# The Use of Iraqi Porcelanite Rocks for Purification of Drinking Water

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**Abstract**

The present study was held to evaluate the performance of Iraqi porcelanite rock as a filter media in the treatment of drinking water supplies. The performance of Sand filter and dual media filter composed of porcelanite and sand were also studied. It was concluded that the porcelanite filter and/ or dual filter can be used instead of sand filter present within the local treatment plants to attain better performance due to expected performance of porcelanite without any mechanical modification of a filter.

**الخلاصة**

اجريت هذه الدراسة لتقييم كفاءة صخور البورسلينايت العراقية كوسط مرشح في تصفية مياه الشرب. تضمن البحث كذلك دراسة امكانية استخدام هذه الصخور كوسط مرشح في المرشحات الثنائية الوسط وبالاشتراك مع الرمل ومقارنته مع المرشحات الاعتيادية الحاوية على الرمل فقط.

تم الاستنتاج بان مرشحات البورسلينايت او/ و المرشحات الثنائية الوسط يمكن استخدامها بدلاً من المرشحات الرملية المستخدمة حالياً في منظومات ومحطات معالجة المياه المحلية للحصول على كفاءة افضل بسبب كفاءة الاداء المتوقع للبورسلينايت وبدون اجراء أي تغييرات ميكانيكية للمرشحات الحالية.

## Introduction

Filtration is a unit process widely used in water and wastewater treatment for the removal of particulate materials commonly found in waters. Filters have been found effective for removing particulate at all size ranges including algae, colloidal humid compounds, viruses, asbestos fibers and colloidal particulates, provided that proper design parameters are used [1].

Filteration is effected by several variables, these are characteristics of filter bed grains, initial concentration of incoming suspensions, porosity of filter beds, water temperature, depth of filter medium, rate of filtration and characteristics of suspension and suspended particle size distribution [2].

A wide range of materials are utilized in filtration systems such as quartzitic sand, anthracite coal, diatomaceous earth, and other local material in each country [1]. The choice of a filter medium is dictated by durability, the desire degree of purification, the length of the Filter run, and ease of backwash [3].

Quartzitic sand filter grains are hard, durable, free from organic matter and carbonates is considered as one of the most important part in any surface water treatment system [4]. This filter may blocked when there is a high concentration of suspended solids present in the water coming from the rivers. The higher the porous the media the lower the blockage to occur in a media. Porcelanite as a local material is one of the media of high porosity and permeability and can be used as an alternative to sand filteration media or be used as a dual filter with sand.

The present study is concerned with the investigation of the performance of the Iraqi porcelanite as filter media compared to the conventional quartzitic sand filter media used in water purification.

**Porcelanite Rocks:**

Porcelanite is a term used by Iraqi geologist to identify siliceous rock resemble to diatomite. These rocks are found in Iraq in different places. One of the important areas is the western desert. It is found in a bed of (o.5-2.0)m. in thickness in the Safra, and Traifawi members of Al-Jeed formation in the Rutba region western of Iraq [5], [6]. Rocks of these deposits are composed of medium ordered crypto and microcrystaline opal-CT associated with authiginic quartz. Opal-CT is a mineral resemble to tridymite or a mineral intergrowth between α-cristobalite and α–tridymite [7]. These siliceous minerals are associated with carbonates, clay minerals, and apatite. Porcelanite rocks are largely Composed of sponge spicules (pore) and some other siliceous microfossils (diatoms and radiolaria), as well as silicified foraminifera and non plankton [5].

Diatomite deposits have been found in many different contrires and varies in their quality, purity, and uses from one area to another. It has many nomenclature, as it called diatomite or de-diatomaceous earth in USA, Kieselguhr in Germany, Tripolite in Algeria, Moler in Denmark [8]. USA is considered the largest country in the production, exporting and uses of diatomite in the world, and its main uses are in filterations and in making filters [7].

