JEE Journal of Ecological Engineering

Journal of Ecological Engineering 2022, 23(11), 18–23
https://doi.org/10.12911/22998993/153005
ISSN 2299–8993, License CC-BY 4.0

Received: 2022.08.07
Accepted: 2022.09.14
Published: 2022.10.01

Comparative Study of Iron Removal from Groundwater Using Low Cost Adsorbents

Shahad A. Raheem[1*], Entidhar Jawad Kadhim[1], Maryam Jawad Abdulhasan[2]

[1] Hydraulic Structures Engineering Department, College of Engineering, Al-Qasim Green University, Babylon, Iraq
[2] Chemical Engineering and Petroleum Industries Department, Al-Mustaqbal University College, Babylon, Iraq
* Corresponding author's e-mail: shahad.ak@wrec.uoqasim.edu.iq

ABSTRACT
Iron is one of the groundwater contaminants that negatively impact health and the environment. This study is attempted at introducing low cost natural adsorbent for that adsorbs iron from synthetically prepared iron water. Sawdust and barley husks were used as a filter media, either alone or at different mixing ratio of sawdust/barley husks (1:1, 0.5:1, 1:0.5), to study the effect of adsorbent dose on the removal efficiency. Synthetic water of iron was used at different initial concentrations (10, 25, 40, 65, and 80) mg/L to study the effect of initial iron concentration on the removal efficiency. The filtration process was conducted at a surface loading rate of 3 m^3/m^2.hr. The results showed higher removal efficiency with the increase of iron initial concentration. The results indicated that removal of iron ranged (90–99.34%) for all types of filter media. The best removal was found to be 99.34% at a mixing ratio of 0.5:1 (sawdust/barley husks) at 80 mg/L initial concentration. As a conclusion, Removal of iron was very successfully observed with absorbent materials sawdust and barley husk, which makes the treatment of iron even possible in rural areas and when high concentration of iron is present.

Keywords: groundwater contamination, iron removal, adsorption, filtration, drinking water, saw dust, barley husks.

INTRODUCTION

The abundance of water in the past met the need for water and it passed through sporadic drought times (Al-Qaisi et al., 2022). Iron is commonly found in groundwater. The presence of iron in the water supply is undesirable. Terrible taste, discoloration, staining, deposition in the distribution system lead to the occurrences of high turbidity in water supplies (Sharma, 2001). Iron bacteria are group of small organisms that convert ferrous iron to ferric state through their metabolic reactions. These organisms cause corrosion by attacking steel pipes to obtain iron. Heavy growth of these organisms forms a gelatinous mass that attack ferric hydroxide and clog the pipes as well as plumbing fixtures and reduce flow rates (Colvin et al., 2011). The maximum limit of iron is 0.3 mg/l according to World Health Organization (WHO) (Akoto et al., 2007). There are many strategies available for removal of metallic elements – among them, the adsorption process is preferred due to its adaptability, high efficiency, reproducibility and being economical (Patel, 2019). Sawdust and barley husks are efficient, readily available, and relatively inexpensive, and have the potential to be applicable alternative adsorbents for heavy metals in water (Zaidun, 2018). Akiladevi et al. (2017) studied the removal of iron from ground water sources by using the locally available low cost materials such as sawdust, rice husk and lime stone. Familusi et al. (2018) investigated into the efficiency of sawdust adsorbent in removing raw water pollutants (Ayokunle et al., 2018). Zaidun Naji Abudi, 2018, investigated the feasibility of sawdust as a new adsorbent and its adsorption mechanism for TOC (Zaidun, 2018). The aim of this work was to assess the efficiency of filter made of local materials like sawdust and barley husks in the removal of iron from groundwater. This study is made an attempt to introduce low cost natural adsorbent for that adsorbs iron from synthetically prepared iron water. The filtration process was carried out at different proportions of sawdust and barley husks.

MATERIALS AND METHODS

Preparation of iron solutions

Iron (III) sulfate (or ferric sulfate), usually yellow as shown in Figure 1, is a rhombic crystalline salt which is soluble in water at room temperature. One liter of iron solutions was prepared with different concentrations of iron (10, 25, 40, 65, 80) mg/L.

Figure 1. Iron sulfate

Preparation of the filtration device

Preparation of limestone

Lime stones are used as a building material and as a raw material in cement manufacturing. The stones used in this study were bought from the local market and the aggregates are hand broken and sieved. The aggregates retained in16 mm sieve and passed in 20 mm sieve are taken and they are washed and oven dried at 60 degree for one hour as shown in Figure 2.

Preparation of sawdust and barley husks

Saw dust and barley husks were ground and sieved in 1.19 mm sieve and washed using water until the color of washed water was normal. Then, they were dried under sun for 3 days, oven dried at 115 °C for 3 hours to remove excessive humidity, and then they were used as filter media. Figure 3 shows the filter media used in this study.

