L)
C ₁	20	10.86
C ₂	50	7.3
C ₃	100	5.94

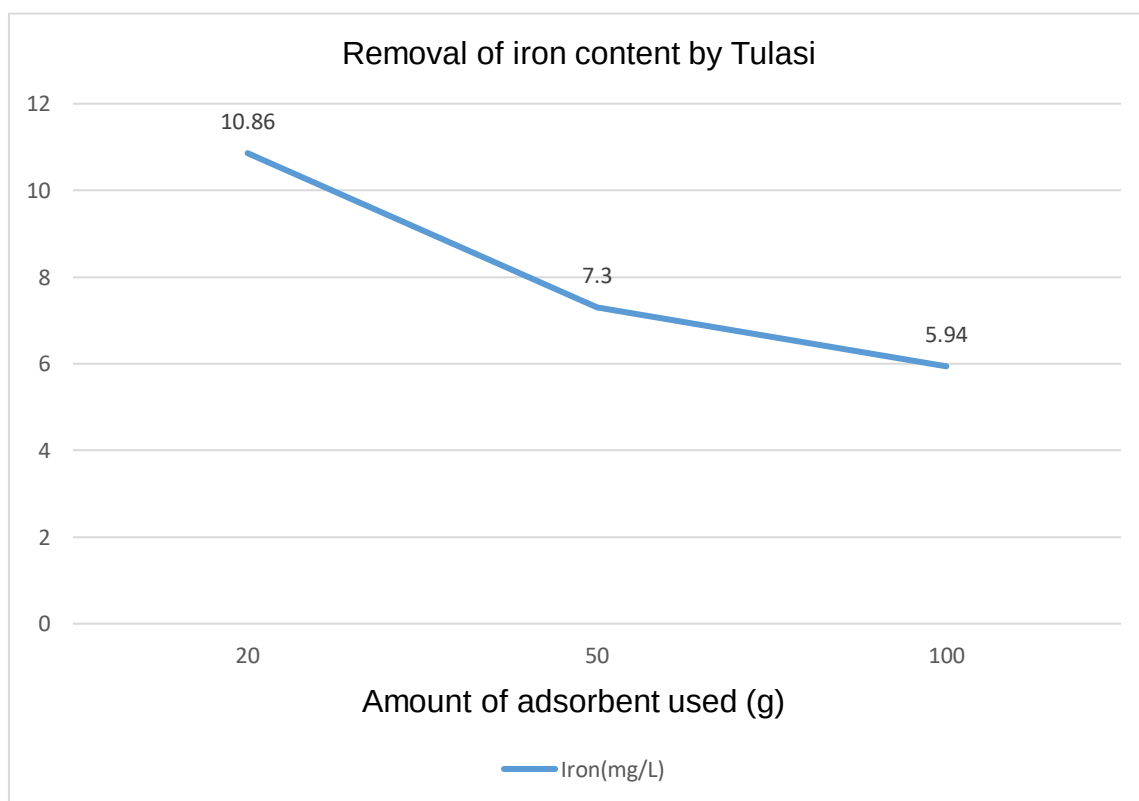


Fig 5.31: Graphical Representation of obtained Iron values

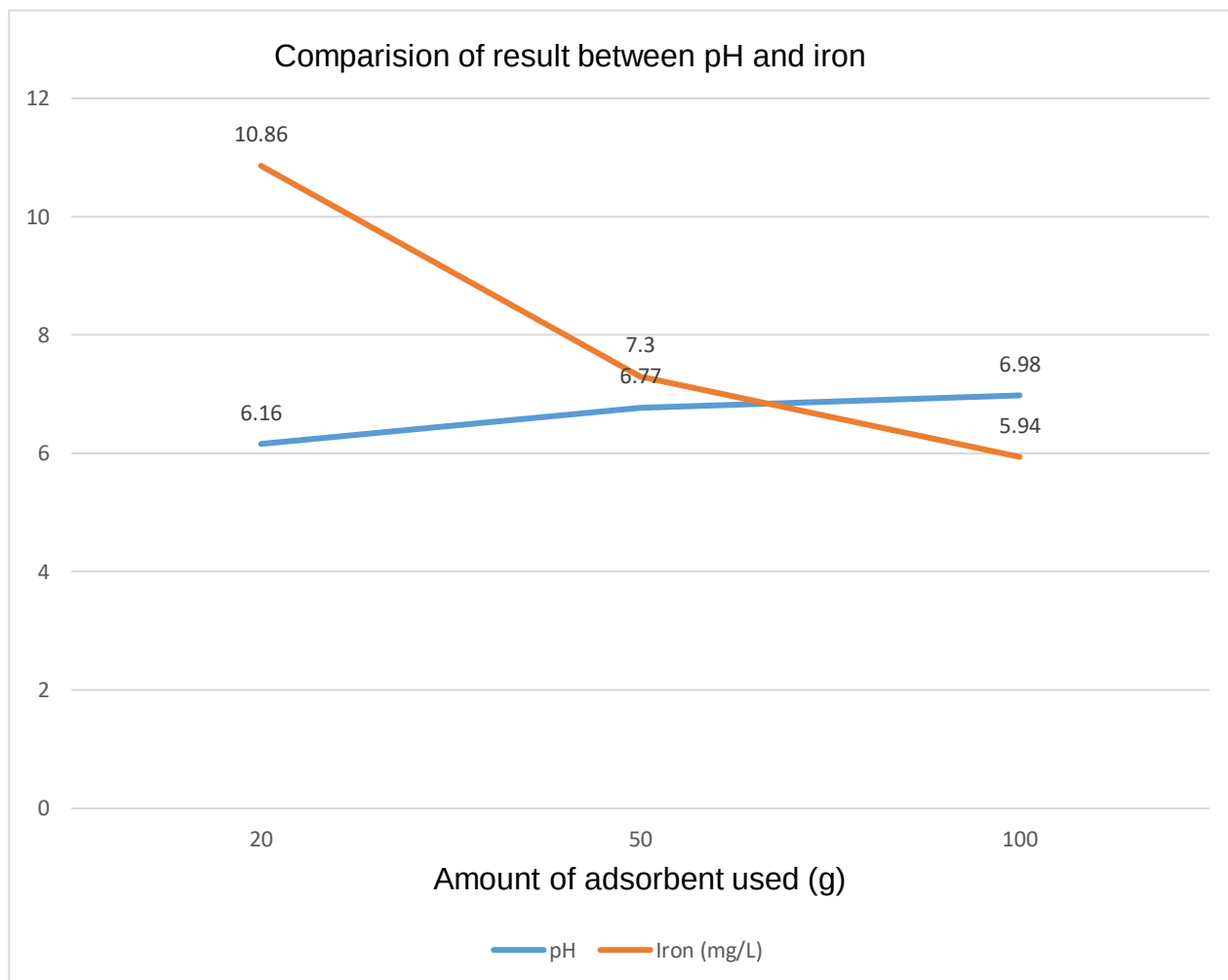


Fig 5.32 Graphical representation of comparison between results

5.4 COMPARISON BETWEEN EFFICIENCY OF ADSORBENTS

From the obtained data, below is the graphical representation of the comparison of efficiency of the adsorbents used for the removal of the iron.

