PORCELANITE ROCKS AS A DUAL FILTER MEDIA IN WATER TREATMENT PLANTS

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ABSTRACT
Porcelanite rocks were selected to be the dual media with sand in this study to improve the performance of the filtration process in water treatment plants. The work required installing a pilot filtration unit in the location of the filters in one of the water treatment plants, so the experimental work was performed on the same influent water of the filters in the plant (the effluent from the sedimentation tank. The pilot filtration consists of three plastic column filters, working parallel and simultaneously. The first contains 70 cm sand (the same type used in the filters of the plant), the second and third were dual filters (porcelanite with sand) of different depths and sizes using different filtration rates (5, 10, and 15 m/hr). The results showed that the dual filters had better performance than sand filters in turbidity and bacterial removal, less initial head losses and less total head losses at different filtration rates.

الخلاصة
اختيرت صخور البورسيلينايت لتكون وسط ثنائي مع الرمل في هذه الدراسة لتحسين أداء عملية الترشيح في مشاريع تصفية المياه. تطلب العمل إنشاء منظومة ترشيح في موقع المرشحات لاحدى محطات التصفية، لإجراء العمل التجريبي على نفس الماء الداخل لمرشحات المحطة (الماء الخارج من حوض الترسيب)بتتكون المنظومة من ثلاث أعمدة ترشيح تعمل بشكل متوازٍ وفي آن واحد بحيث احتوى الأول على ٧٠ سم من الرمل (نفس الرمل المستخدم في المرشحات للمحطة)، والثاني والثالث مرشحات ثنائية تحتوي على البورسيلينايت والرمل بأعماق واحجام مختلفة وباستخدام معدلات ترشيح (٥، ١٠ و ١٥) م/ساعة. أظهرت النتائج بان المرشحات الثنائية كفوءة لإزالة العكرة والبكتريا، أقل في خسائر الشحنة الابتدائية وأقل في خسائر الشحنة الكلية لمختلف معدلات الترشيح.

KEY WORDS
porcelanite rocks, dual filter, filtration, water treatment plants.

INTRODUCTION
Filtration is the most common process for the treatment of surface water, it is the fundamental system in a water treatment process train. Filtration removes suspended solids, including microorganisms such as Crypotosporidium oocysts, Giardia cysts, and Parasite eggs, (*Kawamura, 1999*). Dual media filters offer the advantage of less head losses, a greater capacity for retaining suspended solids, and less emphasis head be placed on settle ability of suspended matter, but greater emphasis on coagulation is required than for rapid sand filters to obtain the same filtered water quality, (*Tuepker & Buescher, 1968*).

Al-Anbari, (1997) selected suitable and durable locally filter media. He tested lightweight materials like [porcelanite rocks (PR) and burnt kaolinite (BK)], and a heavy weight media like [geothite rocks (GR)]. For single media filter, porcelanite (PR) and kaolinite (BK) gave better results in turbidity removal efficiency (TRE %) and net water product (NWP) value (m^3/run) than sand medium. This was because of their higher porosity and angular grain surface textures. Also for dual media filter PR and BK showed the same conclusions in (TRE %), (NWP), increase in length of filter run, and lower head loss accumulation.

Al-Ansary, (1998) evaluated the performance of a locally porcelanite rocks (PR) as a filter media in the treatment of water supplies. The results showed that the PR filter is more effective in turbidity removal, more length in filter run, and less head loss during filtration nearly by (40%).

Al-Auraji, (2003) made a research to improve the performance of the filters of Al-Daura water treatment plant by using locally materials such as porcelanite rocks (PR) and burnt kaolinite (BK) as well as anthracite. The results showed that dual media filter gave better water quality, lower head losses, and longer filter running time than single sand filters.

PORCELANITE ROCKS

Porcelanite rocks in Iraq, are from an industrial bed of (0.5 to 1.3 m) thickness in the Safra, and Trafawi site of the Jeed formation in Al-Rutba region, western of Iraq. Rocks of these deposits are composed of medium ordered crypto and microcrystalline opal-CT, associated with authigenic quartz, carbonates, clay minerals, halite, and apatile. Porcelanite rocks are largely composed of sponge spicules (pores) and some other siliceous micro fossils (diatoms and radiolarian) as well as silicified forminifera and nannoplankton, (*Mohammed, 1993* [Arabic]).