Setting up the filter

The filter was made from glass with height of 60 cm and an opening area of (5 × 5 cm). The outlet is fixed to the filter at one end. The layers of filter media are laid using sand, lime stone aggregates, rice husk and saw dust. The sand layer was laid on the top for 5 cm; then, the next layer was limestone aggregates laid for 10 cm. The middle layer was laid for about 30 cm using barley husks and sawdust at different proportions. Then, the

Figure 2. Limestone used in the study

a)

b)

Figure 3. Adsorbents used in the study: (a) saw dust, (b) barley husks

final layer was again limestone aggregates laid for about 10 cm. Sand and limestone layer were used for well and uniform distribution of water through the filter media. Figure 4 shows the images of filter and the filter media.

Filtration process

The filtration process was carried out at a loading rate of 3 $m^3/m^2 \cdot hr$. Different proportions of filter media were used (sawdust, sawdust/barley husks ratios of (1:1, 0.5:1, 1:0.5), and barley husks) to compare the percentage reduction of concentration of iron using sawdust, barley husks and mixed sawdust and barley husks at different proportions as a filter media. The process was conducted at a constant temperature and pH of 7. The effluent was collected after every trial of a proportion. The collected effluent was tested using atomic absorption spectrometer for iron concentrations.

RESULTS AND DISCUSSION

Effect of initial iron concentration

Different initial concentrations (10, 25, 40, 65, 80) mg/L were studied, as shown in Figure 5 and the percentage removal of iron can be determined by the following formula:

$$\text{Percentage removal} = \frac{C_i - C_f}{C_i} * 100 \quad (1)$$

where: C_i – iron initial concentration, mg/L; C_f – iron final concentration, mg/L. The experiments were conducted at constant temperature and pH of (6.5–7).

