STUDY OF A TRADITIONAL METHOD FOR REMOVAL OF IRON FROM GROUND WATER

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ABSTRACT

Iron is the primary source for discoloration problems in the drinking water. The removal of iron from groundwater is a common treatment step. The presence of iron in groundwater has been recognized as a serious community health problem due to its high toxic nature. The removal of iron is essential and important. 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 500ppm. The optimum residence time for the removal of iron in water was found to be 4 hours. MnO\textsubscript{2} 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 when compared to other coagulant used in the present study and being the cheapest 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 degree Celsius for 4 hours. The designed iron removing method is expected to be suitable for household use.

Key words: Ground water, Coconut Shell Charcoal Ash, Banana Ash, Rice Husk Ash.

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1. INTRODUCTION
Water is the most precious gift of nature, the most crucial for sustaining life and is required in almost all the activities of human - for drinking and municipal use, for irrigation, to meet the growing food and fiber needs, for industries, power generation, navigation and recreation.

Safe drinking water is essential to humans and other life forms even though it provides no calories or organic nutrients. Access to safe drinking water has improved over the last decades in almost every part of the world, but approximately one billion people still lack access to safe water and over 2.5 billion lack access to adequate sanitation. There is a clear correlation between access to safe water and gross domestic product per capita. However, some observers have estimated that by 2025 more than half of the world population will be facing water-based vulnerability. A report, issued in November 2009, suggests that by 2030, in some developing regions of the world, water demand will exceed supply by 50%.

2. OBJECTIVES
- To study the current status of water quality
- To identify the impurities which are harmful to health
- To suggest the optimum way to remove the impurities from water
- Removal of iron from water by using different adsorption media which are naturally available at a low cost
- Designing a simple household setup for water filtration focusing on removal of iron and Turbidity

3. METHODOLOGY
- Collection of water samples
- Testing of raw water samples
- Comparison of samples result with BIS standards
- Analyzing the suitability of water for drinking or other domestic use
- Selection of harmful impurities
- Determination of optimum low cost treatment method
- Testing of treated water samples
- Comparison of result with other materials used in purification
- Result and conclusion

Figure 1 Location of study area
Table 1 Location of water samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Type of Source</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Public hand pump</td>
<td>Near Ford, Maraimalainagar</td>
</tr>
<tr>
<td>2</td>
<td>House hold bore well</td>
<td>Peramanur</td>
</tr>
<tr>
<td>3</td>
<td>House hold tube well</td>
<td>Kattangulathur</td>
</tr>
<tr>
<td>4</td>
<td>Open well</td>
<td>Keezhkaranai</td>
</tr>
<tr>
<td>5</td>
<td>Public hand pump</td>
<td>Near Police Station, Maraimalainagar</td>
</tr>
</tbody>
</table>