**Chemical and mineralogical analysis of Iraqi Porcelanite:**

Three Porcelanite samples were collected from different areas, see Fig (1). The first from Al-Safra member (locality no.1), the second from Trifawi member- Akashat area (locality no.2) and the third from Trifawi member $H_3$ area (locality no.3). These three samples were analysed chemically and the results are shown in table (1). The Table shows that the samples taken from Traifawi member of $H_3$ and Akashat areas are high in silica content and low in calcium and magnesium. Trifawi- $H_3$ location has higher silica and lower Ca and Mg content when it compared with sample from Traifawi- Akashat area. Mineralogical study by using X-ray diffraction analysis, see Fig. (2), also show that the silica content (quartz, cristobalite & tridymite) of traifawi member samples are higher than that of Al-Safra member sample. Trifawi member of $H_3$. Location sample has higher silica content and low in carbonte when compared to Akashat sample, so it is recommended for the present type of works.

**Apparatuses and filter columns:**

The pilot water treatment plant installed in the sanitary engineering laboratory of building and construction engineering department/ University of Technology was used in the present study. See fig. (3).The pilot unit was composed of 220 L. flocculation- sedimentation tank with a mixer, 130 L. plastic storage tank, 64 L. constant head elevated tank, three 7.5cm diameter Pyrex glass columns of 1.7m. length configured for an in- parallel mode of operation, necessary pumps, flow-meters and air water back washing system.

The three down flow filters were operated in parallel to compare the performance of porcelanite, porcelanite-sand and sand filters. The dimensions and design of each column is shown in fig. (4). The two ends of each column are fitted with rubber caps. The upper cap contained an 8mm. hole which was fitted with the inlet glass, and a 6 mm. glass pipe to release air during the filling process. The bottom cap have two 12 mm holes, one was connected to the out let pipe which discharges the water to the collection channel, and the other connected to the back washing system.

For sample collections and pressure drop readings, each column was fitted with four stainless steel nozzles at a 25 cm intervals. At a 25 cm above the filter media an opening at 12 mm for waste wash water were located.

The three different down flow filters are (Fig. 3):

One- Filter no. (1) was chosen as dual layer filter composed of 50 cm depth of sand grains and 25 cm depth as porcelanite grains both of an average grain diameter of 0.725 mm. (Iraqi standard)

Two- Filter no.(2) was chosen of only porcelanite grains of 75 cm depth of 0.725mm. average diameter.

Three- Filter no. (3) was conventional Sand filter of 75cm depth and an average grain diameter of 0.725mm.

The above three filters was laid on gravel support layers, each of 2.4-12.7 mm in grain diameters with a layer thickness of 15 cm.

**Water used for the treatment:**

The water used for the present treatment was prepared by mixing finely crushed clay in tap water. Turbidity measurement are in NTU. The relationship between turbidity and suspended solids content for the synthetic water used in this study is given in fig. (5).

**Experimental works, results and conclusions:**

Attempt were made to operate the three filters at two different flow rates (7.5 and 15) m/hr the two runs were carried out at laboratory temperature of 34 ∓ 2 ˚C.

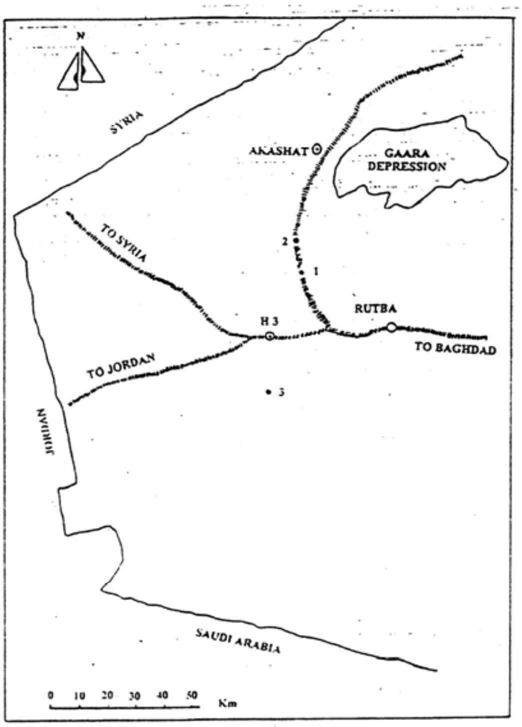
The results of experimental work are given in tables (2) and (3) and in figures (6 a, b, c) and (7a, b, c). The results include influent turbidity, effluent turbidity for four levels within the filter depth, and the manometer head loss reading at each level. The data includes the initial value at t=0 and variation with time. The turbidity was measured at the three layers, each of 25cm depth, and the effluent in each filter at different times during the run.

