A comparative Study of Iron Removal from Groundwater by Different Methods

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Abstract
The growth of industries lead to the increase in iron content in ground water .Thus ,groundwater is a major source of drinking water, this leads to many health issues like loss of strength of teeth, loss colour of teeth, kidney failure ,oral ulcer, hemochromatosis and many more .Many places in Ernakulam faces the issue of iron contamination in ground water. Thus we here address to know the cost effective and efficient way to remove iron content from water. We use the methods like aeration, brings water and air in close contact and helps to remove dissolved metals through oxidation. Biosorption is another method we use, here we use shell charcoal and spent mushroom substrate to remove iron content. Thus, spent mushroom substrate used as a biosorbent is a new method we adopted to remove iron content from ground water.

Keywords: *Adsorbent, Adsorption, Aeration, spent mushroom substrate, shell charcoal.*

Date of Submission: xx-xx-xxxx Date of acceptance:xx-xx-xxxx

I. INTRODUCTION

Iron is a prevalent element in natural water sources, and maintaining its concentration below 0.3 ppm is crucial for water quality. It exists in various forms, including true solution, colloidal particles, inorganic or organic complexes, and suspended particles. In soils and minerals, iron primarily occurs as insoluble ferric oxide and iron sulphide, while in some regions, it can be found as slightly soluble ferrous carbonate (siderite). Ferrous carbonate dissolution is facilitated by dissolved carbon dioxide in groundwater, leading to increased iron levels. Insoluble ferric compounds in soil pose a significant challenge for iron removal as they resist dissolution, even in the presence of high carbon dioxide levels, unless dissolved oxygen is available. However, under reducing (anaerobic) conditions, ferric iron is converted to soluble ferrous iron, enhancing its solubility and promoting its solution in water. Iron contamination is a common issue in groundwater, which serves as a primary source of drinking water worldwide. Despite the absence of specific health-based guidelines for iron concentration, its presence causes aesthetic and operational problems, such as unpleasant taste, discoloration, staining, and the formation of deposits in distribution systems, leading to compromised water quality and increased turbidity. To address iron contamination, various physical and chemical treatment processes are available, including coagulation, flocculation, ion exchange, membrane separation, and oxidation. However, these methods often come with financial burdens, high sludge production, and challenges in handling and disposal. Consequently, the search continues for cost-effective and environmentally friendly approaches to treat metal-contaminated wastewater. Biosorption, a physiochemical process, harnesses the ability of certain biomass to accumulate and bind contaminants onto their cellular structures. It involves the uptake of heavy metal ions through metabolic or physiochemical pathways. Biosorption has gained recognition as an efficient and economical method for removing heavy metals from wastewater. It offers the advantage of utilizing inexpensive biosorbents derived from non-living or microbial biomass obtained from natural sources. In our experimental setup, we utilized three distinct methods to remove iron from groundwater, employing biosorbent derived from coconut shells demonstrating promising iron removal capabilities. We are developing a new method for iron removal using spent mushroom substrate as a biosorbent. The substrate undergoes pre-treatment and is then used to adsorb iron from contaminated water. We measure the initial and final iron concentrations to calculate removal efficiency. Additionally, we incorporated an aeration technique as part of the experimental protocol. Aeration involves introducing air into the water to enhance the oxidation of ferrous iron to ferric iron, which subsequently promotes the precipitation and removal of iron from the water. Through meticulous testing and comprehensive analysis, our objective was to assess the efficiency of these biosorbents and identify the most cost-effective, sustainable, economical method for iron removal from groundwater.

II. METHODOLOGY

The aim of this project is to analyses three method of iron removal and find out the best efficient among them. There are lot of problem surrounding in our locality. Among them the presence of iron is an important one

related to water. Finding a problem, analyzing it, and finding a solution for it is an important process. If proper measure is not taken then it can make the situation bad or more dangerous. The methodology used for the project is as follows: a) collection of reviews of journal and articles to get an idea of work to be conducted. b) fixing the biosorbents to be used for the work and collecting the materials required for the experiment c) conduction of the experiment. i. Spent mushroom substrate as biosorbents ii. Shell charcoal as biosorbent iii. aeration d) determine the amount of iron removed by phenanthroline method e) conduct the comparative study in order to find the efficient one. $efficiency = (output/\text{input}) \times 100\%$ f) arriving to the conclusion.