Table 2 Test reports of raw water samples

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>SAMPLE 1</th>
<th>SAMPLE 2</th>
<th>SAMPLE 3</th>
<th>SAMPLE 4</th>
<th>SAMPLE 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color (Hazen units)</td>
<td>&lt;1.0</td>
<td>4.7</td>
<td>&lt;1.0</td>
<td>6.2</td>
<td>&lt;1.0</td>
</tr>
<tr>
<td>Odour</td>
<td>Agreeable</td>
<td>Agreeable</td>
<td>Agreeable</td>
<td>Agreeable</td>
<td>Agreeable</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Electrical conductivity @ 25°C (micromhos/cm)</td>
<td>1199</td>
<td>1557</td>
<td>1347</td>
<td>1513</td>
<td>1747</td>
</tr>
<tr>
<td>pH value @ 25°C</td>
<td>6.72</td>
<td>7.15</td>
<td>7.67</td>
<td>7.23</td>
<td>7.02</td>
</tr>
<tr>
<td>Total dissolved solids (mg/l)</td>
<td>719</td>
<td>1012</td>
<td>875</td>
<td>983</td>
<td>1135</td>
</tr>
<tr>
<td>Total hardness as CaCO₃ (mg/l)</td>
<td>500</td>
<td>665</td>
<td>720</td>
<td>635</td>
<td>755</td>
</tr>
<tr>
<td>Calcium hardness as CaCO₃ (mg/l)</td>
<td>320</td>
<td>430</td>
<td>525</td>
<td>380</td>
<td>590</td>
</tr>
<tr>
<td>Magnesium hardness as CaCO₃ (mg/l)</td>
<td>180</td>
<td>235</td>
<td>195</td>
<td>255</td>
<td>165</td>
</tr>
<tr>
<td>Magnesium as Mg (mg/l)</td>
<td>43</td>
<td>88</td>
<td>76</td>
<td>61</td>
<td>45</td>
</tr>
<tr>
<td>Calcium as Ca (mg/l)</td>
<td>128</td>
<td>287</td>
<td>245</td>
<td>328</td>
<td>263</td>
</tr>
<tr>
<td>Total alkalinity as CaCO₃ (mg/l)</td>
<td>200</td>
<td>212</td>
<td>230</td>
<td>215</td>
<td>210</td>
</tr>
<tr>
<td>Chlorides as Cl⁻ (mg/l)</td>
<td>169</td>
<td>221</td>
<td>189</td>
<td>316</td>
<td>720</td>
</tr>
<tr>
<td>Sulphates as SO₄²⁻ (mg/l)</td>
<td>146</td>
<td>290</td>
<td>327</td>
<td>284</td>
<td>192</td>
</tr>
<tr>
<td>Total iron as Fe (mg/l)</td>
<td>0.045</td>
<td>2.130</td>
<td>0.23</td>
<td>3.657</td>
<td>0.159</td>
</tr>
</tbody>
</table>

3.1. Treatment of Water

Water treatment is any process that makes water more acceptable for a specific end use. The end may be drinking, industrial water supply, irrigation, river flow maintenance or many other uses including being safely return to the environment. Water treatment removes contaminants or reduces their concentration so that the water becomes fit for its desire end use.

3.2. Method used in Iron Removal

For removal of iron broadly two phenomena had been used in the experiments i.e. adsorption, oxidation followed by precipitation and for removal of turbidity microfiltration by ceramic filter has been adopted.

3.3. Adsorption

Basically the adsorptive filtration is operated under anoxic conditions for removal of iron where oxidation of ferrous iron is suppressed i.e. in case of filtration of ground water. Here we have taken aerobic conditions for filtration in the adsorption media.
3.4. Oxidation and Precipitation
Before filtration of iron, it is needed to be oxidized to a state in which it can form insoluble iron complexes. By use of oxidizing agents, Fe$_{2+}$ can be converted to insoluble Fe$_{3+}$ which forms insoluble iron hydroxide complex Fe(OH)$_3$. Potassium permanganate, chlorine is the most abundantly used oxidizing agents. Here ash produced from banana leaf, stem and rind are being used as an oxidizing agent. Ash obtained from banana rind, pseudo-stem and leaf are rich in potassium. Usually in groundwater which is deprived of oxygen, the iron remains in soluble state. When ash is added to theater, it forms KOH from K$_2$O and K$_2$CO$_3$ present in the banana ash. So the medium becomes alkaline and at high pH, the soluble Fe$_{2+}$ is converted to insoluble geothite (FeOOH) or ferri hydrite (Fe (OH)$_3$). And the precipitate can be filtered using any convenient filter media.

3.5. Materials and Adsorption Medias Used
As per the two methods of adsorption and oxidation, in the first method for removal of iron by adsorption technique, different adsorption media were used for iron removal is listed below which are locally collected at a very cheap cost. In the second methodology, ash obtained from banana residue was used for removal of iron by oxidation followed by precipitation.

3.6. Plain Sand
Fine sand and gravel are naturally occurring glacial deposits high in silica content and low insoluble 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 experiment at ion plane sand passing through 425 micron and 600 Micron IS sieve were used.