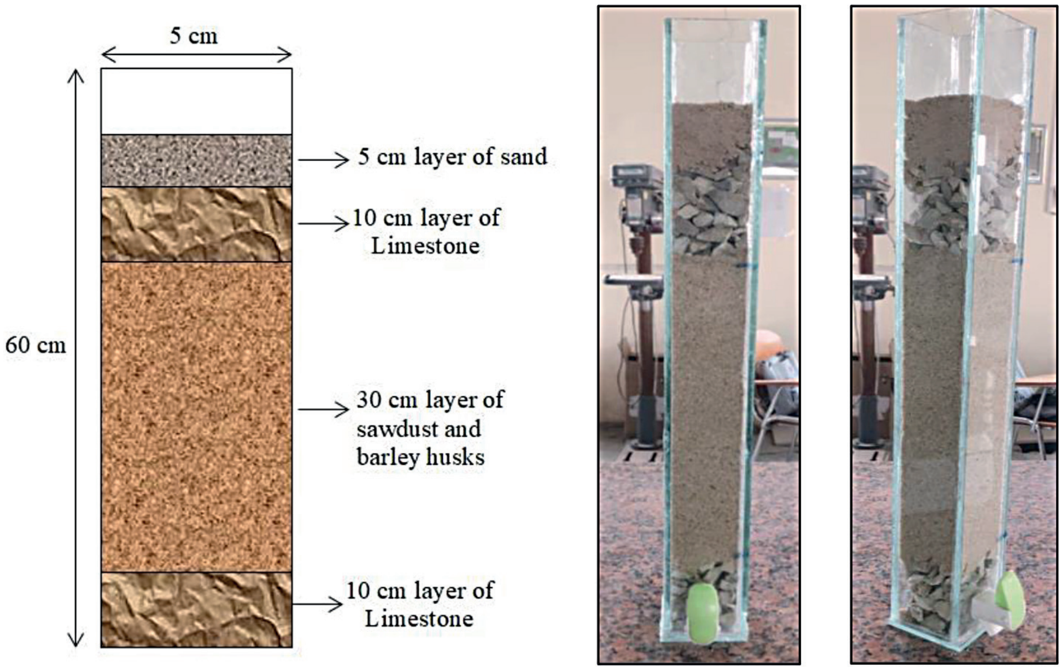

Figure 4. The filter configuration and filter media

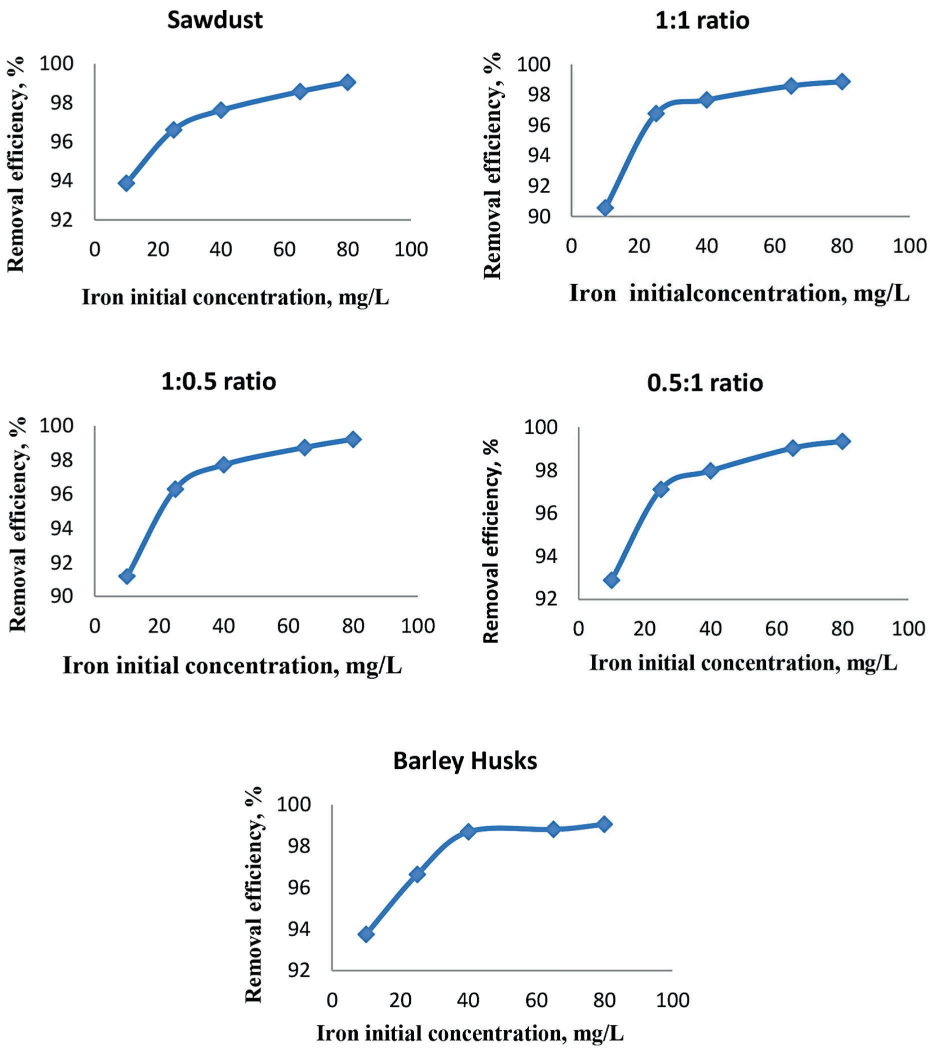

Figure 5. The percentage removal of iron

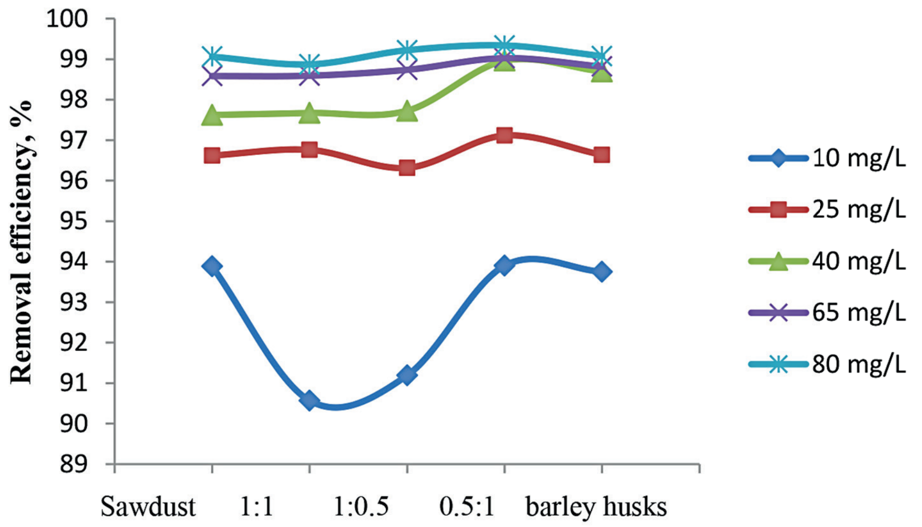

Figure 6. Adsorbent dose effect on the removal efficiency

From the graphs in Figure 5, the highest removal was found 98.87–99.34% at 80 mg/L initial iron concentration. Greater capacity of adsorption found in higher concentration of iron (Salmani et al., 2017).

