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Ground Water Treatment Using Slow Sand Filtration or Conventional System

معالجة المياه الجوفية باستخدام المرشحات الرملية البطيئة أو النظام التقليدى

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الملخص العربى

يمثل وجود أملاح الحديد و المنجنيز مشكلة خطيرة فى المياه الجوفية و على هذا تم استخدام بديلين لمعالجة المياه التى تحتوى على هذه الأملاح من خلال عدد (٢) محطة تجريبية تم إنشاؤهم فى موقع محطة أبار بقرية ولجا مركز منيا القمح محافظة الشرقية بمصر. الغرض الرئيسي للبحث مقارنة نتائج المحطتين لازالة الحديد و المنجنيز. المحطة الأولى بنظام المعالجة البيولوجية باستخدام المرشحات الرملية البطيئة مسبوقة بتهوية طبيعية (multiple trays) أما المحطة الثانية باستخدام النظام التقليدى (مرشحات ضغط) و أيضا مسبوقة بتهوية (برج تهوية)و باستخدام الكيماويات. معدل الترشيح فى محطة المرشحات الرملية البطيئة كان ٣ الى ٦ متر/اليوم و تركيزات الحديد كانت ٦,. و ١,٣ ملجم /لتر و تركيزات المنجنيز كانت ٢ و ٤,٢ ملجم /لتر و كانت كفاءة الازالة فى حدود ٩٧-٩٩%.و تركيزات الحديد و المنجنيز الناتجة من المعالجة البيولوجية أقل بكثير من الحدود المسموح بها فى الكود المصرى. أما فى النظام التقليدى يتم استخدام التهوية و اضافة برمنجنات البوتاسيوم بجرعات من ٢ الى ٦ ملجم /لترو معدل ترشيح ١٥٠ م/يوم و تركيز الحديد ١,٣ ملجم/لتر وتركيز المنجنيز٤,٢ ملجم/لتر، وقد وجد انه بزيادة الجرعة تزيد معها نسبة الإزالة للمنجنيز أما بالنسبة لإزالة الحديد فوجدت متشابهة لكل الجرعات الكيمياوية. ووجد ان تركيزات المنجنيز الناتجة من المعالجة التقليدية أكبر من المسموح به لمياه الشرب لكل جرعات برمنجنات البوتاسيوم المضافة. و بالنسبة للتهوية لها أهمية كبيرة لازالة الحديد و المنجنيز لكل من النظامين. و أخيرا وجد أن نظام المعالجة البيولوجية باستخدام المرشحات الرملية البطيئة يفضل استخدامه فى مصر من النظام التقليدى نتيجة لسهولة التشغيل و الصيانة و عدم استخدام الكيماويات و بجانب الكفاءة العالية لازالة الحديد و المنجنيز للحدود المسموح بها لمياه الشرب.

Abstract:

Iron and manganese represent a serious problem in ground water, therefore this research study two alternatives for water treatment contains these metals through two pilot plants constructed within a groundwater plant in Walga village, Mnia El Kamh Markaz, Sharqia governorate, Egypt. The main objective of this research is to compare the two alternative systems for iron and manganese removal, the first method mainly depends on biological treatment of slow sand filtration (SSF) with pre-aeration (multiple trays), while, the other method is conventional system (pressure filters) with pre-aeration (aeration tank) and using the additional chemicals. Filtration rates used for slow sand filters ranged from 3 to 6 m/d and Fe influent concentration ranged from o.6 to 1.3 mg/l and Mn influent concentration ranged from 2 to4.4 mg/l. Total Fe and Mn removal efficiencies obtained by slow sand filtration system, which functions under natural conditions and without using any chemical agents, are in the range between 97% to 99 % and the effluent concentrations of Mn and Fe for all the runs were less than the Egyptian allowable limits. The conventional system used aeration with influent iron and manganese concentrations of 1.3 and 4.4 mg/l respectively, potassium permanganate doses were in the ranges of 2 to 6 mg/l and the rate of filtration was 150 m^3/m^2/day. The removal of manganese increased by increasing $KMnO_4$ dose but iron removal efficiency was the same for all runs. The effluent concentration of Mn was higher that the allowable limits for all the runs of the conventional system. The aeration step has an important effect on removal efficiency of iron and manganese by slow sand filter and conventional system. Finally, it concluded that the use of slow sand filtration (SSF) plants in Egypt is better than using conventional plants due to the simplicity of operation and maintenance and without using chemicals, further more the high efficiency of iron and manganese removal with acceptable limits for potable water.

Key Words

Iron and Manganese removal, biological treatment, slow sand filtration, ground water.

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1. Introduction

Surface water generally does not contain large amounts of iron or manganese· Iron and manganese are found frequently in water systems that obtain their water from wells and springs. Iron bacteria will use even small amounts of iron present in the ferrous state, oxidize it, and then use the energy. The manganous ion is used in a similar fashion by other bacteria to form organics, which contribute to the iron bacteria slime in the well and/or water system [1}.

In groundwater iron and manganese are found particularly in wells that draw their waters from underground formations comprised of shale, sandstone, and alluvial deposits. In the reducing environment often found in a deep well supply, that is, one which is devoid of oxygen and which possesses a low pH, the iron and manganese will exist in their divalent soluble forms [2]. The ground water is one of the most important media for the environmental cycling of manganese since it receives manganese emitted from various natural and anthropogenic sources. It has been estimated that total emissions of manganese in the world to the water environment, from all sources, are in the range of 0–5 mg/L [3]. Although normally found in their divalent form, iron and manganese may also exist in other forms, thereby complicating the selection of methods for their removal. Complexes of either an organic or mineral nature may occur with both elements. Organic complexes consist of the element sequestered with an organic molecule such as humic, fulvic or tannic acids [4].

Fe and Mn removal by biological processes are based on different stages of biofiltration where beds are colonized by Fe, Mn oxidizing bacteria. In nature, iron oxidizing bacteria (IOB) and manganese oxidizing bacteria (MnOB) are widespread. They are prevalent in groundwater, swamps, ponds, in the hypolimnion of lakes, in sediments, soils, wells and water-distribution systems. In the latter they can cause significant clogging problems. These bacteria which are present in raw water can multiply in slow sand filters under appropriate conditions and are able to oxidize divalent ions Fe(II), Mn(II) and precipitate them under their oxided forms Fe(III) and Mn(IV) [5]. It was found that biologically mediated manganese and iron removal were found to follow a first-order reaction rate, presenting half-life of 3.98 and 0.9 min, respectively. The fast rates of reaction rendered the treatment method quite economic and environmental friendly, because additional use of chemical reagents is not required [6, 7].

Because of differences in optimum conditions for the biological removal of Fe and Mn, when rapid filters are used, it is not possible to carry out removal of Fe and Mn simultaneously in one step, except when very low velocities are used. In several regions of northern Europe, slow sand filter processes including one or two pre-treatment steps are also applied [8, 9, 10].In this study [11] removal of Mn from ground waters, by means of potassium permanganate oxidation followed by flocculation, settling and filtration was investigated. Removal of Mn below the current MCL (0.05 mg/L) was a burdensome task due to the extremely high raw water Mn concentration (up to 1.81 mg/L).

Specifically, longer (30 min) than expected (5–10 min) contact times were necessary to complete Mn oxidation, stressing the need of a reaction (flocculation) tank rather than the widely used in-line filtration for the removal of Mn. Satisfactory removal (above 95%) was obtained at pH 8.5 with a potassium permanganate dose of 1.74 mg/L followed membrane filtration. Based on the actual Mn concentration in the raw water, this permanganate dose was slightly above the 0.5 stoichiometric doses. Oxidized iron precipitated from solution is removed by the pressure filter. Either sufficient ironfree backwash water must be provided from the system, or non aerated water must be fed to the filter for backwash and rewash. Effluent of the pressure filter is delivered to service. Generally, some storage facility elevated or hydropneumatic is incorporated. The disadvantage of this method that air oxidation is usually slower than chemical oxidation, and aeration is typically is not efficient at removing Mn as it for iron [12].