3.7. Silica Sand
Silica sand is one of the most common varieties of sand found in the world. It is used for a wide range of applications. Silica sand is used throughout the world, and in so many different ways it is hard to imagine a world without it. From water filtration, to glass manufacture, to industrial casting, to sand blasting, to producing concrete, to adding texture to slick roads, silica sand impacts every aspect of daily life.

3.8. Activated Carbon
Activated carbon, also called activated charcoal, is a form of carbon processed to have small, low-volume pores that increase the surface area available for adsorption or chemical reactions. Activated is sometimes substituted with active. Due to its high degree of micro porosity, just one gram of activated carbon has a surface area in excess of 3,000 m$^2$ (32,000 sq.ft), as determined by gas adsorption. An activation level sufficient for useful application may be attained solely from high surface area; however, further chemical treatment often enhances adsorption properties.

3.9. Mineral Stone
Mineral stone are mined between 60 and 330 meters below sea level on an unpolluted korean island. The mineral stone contains Germanium which promotes health and prevents cancer. Germanium also absorbs heavy metals, toxins, odour and impurities, the continuously releases more than 30 kinds of ionized minerals for 5 years, and gradually depleting in size. The highly porous mineral stone aid in the oxygenation of water and in the adjustment of the pH of water mild alkaline.
3.10. Alum
Alum is both a specific chemical compound and a class of chemical compounds. The specific compound is the hydrated potassium aluminium sulfate (potassium alum) with the formula KAl(SO₄)₂·12H₂O. Potassium alum has been used at least since Roman times for purification of drinking water and industrial process water. Between 30 and 40 ppm of alum for household wastewater, often more for industrial wastewater, is added to the water so that the negatively charged colloidal particles clump together into "flocs", which then float to the top of the liquid, settle to the bottom of the liquid, or can be more easily filtered from the liquid, prior to further filtration and disinfection of the water.

3.11. Filter Paper
GE’s Whatman Grade 41 environmental pollution papers are among the fastest filter papers in the Whatman ash less range. This gravimetric filter is well suited for quantitative analysis of soil and air.

- Extremely low ash content (0.007% ash maximum)
- 20 µm nominal particle retention rating
- Fast filtration speed (Herzberg 54 s)
- Commonly used for routine air pollution analysis and soil pollution analysis

3.12. Potassium Permanganate
Potassium permanganate is an inorganic chemical compound with the chemical formula KMnO₄. It is a salt consisting of K⁺ and MnO−₄ ions. It is on the WHO Model List of Essential Medicines, the most important medications needed in a basic health system. Potassium permanganate is used extensively in the water treatment industry.

3.13. Charcoal
Coconut shell charcoal is prepared by heating half splited coconut shell at a temperature of 900 °C for 4 hours. The prepared coconut shell charcoal is pulverized and sieved using standard sieves to obtain the required particles size.

3.14. Rice Husk Ash
Rice hull is (or rice husks) are the hard protecting coverings of grains of rice, and the ash was prepared by heating at 500 degrees for 4 hours in oven.

3.15. Ash of Banana Leaf, Rind and Stem
For this method sun dried plant material of banana tree i.e. leaves, rind, pseudo stem were collected and ash was prepared by heating at 500 degrees for 4 hours in oven.

3.16. Filtration Model Development
The effective potable filtration model is developed with below mentioned specification. It consists of two numbers of plastic (polycarbonate) tanks and the upper tank with top covered and ceramic filter for collecting raw water and the lower tank collect the treated water with tap arrangement. The conical shaped container with top and bottom open and it is threaded in top and it is hanged by a joining ring which is connects the two tanks. And it consists of multi layer cartridge and filter paper at top and bottom.

