Removal of iron and manganese from groundwater in El–Behira governorate

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The efficiency of the Granular Activated Carbon (GAC) filtration process in removing iron and manganese from groundwater was studied. The experimental work of this study was divided into two parts depending on the thickness of the GAC filter. In the first part, the GAC filter was used with two differenet thicknesses (20 cm and 40 cm) and in the second part it was used with other two thicknesses (30 cm and 50 cm). The results of the pilot plant showed that iron and manganese can be removed by the adsorption process and the removal was proportional to the thickness of the GAC layer. A GAC filter with a thickness of 30 cm gave a removal efficiency which ranged from 80 % to 96 % depending on the influent concentration of iron. For manganese, the removal efficiency ranged from 94 % to 98 %. To cope with the standard limits of the drinking water, a GAC filter with a thickness of 30 cm was enough.

يهدف هذا البحث إلي دراسة تشغيل أعمدة الكربون المنشط ومدي كفاءتهما في إزالة الحديد و المنجنيز من المياه الجوفية. تم إنشاء نموذج بحثي معملي في المعمل المركزي لشركه البحيرة لمياه الشرب والصرف، وتم الاعتماد علي تغذية النموذج المعملي بمياه مقطره تحتوى علي تركيزات مختلفة من الحديد والمنجنيز. تم تقسيم خطة العمل إلي جزئين اعتمادا علي ارتفاع طبقة الكربون النشط، في الجزء الأول تم استخدام ارتفاعين مختلفين (٢٠ سم و ٤٠ سم) أما في الجزء الثاني فقد تم استخدام الكربون النشط بارتفاع (٣٠ سم و ٥٠ سم). ومن البحث المعملي أتضح أن الحديد والمنجنيز يمكن خفض تركيزهما بعمليه الامتزاز باستخدام الكربون المنشط، وكفاءة الازاله تزيد بزيادة ارتفاع طبقه الكربون المنشط. النسبة المئوية لأزاله عنصر الحديد تراوحت بين ٨٠ % و ٩٦ % أما بالنسبة لعنصر المنجنيز فانها تراوحت الكفاءه بين ٩٤% و ٩٨ % عند ارتفاع ٣٠ سم من الكربون المنشط.

Keywords: Activated carbon, Adsorption process, Groundwater, Iron, Manganese

1. Introduction

Water is located in all regions of the earth. Groundwater is one of the earth's most widely distributed and most important resources. Groundwater is more widely and easily available than surface water, and most groundwater is unpolluted and relatively safe from pollution. Groundwater generally averages out to be a little harder and more mineralized than surface water in the same locality, but its quality is more uniform during the year [1, 2].

Groundwater quality is influenced by the quality of its source. Groundwater is generally much cleaner than surface waters and so does not need the same degree of treatment. In groundwater naturally occurring substances which may need to be reduced or eliminated in groundwater include iron, manganese, hardness and carbon dioxide [3].

At very low concentrations iron and manganese are highly objectionable in water supplies for domestic and industrial use. The most popular methods of reducing iron and manganese concentrations in water are aeration and adsorption [4, 5].

Aeration: Water from groundwater resources contains very little or no dissolved oxygen. Therefore, this water needs to be aerated before it is used. Aeration is one of the earliest methods for removing taste and odors from water supplies. So iron and manganese can also be removed from water by aeration. This is achieved by bringing the water into contact with air. This process is prohibitively expensive because of the vast volume of water that is treated each day [3].

Adsorption: Now Granular Activated Carbon GAC is popular in potable water treatment. As the demand for high quality water increases, the cost of GAC regeneration declines and its reputation for reliability and effectiveness is

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becoming established. Activated carbon provides an effective method for adsorbing a wide range of organic compounds and can be considered for use in the removal of common tastes and odors by reducing the concentration of heavy metals found in water, such as iron and manganese [6]. Fig. 1 shows a sketch of the internal pore structure of activated carbon.

Treatment mechanisms of activated carbon are adsorption, chemical reaction and biological reaction. Adsorption occurs when the attraction at the adsorption surface is stronger than the solution forces available to keep the contaminants dissolved in solution. This process involves three consecutive steps for the transport of a compound from the bulk solution to an adsorption site of a porous adsorbent such as activated carbon as shown in fig. 2. Although the physical adsorption phenomena tends to be the dominant interaction for many organic compounds on activated carbon, chemical reactions significant to disinfection can occur on a carbon surface as well [7].

2. Materials and methods

2.1. Bench scale experimental apparatus

The bench scale apparatus used in this study was installed in the Central Laboratory in ELbehira Water and Drainage Treatment Company. Fig. 3 shows a photograph of the bench scale which was used in this research. As shown, the bench scale consists of two fixed Perspex columns each 5 cm in diameter and one meter height. Water was fed to the two columns via an upper tank with a capacity of 40 liter.

