Efficiency of Micro filtration and oxidation on removal of Iron and manganese in Ground water and surface water


(Mrs.) Thushyanthy Mikunthan
University of Jaffna


Saravanan Suntharalingam
National Water Supply and Drainage Board


Gunaalan Kuddithamby
Technical University of Denmark

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Efficiency of Micro Filtration and Oxidation on Removal of Iron & Manganese in Groundwater and Surface Water

Jancika, G., T. Mikunthan

Department of Agricultural Engineering, University of Jaffna

S. Saravanan

National Water Supply and Drainage Board, Jaffna

and

K. Gunalan

Department of Fisheries, University of Jaffna

ABSTRACT

Water resources are becoming increasingly scarce in many areas of the world due to development, and increased demand. Groundwater is the major water resource in the Jaffna peninsula. One of the problems related to groundwater is the presence of ferrous and manganese which may cause taste, odour, colour, or turbidity problems.The objectives of the study were to focus on removal efficiency of iron and manganese, turbidity, color, and bacteriological parameters through oxidation and microfiltration process using low cost methods suitable at domestic level. Water samples were collected with problematic locations in Thenmaradchi for iron and manganese and pond water in Thirunelvely, Pasaiyoor and Kurunagar areas for coliforms and E.Coli. Preliminary tests were conducted to select suitable aeration time and overnight aeration was identified based on the removal efficiency. The iron, manganese, color, turbidity, pH, electrical conductivity, alkalinity, fluoride, sulphate, total phosphate, chloride, nitrates, total coliforms and E.Coli were tested for raw and treated water samples. The iron removal efficiency through micro filtration alone was varied from 18% to 100% and the manganese removal efficiency was varied from 65% to 100%. Higher percentage of Mn^{2+} *was removed by microfiltration compared to* Fe^{2+}*. But the removal efficiency for both* Fe^{2+} *and* Mn^{2+} *was 95% by oxidation and microfiltration process for surface and groundwater. The color and turbidity both reduced due the removal of iron and manganese. The bacteriological removal efficiency, total coliforms and E.Coli was 100%. There were no differences in other water quality parameters. Microfiltration process also reduces the nitrate nitrogen content of the groundwater. But microfiltration could not be used to remove oil and grease. Microfiltration could be introduced for treatment of groundwater and surface water for color, turbidity, iron and manganese and bacteria removal at domestic level.*

INTRODUCTION

The groundwater is dynamic; replenishable and dependable earth resource with acts as a viable substitute to the surface water supply in many countries. Water resources are becoming increasingly scarce in many areas of the world due to development, and increased demand (Pearce, 2008). Groundwater is the major water resource in Jaffna peninsula and it is used for domestic, agricultural and industrial purposes. Jaffna peninsula has a source of groundwater store in the sub terrain layer of the limestone aquifer. It is an excellent aquifer for storage because the aquifer has several isolated caves and caveins capable of storing groundwater without evaporation losses (Jaffna district statistical information, 2006).

The population of the Jaffna Peninsula is entirely dependent on the groundwater resources for almost all purposes due to seasonal rainfall. However, the region experiences groundwater problems as the resource is limited and its quality has deteriorated over the years. Due to the limestone aquifer, hardness of the water is much high. The groundwater contains dissolved salts and other constituents depending on the geochemistry. One of the problems related to groundwater is the reddish colour caused by the presence of ferrous and manganese. Initially, this colour cannot be seen but after it is exposed to the air, the oxidation of groundwater promotes the precipitation of ferrous and manganese. Eventually, the groundwater turns into reddish in colour (Jusoh et al., 2005). The presence of different chemical and physical constituents in excess of their permissible limits for various uses can create health hazard and environmental problems (Al-sayed, 2012).

The drinking water treatment technology requires new and innovative processes, based on the raw water quality and flows. Among innovative technology, microfiltration process has been identified as good since no chemical agents are used and constant production of treated water with high quality (Podaru et al., 2008). In the traditional process, Fe and Mn in groundwater are initially oxidized using aeration and/or chemical oxidant following the removal by filtration. After the oxidation process, the Fe and Mn oxides are then removed through the sand filter. Moreover, previous studies have indicated that the presence of Mn oxide particles accelerates the formation of Fe-Mn oxide, contributing to the removal of Fe and Mn from groundwater. Granular activated carbon is often used to enhance the adsorption of Mn^{2+} in filtration process. However, the drawback is frequent regeneration or new carbon replacement is required (Podaru et al., 2008)

Ultrafiltration (UF) and microfiltration (MF) are theoretically the best pre-treatment upstream reverse osmosis, which are capable of removing from the feed water most of the potential elements responsible of fouling desalinating membranes such as particles, turbidity, bacteria and large molecular weight organic maters (Bonnelye et al., 2008). This treatment is similar to the conventional one except that depth filtration is replaced by microfiltration. The expected advantage of this treatment is to have a compact separation unit which produces high quality water from a wide range of raw water quality.

