Adsorptive removal of iron from ground water using charcoal and coconut coir

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Abstract- *Purified water is essential for living a healthy life as such everyone should have to access it. Surface water often is the only source; thus, water contaminations are difficult to avoid due to rigorous and reckless use of surface water. Unsafe drinking water may result in fatal diseases. Iron can be a troublesome chemical in water supplies. Making up at least 5 percent of the earth's crust, iron is one of the earth's most plentiful resources. Various types of filters have been designed to remove iron content from ground water, but the cost as well as the filter effectiveness is still not satisfactory and further improvement is still required. By this study we prepared a filter media with charcoal and coconut coir as an adsorbent for the effective removal of iron from the groundwater and got an iron removal efficiency up to 99%. This unit is a low-cost water filtration model that can operate with minimum energy, minimum maintenance, cost effective, environment friendly, implementable with ease.*

Keywords- Adsorption; Artificial groundwater; Adsorption Isotherm; Iron.

I. INTRODUCTION

Iron is one of the most troublesome elements in water. Rainwater as it infiltrates the soil and underlying geologic formations dissolves iron, causing it to seep into aquifers that serve as sources of ground water. Although iron is an essential mineral for human, its presence in ground water above a threshold level make the water unusable mainly for aesthetic considerations such as discoloration, metallic taste, odour, turbidity and staining of laundry. Iron is mainly present in water either the soluble ferrous iron or the insoluble ferric iron. Water containing ferrous iron is clear and colourless due to its soluble nature. On exposure to air, the ferrous iron is converted to ferric iron and turns the water into reddish brown appearance. Moreover, iron oxides, which are formed in reservoirs upon aerial oxidation of dissolved iron promotes growth of microorganism.

There are various methods for removing iron from water including ion exchange, oxidation by oxidizing agents, chemical precipitation, supercritical fluid extraction and accumulation by aquatic macrophyte. However, most of these technologies are either extremely expensive or too ineffective to reduce metal levels from water. In this context, we have chosen the iron removal method of artificial water by adsorption on charcoal and coconut coir by constructing a filtration unit. Parameters such as depth, rate of flow and contact time, were investigated at room temperature. While the adsorption isotherm was used to analyse adsorption process.

II. MATERIALS AND METHODS

A. ADSORBENTS

a) Charcoal

Charcoal is a natural and inexpensive material result from the incomplete combustion of wood. It is characterized by its highly porous structure gives it adsorbent properties. The charcoal of size 0.4mm – 0.2 mm is used as adsorbent in this study.

b) Coir

Coconut coir pith constitutes as much as 70% of the husk, and is a light, fluffy material generated in the separation of the fibre from the husk. Coconut coir activated carbons having good porosity and high surface area. Coconut coir have very good tendency for removal of total iron.

B. STANDARD IRON SOLUTION

Standard iron solution of 10 mg/l iron content was prepared as per IS 10500-2012 from the stock solution. 50 ml of stock iron solution was diluted to 1000ml to make standard solution.

C. ADSORPTION TECHNIQUE

Adsorption is the process of adhesion of adsorbate on the surface of adsorbent. Adsorption process has many advantages such as: low cost of adsorbent, easy application, use of natural, domestic and industrial waste as adsorbents. Iron is a metal which can be easily removed by adsorption process by using different organic and inorganic materials.

The experiment was conducted in a filter media consisting of following materials: charcoal and coir of 20 cm depth each at the top, sand (1-2mm) of 10cm

depth, gravel (5-8mm) of 10cm depth, gravel (8-12mm) of 10cm depth.

We added to 1000 ml of standard iron solution and analysed a mass of charcoal and coir as adsorbents. We provided a contact time of 20 minutes. Then filtered sample is collected and was filtered use whatman filter paper. Spectro-photometer was used to analyse the final concentration of iron.

D. ADSORPTION ISOTHERM

Adsorption isotherm is important model in description of adsorption behaviour. This can indicate the distribution of molecules between solid and liquid phase. Adsorption by charcoal and coir follows Langmuir isotherm.