Fig (6a, b, c) & (7 a b, c) show the head loss at three layers within the filter for each types of filter. For the same volume of water passing through the beds the Sand bed showed a negative pressure while a positive head loss was maintained within the other filters.This phenomenon is due to the high porosity of porcelanite sustaining a greater load of sediments with lower head loss.

For Filtration rate of 7.5m./ hr fig (6 a, b, c), the head loss within the porcelanite seems to be similar to that of dual media due to the lower velocity while different for Sand filter. After 12 hours, sand filter has negative head loss pressure while it is still positive in porcelanite and dual filters.

For filtration rate of 15 m/ hr fig (7a, b, c), it is shown the head loss within porcelanite can reach a negative head loss after 8.5 hrs, while for sand filter at 6.5 hrs. and for dual filter at 7.5 hrs.

It can be concluded that the Iraqi porcelanite and/ or dual filters can be used instead for sand filter within the local treatment plants to attain a better performance at low filtration rate due to the expected performance of porcelanite. The filter runs are expected to be longer reducing the volume of back wash water without the need of any mechanical modifications of the filters. It was also noliced that the porcelanite media showed better filter water quality than that for dual and sand filters. From the removing of suspended particles point of view, porcelanite filter has better ability than the other two filters.




1. porcelanite of Al- Safra member.
2. Porcelanite of Traifawi member- Akashat site.
3. Porcelanite of Traifawi member- H 3 site.

Fig. ( 1 ) Map showing the location of porcelanite sample sites[6]

| Constiuents | Safra(s) (1) | T-Akashat (2) | T-H3 (3) |
|---|---|---|---|
| $SiO_2$ % | 70.75 | 80.65 | 82.86 |
| $Fe_2O_3$ % | 0.85 | 0.78 | 0.71 |
| $AL_2O_3$ % | 4.81 | 4.96 | 4.53 |
| $TiO_2$ % | 0.10 | 0.05 | 0.02 |
| CaO % | 5.5 | 2.45 | 1.96 |
| MgO % | 7.62 | 1.55 | 1.56 |
| $Na_2O$ % | 0.48 | 0.44 | 0.53 |
| $K_2O$ % | 0.16 | 0.17 | 0.18 |
| $P_2O_5$ % | 1.20 | 2.15 | 0.27 |
| L.O.I % | 6.73 | 5.12 | 5.92 |
| Total % | 98.20 | 98.4 | 98.54 |