Chunnagam aquifer is a high capacity aquifer and supplying large quantity of water to the public. However, oil and grease layers were observed in the surrounding of the Chunnagam power station in recent times. The objectives of the study were to focus on removal efficiency of iron and manganese, turbidity, colour, bacteriological parameters and oil and grease through microfiltration process.

MATERIALS AND METHODS

Sample collection

Water samples were collected with problematic locations in Thenmaradchi for iron and manganese (two location, Meesalai and Maravanpulavu), Thirunelvely (Sivan temple and NWS&DB), and pond water from Pasaiyoor and Kurunagar areas for coliforms and E.Coli. Each water samples were poured into three 25 liter plastic buckets after rinsing several times with the sample water. In case of oil and grease, one sample was collected from the contaminated site and for other samples, oil was added to the groundwater and mixed well before analysis.

Preliminary study

The percentage reduction of iron and manganese with aeration time was tested with two hr, four hr and overnight to select suitable aeration time. After aeration all water quality parameters were analysized to see the variability.

Chemical analysis

The procedure of the analysis was based on Sri Lankan Standard 614 part II. This includes test for determining the iron, manganese, colour, turbidity, pH, electrical conductivity (EC), alkalinity, fluoride, sulphate, total phosphate, chloride, nitrates, total coliforms and *E.Coli* of raw and treated water samples. Hexane extractable gravimetric method was used to analyze the oil and grease. Electrical conductivity, pH, iron and manganese were measured at the site for raw water.

Set up of micro filtration

Microfiltration unit is a simple potable water filtration system intended for sustainable low cost purification. The technology is based on a self contained membrane filtration system that operates under minimal head pressure condition without the need for power or conditioning chemicals. All the taps were off before commencing each operating procedure. The microfiltration unit was filled with water through the overhead tank with a total head of 2.25 m from the ground.

Data analysis

The efficiency of Fe and Mn removal by microfiltration process was evaluated. Also the removal efficiency of Fe and Mn after the treatment, aeration was evaluated. There are some standards for drinking water in which SLS maximum desirable level of iron is 0.3 ppm, manganese is 0.1 ppm, number of total coliforms in 100 ml is 10 numbers, and number of *E.Coli* in 100 ml is Nil. The treated water was compared with the SLS maximum desirable level.

RESULTS AND DISCUSSION

Preliminary study

The reduction of iron and manganese were increasing with the aeration time. The reduction percentage was very low in two hours aeration (12%) but in four hour and overnight aeration reduction percentage was 48% and 95% respectively. Finally overnight aeration was selected as the best treatment.

Iron and Manganese removal through micro filtration

Figure 1 shows the concentration of iron and manganese from raw and filtered water through microfiltration. Thenmaradchi area (Meesalai and Maravanpulavu) contained huge amounts of iron and manganese in groundwater. Higher percentage of Mn^{2+} was removed by microfiltration compared to iron. The iron removal efficiency through micro filtration varied from 18% to 100% (Figure 3). Water samples containing low iron contents show high removal efficiency as 100%. Even though Meesalai water sample has high concentration of iron (1.4 mg/L), it was reduced to 0.1 mg/L. The manganese removal efficiency varied from 65% to 100% (Figure 3). Concentrations of texted samples were less than the SLS desirable level.