Effect of adsorbent

The effects of adsorbent dosage (mixing ratios) on iron removal by sawdust and barley husks were studied for each iron concentration as in Figure 6. The highest removal efficiency was found at mixing ratio of 0.5:1. However, the materials i. e. barley husks and saw dust, can separately can remove iron to some extent, but if they are mixed at a mixing ratio of 0.5:1 (sawdust: barley husks) the removal efficiency increases. These materials are locally available cheap material. Hence, this type of media can easily be fabricated by residents for filtering the ground water in small scale in rural areas near iron ore mining places.

Effect of pH

The effect of pH was studied for the pH ranging from 2 to10 and the results obtained were shown in the Figure 7. The initial concentration of iron was 80 mg/L at a mixing ratio of 0.5:1 (sawdust: barley husks). The results obtained showed that the pH has an important influence the removal of iron from the solution. The percentage increases along with the pH increase from 2 to 6.5 and it shows a sudden fall in pH from 6.5 to 10. Therefore, at low pH values, sawdust and barley husks showed very low tendency for removal of iron due to protonation of its functional group or competition of H^+ with metal ions for binding sites (Megha et al., 2019). Sawdust and barley husks show a maximum percentage removal of iron at a pH 6.5.

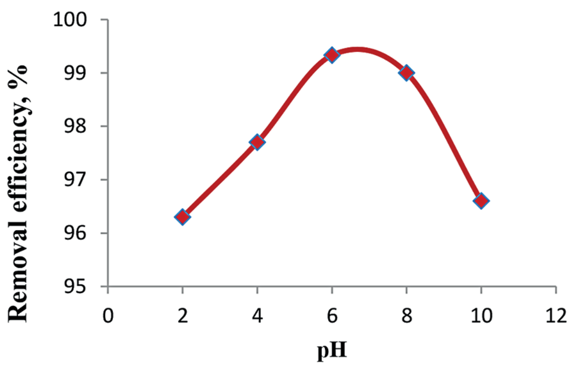

Figure 7. PH effect on the removal efficiency

CONCLUSIONS

Very successful removal of iron was observed with sawdust and barley husk absorbent materials, which makes the treatment of iron possible even in rural areas and when high concentration of iron is present. The results showed that the removal of iron ranged (90–99.34%) for all types of filter media. The best removal efficiency was found to be 99.34% when a mixing ratio of sawdust: barley husks was 0.5:1 and with a concentration of 80 mg/L. Greater capacity of adsorption was found in higher concentration of iron. Saw dust and barley husks serves as a good filtering media for the removal of turbidity. At low pH values sawdust and barley husks showed very low tendency for removal of iron. Sawdust and barley husks show a maximum percentage removal of iron at a pH 6.5. Sawdust and barley husks did not have a significant impact on the pH of water.

REFERENCES

1. Abudi Z.N. 2018. Using Sawdust to Treat Synthetic Municipal Wastewater and Its Consequent Transformation Into Biogas. Journal of Ecological Engineering, 19(5).
2. Akiladevi A.R., Manimozhi R., Renganathan T., Deepa Priya M. 2017. Removal of Iron from synthetic waste water using Sawdust and Rice husk. International Journal of Scientific and Engineering Research, 8(6).
3. Akoto O., Adiyiah J. 2007. Chemical analysis of drinking water from some communities in the Brong Ahafo region. Int J Environ Sci Technol, 4(2), 211–214.
4. Al-Qaisi A.Z., Al-Murshady K.R., Raheem S.A., Ali Z.H. 2022. Drainage Water Application for Irrigation Purposes: Case-Study, HAJI-ALI Drain, Babylon. Water and Energy International.
5. Colvin C., Filipova V., Masic A. 2011. Iron removal.VVAN01 Decentralized water and wastewater treatment.
6. Familusi A.O., Adekunle A., Badejo A.A., Adeosun O.J., Ogundare D.O. 2018. Efficiency of Sawdust Adsorbent In Water Treatment. 8th National Water Conference Held at Olusegun Obasanjo Presidential Library Abeokuta, December.
7. Hossein Salmani M.H., Abedi M., Mozaffari S.A., Sadeghian, H.A. 2017. Modification of pomegranate waste with iron ions a green composite for removal of Pb from aqueous solution. equilibrium, thermodynamic and kinetic studies. DOI: 10.1186/s13568-017-0520-0
8. Megha N.S., Parvathy K.U., Reshma P.R., Shamily Monikka K.J., Sreya C.J. 2019. Removal of Iron from Drinking water by using Low Cost Natural Adsorbents. International Journal of Scientific & Engineering Research, 10(5).
9. Patel H. 2019. Fixed-bed column adsorption study a comprehensive review. Appl Water Sci., 9(3), 45.
10. Sharma S.K. 2001. Adsorptive iron removal from groundwater Sectie Milieutechnologie.