III. MATERIALS USED

3.1 Spent Mushroom Substrate

Spent mushroom substrate is the soil-like material remaining after a crop of mushrooms. Spent substrate is high in organic matter making it desirable for use as a soil amendment or soil conditioner. Sometimes this material is called spent mushroom compost. Substrate prepared specifically for growing mushrooms is a blend of natural products. Common ingredients are wheat straw bedding containing horse manure, hay, corn cobs, cottonseed hulls, poultry manure, brewer's grain, cottonseed meal, cocoa bean hulls and gypsum. Growers may add ground soybeans or seed meal supplements later in the production cycle. On top of the substrate, farmers apply a "casing" layer, which is a mixture of peat moss and ground limestone. The casing material provides support for the growing mushrooms. Spent mushroom substrate still has some nutrients available for the mushroom; however, it is more economical to replace the substrate and start a new crop.

3.2. Shell Charcoal

Coconut shell is the toughest component covered in coconut fruit. The coconut shell is situated between the coconut flesh and the coconut husk. This shell is usually designed to cover the inner portion of the coconut. Shell is used for the development of various handicrafts and other applications. Many handmade decoration items are produced by using coconut shells because of their strength. Coconut shells are also used to produce charcoal, which is used as food, and this coconut charcoal is much stronger than other charcoals. Coconut shell charcoal is commonly used for the manufacture of active carbon. Usually, activated carbon is known as carbon dioxide, which has been treated with oxygen. Active carbon is commonly used to eliminate impurities. Coconut shell charcoals are commonly used in the purification industry and other sectors that use active carbon. Shell Charcoal is obtained by burning the shell of fully matured coconuts with a limited supply of air so that they do not burn away to ash but are only carbonized. The manufacture of shell charcoal shows from the coconut shell has become a very important economic and commercial activity. Furthermore, coconut shell charcoal, which was relatively minor product in the past, has now Figure 4.1.2 Spent Mushroom Substrate as Bed A Comparative study of iron removal from groundwater by different methods Dept. Of Civil Engineering 8 B-Tech 2023 developed into a general commercial commodity due to its intrinsic value as a raw material for the manufacture of activated carbon. Coconut shell charcoal shall be of the following two types: Type I – Coconut shell charcoal – pieces Type II – Coconut shell charcoal – granulated.

IV. EXPERIMENTS DONE

4.1 Aeration

The iron must first be exposed to air or another form of an oxidizing agent. Aeration is the most cost-effective method to oxidize ferrous iron for its removal from water. In many areas around the globe, municipal and industrial operations have the need to remove naturally occurring iron (Fe) from the water to both prevent damage to other equipment as well as to improve water quality. To remove iron from the water it first must be oxidized using the most widely accepted and cost-effective method called aeration. The aeration process changes the iron from its Ferrous (Fe+2) state (soluble) to ferric (Fe+3) a colloidal participate. • Take a clean bucket and pour 5L of distilled water into it. • Add 2 mg/L of iron concentration into it • Mix the solution well • Attach the aeration system into the bucket • Take 75 mL of sample in an interval of 15,30,45,60,120 & 180 minutes • Determine the current iron concentration by phenanthroline method • same as above for 4mg/L and 6 mg/L • plot the graph showing iron concentration/ V/S time.