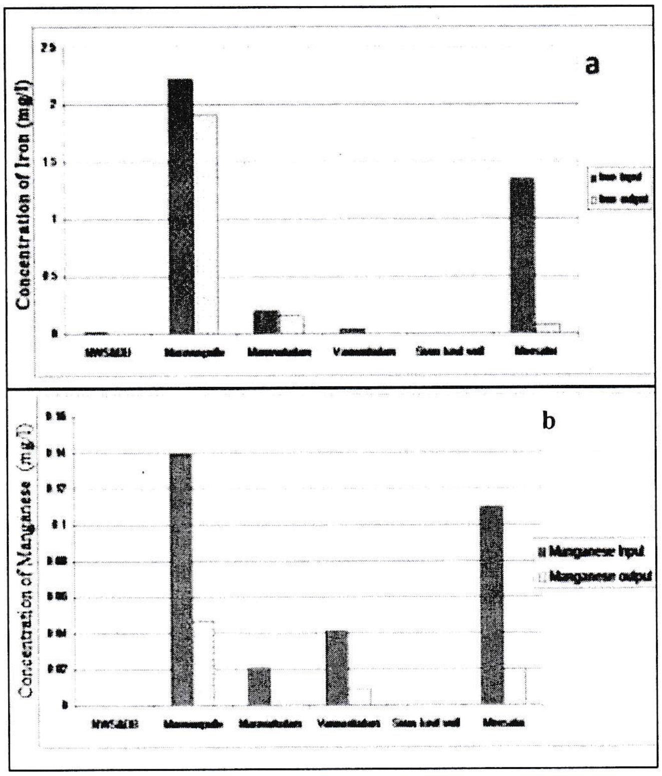

Figure 1: Concentration of iron (a) and manganese (b) in raw and treated water

In case of iron removal, the oxidation process is essential. Because the iron and manganese present in the groundwater are in the form of Fe^{2+} and Mn^{2+} respectively. In microfiltration process Fe^{2+} removal is difficult. So the Fe^{2+} ions were oxidized in the form of Fe^{3+} by aeration. After overnight aeration, reduction percentage of iron and manganese was 95%. The result showed that iron and manganese was almost removed by oxidation and filtration. Removal of iron in groundwater before passing through the membrane filter as pre-treatment technique is advisable to avoid membrane fouling (Ellis *et al.*, 2000). Also overnight aeration is very cheaper method compare to oxidation with potassium permanganate and no any chemical is used in the oxidation process.

The iron and manganese reduction causes the cutback of colour and turbidity measurements and shown in the Figure 2. Normally the colour is depending on the suspended particles of the water. Thenmaradchi area has reddish brown earth soil. The soil colloids and chemical suspended solids cause the reddish colour of water. The turbidity also may produce the colouring effect. The apparent and true colour is present in surface water. The true colour removal is difficult since colour removal was less in surface water (Figure 3, seeMaravarkulum).

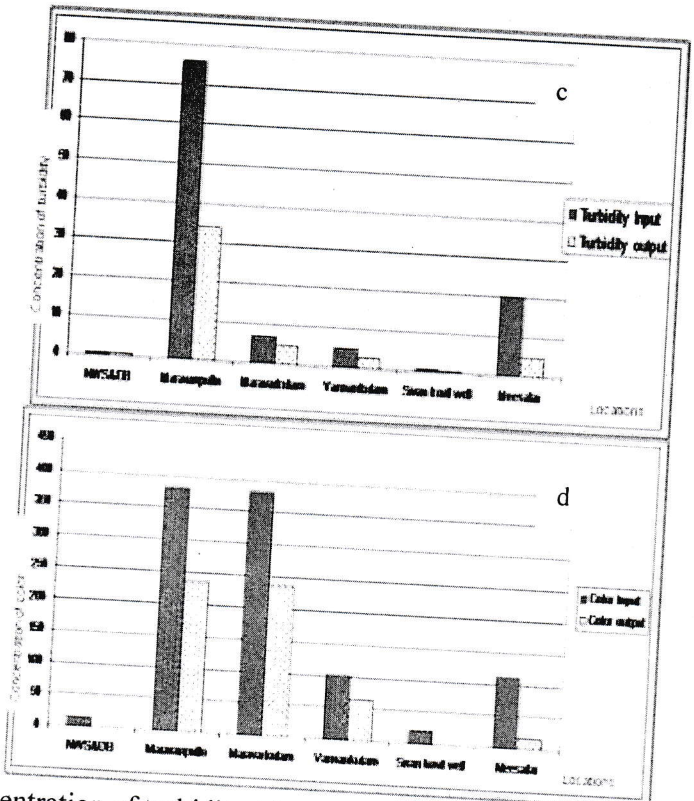

Figure 2: Concentration of turbidity (c) and colour (d) in raw and treated water

Turbidity is a measure of relative clarity or cloudiness of water. Turbidity is not a direct measure of suspended particles, but rather a general measure of the scattering and absorbing effect that suspended particles have on light. The sources and nature of turbidity are varied and complex and are influenced by the chemical, physical and microbiological characteristics of water. The aeration and microfiltration processes are reducing the turbidity, which is caused by dissolving of ions such as iron and manganese and organic suspended particles. The overnight aeration and filtration process increases the removal efficiency of colour and turbidity also.