The main objective of this study is to make a comparison between two different systems for the removal of iron and manganese; therefore two pilot plants were constructed to obtain performance data of each system according to the results obtained from each plant and evaluate the operating and maintenance requirements for the two systems.

2. Materials and methods:

2.1 Location of Study Site:

Many sites were investigated in Dakhlia, Mnofia and Sharqia governorates to choose the site which could be suitable for the study. However, Walga (plant in Walga village, Mnia El Kamh Markaz, Sharqia governorate) groundwater plant was finally chosen because the natural groundwater containing high amounts of iron (1.3 mg/l) and manganese (4.4 mg/l) in addition to the existing of land area enough for the construction of the two pilot plants to be compared in the same conditions, and also according to the facilities given by Sharqia drinking water and sanitation company.

2.2 Raw water Characteristics

In the beginning the physical and chemical characteristics of the influent water (the raw water quality characteristics) were measured as shown in Table 1 to study the effect of its effect on removal of iron and manganese.

Table 1 Raw water quality characteristics

Parameter	Raw water	Limit acc. in Egypt
pH	7.3	6.5-8.5
DO (mg/L)	2.4	-
Temperature (°C)	22	-
Fe (mg/L)	1.3	0.3
Mn (mg/L)	4.4	0.4
TDS (mg/L)	925	1000
Ca (mg/L) (as $CaCO_3$)	144	350
Mg (mg/L) (as $CaCO_3$)	91	150
SO_4 (mg/L)	168	250
Cl (mg/L)	90	250

2.3 Description the two Pilot plants:

Fig.1 shows a general layout of the two pilot plants located at Walga plant used in the study. The first pilot plant [No.1] mainly depended on biofiltration of slow sand filters that using the environmental effects of the biological role of microorganisms for iron and manganese removal. However, the natural aeration by multiple tray aerators unit was constructed before slow sand filters to increase dissolved oxygen and pH concentration which could assist iron and manganese bacteria to be developed. The second pilot plant No.2 relied on the oxidation of iron and manganese by chemical additions such as potassium permanganate ($KMnO_4$) which injected in an aeration tank. Compressed air was injected into the aeration tank by air compressor unit.

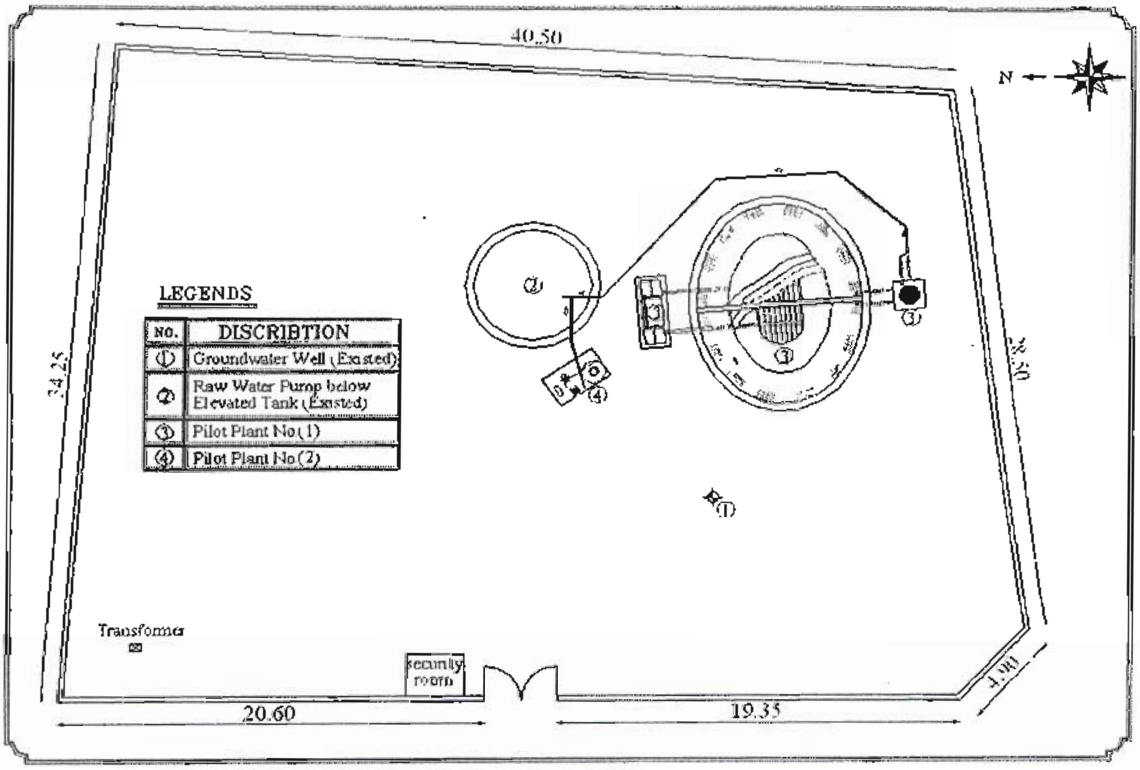

Fig. 1 General layout of the two pilot plants

2.3.1 Description of Pilot Plant No.1 (Slow sand filtration)

As shown in Photo 1 and Fig. 2 the pilot plant No.1 consist of the following main parts:

1-Influent raw water: The two pilot plants utilize raw water from elevated tank with 60 m3 capacity and 18 meter height that served the village. The raw water is pumped from well to the tank by two pumps that are operated alternatively and located at pump room below elevated tank.

2-Multiple tray aeration unit: A multiple-tray aeration unit consisted of 4 trays galvanized steel sheets (3 mm thickness) with respectively 40, 50, 60, and 70 cm diameter from top to bottom and with perforated bottoms which contained 600 holes/m^2 and 1 mm diameter of each hole.

3-Two slow sand filters: The two slow sand filters were constructed together as a pond with elliptical shape as shown in photo 1. The total depth of pond was 3 m while the length and the width were 7.25 and 5 m respectively at mid depth. The pond has a side slope of 45° on the horizontal; the surface area for each filter at mid depth was approximately 14 m^2. The bed thickness of sand layer was chosen 100 cm in the two filters with size varied from 0.15 to 0.30 mm.

4-Two outlets chambers: The outlet chambers installed within soil after slow sand filter units for clear water effluent.

5- Piezometers chamber.

6-Return effluent tank: A 1 m^3 fiberglass tank was installed to dilute the concentration of iron and manganese in influent water in order to use another concentrations that can serve the study.

2.3.2 Description of Pilot Plant No.2 (Conventional System)

As shown in Photo 2 and Fig. 3 the pilot plant No.2 consist of the following main parts:

1-Influent raw water: The two pilot plants utilize raw water from elevated tank with 60 m3 capacity and 18 meter height that served the village. The raw water is pumped from well to the tank by two pumps that are operated alternatively and located at pump room below elevated tank.

2-Aeration tank: The aeration tank was made of steel with circular cross section (0.50 m diameter), the total depth of tank was 1.60 m

3-Air Compressor: A 1.5 Hp air compressor motor model (Fiac FX95) was used for feeding aeration tank with air.

4-Chemical feeding tank: A 200 liters fiberglass tank was used as chemical tank for preparing potassium permanganate solution with the required concentration.

5-Pressure filter: The pressure filter was made of steel with circular cross section with an internal diameter of 1.10 m , 0.95 m^2 area at surface of media layer. The total depth of the tank was 1.40 m. The filter medium was sand bed layer capped with anthracite coal layer to avoid taste and odor problems.

