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INVESTIGATING THE ABILITY TO USE NATURAL IRAQI MATERIAL "CRUSHED PORCELANITE ROCKS" IN GREYWATER FILTRATION, AND COMPARE IT WITH SAND FILTER

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Abstract

For several years now Iraq suffering from an urgent water crisis, and it is seriously affected by this, because there are no alternative sources of water proportional with consumption. Particularly after recent environmental, and climatic changes, the water scarcity in rivers, dams, and the shortage of rainfall with a time of increasing water demand through increased consumption. So the Iraqis have to verify water scarcity, and treatment the water by different, and innovative ways to reuse it, and overcome this problem. The agricultural sector become the highest water consumer, therefore, attention going to the reuse of greywater as an alternative water resource, and an environmentally friendly method as control of water pollution. This article presents the precise design of small scale greywater treatment plant, that is a combination of natural, and physical methods such as screening, aeration, primary sedimentation, and filtration using Natural Iraqi Material "Crushed Porcelanite Rocks", and compares it with sand filter. The performance of these units for the treatment of greywater from Iraqi house in Baghdad city during 2019, and that collected from bathrooms, washbasins, kitchen sink, and laundry, was shown in expression of removal efficiency of water pollutants like Chemical oxygen demand (COD) 85%, Oil 86%, and Turbidity 84%. Consequently, this technology could be reliable for greywater treatment in a residential area.
Keywords: Greywater Treatment, Porcelanite Rocks, Removal efficiency, Chemical oxygen demand, Filtration.

Introduction

Some point out that Iraq's population growth is the most essential reason for water scarcity. That trebled from nearly 10 million in 1980 to about 37.5 million in 2016 over the last four decades making Iraq's present population growth rate approximately 15%, one of the greatest rates in the world. With this population growth, and with the analogous increase in demand for food, an agricultural policy formulated by the prior government aimed to attain self-adequacy in food. So the agricultural sector turns into the biggest water consumer. Three principal reasons are visible that interrelated, and interdependent lead to an increase in water demand: The population increase, the needs for development, and Immoderate over-consumption of water (Ali, 2018).

Conventional surface water and groundwater sources are becoming more and more vulnerable to natural, anthropogenic, and industrial pollution. The most suitable alternative, and cost-effective approach in rural areas is the reusing of greywater (Parjane & Sane, 2011). This an alternative exporter of water able to save considerable quantities of freshwater. Graywater is non-artificial wastewater produced from home activities like a washbasin, dishwashing, bathing, and laundry (Emmerson, 1998). Graywater is differentiated from black water in the quantity, and ingredient of its biological, physical, and chemical contaminants. Shower, dish, laundry, and sink water include 50-80% of residential wastewater (Hussain *et al.*, 2002). In each country, domestic water usage is different, so that cause a significant fluctuation into the amount of greywater, as well as its components. Geographic location, available infrastructure, customs, habits, and, living standards, produce alterations in the amount, and characteristic of greywater (Boyjoo *et al.*, 2013). Fig. 1 shows the greywater generation rates Liter per capita per day (L/c.d) in current study, and different countries (Martin, 2005).

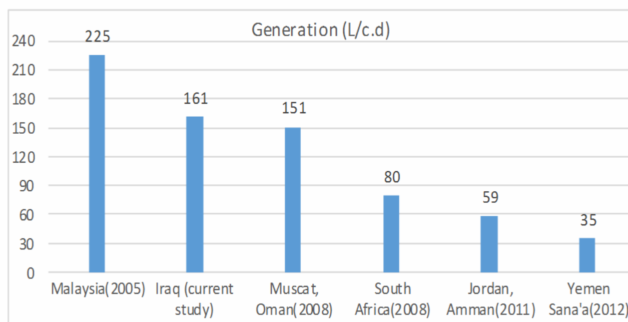


Fig. 1: The greywater generation rates in different countries. (Jamrah *et al.*, 2008)

The property of greywater chiefly be conditional on the supply source of water, the kind of water distribution arrangements, and the household liveliness (Eriksson *et al.*, 2002). According to the source, greywater able to categorize to two principal classes: greywater including high pollutant load (Nolde, 2000), for example from kitchen sink, and laundry, and greywater including low pollutant load (Al-Jayyousi, 2003) for example from shower, and washbasin. The primary phase, ere estimating the potential greywater applications, is to identify its physical, microbial, and chemical characteristics (Kimwaga, 2014). Storage is achieved for the raw greywater, previous to treatment, and treated greywater prior to its application. The raw greywater can store up to 24 hours although it is strongly suggested not to exceed 12 hours to limit odors development, plus the pathogens regrowth. (Oron *et al.*, 2014). In this regard the treated greywater can reuse for toilet flushing, garden, and also for landscape plant watering, agricultural irrigation, washing the floor, and the cars (Parjane & Sane, 2011). It can use for ground recharging (Ajit, 2016). The property of water used for these purposes is not necessarily of portable property. Therefore, treated greywater could be employed easily for non-potable use with essential treatments.

