Optical and Physical analyses of water Turbidity for crushed glass and ceramic wastes as a filtration medium in drinking water plants

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Abstract

Filtration is one of the important operations carried out to produce drinking water. Sand filtration is the conventional method for drinking water filtration. This work aims at investigating the replacement of sand with crushed glass or ceramics and utilizing such wastes to reduce the drain of non-renewable natural resources. Samples of crushed glass and ceramics were washed, sieved to the nominal size. Filtration columns were filled with crushed glass or ceramics or sand at different height (30, 45 and 60 cm) and the turbidity of feeding water after coagulation process (2.9, 4.8 and 6.5 NTU) at a flow rate (4, 6 and 8 $m^3/m^2/h$). Filtration process is running and filtrated water is collected and analysed the turbidity and pH. Results showed that all samples of feeding raw water turbidity are reduced after filtration using crushed glass, crushed ceramics and sand media. Turbidities values of filtrated water using crushed glass as a filtration media was recorded values ranged from (0.51-1.88 NTU) and the filter containing crushed ceramics produced effluent turbidities ranged from (0.69-2.11 NTU) and the filter containing sand produced effluent turbidities ranged from (0.48-1.86 NTU). Results of pH of filtrated water using crushed glass media and sand media was recorded the same values before and after filtration and when crushed ceramics was used as a filtration media with entrance feeding raw water of pH 7.38 the filtrated water was recorded pH ranged from (7.42-7.61). From the results it can be conclude that crushed glass media and ceramics. The media has the ability to remove turbidity and provide high quality wastewater that complies with international specifications (less than 1 NTU). Filters containing grinded glass produce the same turbidity and pH as those obtained with sand filters.

Keywords: Filtration media, Crushed Glass, Crushed Ceramics, Turbidity.

Introduction

Filtration is the final step in the solids removal process. From a water quality standpoint, filter runoff turbidity is a good indicator of overall process performance. Filter outflow turbidity may be monitored and recorded on a continuous basis by turbidity meter. A continuous water quality monitors, such as turbidity meters, and pH monitors will give early warning of process failure and will aid in making a rapid assessment of process performance. Sand filtration is the conventional method for drinking water filtration. This work aims at investigating the replacement of sand with crushed glass or ceramics [1-12].

Water is one of the most important requirements for life, and most human activities involve the use of water in some way. It is now widely accepted that providing safe water to the community can prevent the spread of water-borne diseases. Untreated surface water has long been known to be the cause of many human illnesses. The main purpose of a water supply plan is to provide a sufficient amount of safe water. To achieve high quality drinking water, the water must be subjected to a series of treatment processes such as screening, coagulation, aggregation, sedimentation, filtration and disinfection. In most developing countries, surface water is the main source of water. The main problems with using surface water as a water source are high concentrations of clay and suspended solids. Filtration is the most common method for removing clay and suspended solids. In the filtration process, water is purified by passing through a bed of porous medium, causing retention of suspended matter. In surface water filtration, slow sand filters and rapid sand filters are widely used to remove suspended solids in water. Rapid sand filtration is the most popular for surface water treatment of urban water because of its small area requirement, high production capacity and high flexibility. Contact coagulation filtration is the most cost-effective method for low turbidity surface waters because it is easier to operate and maintain by avoiding settling equipment. During this process, suspended solids are aggregated by the addition of chemicals and sent to the filter [13-20].

In the 1700s, the first household water purifiers were applied [21-31]. These were made of wool, sponge and charcoal. In 1804, the first real urban water treatment plant designed by Robert Tom was built in Paisley, Scotland. The water treatment was based on slow sand filtration, with horses and carts distributing the water. In 1854, it was discovered that the cholera epidemic spreads through water[32-49]. The outbreak seemed less severe in areas where sand filters were installed. British scientist John Snow found that the direct cause of the outbreak was water pump contamination by sewage water. He applied chlorine to purify the water, and this paved the way for water disinfection[50-59].