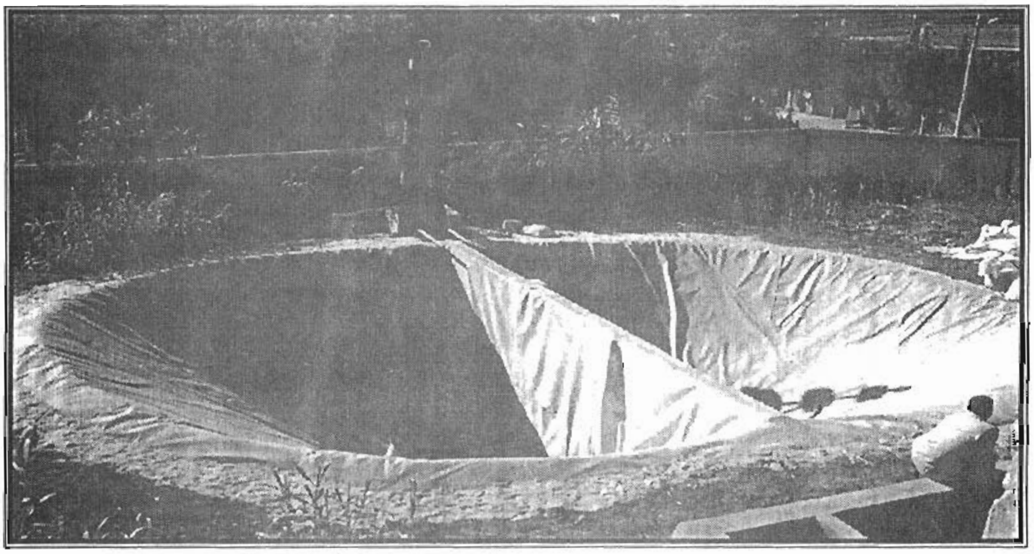

Photo 1 Slow sand filters plant No.1 after lining

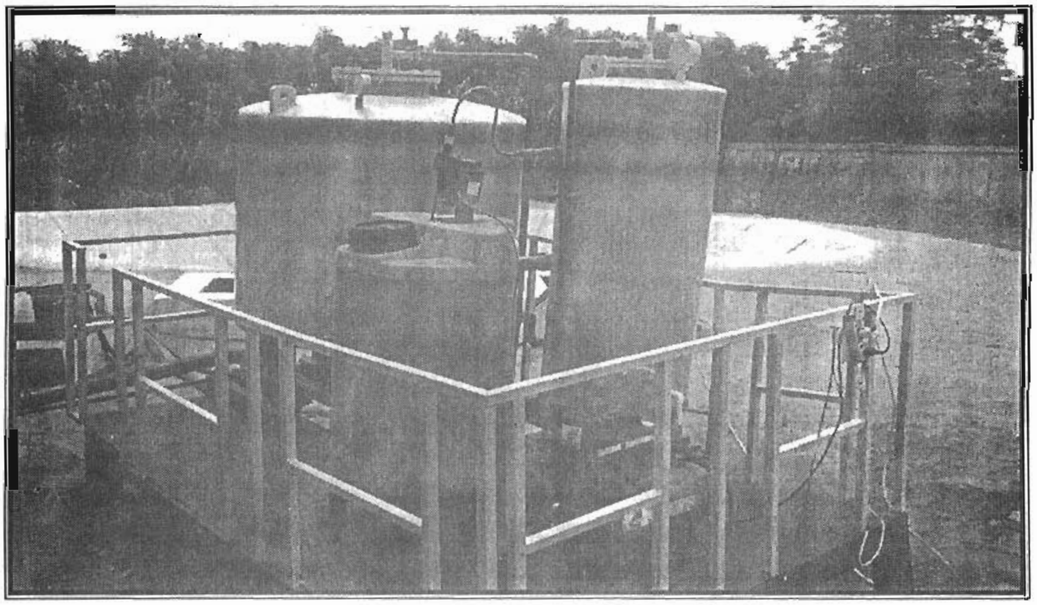

Photo 2 Conventional system pilot plant No. 2

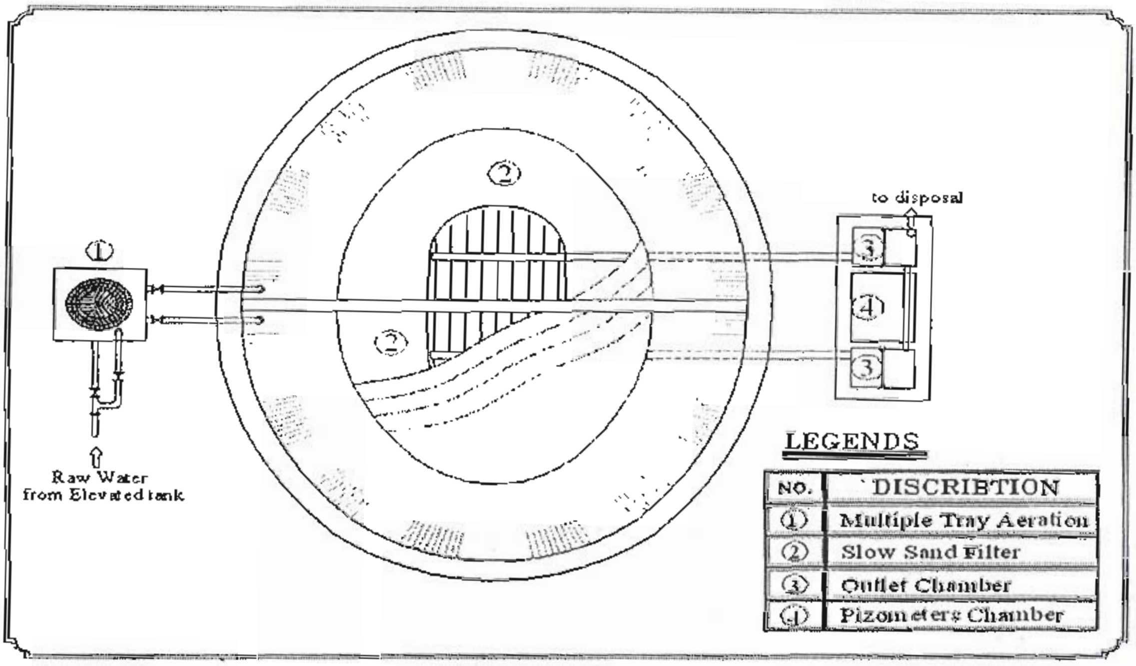

Fig. 2 General plan of pilot plant No.1

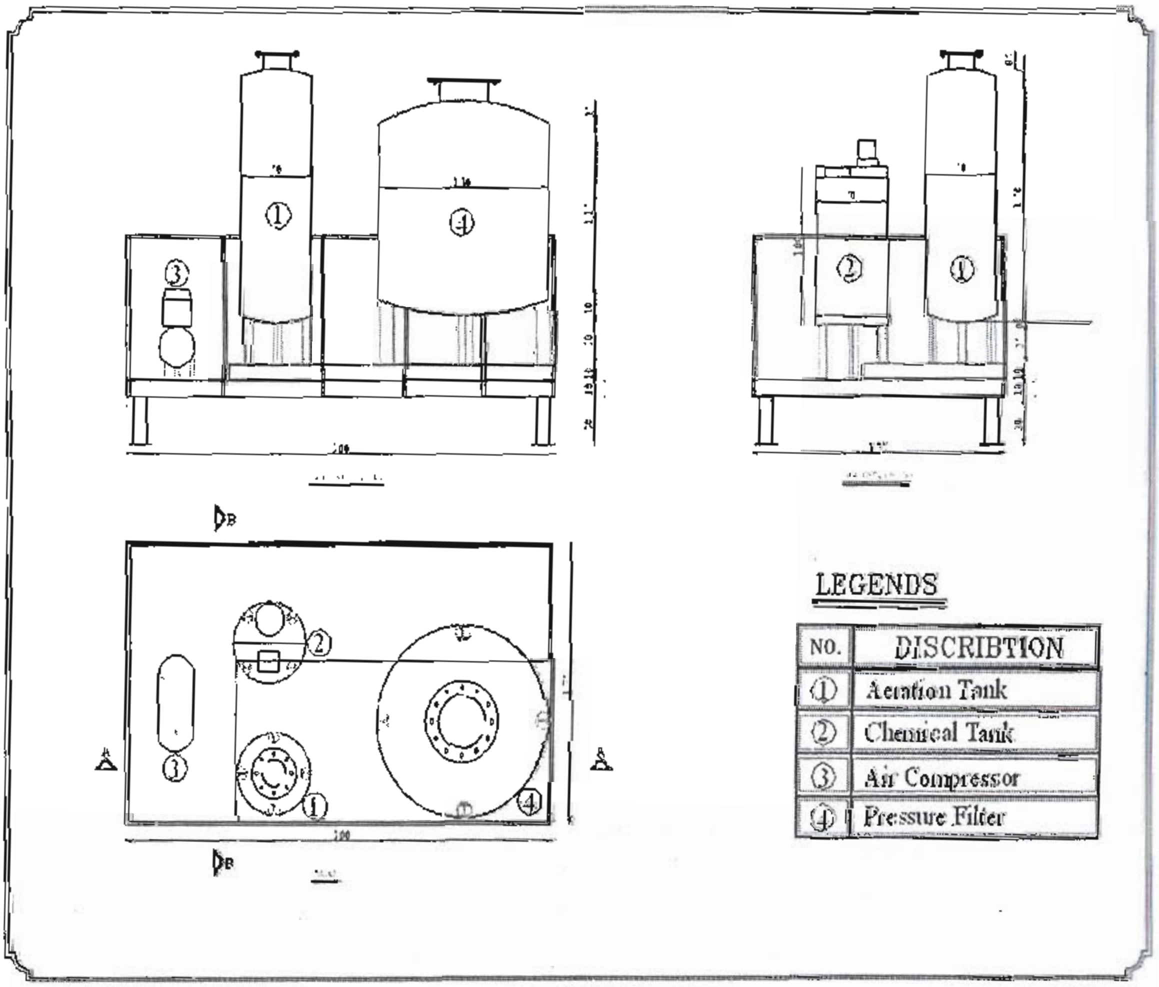

Fig. 3 General plan of pilot plant No. 2

2.3 Analytical methods

In order to investigate the performance of the slow sand filter and conventional system during its operation, analyzing different parameters was carried out in this study.

2.3.1 Instruments

A microprocessor-based photometer model (Hanna Hi 83200) that measure 36 parameters in water and wastewater was used at the site of pilot plants. In this study photometer measured 6 parameters in groundwater placed in the following table (2).

Table (2) The measured parameters

Parameter	measured Range
Iron High Range	0-5 mg/l
Iron Low Range	0-400 µg/l
Manganese High Range	0-20 mg/l
Manganese Low Range	0-300 µg/l
DO	0-10 mg/l
pH	6.5-8.5 mg/l

2.3.2 Head Loss Measurements

For slow sand filters the total head loss on a filter was the difference in height levels at piezometers chamber between piezometer of water above surface sand layer and piezometer of water at the bottom of filter (outlet). For pressure filter the total head loss on a filter was the difference in head pressure between the inlet and the outlet that measured by manometers.

2.3.3 Flow Measurement

For the two pilot plants the influent flow was controlled by the inlet valves. Influent and Effluent flows were manually measured. For slow sand filtration plant the discharge was set according to the required rate of filtration and the water returned to the effluent tank, while constant flow was carried out for pilot plant No.2 that operated with maximum discharge (rate of filtration 150 m^3/m^2/day).

2.3.4 Samples

For slow sand filter pilot plant No.1, four samples were taken once a day from the following places: Raw water before multiple tray aerator, aerated water after aeration unit and the effluent of each filter.

For conventional pilot plant No.2 two samples were taken once every four hours from the following places: Raw water before aeration unit, aerated water after aeration unit and the effluent of filter.

For slow sand filtration pilot plant, there was five runs (A-1 to A-5) were carried out to evaluate its removal efficiency at different operation conditions such as; filtration rate, using aeration before SSF or not, and the influent iron and manganese concentrations.