Abed-Ohn, (2003) [Arabic] showed the high efficiency of porcelanite to extract ions of heavy metals (Fe, Zn, Cr, Cu, Ni, Co, Cd, Pb, Mn) from water, and lowering their concentrations to less than the environmental limits. This was achieved when using porcelanite of granular size (0.15 to 0.25 mm). The adsorption capacity of porcelanite is due to the large surface area within the composition of cristobalite and tridymite. Some of the chemical and physical analysis for the porcelanite samples is shown in Table (1).

Table (1) Chemical and physical analysis for the porcelanite samples of Traifawi site H_3

Chemical Composition	SiO_3	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	CaO	MgO	Na_2O	K_2O	L.O.I
%	83.57	0.62	4.45	0.01	1.82	1.46	0.5	0.16	0.22	5.9
Specific gravity (SG)	Range for 5 Sample			Average (SG)			Recommendation			
	1.5-1.61			1.554			Ok			
Porosity				0.52						

THE PILOT FILTRATION UNIT

Fig.(1) is a schematic representation of the pilot filtration unit that was installed in the location of the filters in Al-Wathba Water Treatment Plant. The pilot filtration unit consists of: a galvanized cylindrical tank of capacity 500 L was set at a distance of (3 m) above ground level to achieve the required head of flow; three plastic columns were designed and constructed to run in parallel with down flow direction, these columns are (10 cm) in diameter according to (*Robeck & Woodward, 1959*) and

(*AWWA Manual, 2000*) and (180 cm) in length. The arrangement of layers for the three down flow filters are shown in fig.(2).

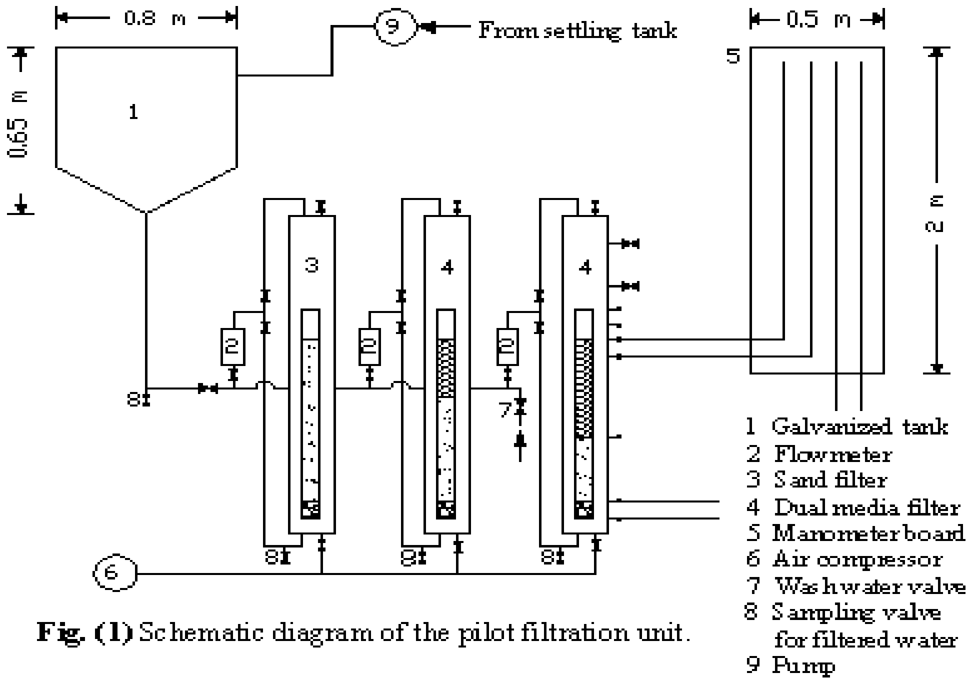

Fig. (1) Schematic diagram of the pilot filtration unit.