The aim of the research is to develop a type of filter from waste materials like glass and ceramics. Due to the rapid population growth and continuous increase in consumption, a large amount of waste is generated. Among them, waste glass and waste ceramic materials. Recycling crushed glass and crushed ceramics can save energy and reduce environmental waste. Focusing on glass recycling technology will broaden the scope of waste glass and facilitate further development of glass technology. Increasing awareness of glass recycling has led to a focus on the use of different forms of waste glass in different areas. Each country produces a large amount of household waste, industrial waste and mining waste every year. Using recycled materials instead of virgin materials reduces the demand for virgin materials.

Sand filtration is the conventional method for drinking water filtration. The replacement of sand with crushed glass or ceramics and utilizing such wastes to reduce the drain of non-renewable natural resources.

Experimental work

Samples of glass and ceramic

The grinded waste glass was obtained from waste sheet glass (window glass-soda lime glass) bottles which used daily in market and samples of crushed ceramics are collected from waste ceramics used in flooring as shown in Figures 1 and 2. The glass and ceramics crushed by crushing machine for grinding glass and ceramic, and Shaker with Sieves. The crushed glass or crushed ceramics samples was shack by the shaker to obtain the objective size.

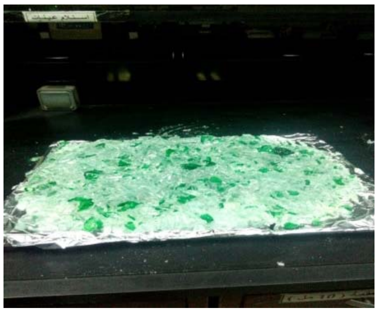


Figure (1) Crushed glass after washing and drying

Figure (2) Crushed ceramic after washing and drying

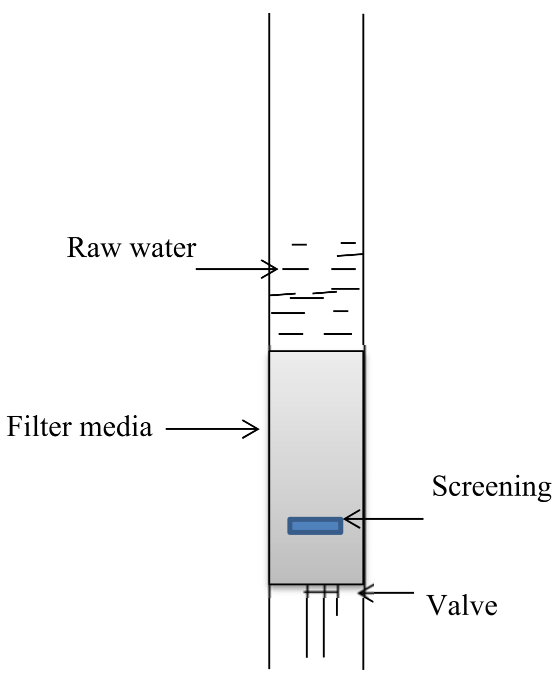


Figure (3) Column filter

Pilot plant

A laboratory scale pilot filter was designed for this study, the pilot plant was constructed from glass, a column with height 85 cm and dimension 5 cm * 5 cm and connected from bottom by valve to controlled the rate of filtration of water. The pilot plant was installed at Al-Ameria WTP laboratory as shown in Figure 3.

Source of Raw water

Raw water used in this study is water after coagulation stage from Al-ameria WTP. An Oven used for drying crushed glass, crushed ceramic and sand after washing. The pH meter analysis used by Jenway 3510. The Turbidity meter measuring turbidity of raw water and filtrated used by HACH 2100.

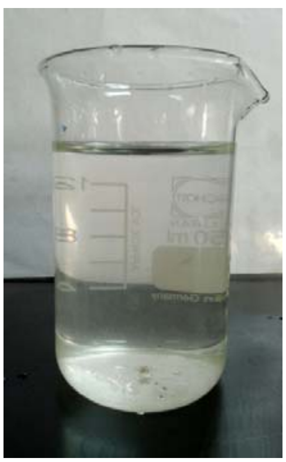


Figure (4) 2.9 NTU Figure (5) 4.8 NTU Figure (6) 6.5 NTU

Turbidity Test:
Water turbidity is caused by the floating of colloidal substances such as clay, silt, finely divided organic and inorganic substances, and fine organisms such as plankton. Turbidity is an expression of the optical properties of a sample placed in a clean beaker that scatters and absorbs light rather than transmitting it without changing its direction or flux level. The instrument was used is HACH 2100. As shown in Figure 4,5,and 6.

pH Test:
pH is a measure of the acidity or alkalinity of water. The pH test is one of the most common analyzes performed in volunteer estuary monitoring programs. Measured on a scale of 0-14. An electronic pH meter is used in this study. The electronic pH meter used is Jenway 3510.