Six runs were carried out for pilot plant No. 2 that using potassium permanganate with aeration followed by pressure filter. The following parameters were analyzed; Fe, Mn, pH, DO, and temperature in terms of different dosages of $KMnO_4$.

3. Results and Discussions

3.1 Slow Sand Filtration Plant No. 1

3.1.1 Effect of filtration Rate on Removal Efficiency

From runs that were implemented in the slow sand filter pilot plant, three different filtration rate were carried out to study the effect of filtration rate on iron and manganese removal efficiency and predict the relationship between filtration rate and run length. For these reasons, two comparisons in the same operation conditions can be formed for each run.

The first comparison between run A-1 and A-2, with filtration rates of 3 m/d and 4.4 m/d respectively, the operation conditions for both runs were as follows:

-Aeration followed by filtration.

-Influent iron and manganese concentrations were 1.3 and 4.4 mg/l respectively.

The second comparison between run A-4 and A-5, with filtration rates of 3 m/d and 6 m/d respectively, the operation conditions for both runs were as follows:

-Aeration followed by filtration.

- Influent iron and manganese concentrations were 0.6 and 2 mg/l respectively.

The main difference between the above two comparisons is iron and manganese influent concentrations.

Results show that the filtration rate has a little effect on the iron removal efficiency as shown in fig (4). It was observed that the removal efficiency of Fe at run A-1 with filtration rate 3 m/d (99%) is slightly better than Fe removal efficiency at run A-2 with filtration rate 4.4 m/d (98%).

Fig. (5) shows that the filtration rate has a little effect on manganese removal efficiency, Mn removal efficiency at run A-1 with filtration rate 3 m/d (98%) is slightly better than Mn removal efficiency at run A-2 for filtration rate 4.4 m/d (97.4%).

Fig. (6) shows that Fe removal efficiency at run A-4 with filtration rate 3 m/d (98%) is better than Fe removal efficiency at run A-5 with filtration rate 6 m/d (96%), also run length of run A-4 (181 days) is longer than run A-5 (19 days).

Fig. (7) shows that Mn removal efficiency at run A-4 with filtration rate 3 m/d (98.5%) is better than Mn removal efficiency at run A-5 with filtration rate 6 m/d (97%).

So, as expected the filtration rate affect slow sand filter performance in general even though the different of influent concentrations. The relationship between removal efficiency and filtration rate is proportional while it is inversely with run length.