Agricultural irrigation is largely preferred in tropical countries (Edwin *et al.*, 2014). For its maximum uses greywater treatment systems shall be uncomplicated, and inexpensive. Consequently, greywater reuse shall be environment-friendly without making any audience health hazard. Although there are no guidance, and regulations on the reuse, and treatment of greywater in several developing countries (Allen *et al.*, 2010). The greywater treatment methods chiefly depending on the quantity of greywater, its physicochemical, and biological components, energy requirement, and the objectives for which treated greywater will be used for (Edwin, *et al*., 2014). The present study is made to assess the greywater generated at domestic sources of local house, and the need for conceptualizing a treatment system to preserve water. In general, design principles were based on the need to decrease the cost. Because of simplicity, easily available materials, also little maintenance be the key principles for the Middle East country (Shegokar *et al.*, 2015). Some of the organic, and inorganic pollutants like (Chemical oxygen demand (COD), Oil, Turbidity, Bicarbonates, Calcium, Magnesium, Sodium, and Chloride) in the greywater are reduced using local Iraqi materials "Porcelanite Rock" as filter media with primary treatment

Materials and Methods

Study Area Description

Deferent houses in Baghdad city in the middle of Iraq were chosen as a case study in this research, for collecting the greywater which came from a bathroom, laundry, washbasin, and kitchen sink.

Greywater Sampling and Analysis.

The average quantity of greywater produced from four sources (bathroom, laundry, washbasin, and kitchen sink) were predestined in three home sites during winter. Every one of the houses has various family styles as explained in Table 1, and Fig. 2 as a Pie chart.

Table 1 : Greywater production in the study area during winter.

Fixture	Quantity (L/c.d)	Percent %
Bathroom	90	56
Wash Basin	27	17
Kitchen sink	20	12
Laundry	24	15
Total	161	100

Which is account about 35.8% of the proposed quantity of water supplied by the municipality for urban areas (450 L/c.d).

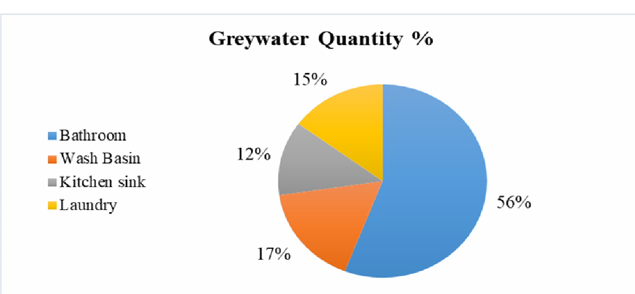


Fig. 2 : The percent of greywater produced in the study area during winter.

Analyses of selected, and significant physical, and chemical characteristics of the collected samples were done in the "Ministry of science, and technology" (Environmental, and water research, and technology directorate). Table 2. Explains the characteristic of greywater during the study period.

Table 2 : The greywater characteristic during the study period

No.	Parameter	Rang
1	pH	6.4 – 7.1
2	Turbidity (NTU)	131 – 400
3	TDS (mg/L)	400 – 605
4	EC (µs/cm)	667 – 1010
5	COD (mg/L)	633 – 830
6	Oil (mg/L)	85 – 120
7	HCO_3 (mg/L)	130 – 180
8	Ca^{+2} (mg/L)	150 – 230
9	Mg^{+2} (mg/L)	35 – 60
10	Na^{+} (mg/L)	65 – 100
11	Cl^{-} (mg/L)	100 – 130
12	CO_3 (mg/L)	Nil