4.2 Spent mushroom substrate as a biosorbent

Spent mushroom substrate is a waste product obtained from the cultivation of mushroom. This can be used as a biosorbent for the removal of iron. This will be a cheapest and simple form of filtration. It is also a time consuming innovative experimental setup. • Take a clean bucket and pour 5L of distilled water into it. • Add 2 mg/L of iron concentration into it • Mix the solution well • Collected mushroom should be properly cleaned, chopped, and allow for sunbath for 24 hours • take 500gm of biosorbent and add into the bucket • Take 75 mL of

sample in an interval of 15,30,45,60,120 & 180 minutes • Determine the current iron concentration by phenanthroline method • same as above for 4mg/L and 6 mg/L • plot the graph showing iron content V/S time.

4.3 shell charcoal as a biosorbent

Shell charcoal is a good biosorbent. It can be used for many filtrations process having the best cheapest method. It is a conventional method which is used as a commercial purpose. Also, coconut shell is an easily available material. It contains activated carbon which is a best material for the filtration purpose • Take a clean bucket and pour 5L of distilled water into it. • Add 2 mg/L of iron concentration into it • Mix the solution well • Take the shell charcoal and cut into pieces and provide 420 ℃ in muffle furnace • Take the shell charcoal and allow for cooling and after 30 minutes clean it well with water • Take 500gm of biosorbent and add into the bucket Figure 5.2.1 spent mushroom substrate as a biosorbent A Comparative study of iron removal from groundwater by different methods Dept. Of Civil Engineering 13 B-Tech 2023 • Take 75 mL of sample in an interval of 15,30,45,60,120 & 180 minutes • Determine the current iron concentration by phenanthroline method • same as above for 4mg/L and 6 mg/L • plot the graph showing iron content V/S time.

V. RESULTS AND DISCUSSION

5.1Aeration

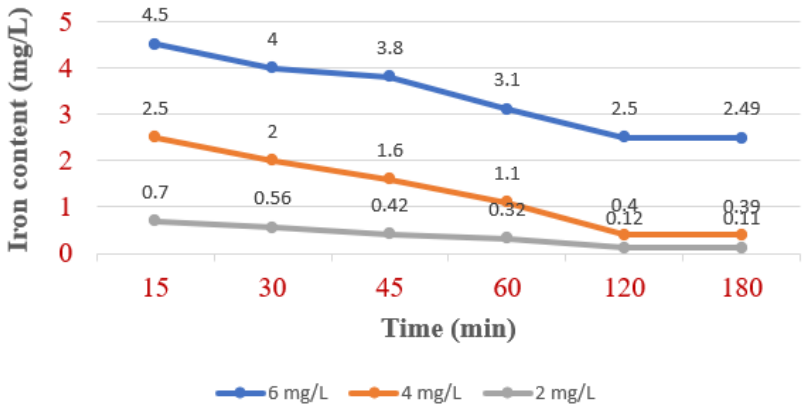

Fig 1: Graphical representation of iron conc in aerated iron water

From this graph we can conclude that there is a drastic change in iron content after 15 minutes. Later small variations are happening. After 120 minutes its almost the same. This is also a cheap method. They will act as a biosorbent and remove iron from the water. it can act as a removal technique of iron.

5.2 SMS

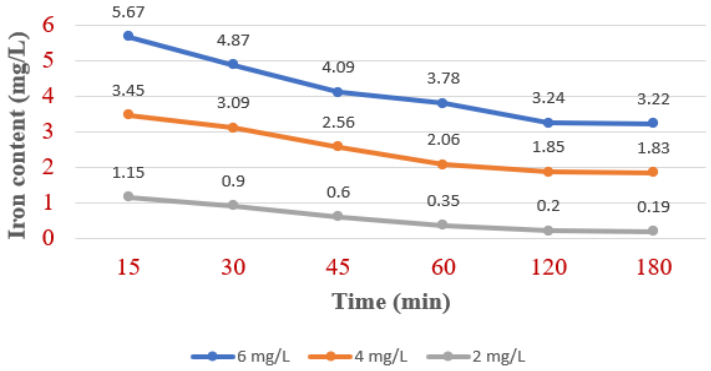

Fig 2: Graphical representation of iron conc in SMS treated iron water

From this graph we can conclude that there is a drastic change in iron content after 15 minutes. Later small variations are happening. After 120 minutes its almost the same. This is also a cheap method. They will act as a biosorbent and remove iron from the water. it can act as a removal technique of iron.