Table (1): chemical analyses of Iraqi porcelanite

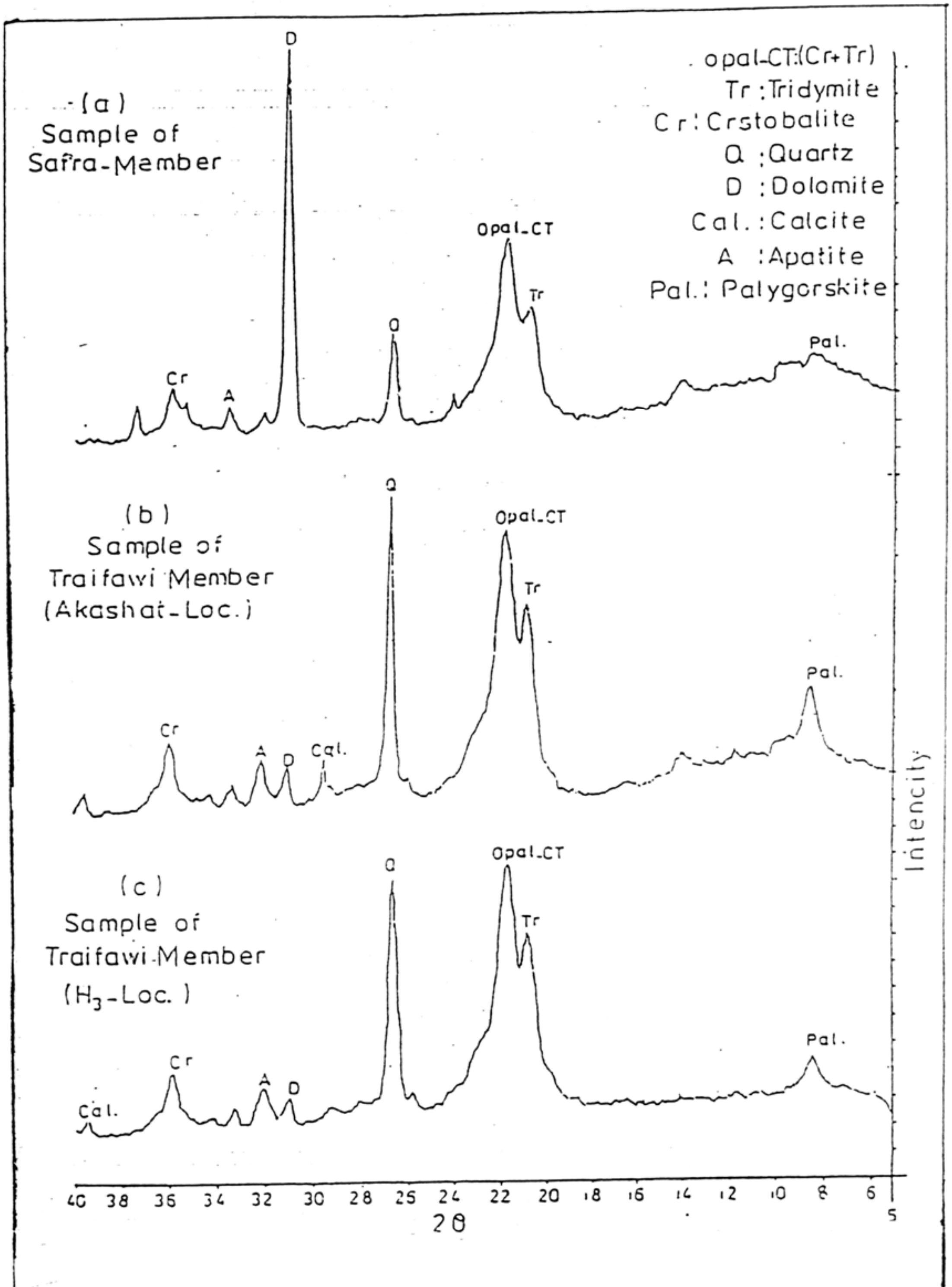
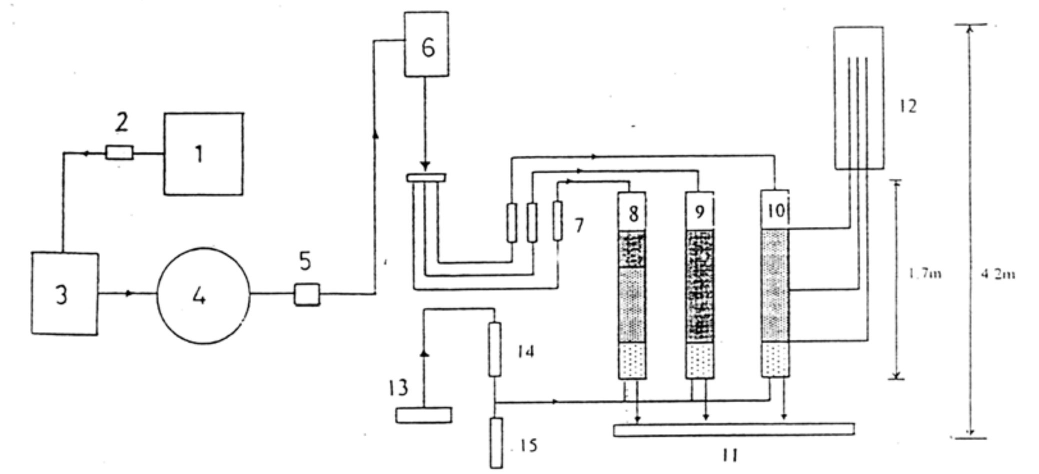