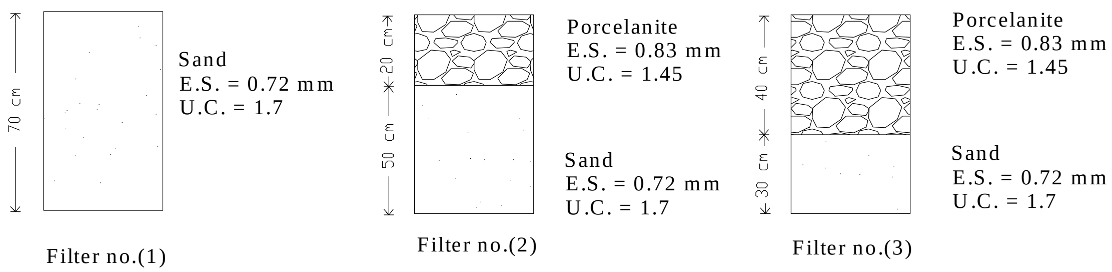

Fig.(2) Arrangement of layers of filter columns

EXPERIMENTAL WORK

Nine runs were operated as down flow filtration in order to compare the performance of the sand filter and dual filters.

RESULTS

Turbidity Removal

Tables (2) summarizes turbidity removal efficiency for each run. It could be observed from this table that the three filters were efficient in turbidity removal, in filter no.(1) the removal efficiency ranged (82 to 95 %) as for filter no.(2) it ranged (82 to 96 %) and in filter no.(3) it was (83 to 95%). At the same period and under the same operation conditions the filters of the plant showed a turbidity removal ranging between (79-97%) as shown in table (3). So the dual filters performed within the same range as of the filters of the plant for turbidity removal.

Fig. (3) to (5) show the changes in turbidity with time. As shown from these figures, the turbidity decreased with time through the filtration run and the turbidity of the treated water in all runs was less then 3.2 NTU. All the filters gave similar removal efficiency for turbidity.

Table (2) Turbidity removal efficiency for the three filters.

Run No.	Filtration Rate (m/hr)	Average influent turbidity (NTU)	Average effluent turbidity (NTU) Turbidity removal efficiency (%)		
			Filter No. (1)	Filter No. (2)	Filter No. (3)
1	5	10.67	0.554	0.46	0.5
			95	96	95
6		13.71	0.95	1.04	1.06
			93	92	92
7		10.31	1.41	1.38	1.29
			86	87	87
3	10	7.49	0.73	0.7	0.71
			90	91	91
5		7.9	0.8	0.81	0.96
			90	90	88
8		15.5	2.86	2.85	2.7
			82	82	83
2	15	6.33	0.62	0.43	0.46
			90	93	93
4		8.25	0.85	0.83	0.87
			90	90	90
9		10.95	1.64	1.51	1.59
			85	86	85

Table (3) Turbidity removal efficiency of filter no. (1) and the filters of the plant

Run No.	Influ. Turb. (NTU)	Effluent turbidity (NTU) Turbidity removal efficiency (%)				
		Filters of the plant				Filter No. (1) of the pilot unit
		Filter No. (2)	Filter No. (4)	Filter No. (6)	Filter No. (8)	
1	7	1.5	0.5	0.5	2.5	0.3

		79	93	93	64	96
6	23	0.7	0.6	0.6	1.7	1.2
		97	97	97	93	95

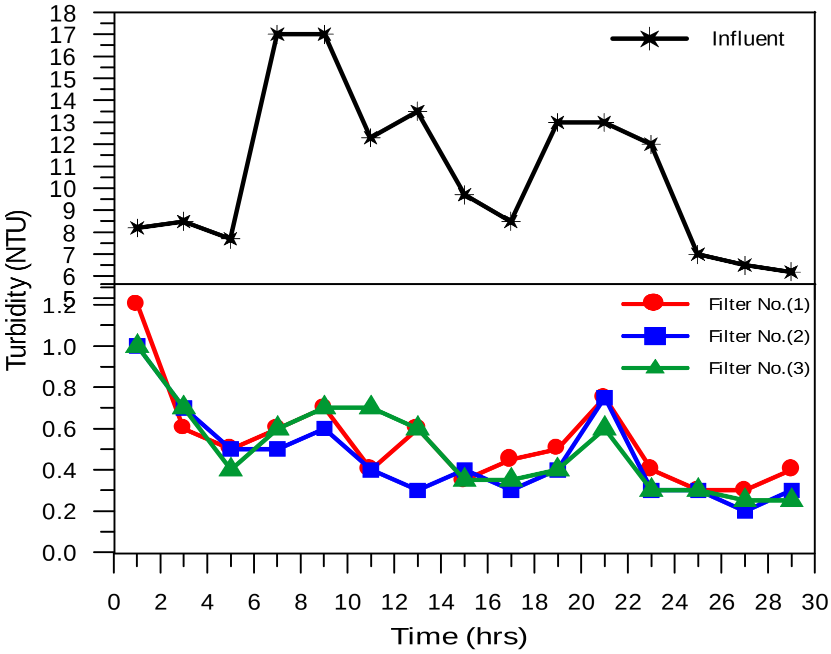

Fig.(3) Influent and effluent turbidity with time, filtration rate = 5 m/hr, Run No. (1).