Sieve Analysis
Sieve analysis is to assess the particle size of granular material by allowing the material to gradually pass through a series of sieves of smaller mesh size and measuring the amount of

material stopped by each sieve as part of the whole. It is a practical procedure used for. Mass. From sieve analysis we determine the effective size and uniformity coefficient of filter medium.
The effective size (ES) is D10.
The uniformity of the filter material can be expressed in the uniformity coefficient, defined as:

$$U = d60 / d10$$

In which:
U = uniformity coefficient
d10 = size of sieves that let pass 10% of the sand mixture (mm)
d60 = size of sieves that let pass 60% of the sand mixture (mm)
For rapid filtration the value of the uniformity coefficient should be between 1.3 and 1.5 to avoid stratification of the filter bed during backwashing.
Samples of crushed glass and crushed ceramic shown in Figures 7 and 8 are grinding by crusher machine then shaking by shaker with sieves with diameter size 1.4 mm, 0.8 mm. then the samples of specific diameter are collected.

Figure (7) Crushed glass

Figure (8) crushed ceramic

Filtration Process
The crushed waste glass and crushed ceramics were cleaned and then crushed manually and mechanically to get the required nominal size. Crushed glass and ceramics were sieved to obtain the objective particle size. The particle size has a diameter of 0.8 -1.4 mm. A laboratory scale pilot filter was designed for this study. Experimental work has been conducted in Al-Ameria WTP to evaluate the performance of the pilot under different operating conditions (Rof – feeding raw water turbidity – pH – height of medium). Filtrated water was monitored and recorded the turbidity and pH. And turbidity removal efficiency of crushed glass media and crushed ceramic media are evaluated.

Operation Condition

The Procedure of filtration process

Using conventional sand as a filer media as shown in Figure 9.

- The sand was washed by clean water then dried by oven.
- sand was filled the filtration column at highest 30 cm,
- Raw water with turbidity 2.9 NTU was filled the filtration column on the surface of crushed glass.

- The valve was opened at flow rate 4, 6 and 8 m^3/h rate.
- The filtrated water was received where turbidity and pH was recorded.
- The previous steps was repeated with raw water has turbidity of 4.8 NTU and 6.5 NTU.
- Previous steps was repeated with height of 45 cm and 60 cm of crushed glass.
- The filtration column was emptied and cleaned.

Table (1). Showed operation condition of filtration process.

parameter	Sand	Crushed glass	Crushed ceramics
Turbidity of raw water used (water after coagulation)	2.9 , 4.8 , 6.5 NTU		
particle size diameter	0.8 mm – 1.4 mm		
Effective size	0.95mm	0.96mm	1.05mm
Uniformity coefficient	1.5	1.51	1.69
Height of filtration medium	30 cm , 45 cm , 60 cm		
Rate of filtration	4 , 6 and 8 m^3 /m^2/ h		
pH of raw water	7.38– 7.48		