Fig. (2): X-ray result of Iraqi Porcelanite rock of Alsafra, Traifawi-Akashat, and Traifawi-$H_3$




1. Galvanized storage tank.
2. Pump.
3. Sedimentation / Flocculation tank.
4. Ground storage tank.
5. High lift pump.
6. Constant – head elevated tank.
7. Water flow – meters.
8. Filter No.(1), (porcelanite-sand filter).
9. Filter No.(2), (porcelanite-filter).
10. Filter No.(3), (sand filter).
11. Collection channel.
12. Manometers board.
13. Air compressor.
14. Air flow – meter.
15. Water flow – meter.

Fig. ( 3 ) Schematic diagram of the pilot plant

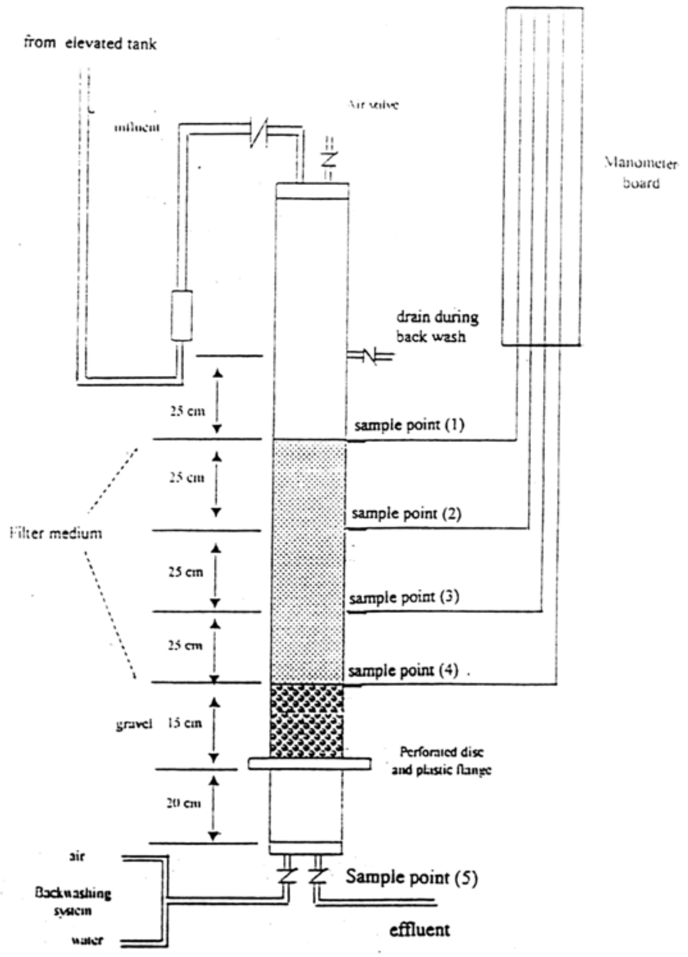



Fig. ( 4 ) Details of a filter column

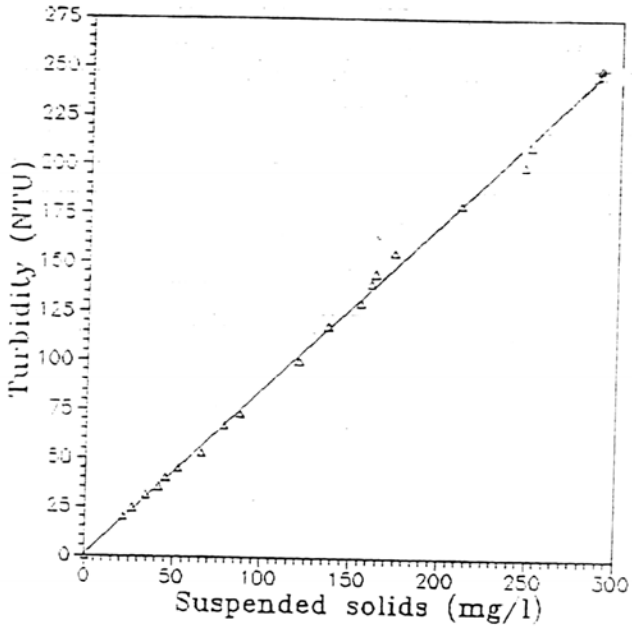



Fig. (5) Relation of turbidity – suspended solids for the clay used in the study

**Table (2):** Experimental data for run No. (1) for the three types of filters

| Time from beginning (hrs) | Influent (NTU) | Filter No. (1) | | | | | | | | Filter No. (2) | | | | | | | | Filter No. (3) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 NTU | 3 NTU | 4 NTU | Eff. NTU | $H_{t}$ cm | $H_{1-2}$ cm | $H_{1-3}$ cm | $H_{1-4}$ cm | 2 NTU | 3 NTU | 4 NTU | Eff. NTU | $H_{t}$ cm | $H_{1-2}$ cm | $H_{1-3}$ cm | $H_{1-4}$ cm | 2 NTU | 3 NTU | 4 NTU | Eff. NTU | $H_{t}$ cm | $H_{1-2}$ cm | $H_{1-3}$ cm | $H_{1-4}$ cm |