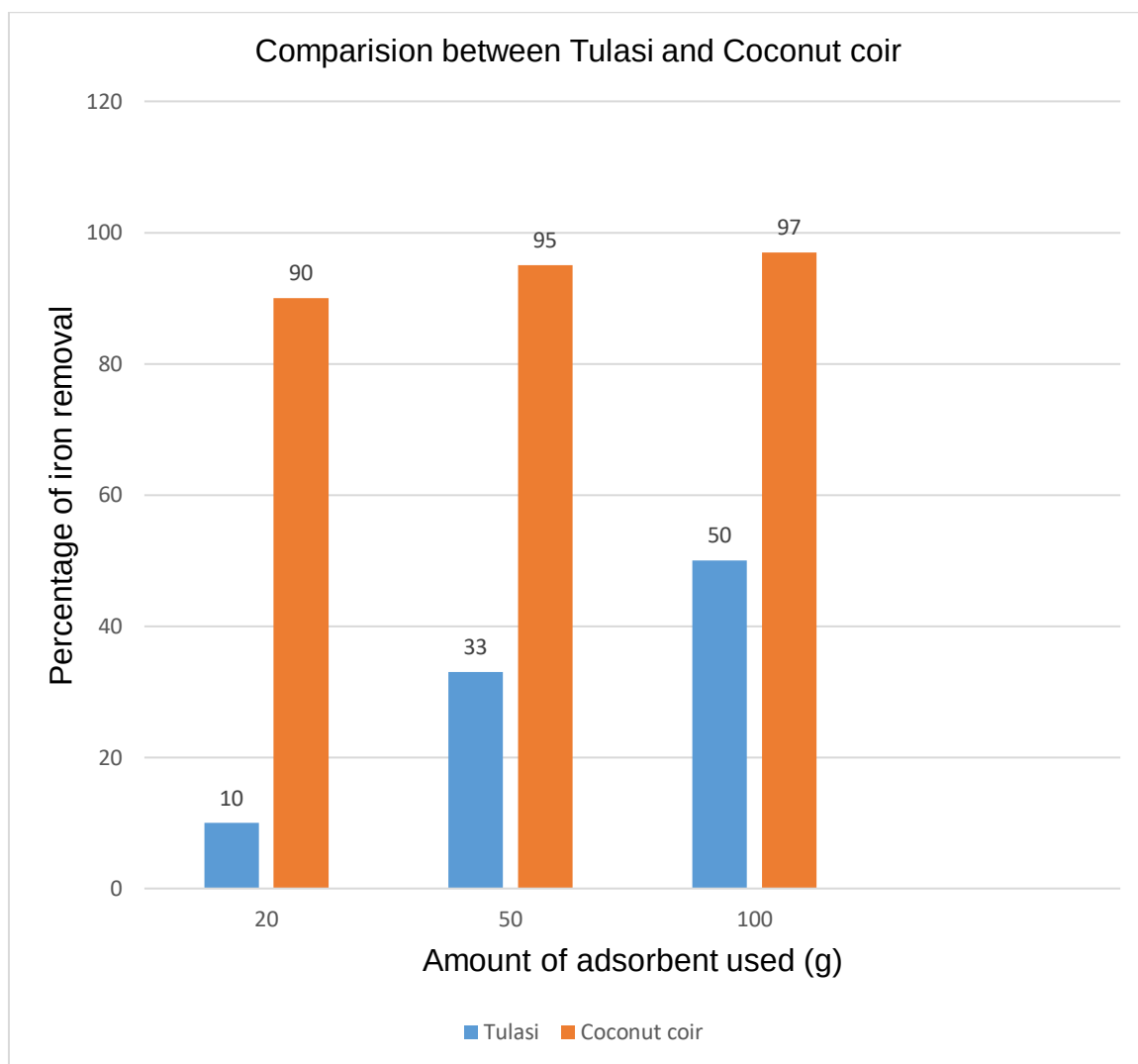


Fig 5.41: Comparison between Efficiency of Adsorbents

5.5 DISCUSSIONS

5.5.1 Test Results Obtained from Report

After the filtration of all the 6 samples, the testing was done. From the results, it was observed that there is a noticeable change in all the values of the parameters considered.

The values of the parameters like pH and Alkalinity are increased and the values of parameters Total hardness, Total Dissolved solids, Iron are decreased. All the values lie in the range of WHO standards.

5.5.2 Coconut coir as Adsorbent

The results obtained for the samples using coconut coir are observed as quite efficient. Percentage of removal of Iron is appreciably high.

5.5.3 Tulasi powder as Adsorbent

The results obtained for the samples using coconut coir are observed as fine. Percentage of removal of Iron is acceptable.

5.5.4 Comparison between pH and Iron values

The results acquired for tests shows that the pH values increases and the iron values decreases. From this it is observed that these properties of water have a relation.

5.5.5 Comparison of Iron with other parameters

The derived values of the parameters show that properties of water are analogous.

5.5.6 Comparison between Adsorbents

The results procured manifest that the adsorbents adopted are efficient for removal of iron. It indicates the percentage of removal of iron is higher using Coconut coir as an adsorbent than Tulasi Powder.

5.6 COST OF THE FILTER

A chart had been provided on cost analysis for making the water filter used in the project. Each cost of material and used adsorbents cost are given in the table.

Table 7: Material cost of filter used in project

Material	Amount of material used	Cost in rupees
Coconut Coir	170g	150/-
Tulasi powder	170g	160/-
Containers	-	300/-
Filter paper	2	1.33/-

- Total cost of filter= 611Rs

CHAPTER 6

SUMMARY AND CONCLUSION

- Adsorption being the simplest and cheapest technique for iron removal, it has several advantages, like longer filtration runs, shorter ripening time, better filtrate quality. But the only limitation is back wash water requirement is essential for the filter media to run effectively.
- This study shows that the two adsorbents have significant effect on iron removal.
- Sand as an adsorbing surface is very effective in removal of dissolved iron from drinking water and the rate of filtration is also very high. The only demerit is subsequent development of bacterial layer due to rigorous use back washing is needed from time to time.
- Coconut Coir, crushed to small pieces have depicted greater efficiency in removal of iron from the selected samples.
- Tulasi powder as an adsorbent have shown not so significant removal of iron.
- Increasing the amount of Tulasi powder might show satisfactory efficiency.
- Greater the pH, smaller will be the amount of iron present in water.
- Coconut coir and Tulasi powder are easily available and eco-friendly. These can be used for the removal of iron from water.

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