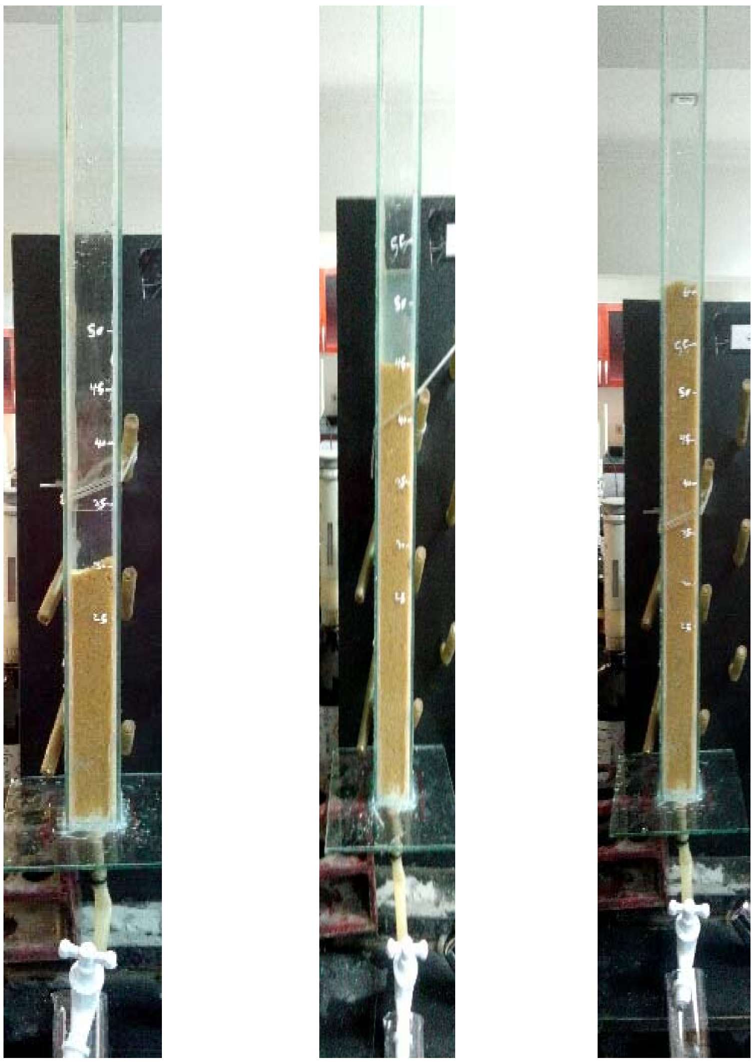
Using crushed glass as filer media as shown in Figure 10.

- The crushed glass with effective grain size of 0.96 mm was washed by clean water then dried by oven.
- Crushed glass was filled the filtration column at highest 30 cm,
- Raw water with turbidity of 2.9 NTU was filled the filtration column on the surface of crushed glass.
- The valve was opened at flow rate 4, 6 and 8 m^3/h.
- The filtrated water was received where turbidity and pH was recorded.
- The previous steps was repeated with raw water has turbidity 4.8 NTU and 6.5 NTU.
- Previous steps was repeated with height of 45 cm and 60 cm of crushed glass.
- The filtration column was emptied and cleaned.

Using crushed ceramic as filer media as shown in Figure 11.

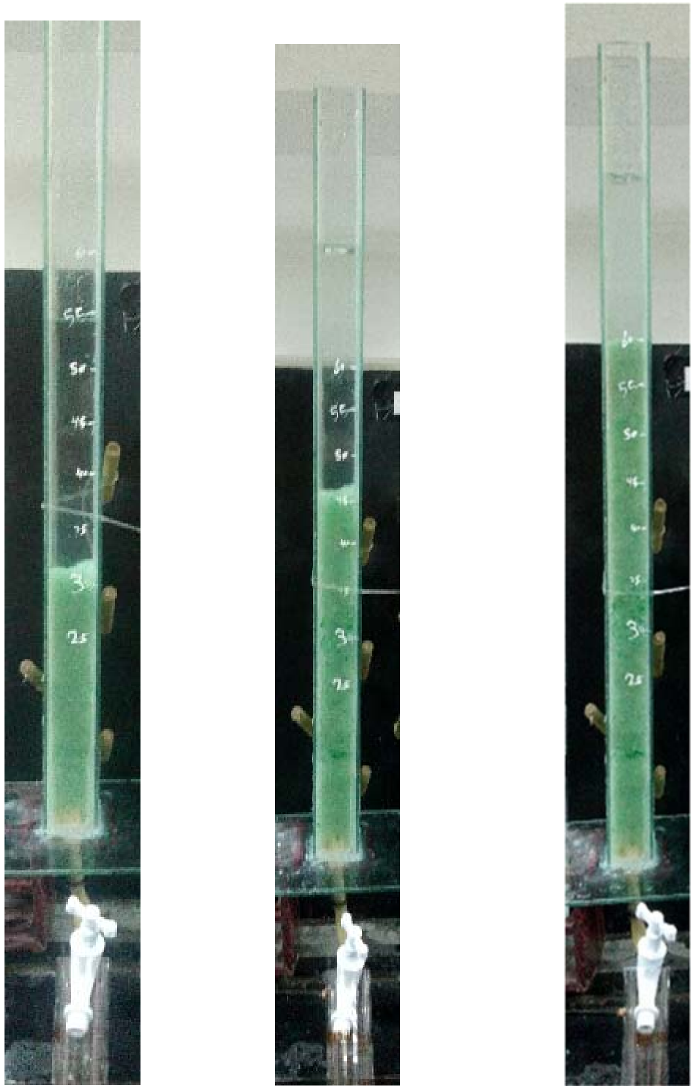
- The crushed ceramic with effective grain size of 1.05 mm was washed by clean water then dried by oven.
- Crushed ceramic was filled the filtration column at highest 30 cm,
- Raw water with turbidity of 2.9 NTU was filled the filtration column on the surface of crushed ceramic.