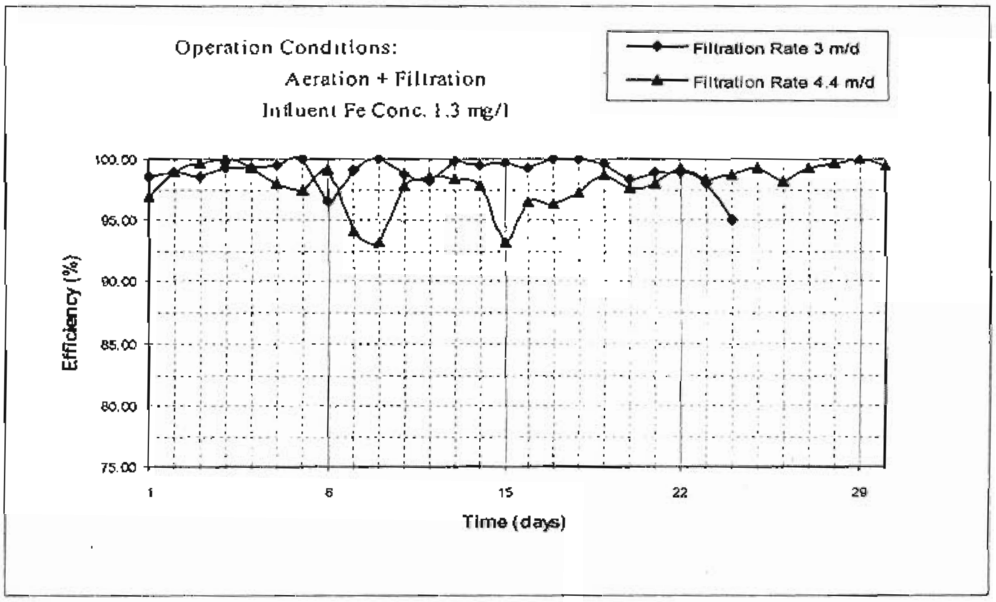

Fig. (4) Effect of filtration rate on Fe removal efficiency (Runs A-1 &A- 2)

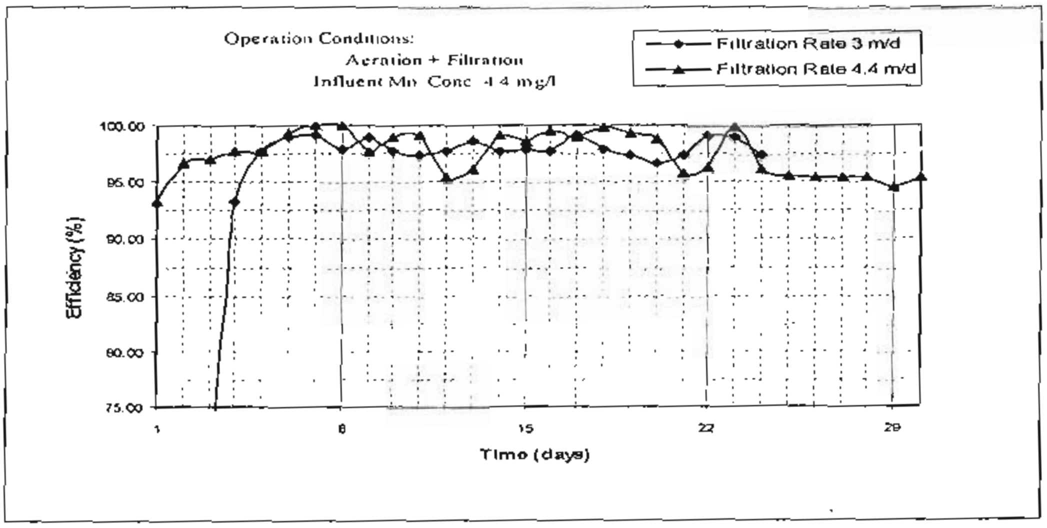

Fig. (5) Effect of filtration rate on Mn removal efficiency (RunsA-1 &A-2)

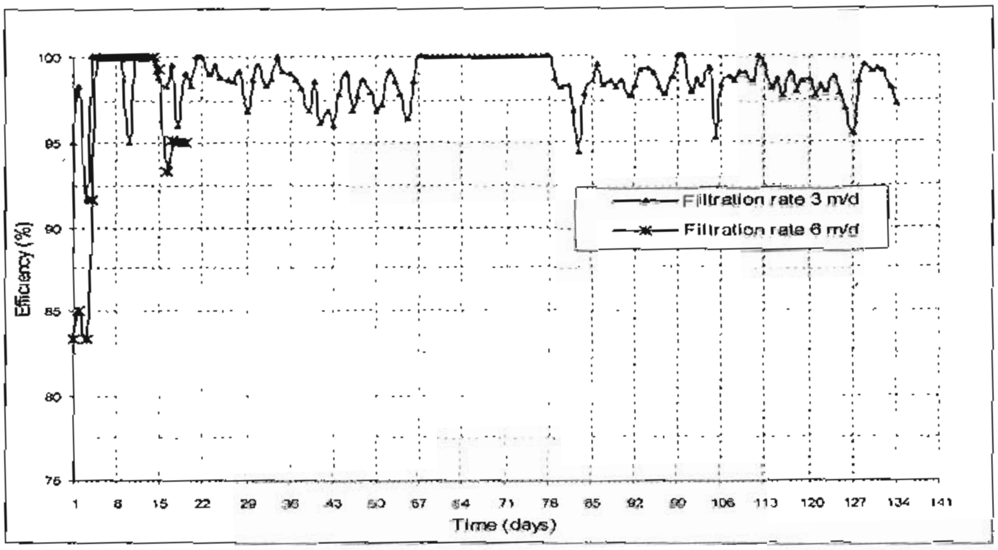

Fig. (6) Effect of filtration rate on Fe removal efficiency (Runs A-4 & A-5)

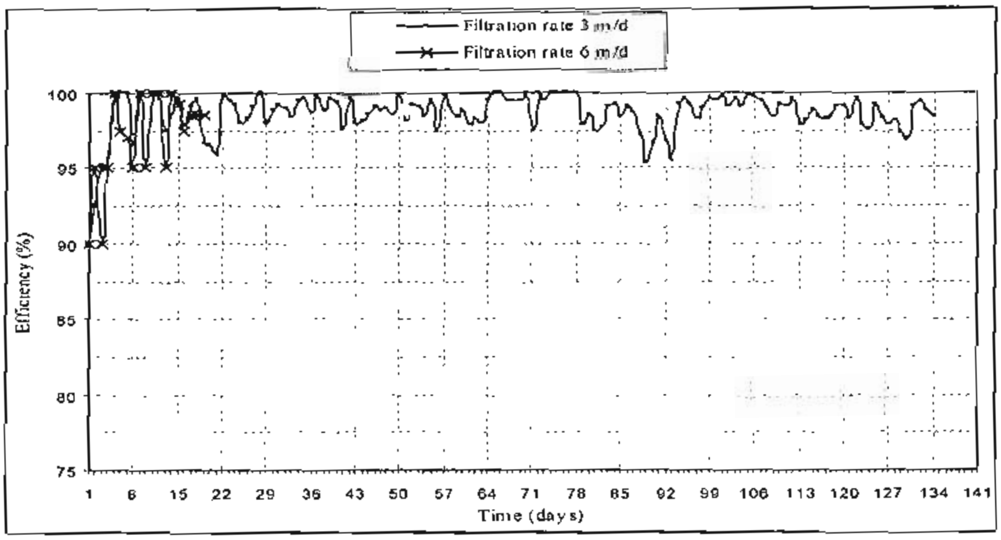

Fig. (7) Effect of filtration rate on Mn removal efficiency (Runs A-4 &A-5)

3.1.2 Effect of Aeration on Removal Efficiency

To study the effect of aeration unit before slow sand filtration stage on Fe and Mn removal efficiency, two runs were carried out in the same time. These runs were A-2 and A-3, and as illustrated before multiple tray aeration unit was bypassed at run A-3 while all remaining operation conditions for both runs were alike as follows:
Filtration rate was 4.4 m^3/m^2/day and influent iron and manganese concentrations were 1.3 and 4.4 mg/l respectively.
Fig. (8) shows that Fe curve for run A3 (without aeration) is unsteady compared with run A-2 that used aeration. Also removal efficiency of iron for run A-2 (98%) is better than removal efficiency for run A-3(97%).
Fig. (9) shows that the Mn removal efficiency at run A-2 (97.4%) is much better than that of run A-3(79%). This is appear clearly at Mn curve, we notice that the curve for run A-3 (without aeration) is unsteady and its start up period is long compared by run A2 that used aeration.

The above results indicated that the aeration step has an important effect on treatment performance and especially on Mn removal efficiency. The relationship between aeration efficiency and Fe and Mn removal efficiencies is proportional.