The Langmuir isotherm equation is given as:

$$qe = ((C_o - C_e)*V)/m \quad (1)$$

Where, qe = The amount of iron adsorbed per unit mass adsorbent (mg/g)

C_o = Initial iron content in mg/L

C_e = Final iron content in mg/L

V = Volume of liquid, L

m = Mass of adsorbent, g

Regression value is the estimation or prediction of unknown values of one variable. After establishing the correlation between two variables, there is to know the extent to which one variable varies in response to the other given variable. Regression measures the nature and extend of correlation. R-value ranges between -1 to +1.

$$R=\sqrt{(bxy*byx)} \quad (2)$$

Where, bxy = Regression coefficient of x on y

byx = Regression coefficient of y on x

R-value of charcoal = 0.998

R-value of coir = 0.997

III. RESULTS AND DISCUSSIONS

A. Effect of depth

The effect of depth of adsorbents were studied by varying the depth by 5cm, 10cm, 15cm and 20cm. As the depth increases, the adsorption capacity also increases. Thus from the above depths, maximum adsorption efficiency was obtained for 20cm depth. The increase in the amount of adsorption leads to an increase of the surface adsorption zone which provides a greater number of active sites for adsorption.

B. Effect of contact time

The effect of contact time on the amount of Fe2+ adsorbed by charcoal and coir were studied using an initial concentration (10mg/l).

The results show that adsorption process is clearly time dependent. As contact time increases, the adsorption capacity of iron in the solution increased rapidly at the beginning and later slows down until it remained constant at about 20min. adsorption efficiency of 98.4 % were obtained at 20min for 20cm depth of adsorbents.. The initial rapid phase of iron adsorption may be due to the large number of sites available at the initial period of the adsorption. After 20 minutes, extending the contact time has no effect on the residual concentration of iron in the solution; this explains the saturation of adsorbent.

C. Effect of rate of flow

The inlet sample flow to the filter unit was controlled using regulator. Effect of rate of flow was studied by considering two conditions, such as full flow and half flow. We found that there is no much difference for this effect, even though full flow shows much slighter efficiency than the other.

D. Adsorption Isotherm

The study of the adsorption isotherm is fundamental to determining the capacity and the nature of adsorption. They indicate how the metal ions are partitioned between the adsorbent and liquid phases at equilibrium as a function of increasing metal concentration. In our study, Langmuir and Freundlich isotherm were employed to investigate the adsorption behaviour.

The Langmuir isotherm model obtained for charcoal and coir is shown in the fig.1 and fig.2 respectively. The determination of regression value R from the equation (2) for the Langmuir model that R nearly =1, the model of Langmuir is favourable. The R value for Freundlich isotherm indicated that the adsorption is unfavourable.

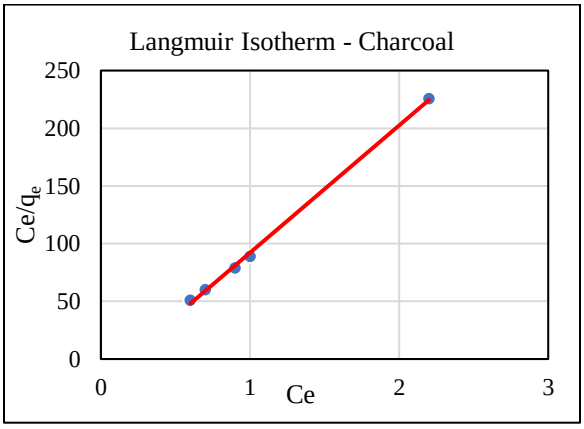

Fig.1 Langmuir isotherm for charcoal

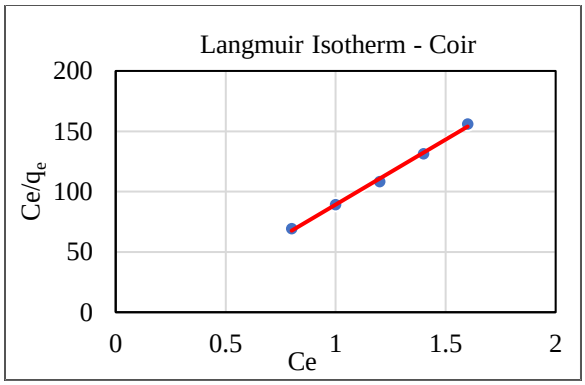

Fig.2 Langmuir isotherm for coir

IV. CONCLUSION

From the obtained results, it is evident that charcoal and coconut coir are good adsorbents for removal of iron. The amount of iron removal increased with increasing contact time and depth. The isotherm study indicates that the adsorption data can be adequately modelled by Langmuir.

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