- The valve was opened at flow rate 4, 6 and 8 m^3/h.
- The filtrated water was received where turbidity and pH was recorded.
- The previous steps was repeated with raw water has turbidity of 4.8 NTU and 6.5 NTU.
- Previous steps was repeated with height of 45 cm and 60 cm of crushed ceramic.
- The filtration column was emptied and cleaned.



30 Cm **45 Cm** **60 Cm**

Figure (9)
Filtration using sand as a filtration medium



30 Cm **45 Cm** **60 Cm**

Figure (10)

Filtration using crushed glass as a filtration media

Calculation rate of flow (ROF)

- recommended that the filtration rate through the medium is 4 m^3 /m^2 /h.
- The pilot plant has a surface area of 0.05 m * 0.05 m = 0.0025 m^2.
- hydrolic loading rate = filtration rate * surface area.

= 4 m^3 / m^2 / h * 0.0025 m^2 = 0.01 m^3 / h.

- Loading rate = 0.01 m^3 / h * 1000 = 10 liter / h.

When recommended filtration rate is 6 m^3 / m^2 / h.

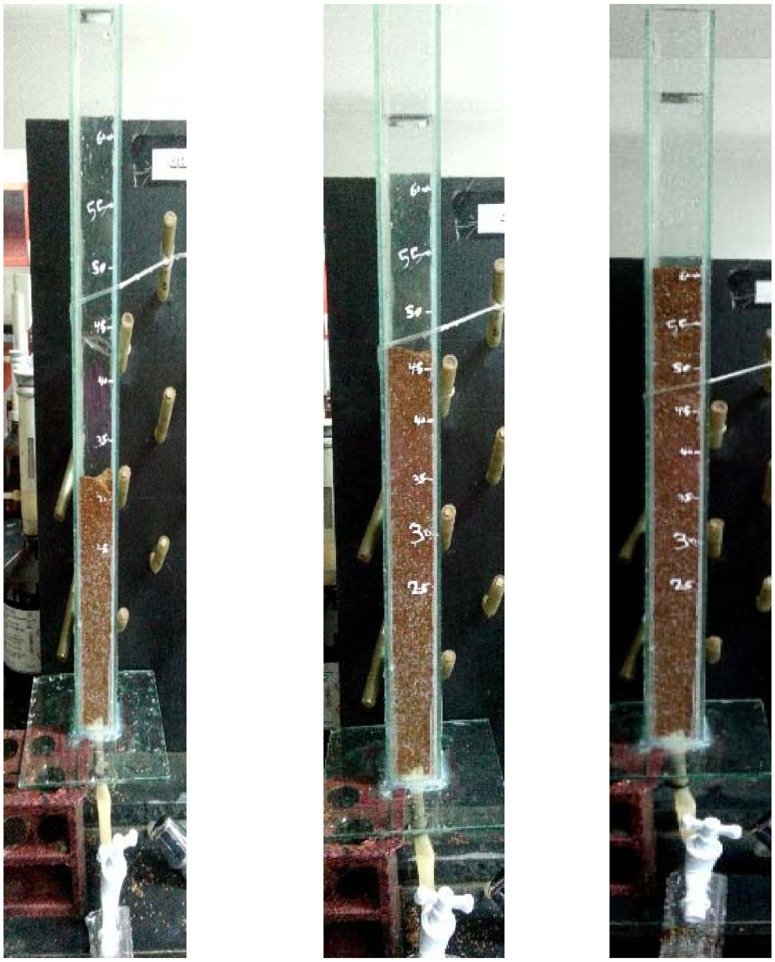
Thus Loading rate = 6 m^3 / m^2 / h * 0.0025 m^2 = 0.015 m^3 / h.