Crushed Porcelanite Sampling and Analysis

Porcelanite used during the study was supplied by the Ministry of Construction, and Housing, Building Research Directorate. The natural Porcelanite rocks which locally available are used to examine the possibility of filtration the greywater. Porcelanite rock is one of the manufacturing sedimentary rocks (Ali, 2010) Fig. 3. It is discovered by nature in Wadi Al-J, andali , and Traifawi which lie in the Iraq western desert near Rutba as sediment rocks strata (Mohammed, 2016). The rocks were imparted from Trefawi zone in Rutba, at Governorate of Al Anbar. The chemical analysis of these rocks are shown in Tables 3. The analyses made in Building research directorate. Ministry of housing, and construction. (Al-Saqqar & Al-Bayaty, 2008) Were selected the Porcelanite rocks to be the dual media beside sand to enhance the filtration process efficiency in water treatment plants. The experimental work was done on the effluent from the settling tank. Filtration system is composed of three columns which are plastic filters, operating in parallel, also concurrently. First column includes 70 cm of sand, second, also the third column were dual filters which is crushed Porcelanite rocks with sand of various sizes, and depths using various filtration rates like (15, 10, and 5) m/hr. Results explained the dual filters were effective in turbidity removal such as in sand filters. The treated water turbidity was less than three NTU. The highest turbidity removal efficiency for the sand was 95 %, and for dual filters 96 % at 5 m/hr. filtration rate.

Fig. 3 : Crashed Porcelanite

Table 3 : The Chemical analysis of Crushed Porcelanite Rocks.

The chemical ingredient	Present analysis results %
SiO_2	69.53
MgO	Nil
CaO	6.5
Al_2O_3	19.92
Fe_2O_3	0.66
SO_3	0.76
L.O.I	2.62
Total	**99.99**

Sieve analysis was achieved on 400.5 gm crashed Porcelanite according to (ASTM, 1970). Fig. 4 and Table 4. Explains the graphical representation of the sieve analysis results.

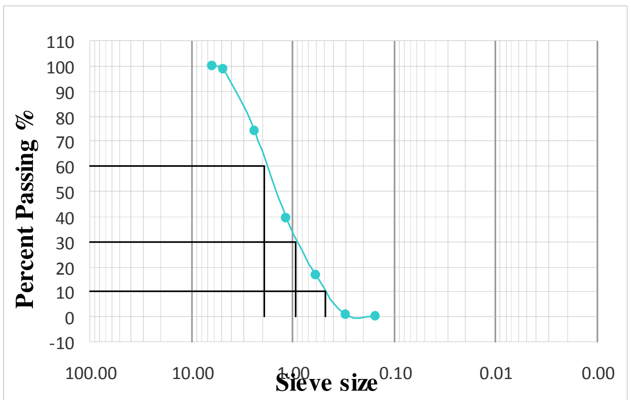


Fig. 4 : Sieve Analysis for crashed Porcelanite media.

Table 4 : Grain Size Analysis of Porcelanite

Property	Value
(D_{10}) Effective size	0.48
(D_{60})	1.88
(Cu) Uniformity coefficient	3.92
(Cc) Coefficient of curvature	0.99
(Ct) Sorting coefficient	1.73

Sand Sampling and Analysis

The sand provide from Al-Qadisiyah water treatment plant was used in this research. In order to evaluate the work of filters in the project. Sieve analysis was achieved on 476.5 g sand according to (ASTM, 1970) Fig. 5 and Table 5. Explains the graphical representation of the results.

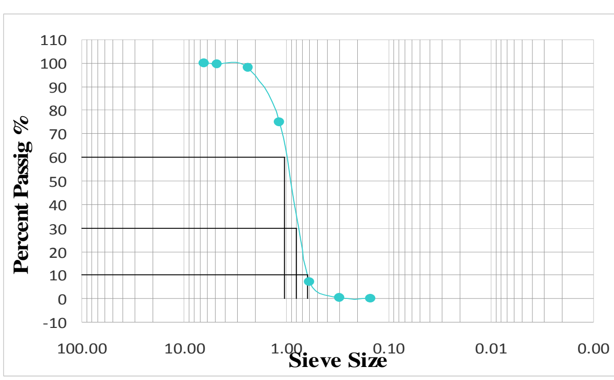


Fig 5. Sieve Analysis for Sand.

Table 5 : Grain Size Analysis of Sand media .

Property	Value
(D_{10}) Effective size	0.63
(D_{60})	1.05
(Cu) Uniformity coefficient	1.68
(Cc) Coefficient of curvature	0.96
(Ct) Sorting coefficient	1.26

Experimental setup

The treatment train is illustrated in the schematic diagram Fig. 6. Three treatment approaches were reviewed as follows:

- The 1st unit is to aerating the greywater using two diffusers in the aeration tank Fig. 7(a) in order to provide sufficient oxygen.

