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Removal of Iron and Manganese by the Fabric Capillary Action

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--***ABSTRACT***--

Filtration using fabrics through capillary action is a simple tool for removing iron and manganese from the groundwater. This work aims to assess the treated water quality after filtration in perspective of the removal of iron and manganese. In the present study, the non-woven fabrics were selected as filter media. The filter model was designed to filter 6-24 m^3/d of the extracted groundwater where the filtration rate ranges between 5-20 m /d to assess the impact of filtration rate on the removal efficiencies of iron and manganese. The obtained results revealed that the optimum range of the filtration rate is between 5-15 m/d to guarantee that the iron and manganese concentrations comply with the international standards of potable water.

KEYWORDS; *fabric capillary action, filtration, iron, manganese*

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I. INTRODUCTION

Extraction of groundwater is one of the most important methods of water supply. However, water quality control is essential to ensure compliance with the hygienic conditions and standard specifications of potable water. Sometimes, the extracted groundwater needs to specify in-situ treatment [1-7].

In some cases, excess concentrations of iron and manganese appear in the extracted groundwater where they need to be removed to prevent any undesirable taste or colour in the water, as well as to protect the pipes and sanitary accessories from rust and corrosion [8-10].

El-Gamal et al. [3], and Fadel [4] applied the concept of fabric capillary action in water filtration. Their investigations were completed after running a pilot filtration unit where the water flows through fabrics allocated between the adjacent channels in the filter unit to remove the turbidity according to their studies. Fadel [4] reported that the water filtration using fabrics is more beneficial than the slow sand filters.

This work aims to assess the treated water quality after fabric filtration in perspective of the removal of iron and manganese. In the present study, the non-woven fabrics were selected as filter media.

II. METHODOLOGY

Study Area

The raw water resource is a groundwater well located in Abu-Rady District, El-Mahalla El-Koubra City, Egypt. The extracted groundwater flows to the filtration system located in this site.

Water Quality and Sampling

Analyses of iron and manganese were conducted via the Atomic Absorption Spectrometry (AAS) iCE 3000, Thermo Fisher Scientific® according to the Standard Methods for the Examination of Water and Wastewater [11]. Table (1) shows the descriptive statistics of the results of iron and manganese concentrations in raw water (the extracted groundwater) during the period of conducting the experiments.

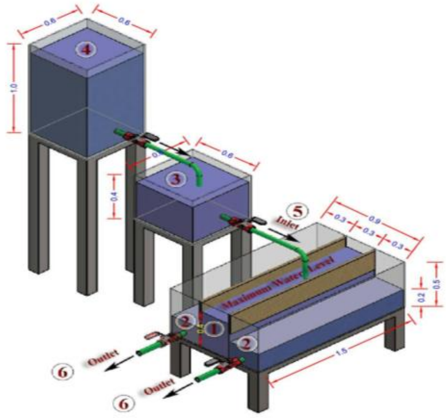
Table 1 Descriptive statistics of iron and manganese analyses and the standard values according to WHO [12]

Parameter	Results of the statistical analysis				Standards [12]
	Max.	Min.	Mean	Standard deviation	
Iron (Fe), mg/L	1.9	0.3	0.81	0.5	0.3
Manganese (Mn), mg/L	0.25	0.08	0.16	0.05	0.1

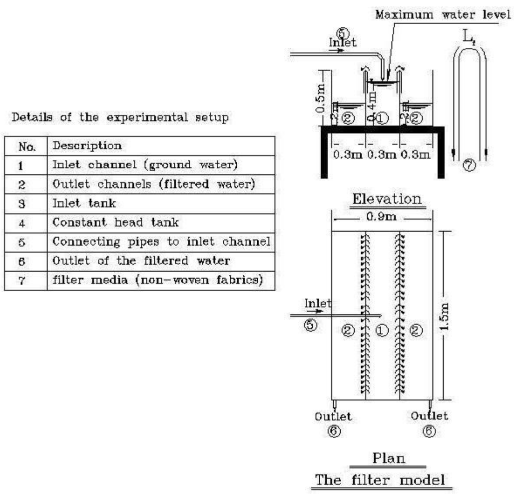
Filter Model

The filter model was designed and fabricated on the basis of the innovative design of the water filtering system created by El-Gamal et al. [3] and Fadel [4]. This model was designed to filter 6-24 m^3/d of the extracted groundwater where the filtration rate (ROF) ranges between 5-20 m/d to assess the impact of filtration rate on the removal efficiencies of iron and manganese.

The filter was fabricated from a metallic sheet with a thickness of 0.7 mm. Figure (1-a) shows the constituents of the experimental setup, whereas, figure (1-b) represents the filter model and description of the whole components.