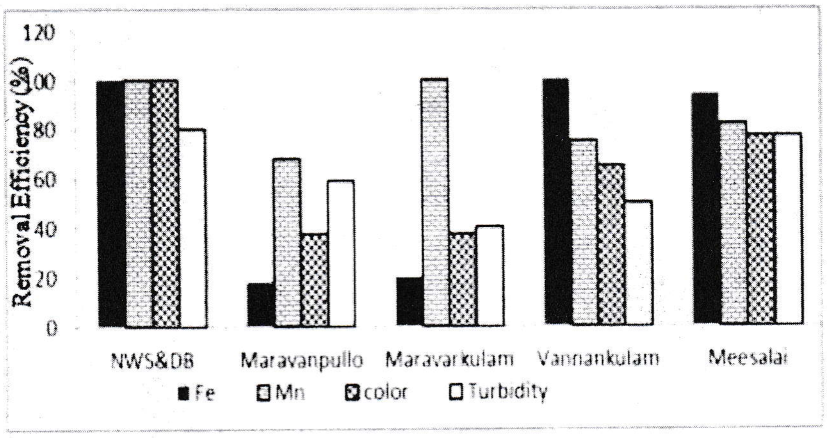

Figure 3: Removal eficiency by micro filtration

Oil and grease removal through micro filtration

Figure 4 shows the oil and grease concentration and filtration efficiency in raw and treated water. The efficiency of first sample was high subsequently the efficiency was reduced. Because oil and grease particles are settled in the membrane module.

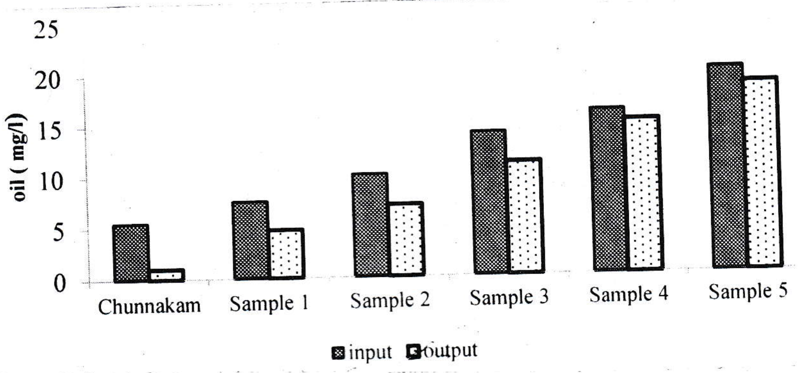

Figure 4: Oil and grease removal

Removal of bacteriological parameters

Table 1 shows the bacteriological parameters of raw and treated water in different locations. The bacteriological removal efficiency was high. And nearly 100% and is within the SLS desirable level.

Table 1: Bacteriological parameters of raw and treated water in different locations

Parameter	NWS &DB	Maravan pulavu	Maravar kulam	Vannan kulam	Sivan kovil	Meesalai
No of total coliforms in 100ml	Input	Countless	Nil	Countless	Countless	Nil
	output	Nil	Nil	Nil	Nil	Nil
No of *E.Coli* in 100ml	Input	88	Nil	Countless	39	Nil
	output	Nil	Nil	Nil	Nil	Nil

Other water quality parameters

Table 2 shows the concentration of other water quality parameters of raw and treated water. All the parameters were reduced during the microfiltration process. Microfiltration process also reduces the nitrate nitrogen content of the groundwater which is the other main problem in Jaffna Peninsula.

Table 2: Other quality parameters of raw and treated water

Location	Sample	Chlorides mg/l	Alkalinity mg/l	Sulphate mg/l	pH	EC µS/cm	Nitrates mg/l	Fluoride mg/l	Phosphate mg/l
NWS&DB	raw	974	663	98	7.28	3490	3.6	0.48	1.09
	treated	914	635	97	7.43	3450	2.6	0.46	1.07
Maravanpulavu	raw	658	360	1052	8.2	1385	1.3	0.91	0.44
	treated	649	341	1048	8.16	1363	0.7	0.82	0.27
Maravarkulam.	raw	513	274	374	8.15	1059	0.5	0.47	0.32
	treated	361	237	301	8.14	896	0.2	0.43	0.07
Vannankulam	raw	966	151	145	8.55	1714	0.5	0.18	0.37
	treated	897	104	142	8.47	1699	0	0.13	0.29
Sivan kovil	raw	154	246	41 .	8.9	812	1.7	**	**
	treated	128	227	41	8.2	724	0.5	**	**
Meesalai	raw	103	118	12	8.02	363	**	**	**
	Aeration after filter output	90	113	12	8.05	325	**	**	**
	Aeration	85	109	11	8.3	328	**	**	**

CONCLUSIONS

Microfiltration process can be applied properly for improving water quality to comply more stringent water quality standards. The iron removal efficiency through micro filtration alone was withn 18% to 100% and the manganese removal efficiency was within 65% to 100%. But the combination of oxidation and microfiltration removed the iron and magnesium completely (95%). The color and turbidity both reduced due the removal of iron and manganese. The bacteriological removal efficiency (total coliforms and *E.Coli*) was 100%. Microfiltration process also reduces the nitrate nitrogen content of the groundwater. Microfiltration could be introduced for treatment of groundwater and surface water for color, turbidity, iron and manganese and Bacteria removal. Membrane systems are compact and easy to operate and are becoming the technology of choice for small communities and remote area.

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