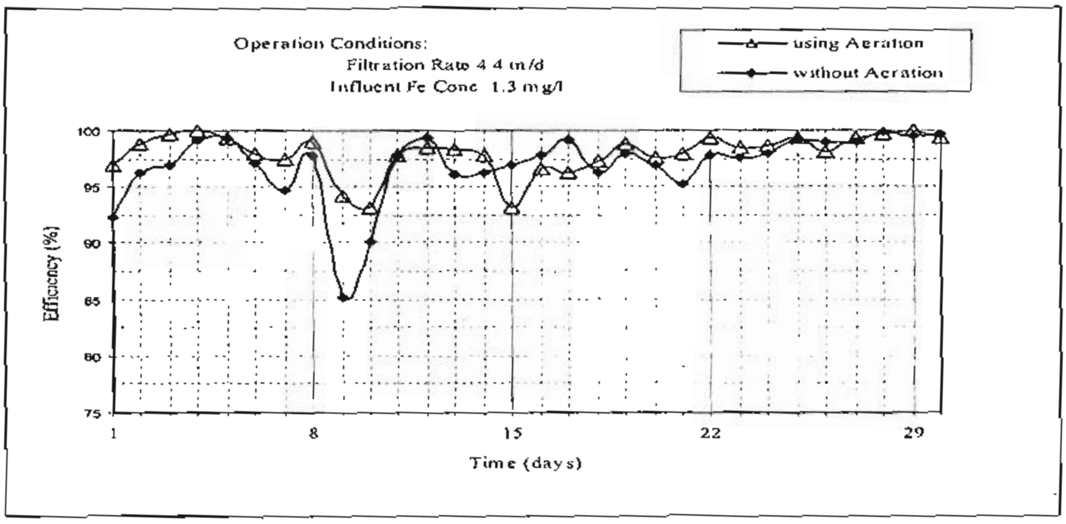

Fig. (8) Effect of aeration step on Fe removal efficiency (Runs A-2 &A-3)

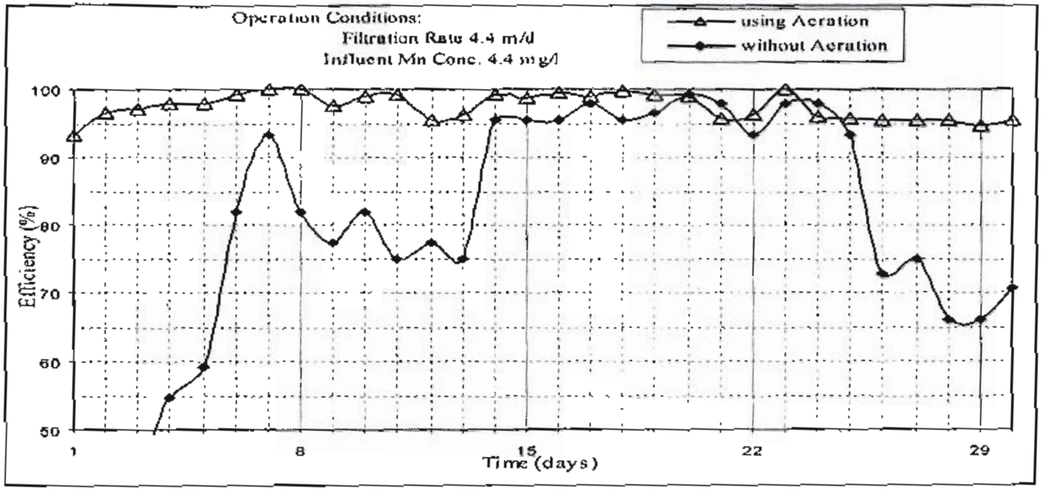

Fig. (9) Effect of aeration step on Mn removal efficiency (Runs A-2 & A-3)

3.1.3 Effect of Influent Concentrations on Removal Efficiency

To study the effect of influent concentration of Fe and Mn on its removal efficiencies, two runs were carried out with the same filtration rate (3 $m^3/m^2/day$) and by using aeration stage before filtration. The operation conditions for runs A-1 and A-4 were as followed:

For run A-1: Influent Fe and Mn concentrations were 1.3 mg/l and 4.4 mg/l respectively.

For run A-4: Influent Fe and Mn concentrations were 0.6 mg/l and 2.0 mg/l respectively.

Fig. (10) shows that influent concentration of iron hasn't clear effect on removal efficiency while it has clear effect on length of run where run length of run A-1 was only 24 days while run length of run A-4 was 181 days, may be affected by oxidation particles of manganese.

Fig. (11) shows that influent concentration of Mn has a little effect on Mn removal efficiency. Mn removal efficiency of run 4 (98.5) % is better than that of run A-1 (98%). it has a significant effect on run length since the run length of run A-1 was only 24 days due to clogging of top sand layer with big amount of solids resulting from oxidation of iron and manganese while run length of run A-4 was 181 days.

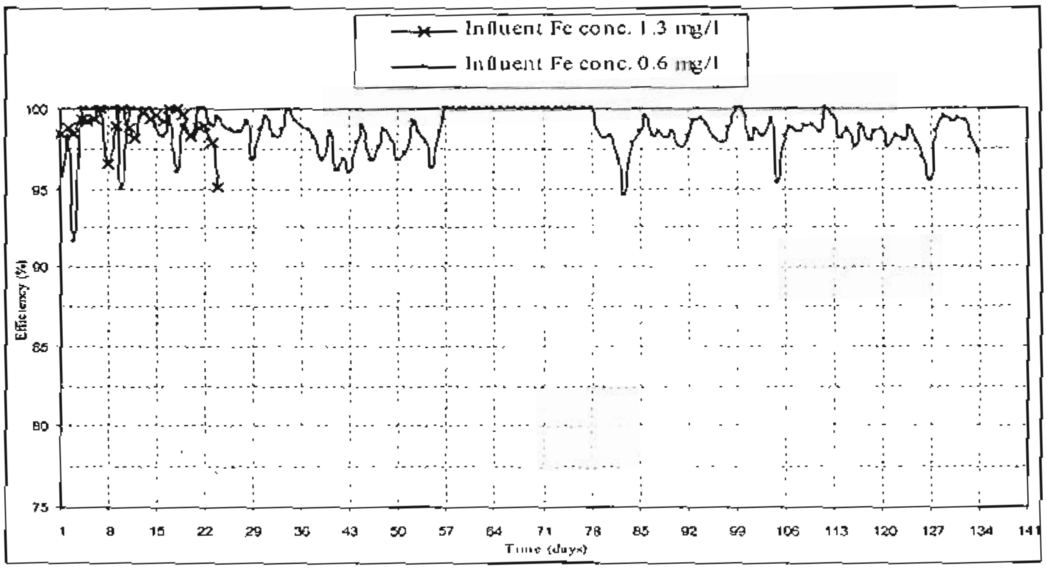

Fig. (10) Effect of influent concentrations on Fe removal efficiency (Runs A-1 &A- 4)

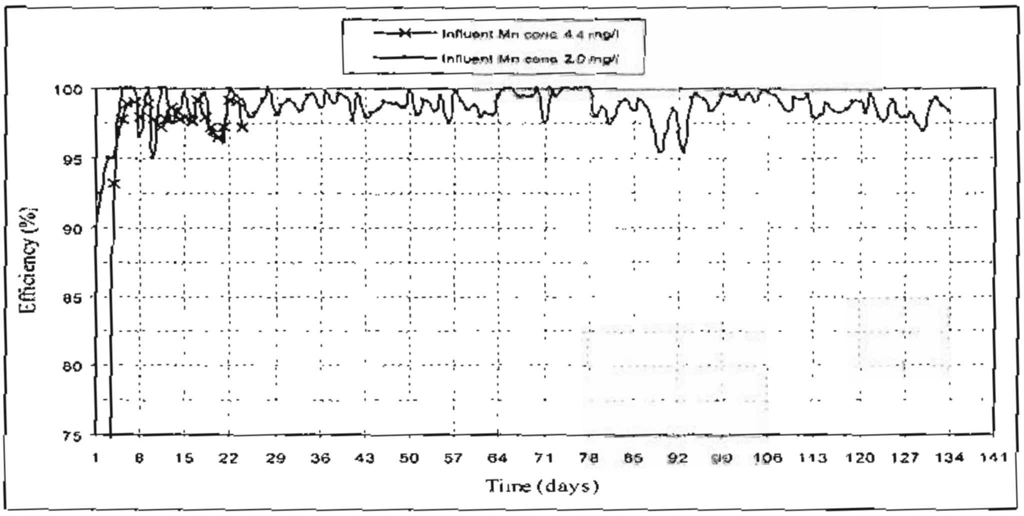

Fig. (11) Effect of influent concentrations on Mn removal efficiency (Runs A-1 &A- 4)

3.2 Conventional pilot plant No.2

3.2.1 Effect of Permanganate Dose on Removal Efficiency

Many different dosages of permanganate were applied for the conventional pilot plant No.2 to study the effect of permanganate dosages on Fe and Mn removal efficiencies.