| 1 | 110 | 24 | 7.0 | 3.8 | 3.5 | 161 | 10 | 15 | 22 | 24 | 6.8 | 3.5 | 3.5 | 160 | 9 | 12 | 18 | 26 | 7.5 | 4.0 | 3.5 | 160 | 14 | 22 | 30 |
| 3 | 100 | 36 | 11 | 5.2 | 5.0 | 160 | 15 | 26 | 34 | 34 | 10 | 5.0 | 4.5 | 160 | 17 | 23 | 28 | 38 | 12 | 5.8 | 5.5 | 160 | 27 | 40 | 48 |
| 5 | 118 | 44 | 16 | 8.0 | 7.5 | 160 | 22 | 34 | 44 | 40 | 14.0 | 7.5 | 7.0 | 160 | 25 | 33 | 40 | 46 | 17 | 9.0 | 8.7 | 160 | 40 | 55 | 63 |
| 7 | 110 | 50 | 19 | 11.0 | 11.0 | 160 | 27 | 38 | 47 | 49 | 17 | 9.5 | 9.5 | 160 | 31 | 40 | 44 | 52 | 21 | 12.5 | 12 | 160 | 44 | 63 | 74 |
| 9 | 115 | 61 | 23 | 13.5 | 13.0 | 160 | 34 | 51 | 62 | 58 | 21 | 12.5 | 12.5 | 160 | 39 | 49 | 57 | 64 | 27 | 16.5 | 16 | 160 | 50 | 74 | 93 |
| 11 | 110 | 69 | 27 | 17 | 16 | 160 | 45 | 61 | 78 | 67 | 25 | 15 | 14.5 | 160 | 50 | 61 | 74 | 72 | 30 | 19.0 | 18.0 | 160 | 67 | 90 | 120 |
| 12 | 115 | 77 | 36 | 23 | 22 | 160 | 57 | 69 | 105 | 74 | 32 | 20 | 20 | 160 | 55 | 67 | 92 | 80 | 38 | 25 | 25 | 160 | 75 | 123 | 157 |
| Starting time | | 8:52AM | | | | | | | | 8:52AM | | | | | | | | 8:52AM | | | | | | | |
| End time | | 8:52PM | | | | | | | | 8:52PM | | | | | | | | 8:52PM | | | | | | | |