Thus loading rate = 15 liter / h.

When recommended filtration rate is 8 m3 /m^2 /h.

Thus loading rate = 8 m3 /m^2 /h * 0.0025 m^2 = 0.020 m^3 / h.

Thus loading rate = 20 liter / h.



30 Cm **45 Cm** **60 Cm**

Figure (11)

Filtration using crushed ceramic as a filtration medium

Results and discussions

Composition of crushed glass and crushed ceramic samples.

- The results of XRF analysis of crushed glass and ceramic samples used are given in Table (2) and shown in Figures 12 and 13.

Table (2) showed the chemical composition of crushed glass and crushed ceramics samples.

Contents	Crushed glass	Crushed ceramics
SiO_2	74.88 %	65 %
TiO_2	0.02 %	0.8 %
$Al2O_3$	0.51 %	0.84 %

Fe_2O_3	0.09 %	1.0 %
MnO	0.01 %	0.01 %
MgO	3.02 %	0.6 %
CaO	8.15 %	18.4 %
Na_2O	12.79 %	0.2 %
K_2O	0.17 %	1.2 %
P_2O_5	0.01 %	0.01 %

Sieve analysis of crushed glass.

Table (3). Showed sieve analysis of crushed glass.

Nominal Aperture Width (mm)	**Diameter of particles residual (mm)**	**Weight (g)**		**Fraction**		**Cumulative Undersize %**
		Tare	**Gross**	**(g)**	**(%)**	
2	> 2	520.0	520.4	0.4	0.4	99.60
1.6	1.6-2	484.7	485.8	1.1	1.1	98.50
1.4	1.4-1.6	495.8	503.1	7.3	7.3	91.20
1.18	1.18-1.4	399.2	458.7	59.5	59.5	31.70
1	1-1.18	307.8	326.3	18.5	18.5	13.20
0.9	0.9-1	467.2	473.9	6.7	6.7	6.50
0.8	0.8-0.9	453.6	459.1	5.5	5.5	1.00
0.6	0.6-0.8	288.2	288.9	0.7	0.7	0.30
	0.0-0.6	450.5	450.7	0.2	0.2	

D 60	1.46
D 10	0.96
Effective Size, D10	0.96
Uniformity Coefficient D60/D10	1.51

Sieve analysis of crushed ceramic.

Table (4). Showed sieve analysis of crushed ceramic.

Nominal Aperture Width	Diameter of particles residual	Weight (g)		Fraction		
		Tare	Gross	(g)	(%)	Cumulative Undersize %
2	> 2	520.0	523.2	1.2	1.2	98.80
1.6	1.6-2	484.7	490.0	5.3	5.3	93.50
1.4	1.4-1.6	495.8	512.1	16.3	16.3	77.20
1.18	1.18-1.4	399.2	450.8	51.6	51.6	25.60
1	1-1.18	307.8	318.3	10.5	10.5	15.10
0.9	0.9-1	467.2	475.6	8.4	8.4	6.70
0.8	0.8-0.9	453.6	455.8	2.2	2.2	4.50
0.6	0.6-0.8	288.2	292.0	3.8	3.8	0.70
	0.0-0.6	450.5	460.0	0.5	0.5	

D 60	1.77
D 10	1.05
Effective Size, D10	1.05
Uniformity Coefficient D60/D10	1.69

Sieve analysis of sand.