Aeration: Type of treatment which done to remove colors, odors, and taste from the greywater. During this process air, and water being in intimate contact, in order to absorb oxygen, and for removing carbon dioxide gas. It may additionally help in killing bacteria to a certain limit. Oxygen is needed by bacteria, and microorganism's residents in water for the pollutants breakdown. Further to oxidize iron, and manganese existing in the water. This process is made by air diffusing method, plus it helps in decreasing the chemical oxygen demand, and the quantity of oil in the greywater.

- The 2nd unit is settling the greywater in the settling tank in absence of any chemicals.

Plain Sedimentation: The largest amount of the suspended impurities presents in greywater tend to settle down by gravity, therefore, the greywater is allowed to still in the basin, so this process is described plain sedimentation. Which means the separation of impurities (the discrete particles) from the fluid via the action of natural forces. The basin that the greywater is detained is described settling basin or sedimentation basin or clarifier, furthermore, the theoretical average time for detaining the greywater in the tank is called detention time.

- The 3rd unit is receiving the greywater, passing it on the filter container to filtering the greywater through the filter media.

Arrangement of the filter columns: The dimension of each column is (24 cm for height, and 9 cm for diameter). The mono-media filter in container No. 1 which is 20 cm crushed Porcelanite rock, and in container No. 2 the dual media including 10 cm crushed Porcelanite rock, and 10 cm sand while the container No. 3 is the sand filter, all filters with 4 cm head, as shown in Fig. 8 (a). This is an environmentally friendly, and cost-effective treatment method.

Description of Experimental Apparatus

1. Plastic tank: It is a trapezoidal tank with a capacity of about 100 liters. It is set at the ground level, work as aeration tank by providing two diffusers, and the four ventilation plates were distributed in four parts in the bottom of the tank in order to provide adequate oxygen in greywater in order to reduce chemical oxygen demand, and oil thereafter, the greywater transferred to the sedimentation tank of the same type.
2. Flow meter: Three flow meters applied to estimate the influent quantity of greywater flowrate. The flow meter

consisted of a glass tube including a stainless steel float, and was fixed on the feeding pipe before the filters as shown in Fig. 8 (b). The flow meter has ability to record flowrate of water from 0 to 250 mL/min.

3. Air diffuser: A piece of aeration equipment usually in the form of a tube, plate or disc, which produce a plethora of either fine or coarse air bubbles that high tardily from the aeration tank floor, also supply substantial, also effective oxygen mass transfer for the greywater. Oxygen joint with the source of food, greywater, lets the bacteria to production the enzymes that aid to breakdown the pollutants in order to settle it in the sedimentation basin or be filtered. The quantity of discharge used by the diffuser is 210 L/hr. as shown in Fig. 7(b).

4. Pump: A submersible pump for pumping greywater from the sedimentation basin to the filter system its discharge capacity of 1400 L/hr. flow, and 2.8 m head as shown in Fig. 7(c)

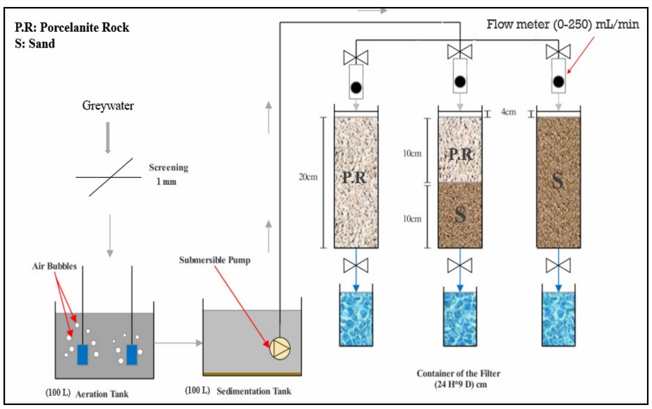


Fig. 6 : Schematic diagram of the set (Flow diagram).