5.3. Shell Charcoal

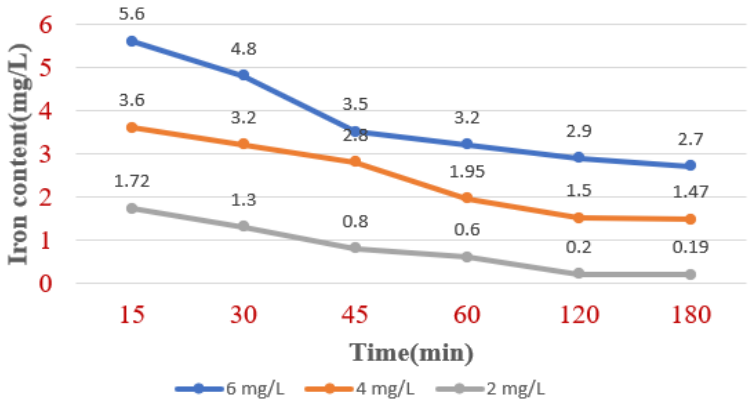

Fig 3:Graphical representation of iron conc. in Shell charcoal treated iron water

From the graph we can understand that iron remove through shell charcoal when it is used as a biosorbent. After 120 minutes it showing the same value itself. That is it has achieved its saturation point. A slight change can be done in 45 minutes.

VI. COMPARATIVE STUDY

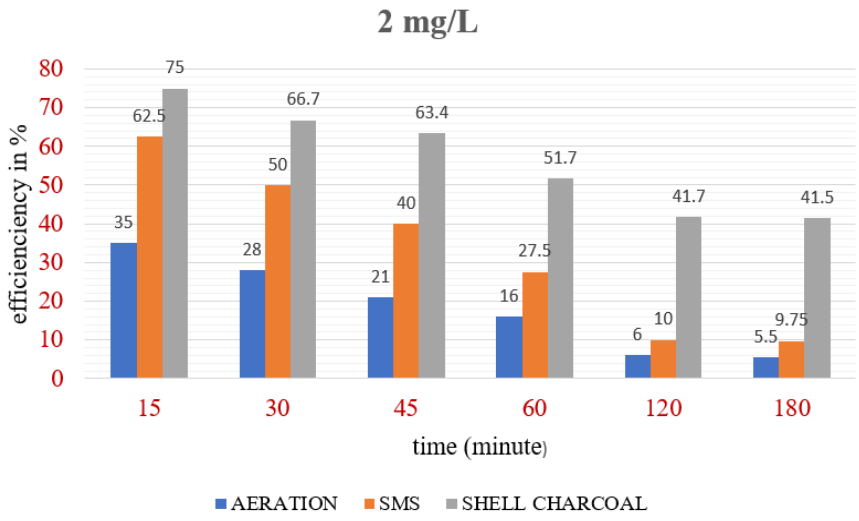

Fig 4: Comparison chart of 2mg/L concentration

From the graph, we can understand that shell charcoal has greater efficiency comparing to the other methods. Aeration has only small capacity to remove iron from water. in 15 minutes, its only 35%. At 180 minutes it shows 5.5% for aeration and 41.5% for shell charcoal and for spent mushroom substrate 9.75%.