No. of run: 1
Velocity: 7.5 m/hr: 28.9l/h

**Table (3):** Experimental data for run No. (2) for the three types of filters

| Time from beginning (hrs) | Influent (NTU) | Filter No. (1) | | | | | | | | Filter No. (2) | | | | | | | | Filter No. (3) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 NTU | 3 NTU | 4 NTU | Eff. NTU | $H_{t}$ cm | $H_{1-2}$ cm | $H_{1-3}$ cm | $H_{1-4}$ cm | 2 NTU | 3 NTU | 4 NTU | Eff. NTU | $H_{t}$ cm | $H_{1-2}$ cm | $H_{1-3}$ cm | $H_{1-4}$ cm | 2 NTU | 3 NTU | 4 NTU | Eff. NTU | $H_{t}$ cm | $H_{1-2}$ cm | $H_{1-3}$ cm | $H_{1-4}$ cm |
| 0.5 | 85. | 25 | 10 | 5.2 | 5.0 | 150 | 16 | 34 | 53 | 23 | 9.5 | 4.8 | 4.5 | 150 | 13 | 26 | 42 | 26 | 11.0 | 6.0 | 6.0 | 151 | 20 | 39 | 55 |
| 1.5 | 95 | 30 | 13.0 | 6.1 | 6.0 | 151 | 20 | 44 | 58 | 28 | 12.0 | 5.6 | 5.3 | 150 | 18 | 29 | 48 | 31 | 13.5 | 7.0 | 7.0 | 150 | 26 | 48 | 63 |
| 2.5 | 90 | 34 | 18.0 | 8.0 | 7.5 | 151 | 27 | 51 | 72 | 37 | 16.5 | 7.0 | 6.8 | 151 | 21 | 36 | 53 | 40 | 19.0 | 9.2 | 9.0 | 150 | 32 | 57 | 75 |
| 3.5 | 93 | 48.5 | 23.5 | 11.3 | 11.0 | 150 | 33 | 59 | 78 | 46 | 22.0 | 10.0 | 9.0 | 150 | 26 | 45 | 59 | 50 | 25 | 12.5 | 12.0 | 150 | 40 | 69 | 86 |
| 4.5 | 95 | 57.6 | 30.5 | 16.5 | 16.0 | 150 | 42 | 73 | 91 | 54.3 | 27.5 | 14.0 | 13.8 | 150 | 32 | 56 | 68 | 58.5 | 32 | 17.5 | 17.0 | 150 | 51 | 86 | 103 |
| 5.5 | 100 | 69.6 | 39.5 | 22 | 20 | 150 | 59 | 98 | 122 | 67.2 | 37.3 | 20 | 18 | 150 | 48 | 71 | 81 | 71.3 | 45 | 25 | 24 | 150 | 71 | 110 | 138 |
| 6.5 | 97 | 77.3 | 49.5 | 29 | 27 | 150 | 73 | 110 | 138 | 74.3 | 45.6 | 26 | 23.7 | 150 | 61 | 88 | 100 | 81.5 | 55 | 33 | 31 | 150 | 95 | 138 | 149 |
| 7.5 | 100 | 85.2 | 62.5 | 41 | 39 | 150 | 81 | 125 | 151 | 81.4 | 59.5 | 38 | 37.5 | 150 | 69 | 101 | 125 | | | | | | | | |
| 8.5 | 92 | | | | | | | | | 86.3 | 68.3 | 45 | 43 | 150 | 87 | 118 | 148 | | | | | | | | |
| Starting time | | 8:30AM | | | | | | | | 8:30AM | | | | | | | | 8:30AM | | | | | | | |
| End time | | 4:00PM | | | | | | | | 5:00PM | | | | | | | | 3:00PM | | | | | | | |

No. of run: 2
Velocity: 15 m/hr

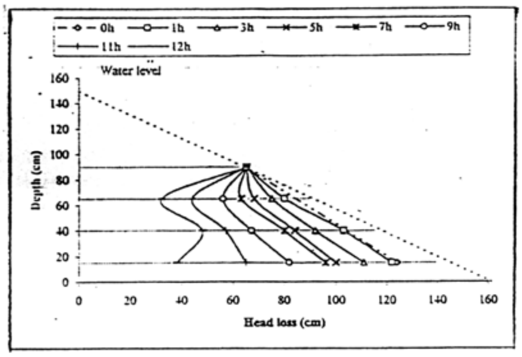



Fig. (6a) Head loss during filter No. (1), for velocity = 7.5 m/hr, run No. (1)