(a)

(b)

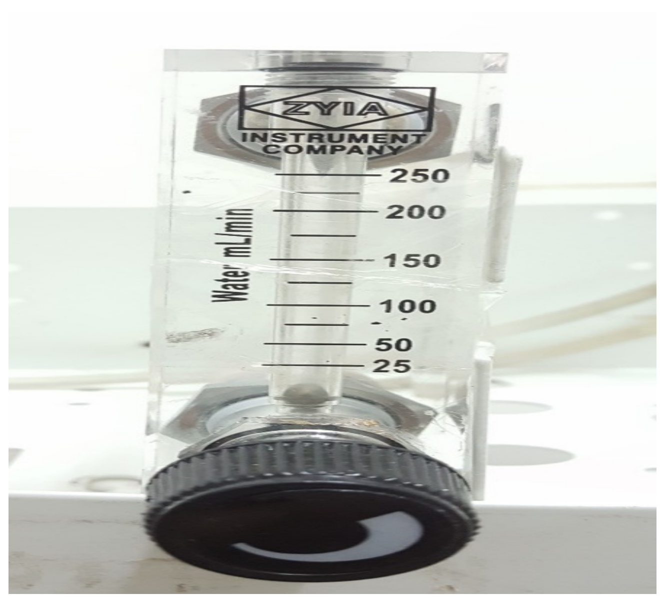
(c)

Fig. 7: (a) Aeration tank

(b) Air diffuser with discharge capacity of 210 L/hr.,

(c) Submersible pump with discharge capacity of 1400 L/hr

(a)



(b)

Fig 8. (a) Filter system, (b) Water flow meter.

Procedure of the operation runs.

After installing the filter media, a 50 mg/L of sodium hypo-chloride disinfectant solution is added to each column. This liquid has been pulled inside the column unto it filled the media of the filter ((CWC), 1995).

The procedure of the operation runs are as follows:

1. Passing the raw greywater from the screen of (1 mm).
2. Collecting the greywater in the aeration tank, and turn on the diffusers.
3. Greywater transformed from aeration tank to sedimentation tank, sedimentation time is (1-2 hr.), then greywater from the sedimentation tank is pumped to the filter columns through the flow-meters.
4. The influent filtration rates of each filter are maintained equally. (Kawamura, 2000) has recommended, using a constant rate filtration process for the pilot filter unit. Filtration rates of 3, 4.5,6, and 7.5 m^3/hr. should be raised.
5. Adjustment of the effluent valve was made continuously throughout each run for maintaining the required flow rate.
6. Samples of the effluent collected by the effluent valves, and analyzed at certain time intervals during the run.

Table 6 : Procedure of the Operation Runs.

Run No.	Aeration Time (hr.)	Flow rate (mL/min)
1	1	25
		50
		75
		100
2	2	25
		50
		75
		100
3	3	25
		50
		75
		100

Results and Discussion

High concentrations of (Chemical oxygen demand (COD), Oil, and Turbidity) were recorded in samples of the greywater. This can explain via the activities done at home like washing dishes, detergent, soap, combing, and brushing, shampoo, hair dyes, and tooth brushing, mainly in the morning. Higher concentrations of COD were recorded in samples of kitchen sinks, possibly due to the presence of detergents. The same pattern has been observed in oil that may occur due to the amount, and variety of foods. While the high amount of turbidity can be caused by the washing machine, and hand washing as shown in Table 7.

Table 7 : Treated greywater characteristics

No.	Parameter	Treated greywater Rang	Iraqi Effluent Limitations 2012	Jordanian Standard 2002
1	pH	6.6 - 7	6.4 - 8	
2	Turbidity(NTU)	64 - 195		
3	TDS (mg/L)	445 - 480	2500	1500
4	EC (μs/cm)	850 - 933		
5	COD (mg/L)	124 - 200	100	
6	Oil (mg/L)	16 - 56	-	
7	HCO_3 (mg/L)	115 - 135		400
8	Ca^{+2} (mg/L)	110 - 135	450	230
9	Mg^{+2} (mg/L)	24 - 43	80	100
10	Na^{+} (mg/L)	60 - 70	250	230
11	Cl (mg/L)	78 - 90		400
12	CO_3 (mg/L)	Nil	-	

The highest removal efficiency was in the dual media filter, and the duration of aeration was two hours with the flow rate influent to the filter be 50 mL/min. which is 85%, 86%, and 84% for Chemical oxygen demand, Oil, and Turbidity respectively. This chemical oxygen demand removal efficiency is close to the removal efficiency of the research of the professors (Parjane & Sane, 2011) where the value of greywater before, and after treatment with filter is 327 mg/L and 58 mg/L respectively, with a removal efficiency of about 84.4%.

Effect of Aeration duration of the process on removal efficiency

Experimental work showed that the removal efficiency of the chemical oxygen demand, oil, and turbidity increases when aeration time increases, and two diffusers operate instead of one. This is due to the increase in the amount of oxygen that is pumped into the greywater, and increase the oxidation processes, thus reducing the amount of the chemical oxygen demand, and increase the oil which float to the surface of the basin, which are skimming manually every half an hour.