The operation conditions for runs were as follows:

-Influent iron and manganese concentrations were 1.3 and 4.4 mg/l respectively.

-Aeration followed by filtration.

-No chemicals were added in the first run.

-The dosages of permanganate were 2, 3, 4, 5, and 6 mg/l for runs from B-2 to B-6 respectively.

Fig. (12) shows the variation of Fe removal efficiency in all runs of the pilot plant No.2. It was observed that potassium permanganate dosages have less effect on iron removal efficiency but the run length decreased by increasing the dose due to the decreasing of head loss in pressure filter resulting from the particles of Fe and Mn oxidation which precipitated on the sand media and lead to its clogging. The Fe removal is over 95 percent with average of 98.8%. The removal efficiency of iron in run B-2 is less than the other remaining runs because of the low concentration of DO in water in this run compared by the other runs since the inlet air to oxidation tower was controlled.

Fig. (13) shows the variation of Mn concentration in all the runs, it was observed that as the potassium permanganate dosage increase, the concentration of manganese in the effluent water decrease up to an average of 1.3 mg/l at 6 ppm dose but this value still more than the recommended level in Egypt by 0.9 mg/l. The removal efficiency for total Mn at pilot plant No.2 improved by increasing the permanganate dose but don't exceed 70% especially in high dosages more than the normal (1-4 mg/l). In addition the effluent water is pink colored at dosing more than 4 ppm; this is not advisable from consumptions. The above results show that $KMnO_4$ dose has an important effect on treatment performance and especially on Mn removal efficiency. Also Fe oxidation is very easy compared by Mn oxidation coincides with many researchers.

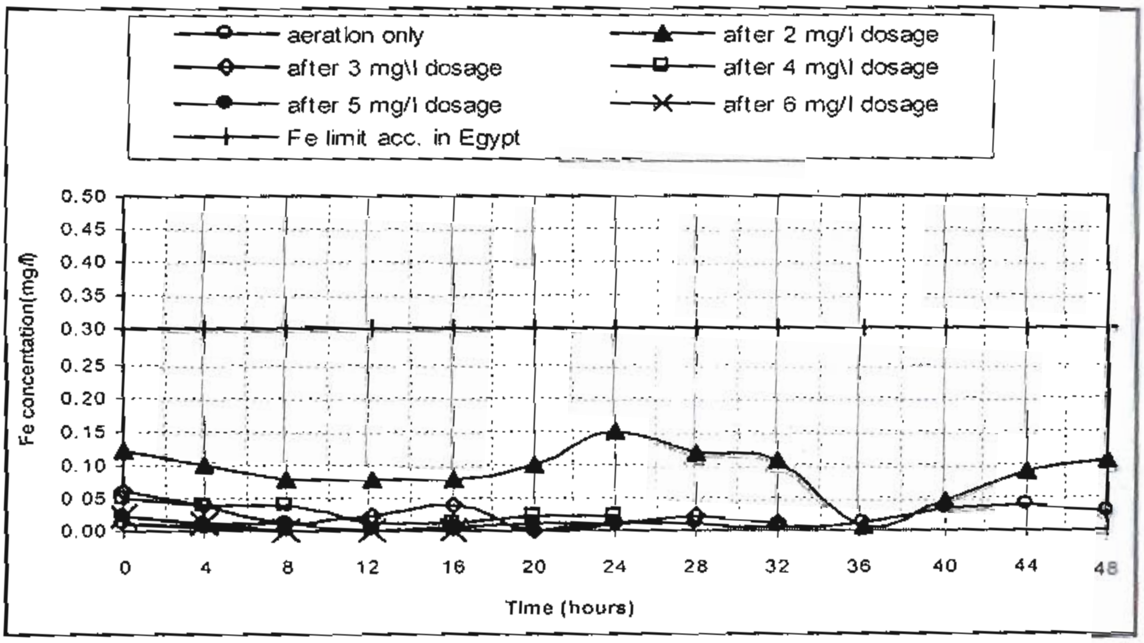

Fig. (12) Effect of Permanganate Dose on Fe Variation

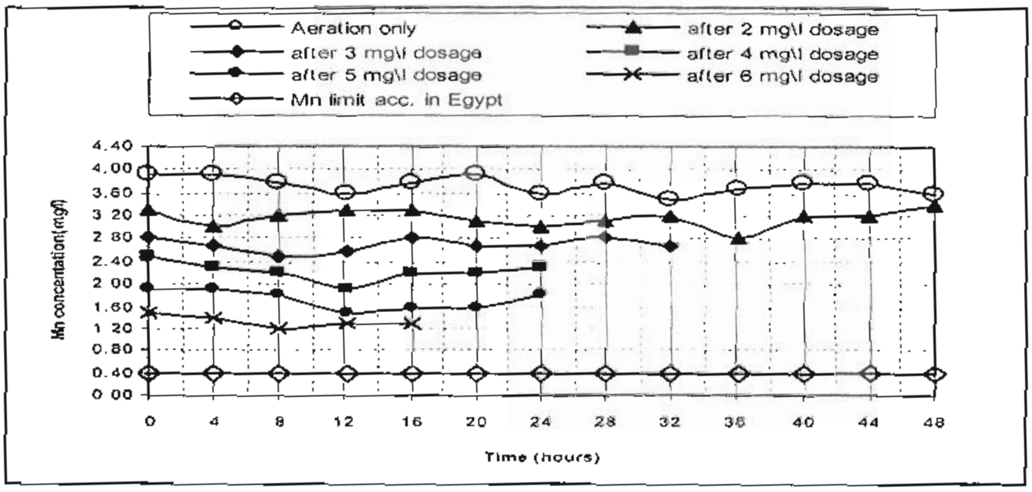

Fig. (13) Effect of Permanganate Dose on Mn Variation

4. Discussions

Fig. (14) shows the removal efficiencies of iron and manganese for all runs of the slow sand filtration pilot plant, these can be concluded:

- Total Fe and total Mn removal efficiencies obtained by this system at the effluent of SSF, which operate under natural conditions and without using any chemical agents, were high and the effluent concentrations of Mn and Fe for all the runs were less than the Egyptian allowable limits.
- The best removal efficiency in all runs is run A-4 which has the lowest filtration rate and receives small concentrations of iron and manganese.
- The worst removal efficiency was in run A-3 which hasn't aeration step before SSF where the average removal of Mn is 79%.