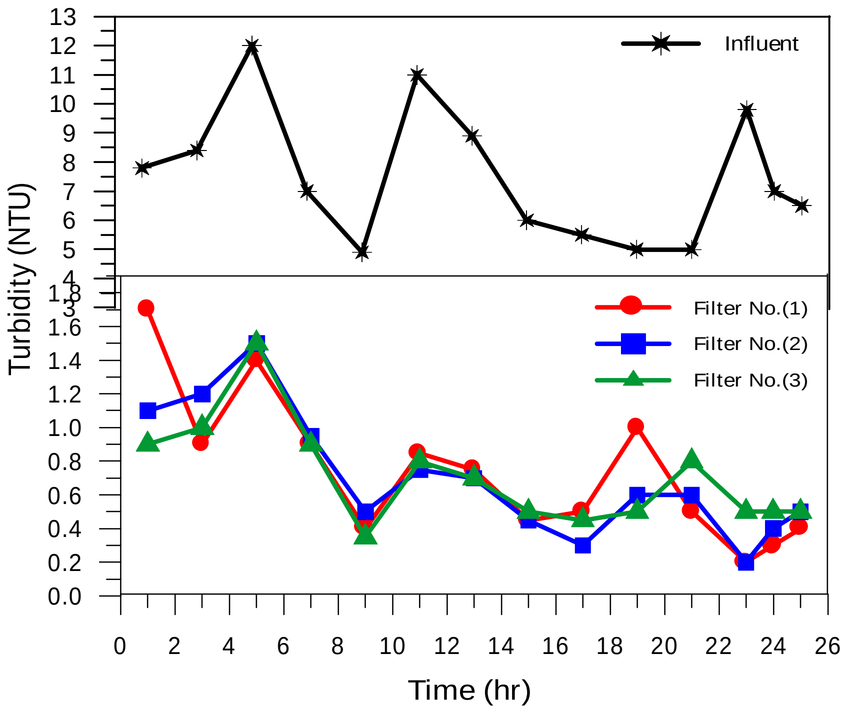

Fig. (4) Influent and effluent turbidity with time, filtration rate = 10 m/hr, Run No. (3).