2.2. The influent water

In this study, the influent water was synthetic water (distilled water) containing different concentrations of iron and manganese. The iron and manganese concentrations used in this study were (0.3, 0.5, 0.7, 1.0, 1.5 and 2.0 mg/L).

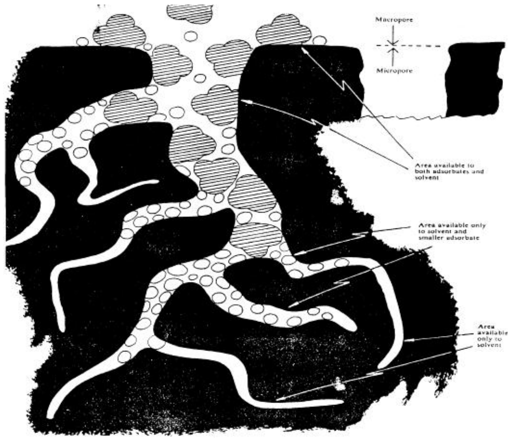

Fig. 1. Sketch of internal pore structure of activated carbon.

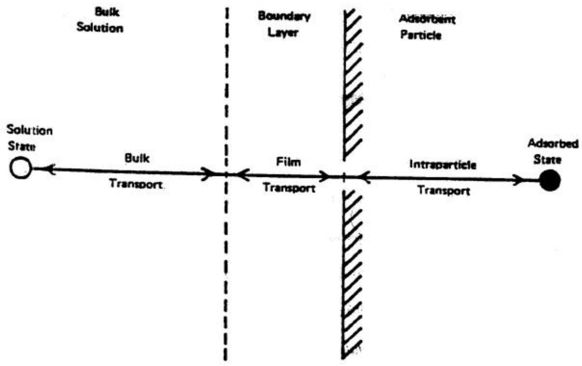

Fig. 2. Transport steps in adsorption by porous adsorbent.

Fig. 3. Photograph diagram of the bench scale apparatus.

2.3. Physical properties of GAC

GAC used in this study was produced in Sweden. Table 1 shows the physical properties of the GAC used in this study

2.4. Experimental schedules

The experimental work was divided into two stages. These were carried out to investigate the removal of Iron and manganese from ground water. In the first stage, GAC was used in two different thicknesses (20 cm and 40 cm) and the feeding water was synthetic water containing different concentrations of iron and manganese as shown in table 2. In the second stage GAC was used in other two different thicknesses (30 cm & 50 cm) and with the same feeding water used in the first stage. All analyses were carried out by an atomic absorption apparatus according to the American Standard Methods for the examination of Water and Wastewater, 1995.

Table 1
Physical properties of the GAC

Characteristics	AquaSorb 1000	AquaSorb 2000
Carbon tetrachloride (ctc)activity %	55	65
Surface area m2 /g	950	1050
Total pore volume cm3 /g	0.92	1.05
Apparent density g / cm3	0.52	0.47
Density backwashed and drained	0.45	0.41
Moisture as packed %	2	2
Ash content %	12	12
Ball-pan hardness number %	96	95
Water soluble matter %	0.1	0.1

Table 2
Experimental schedule for this study

Synthetic water		Period of study	Number of samples
Iron concentration	Manganese concentration		
0.3 mg/L	0.3 mg/L	2 weeks	7
0.5 mg/L	0.5 mg/L	2 weeks	7
0.7 mg/L	0.7 mg/L	2 weeks	7
1.0 mg/L	1.0 mg/L	2 weeks	7
1.5 mg/L	1.5 mg/L	2 weeks	7
2.0 mg/L	2.0 mg/L	2 weeks	7

3. Results and discussion

3.1. Ground water characteristics

The important source of drinking water at El – Behira governorate is ground water. There are more than 64 water wells as shown in fig. 4. The ground water contains iron and manganese which are highly objectionable for domestic usage and can affect the taste of water. Fig. 4 shows the actual, the allowed and the maximum concentrations of iron and manganese for ground water. More than 6 wells contain iron in concentrations greater than the standard limits of drinking water (1.0 mg/L), and 28 wells contain manganese in concentrations greater than the standard limits of drinking water (0.5 mg/L). So, water from these wells is unacceptable for potable usage.

3.2. Iron removal

Table 3 shows the iron concentration in the feed water and after the adsorption process. Fig. 5 shows the removal efficiency of iron for four different thicknesses of the GAC filter. From the figure, it can be noted that the GAC filter reduced the iron concentration in ground water even when the concentration of iron was greater than the standard limits of drinking water.

3.3. Manganese removal

Table 4 shows manganese concentrations in the feed water, and after the adsorption process. Fig. 6 shows the removal efficiency of manganese for four different thicknesses of the GAC filter. From the figure, it can be noted that the GAC filter reduced manganese concentration in ground water even when the concentration of manganese was greater than the standard limits of drinking water.