- Dimensions : Top diameter -8cm ,Bottom diameter -7cm, Height -14cm Top layer (sand) -5cm, 2nd layer (activated carbon) -1cm, 3rd layer (silica sand) -1cm, 4th layer (zeolite) -1cm, Bottom layer (mineral stones) -1cm,Capacity- 16 liters.
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The lower tank also consist a strainer with alum to remove the sediments. The complete set up was fixed in a base to keep the set up in position and to collect the water. Rate of filtration is 0.32 liters per minute.

4. EXPERIMENTAL PROCEDURE

- The raw ground water is collected from a source of the selected area.
- The coagulants such as Coconut shell charcoal, rice husk ash and banana leaves, rind, pseudo stem ash are need to be prepared before the treatment process, because it’s are all agricultural waste products need to be in sun dried form and it’s ash and charcoal.
- Each coagulant weighed and mixed with a small amount of water and to get a form of paste, and mixed with a liter of raw water about at least one minute to activate the coagulants.
- The prepared raw water then allowed passing on filter setup and the filtered water is collected with less concentration of iron.
- Finally the treated water is further tested for the quality check with BIS.
- If, the quality of treated water not in the permissible limit repeat the above mentioned procedure with different amount of coagulants and deferent mix.

5. RESULTS AND DISCUSSION

5.1. Coconut Shell Charcoal (without shaking)
The samples are analyzed with different amount of coconut shell charcoal (CSC) (0.6mm) and different detention time. The concentrations of iron for treated samples are tabulated below in which the initial iron concentration is 3.657ppm. As, it can be observed, the reduction of iron concentration is mentioned above, which are above the desirable limit and not within the permissible limit.

5.2. Coconut Shell Charcoal (with shaking)
The samples are analyzed with different amount of coconut shell charcoal (CSC) 0.6mm with different shaking time and different detention time. The concentrations of iron for treated samples are tabulated below in which the initial iron concentration is 3.657ppm. As, it can be observed, the reduction of iron concentration is mentioned above, which are within the permissible limit and slightly differs from desirable limit.
5.3. Coconut Shell Charcoal with Potassium Permanganate
The samples are analyzed with different amount of coconut shell charcoal (0.6mm) with the standard known quantity of 1.0 ppm potassium permanganate (KMnO₄). The concentration of iron for treated samples are tabulated below in which the initial iron concentration is 3.657ppm. As, it can be observed, the reduction of iron concentration is mentioned above, which are within the permissible limit and slightly differs from desirable limit.

5.4. Coconut Shell Charcoal with Rice Husk Ash
The samples are analyzed with the standard known quantity of 600ppm of coconut shell charcoal (CSC) 0.6mm with different amount of rice husk ash (RHA) and different detention time. The concentrations of iron for treated samples are tabulated below in which the initial iron concentration is 3.657ppm. As, it can be observed, the reduction of iron concentration is mentioned above, which are above the desirable limit and also not within the permissible limit.

5.5. Coconut Shell Charcoal with Mixer of Banana Rind, Stem and Leaf Ash
The samples are analyzed with different amount of coconut shell charcoal (CSC) 0.6mm with different amount of mixture banana rind, stem, and leaf ash (BA) and different detention time. The concentrations of iron for treated samples are tabulated below in which the initial iron concentration is 3.657ppm. As, it can be observed, the reduction of iron concentration is mentioned above, which are within the desirable limit.

Figure 4. Efficiency of filter medium
(CSC 0.6 mm - detention time)

Figure 5. Efficiency of filter medium
(CSC 0.6mm - shaking time and detention time)
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**Figure 6.** Efficiency of filter medium (CSC 0.6mm with 1.0 ppm KMnO₄)

**Figure 7.** Efficiency of filter medium (CSC 0.6mm with RHA)

**Figure 8.** Efficiency of filter medium (CSC 0.6mm with BA)

**Figure 9.** Comparison of iron concentration

**Figure 10.** Comparison of initial and final iron concentration bar chart
6. CONCLUSIONS

- 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 500⁰C for 4 hours.

REFERENCES