Effect of Filtration Rate on the Removal Efficiency

The experimental work showed that the Chemical oxygen demand (COD), Oil, and Turbidity removal efficiency reduced when the filtration rate increased. This is due to the high discharge of greywater influent, and effluent from the filter, and therefore a decrease in the filtration run.

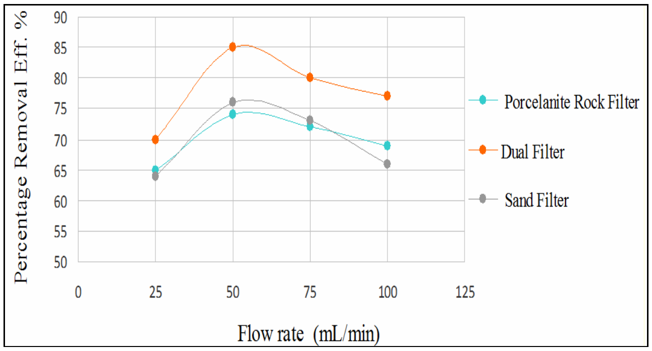


Fig. 9 : Chemical oxygen demand Removal Efficiency (2-hr. Aeration time)

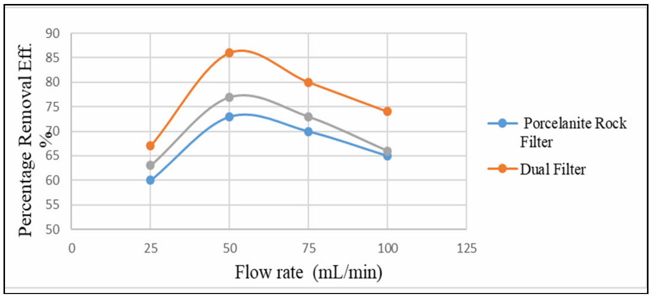


Fig. 10 : Oil Removal Efficiency (2-hr. Aeration time)

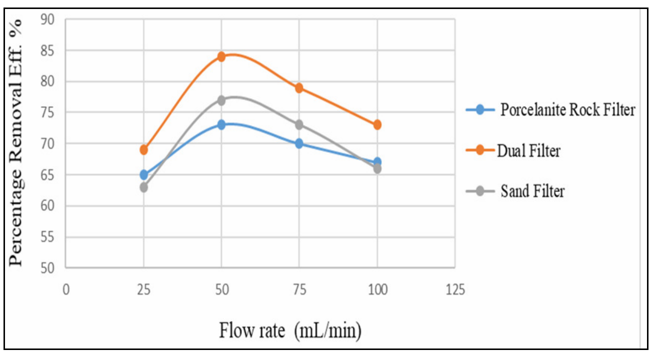


Fig. 11 : Turbidity Removal Efficiency (2-hr. Aeration time)

The experimental work showed that the Chemical oxygen demand (COD), Oil, and Turbidity removal efficiency reduced when the filtration rate increased. This is due to the high discharge of greywater influent, and effluent from the filter, and therefore a decrease in the filtration run.

Conclusion

This research analyzed greywater characteristics and treatment systems. Through experimental work by the small scale traditional treatment systems used, filtration systems appear worthwhile and have the potential of integration besides another method to perform the target particular treatment. This Results found that the possibility of natural material like Porcelanite rocks for being applied as filter media in greywater treatment methods. This natural material is vastly obtainable in Iraq, and its complete integration in the filtration process ought to examine. Nevertheless, it able to be employed for designing a simplistic house level of greywater treatment systems which objective a specific reuse choice and that way raise local level involvement. This important conclusion can be summarized according to the prior Figures (9, 10, and 11) in some points:

1. The removal efficiency was close within the aeration process for two hours, and three hours, so it is recommended to keep the greywater for two hours for aeration in the aeration basin with the operation of the diffusers.
2. It has been concluded that the aeration process could successfully approach the objectives of the suggested treatment process.
3. Increasing the settling time lead to significant increasing in the removal rate of the pollution parameters.
4. Porcelanite rocks appear for being proper media for using in small scale filtration systems to treat the greywater for irrigation water quality, concerning COD, Oil, and Turbidity.
5. Greywater reuse offers a potential option for the management of water demand that can contribute to the reduction of freshwater consumption for irrigation, particularly in the rural and remote areas.

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