A GAC filter with a thickness of 30 cm gave a removal efficiency ranging from 80 % to 96 % depending on the influent concentration of iron, and gave a removal efficiency ranging from 94% to 98% for manganese concentrations. As an economic point, removal efficiencies obtained from GAC with a thickness 30 cm were enough to cope with the standard limits of drinking water.

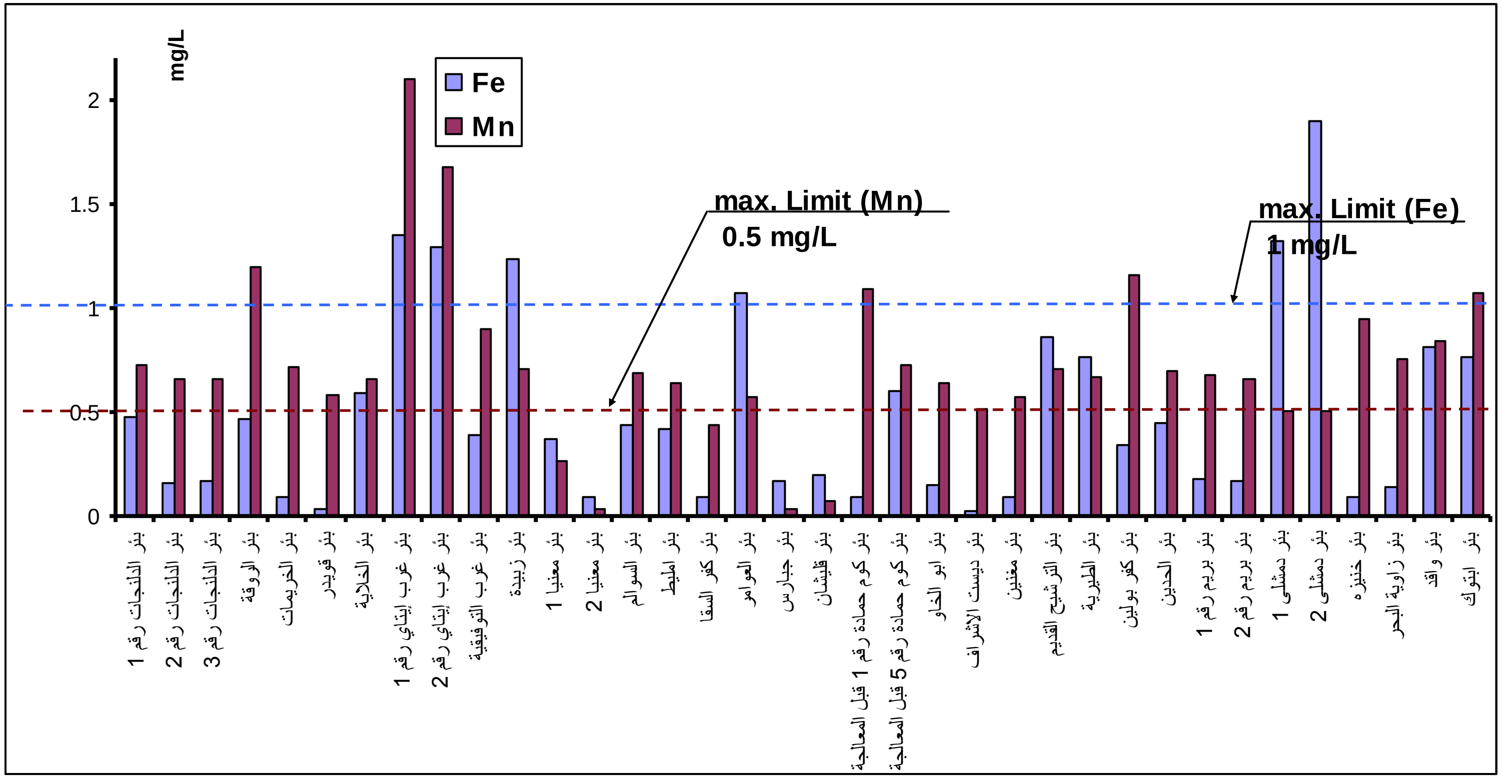

Fig. 4. Ground water characteristics at El – Behera governerate.