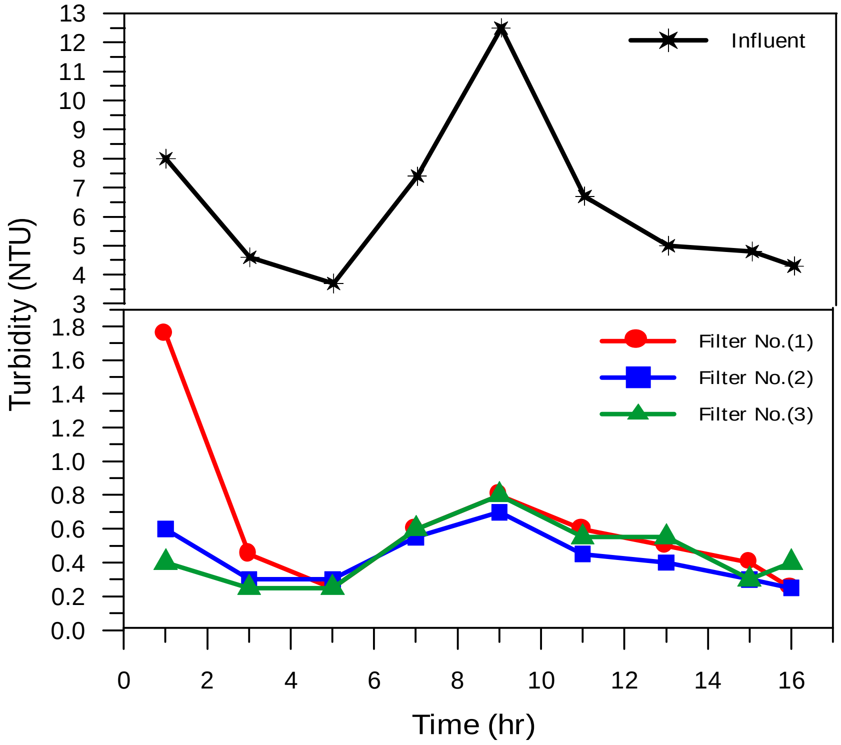

Fig. (5) Influent and effluent turbidity with time, filtration rate = 15 m/hr, Run No. (2).

Effect of Filtration Rate on the Turbidity Removal

The experimental work showed that the turbidity removal efficiency reduced when the filtration rate increased. From fig. (6) the three filters had approximately the same efficient in turbidity removal at different filtration rates.

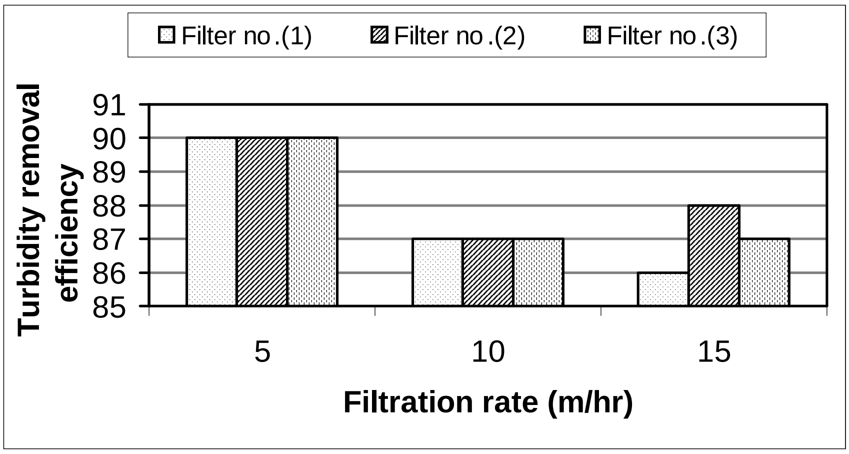

Fig.(6) Average turbidity removal efficiency at different filtration rates for the three filters

Head Loss through Filters

Initial Head Loss

The average value of the initial head losses for the filters are shown in table (4). Filter no. (1) showed the highest value in initial head loss for all filtration runs. The dual filter No. (1) showed the less initial head losses. The initial head losses increased when the filtration rate increased.

Table (4) Average initial head loss for the three filters

T °C	Filtration rate m/hr	Initial head loss (cm)		
		Filter No. (1)	Filter No. (2)	Filter No. (3)
14	5	14	11	9
16	10	28	20	18
16	15	38	31	27

Head Loss Variation with Time

Fig. (7) to (9) show the variation in the head loss with time at different depths for each filter. For the same volume and quality of water passing through the filters, sand filter no. (1) showed the higher head loss at different depths. This phenomenon is due to the high porosity of porcelanite compared with sand, sustaining a greater load of sediments with lower head losses and the removal is confined within the top layers of the filters.