Figure (15) shows the removal efficiency of iron and manganese for all runs of the conventional pilot plant, these can be concluded:

- The removal of manganese is increased by increasing $KMnO_4$ dose but iron removal efficiency is similar for all runs.
- The best Fe removal efficiency in all runs is run B-1, although this run hasn't receive any chemical dosing but it has high efficiency due to the abundance air compressed in the aeration tank.
- The best Mn removal efficiency in all runs is run B-6 due to high amount of $KMnO_4$ dose but water has a pink color, so the maximum dosage for this system without changing the water color is 4 mg/l.
- Every 1 mg potassium permanganate remove approximately 0.5 mg manganese, this is coincide with other researchers.

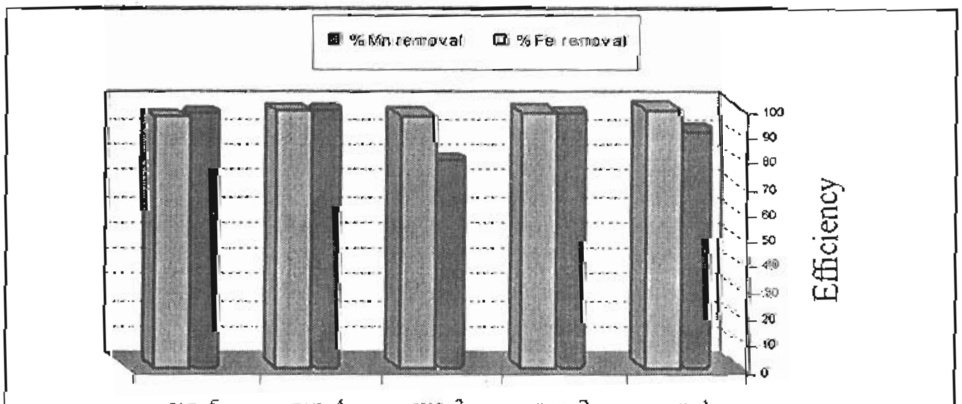

Fig. (14) Iron and Manganese removal efficiency of the slow sand filter plant

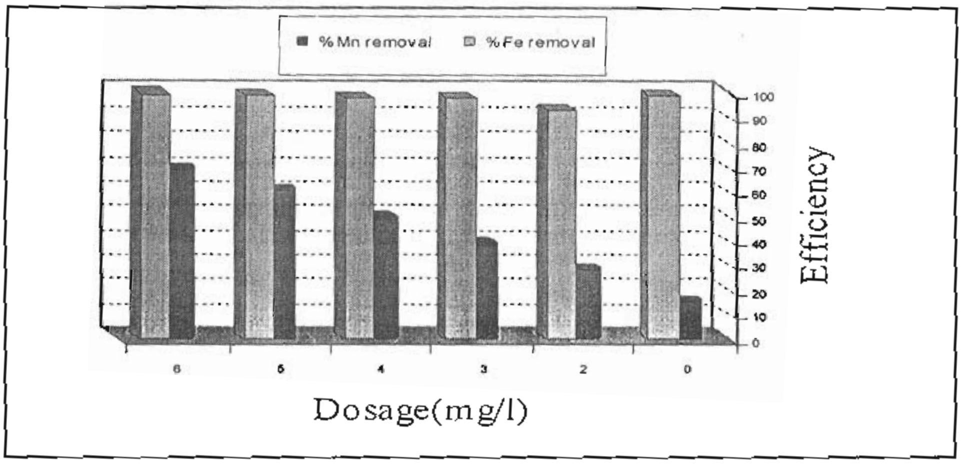

Fig. (15) Iron and Manganese removal efficiency of The conventional Plant

5. Comparison between SSF and Conventional Plants

Fig. (16) shows the removal efficiency of iron and manganese for some runs of slow sand filter and conventional pilot plants, these run were chosen due to the same influent Fe & Mn concentrations and runs B-1 was ignored for no dose adding and B-5 & B-6 for low atheistic quality. the following was concluded:

- Iron removal efficiency of the two pilot plants was similar except run B-2 because of low compressed air supplied.
- Manganese removal efficiency of slow sand filter plant is very high except for run A-3 due to the removing of the aeration step, while the manganese removal efficiency of conventional plant at run B4, that was the maximum run removal without change water color, didn't exceed 50 percent.

From observing of operation for each pilot, the following was concluded:

- Slow sand filter plant operation is simple and easy while conventional plant require the controlling of air amount and chemical dose.
- The slow sand filter don't require to be backwashed as pressure filter, only scraping off the top layer (2 cm) of sand at the end of the run.
- The air compressor may require to maintained, but multiple tray aerator work with high efficiency naturally.
- The water quality of SSF plant is better than that of conventional plant.
- The run length of SSF plant is much longer than conventional plant, which minimize the losses of water in the SSF plant.

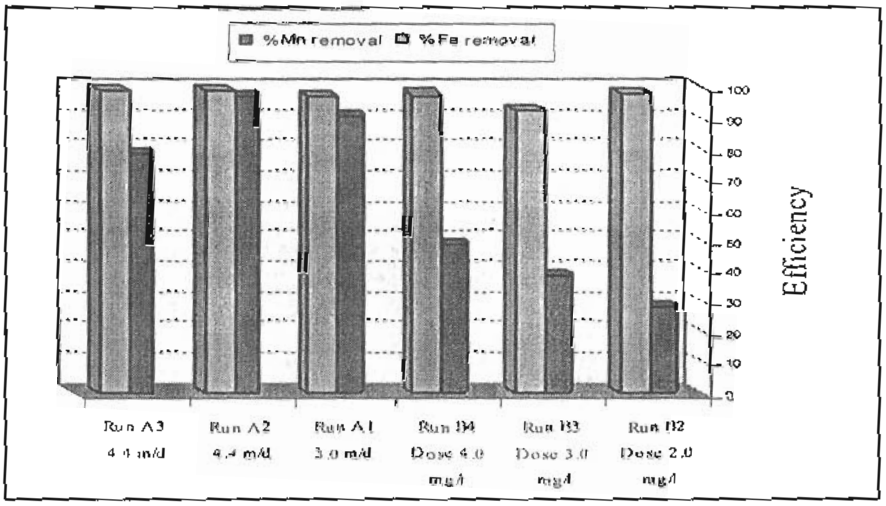

Fig.(16) Comparison between removal efficiency of SSF & conventional plants for Fe & Mn

6. Conclusions

According to the comparison between slow sand filtration system and conventional system, the conclusion could be drawn as the follow:

1. Slow sand filtration plants are appropriate system to be applying in Egypt especially at high concentration of Mn in raw water.
2. Slow sand filters play a significant role in water treatment since it achieve a very high Fe and Mn removal efficiency in one step without requiring any chemical additions. This represents an interesting option to upgrade the existing plants in many places in Egypt.
3. Total Fe and total Mn removal efficiencies obtained by slow sand filtration system, which functions under natural conditions and without using any chemical agents, is very high and may be up to 99 % removal efficiency.
4. The aeration step has an important effect on the removal of iron and manganese by slow sand filter as it increase DO and pH that make a suitable environment to develop bacteria which have the ability to remove iron and manganese.
5. High concentration of iron and manganese assist slow sand filter to work speedy and decreased the start up period.
6. The start up period in the first run of each filter is longer than the next runs, because of the remained bacteria through media layers.
7. Slow sand filter run length is much longer than conventional methods, as it is up to six months at low concentrations and low filtration rate (3 m^3/m^2/day)
8. Slow sand filter plant is easier than conventional plant in operation and maintenance, there is no need for backwashing that was a requirement for pressure filter at the end of each run.
9. The aeration only in conventional plants for treatment of manganese is not efficient and the addition of Potassium permanganate is a must to remove Mn from water.
10. The high dosage of potassium permanganate has an influence on water quality especially on color.
11. The removal of manganese in conventional plant is increased by increasing the dose of potassium permanganate but the effluent Mn exceed the potable water limits in Egypt and iron removal efficiency is approximately similar for all dosages.
12. Every 1 mg potassium permanganate remove approximately 0.5 mg manganese or 1 mg iron.

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