Table 3
Influent and effluent concentrations of Iron

Influent concentration	Effluent concentration			
	20 cm	30 cm	40 cm	50 cms
0.3 mg/L	0.14	0.13	0.06	0.03
0.5 mg/L	0.21	0.08	0.06	0.02
0.7 mg/L	0.1	0.056	0.05	0.0157
1.0 mg/L	0.1	0.07	0.055	0.05
1.5 mg/L	0.16	0.07	0.045	0.037
2.0 mg/L	0.16	0.078	0.05	0.017

Table 4
Influent and effluent concentrations of manganese

Influent concentration	Effluent concentration			
	20 cm	30 cm	40 cm	50 cm
0.3 mg/L	0.03	0.016	0.006	0.003
0.5 mg/L	0.043	0.01	0	0
0.7 mg/L	0.1	0.03	0.02	0.006
1.0 mg/L	0.14	0.059	0.011	0.01
1.5 mg/L	0.17	0.04	0.02	0.004
2.0 mg/L	0.27	0.087	0.058	0.012

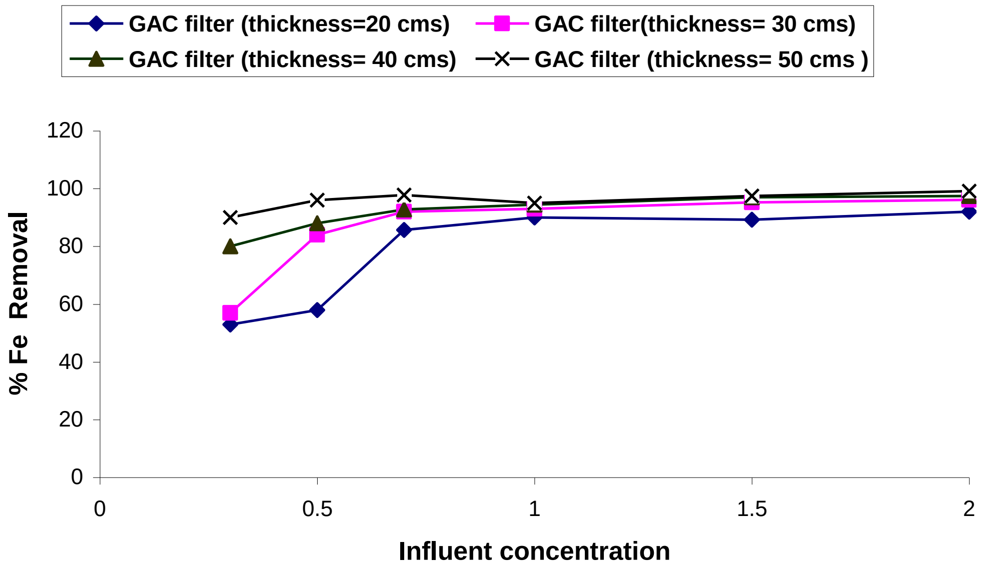

Fig. 5. The relation between % removal efficiency of Iron through GAC and influent concentration.

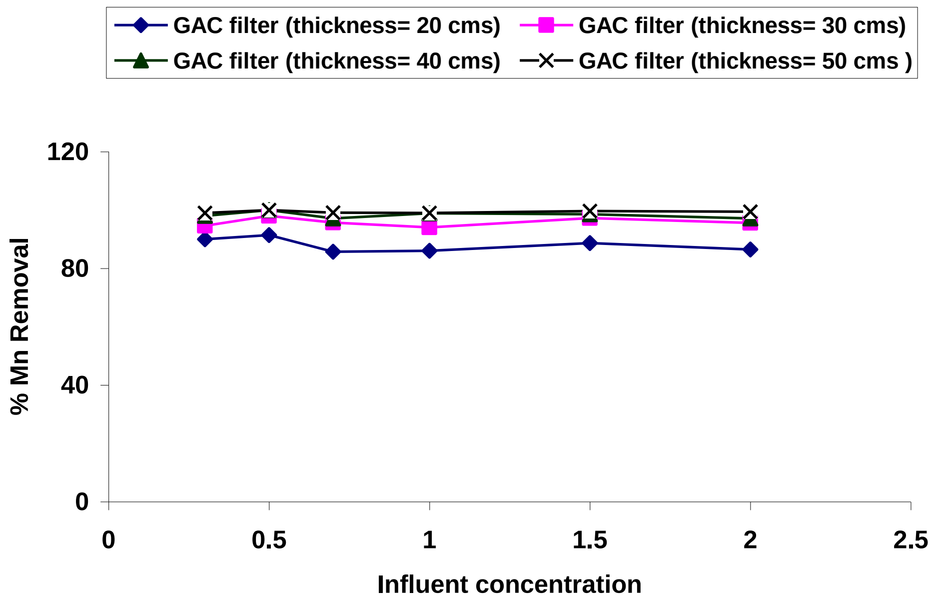

Fig. 6. The relation between % removal efficiency of manganese through GAC and influent concentration.

4. Conclusions

Based on the observation and the results obtained from this study the following points were concluded.

1. Iron and manganese can be reduced by the adsorption process and the removal efficiency is proportional to the thickness of the GAC layer
2. Increase in Influent concentration of iron and manganese has no effect on the efficiency of GAC
3. GAC with a thickness of 30 cm was enough to cope with the standard limits of drinking water.

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