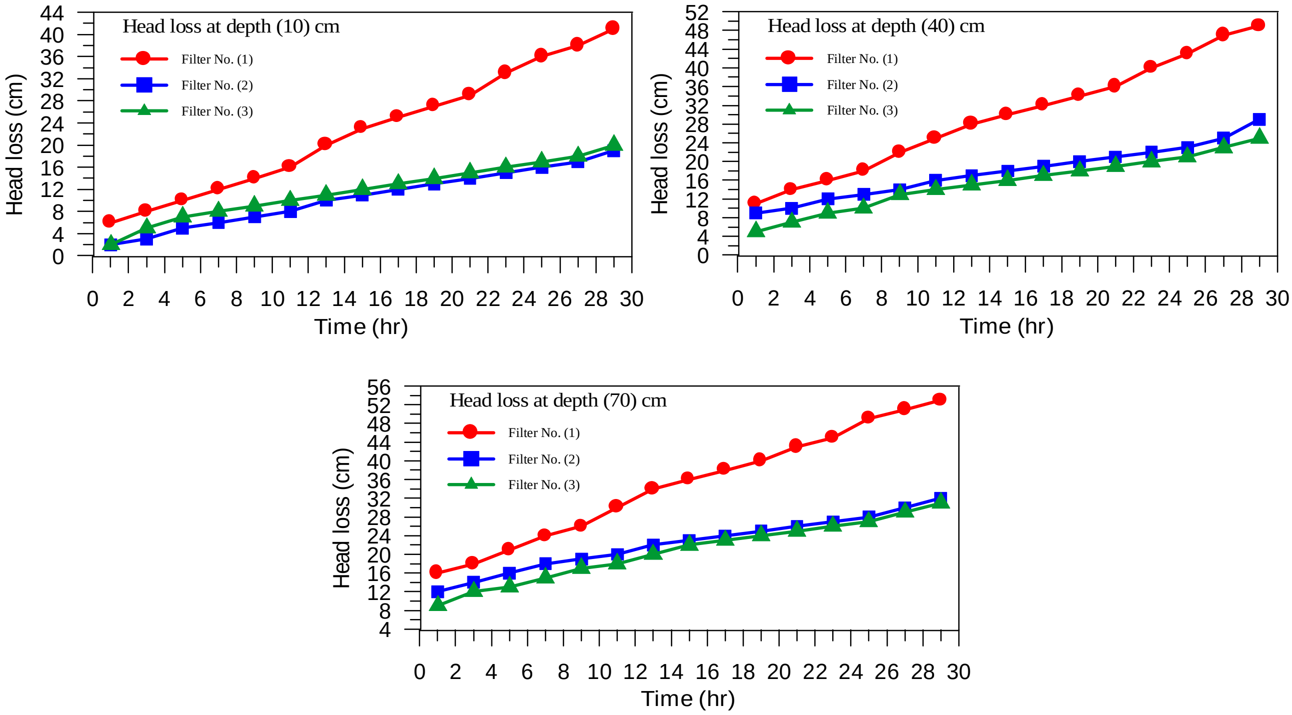

Fig. (7) Head loss verses time at different depths, filtration rate = 5 m/hr

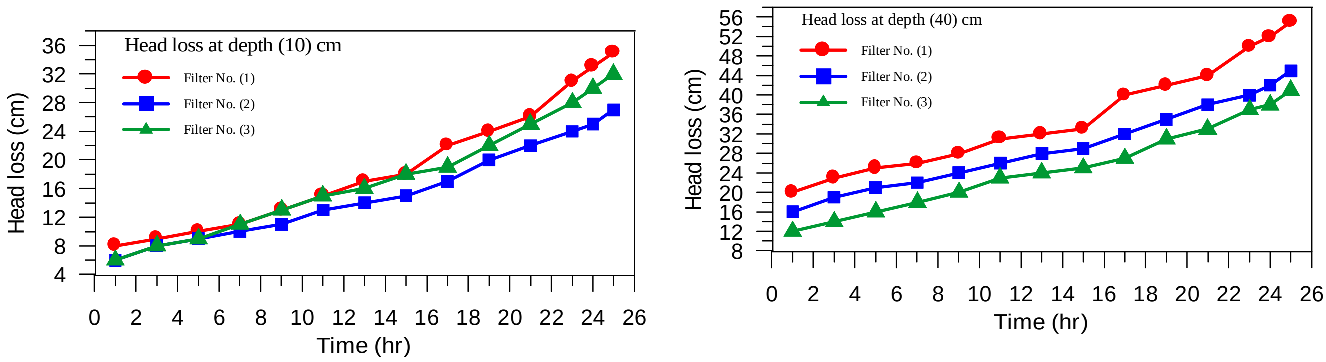

Fig. (8) Head loss verses time at different depths, filtration rate = 10 m/hr

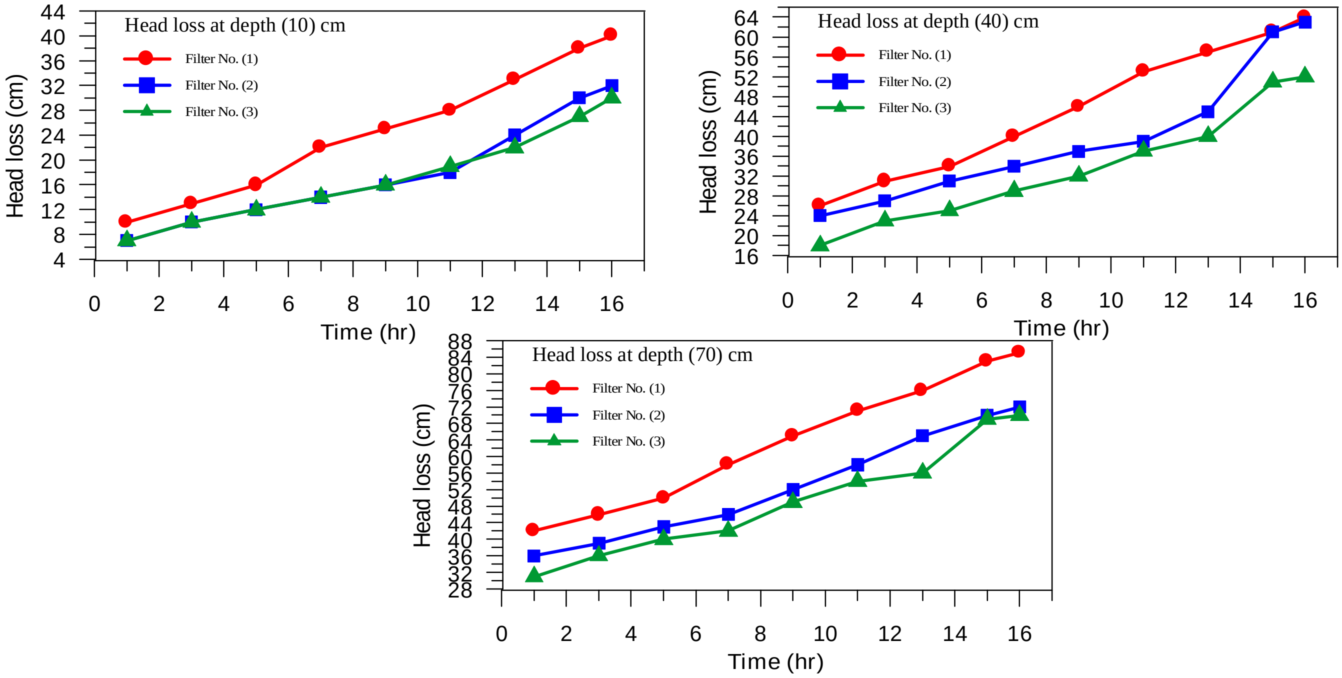

Fig. (9) Head loss verses time at different depths, filtration rate = 15 m/hr

Fig. (10) shows the effect of different filtration rates on the head loss in each filter. It is clear that, increasing the filtration rate will increase the head losses in the tests filters. The dual filters show less head losses then sand filter which is clear in table (5). The head loss in filter no.(2) is (15 to 43 %) lower than that in the sand filter and filter no.(3) is (18 to 46 %) lower.