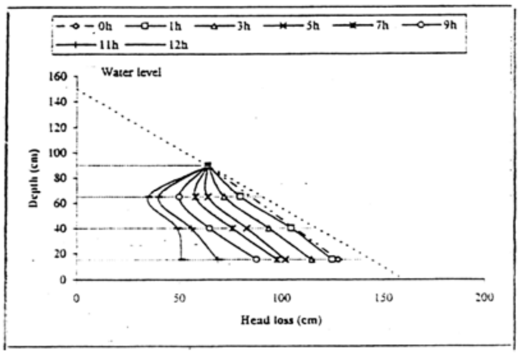



Fig. (6b) Head loss during filter No. (2), for velocity = 7.5 m/hr, run No. (1)

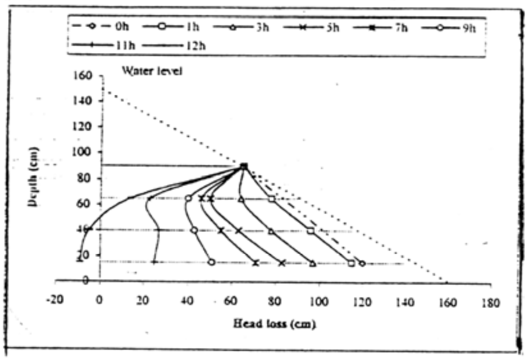



Fig. (6c) Head loss during filter No. (3), for velocity = 7.5 m/hr, run No. (1)

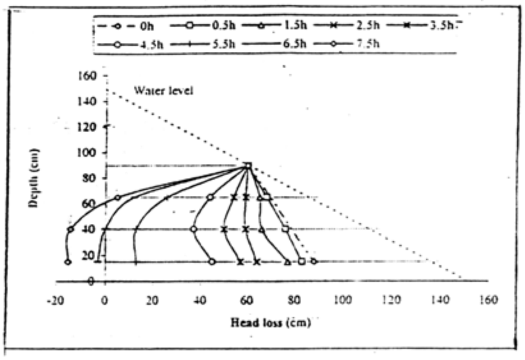



Fig. (7a) Head loss during filter No. (1), for velocity = 15 m/hr, run No. (2)

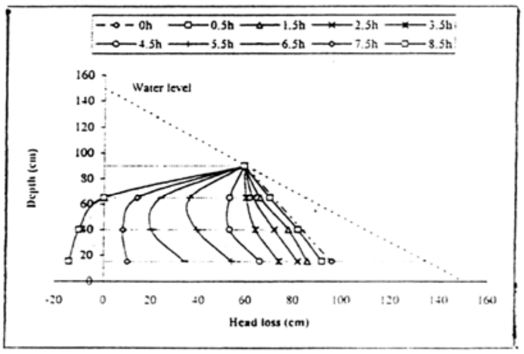



Fig. (7b) Head loss during filter No. (2), for velocity = 15 m/hr, run No. (2)

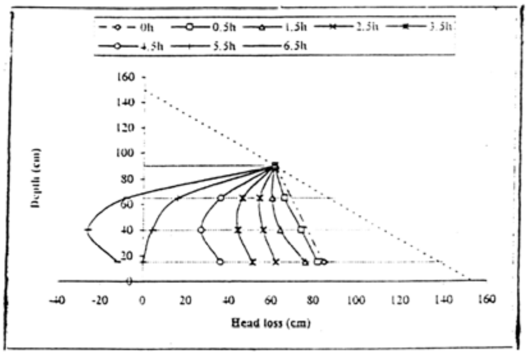



Fig. (7c) Head loss during filter No. (3), for velocity = 15 m/hr, run No. (2)

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