(a)



(b)

Figure 1 The experimental setup for the filtering system using fabric capillary action in (a) an isometric view, (b) a tabulated description of the whole system

The experimental setup essentially contains a constant head tank, inlet tank, and the filtration tank where the water enters the middle of the tank and flows through the fabrics to be collected from both sides of the filtration tank. Dimensions of the filter model are 1.5 m of length, 0.9 m of width, and 0.5 m of depth. The fabrics were placed overhead the inlet channel to absorb the inlet water, then filtering it via capillary action. Moreover, the fabric specifications are new-nonwoven polyester, with a thickness of 1.65 mm, dimensions of 0.8m*1.5m, surface porosity of 98%, and weight of 576 gm. These specifications are conformed to those recommended by El-Gamal et al. [3] and Fadel [4].

III. RESULTS AND DISCUSSION

Effect of the Filtration Rate on the Iron Removal

The iron concentrations in the filtered water were measured as indicated by different filtration rates ranged between 5-20 m/d as shown in figure (2). It is noticed that the iron concentrations of the filtered water were ranged between 0.16-0.33 mg/L, whereas the removal efficiency improves to some extent (from 70% to 85%) with descending filtration rates due to a slowing of the water transfer throughout the permeable spaces in the fabric, attributable to the forces of adhesion, cohesion, and surface tension [13]. The iron concentration after a filtration rate of 20 m/d is 0.33 mg/L which does not comply with the maximum allowable value of 0.3 mg/L.

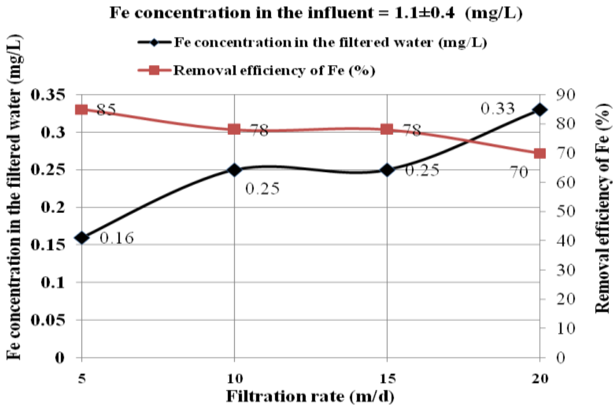


Figure 2 The removal efficiency of the iron and its concentration in the filtered water versus the filtration rate

Effect of the Filtration Rate on the Manganese Removal

The manganese concentrations in the filtered water were measured as indicated by different filtration rates ranged between 5-20 m/d as shown in figure (3). It is noticed that the manganese concentrations of the filtered water were ranged between 0.07-0.15 mg/L, whereas the removal efficiency improves to some extent (from 34% to 65%) with descending filtration rates due to a slowing of the water transfer throughout the permeable spaces in the fabric, attributable to the forces of adhesion, cohesion, and surface tension as mentioned before [13]. The manganese concentration after a filtration rate of 20 m/d is 0.15 mg/L which does not comply with the maximum allowable value of 0.1 mg/L.

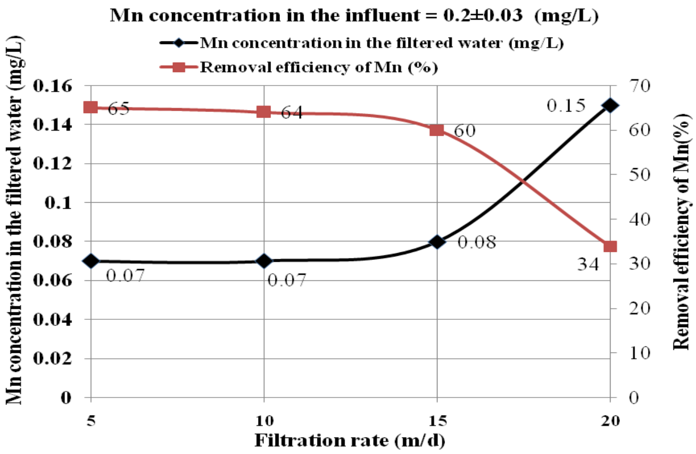


Figure 3 The removal efficiency of the manganese and its concentration in the filtered water versus the filtration rate

Therefore, the recommended filtration rate is between 5-15 m/d to guarantee that the iron and manganese concentrations comply with the international standards of potable water [12]. Therefore, the optimum filtration rate using fabric capillary action is well-matched with that detailed in El-Gamal et al. [3] and Fadel [4].

IV. CONCLUSION

Filtration using capillary fabrics is a simple tool for removing iron and manganese from the groundwater. The obtained results revealed that the optimum range of the filtration rate is between 5-15 m/d to guarantee that the iron and manganese concentrations comply with the international standards of potable water.

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