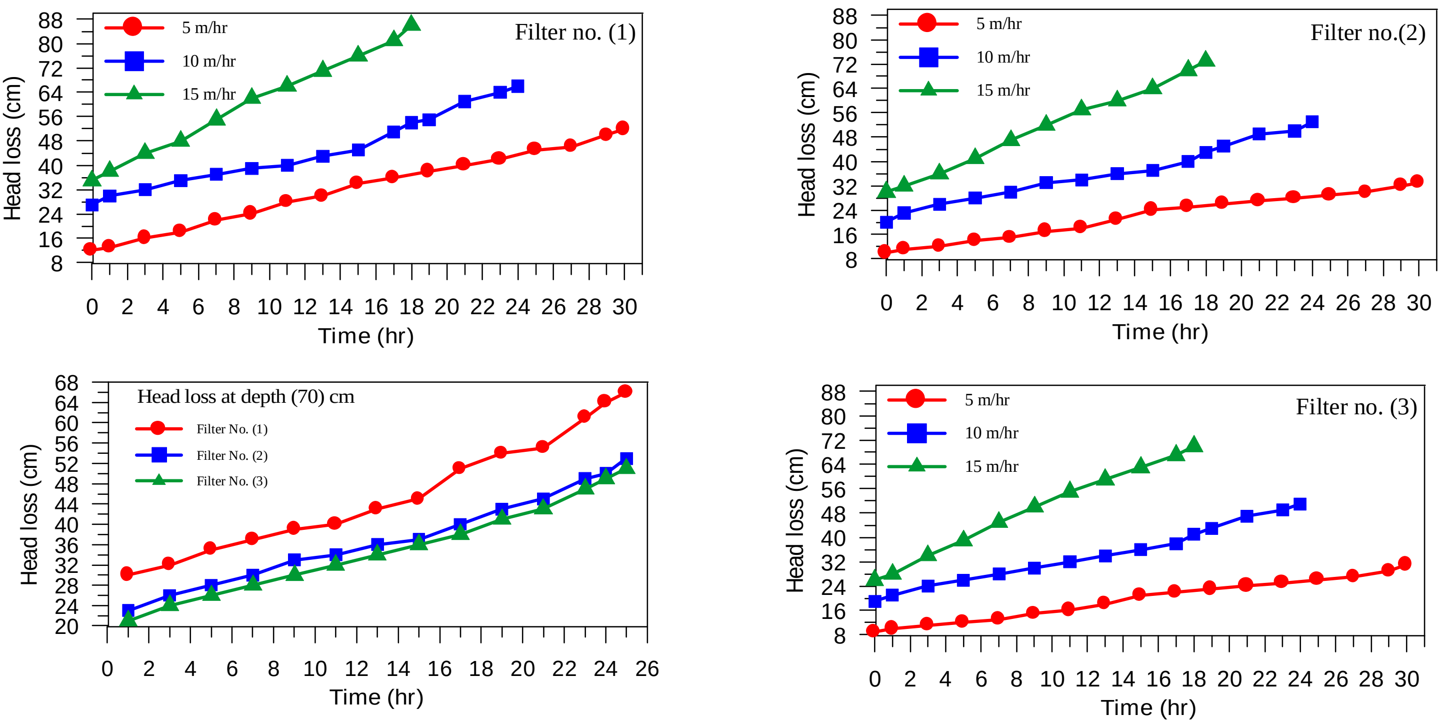

Fig. (10) Head loss verses time at different filtration rate

Bacterial Removal

Table (6) shows the average bacterial removal efficiency for the three filters. It is clear that the dual filters (2 and 3) gave higher removal efficiency than the sand filter for all filtration rates through out the experimental work.

The average bacterial removal efficiency for the three filters decreased slightly when the filtration rate increased.

Table (5) Head loss for the three filters

Run No.	Filtration rate m/hr	Run time (hr)	Head loss at the end of run (cm)			% Reduction compared to filter no. (1)	
			Filter No. (1)	Filter No. (2)	Filter No. (3)	Filter No. (2)	Filter No. (3)
1	5	29	53	32	31	60	58
2	15	16	85	72	70	85	82
3	10	25	66	53	51	80	77
4	15	18	86	73	70	85	81
5	10	16.5	70	54	50	77	71
6	5	30	52	33	31	63	60
7	5	8	27	19	16	70	59
8	10	8	45	34	32	76	71
9	15	8	96	55	52	57	54

Table (6) The average bacterial removal efficiency for the three filters

Filtation rate m/hr	Plate count removal efficiency %		
	Filter No. (1)	Filter No. (2)	Filter No. (3)
5	77	83	88
10	68	73	74
15	68	73	74

CONCLUSIONS

This study introduced a dual filter to improve the performance of the filters in water treatment plants. To approach this aim a local material knows as porcelanite was used as the dual filter. From the experimental work of the pilot filtration unit this filter gave the following results:

1- The dual filters were efficient in turbidity removal as in sand filters. The turbidity of the treated water was less then 3 NTU when using different filtration rates (5, 10, and 15 m/hr). The maximum turbidity removal efficiency for the sand was 95 % and for dual filters 96 % at 5 m/hr filtration rate.
2- The initial head losses increased when the filtration rate increased and the dual filter showed less initial head losses than sand filters about (21 to 29%) at different rates.
3- The total head loss in the dual filters was about (15 to 46 %) lower than that for sand filters at filtration rates (15 to 5 m/hr), respectively. High filtration rates increased the head loss at different depths.
4- Bacterial removal efficiency was high, about 6 % more in the dual filters than in sand filters at filtration rate 5 m/hr. It decreased slightly when the filtration rate increased.

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