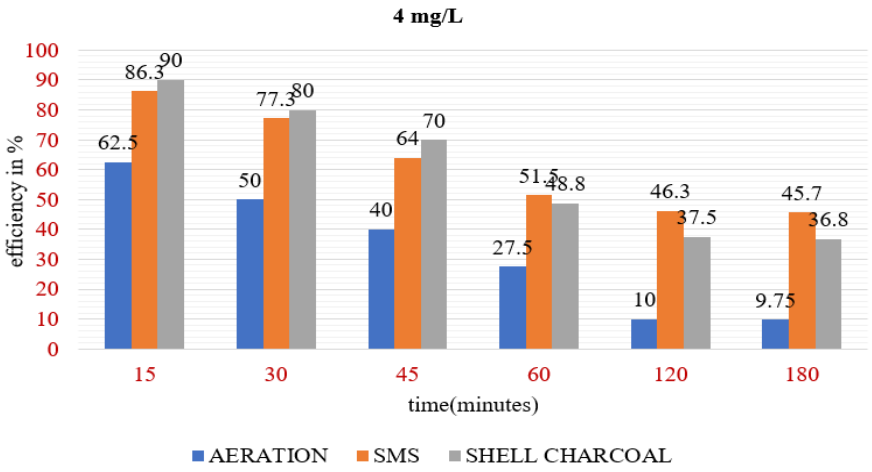

Fig 5: Comparison chart of 4mg/L concentration

From this bar chart, the most efficient one is shell charcoal. At 15 minutes the efficiency of aeration is 62.5% and for spent mushroom substrate 86.3% and 90% for shell charcoal. When it reaches 60 minutes the adsorption capacity of spent mushroom substrate is get increased comparing to the shell charcoal. All the three method has a drastic change.

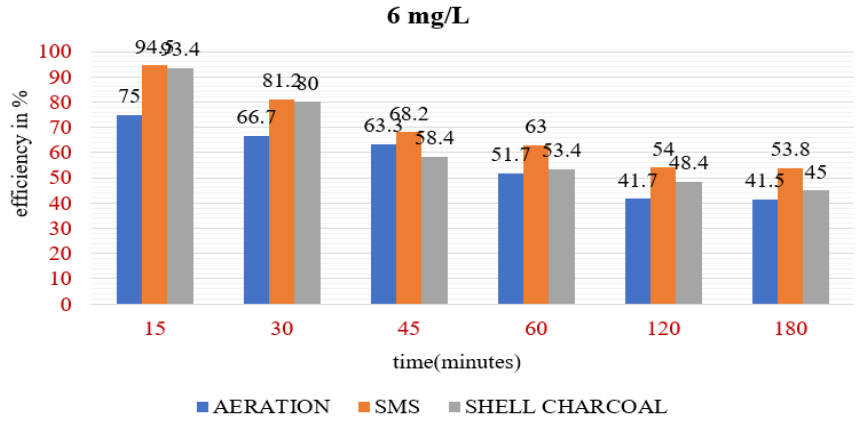

Fig 6: Comparison chart of 6mg/L concentration

From the graph, it can be understood that spent mushroom has a great adsorption capacity. It is having 94.4% in 15 minutes and that for shell charcoal 93.4% and 275% for aeration. The adsorption is almost same in 15 minutes. All three are gradually removing the iron concentration from water.

VII. CONCLUSION

Through the series of experiments, we have compared the methods to remove iron concentration from ground water by aeration and by using biosorbents like shell charcoal and SMS. And we come to a conclusion that shell charcoal as a biosorbent have the highest efficiency of iron concentration removal from water. And we were able to prove that spent mushroom substrate is a protentional source of adsorption of Fe^{2+} from iron contaminated water. The order of efficiency we obtained is biosorption with shell charcoal followed by biosorption with SMS and then aeration process. Shell charcoal have showed efficiency in range of 75 to 45%, SMS have shown an efficiency between 94 to 54.8% and Aeration showed an efficiency of 75 to 41.5% between the time interval of 15 mins and 180 mins Here, we have effectively utilized the waste materials like shell charcoal and SMS. Also, we have done the process of iron removal biofriendly, economically and sustainably. The efficiency of biosorbents decreases due to the saturation of iron concentration in biosorbents. This can be overcome by add more volume, replacement and also by backwashing. Further studies have to carried out in case of SMS as biosorbent in removal of iron concentration from water.

VIII. REFERENCES

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