Table (5). Showed sieve analysis of sand.

Nominal Aperture Width	Diameter of particles residual	Weight (g)		Fraction		
		Tare	Gross	(g)	(%)	Cumulative Undersize %
2	> 2	520.0	522.0	2	1.5	98.50
1.6	1.6-2	484.7	490.0	5.3	2.1	96.40
1.4	1.4-1.6	495.8	520.0	24.2	8.3	88.10
1.18	1.18-1.4	399.2	420.0	20.8	55.1	33.00
1	1-1.18	307.8	320.0	12.2	18.2	14.80

0.9	0.9-1	467.2	492.0	24.8	7.2	7.60
0.8	0.8-0.9	453.6	460.0	6.4	5.3	2.30
0.6	0.6-0.8	288.2	292.0	3.8	2.1	0.20
	0.0-0.6	450.5	450.7	0.2	0.2	

D 60	1.45
D 10	0.95
Effective Size, D10	0.95
Uniformity Coefficient D60/D10	1.53

Sieve curve of crushed glass and crushed ceramic.

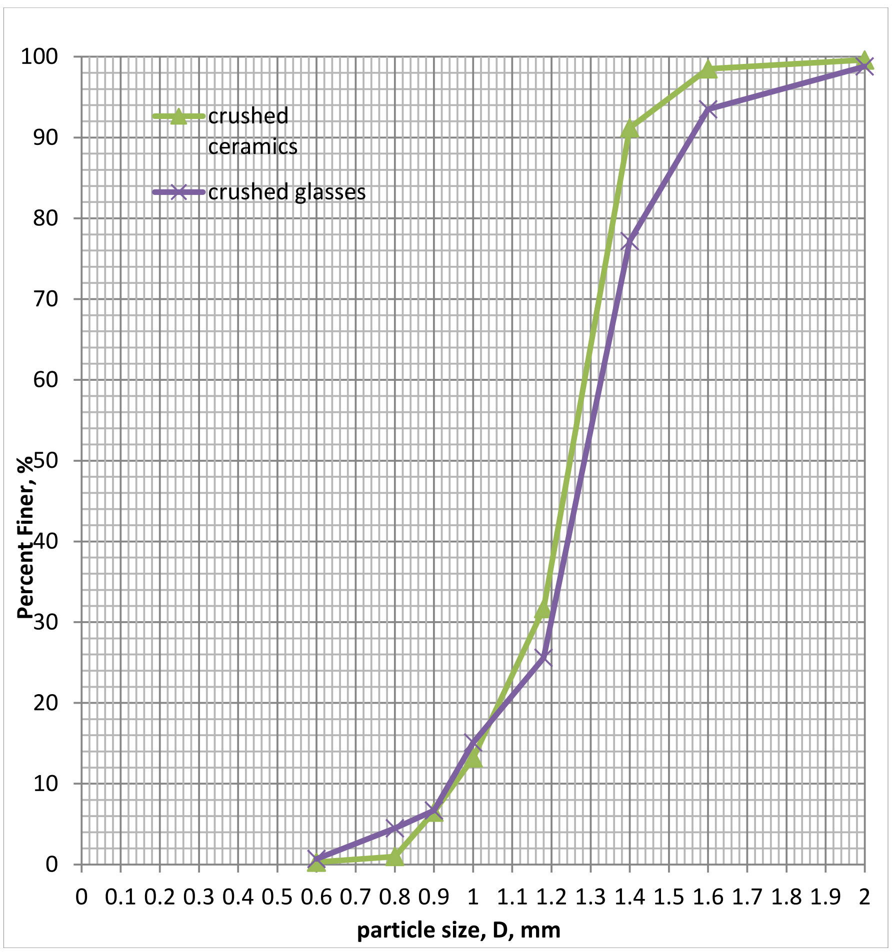


Figure (12) sieve curve of crushed glass and crushed ceramic.

Sieve curve of sand.

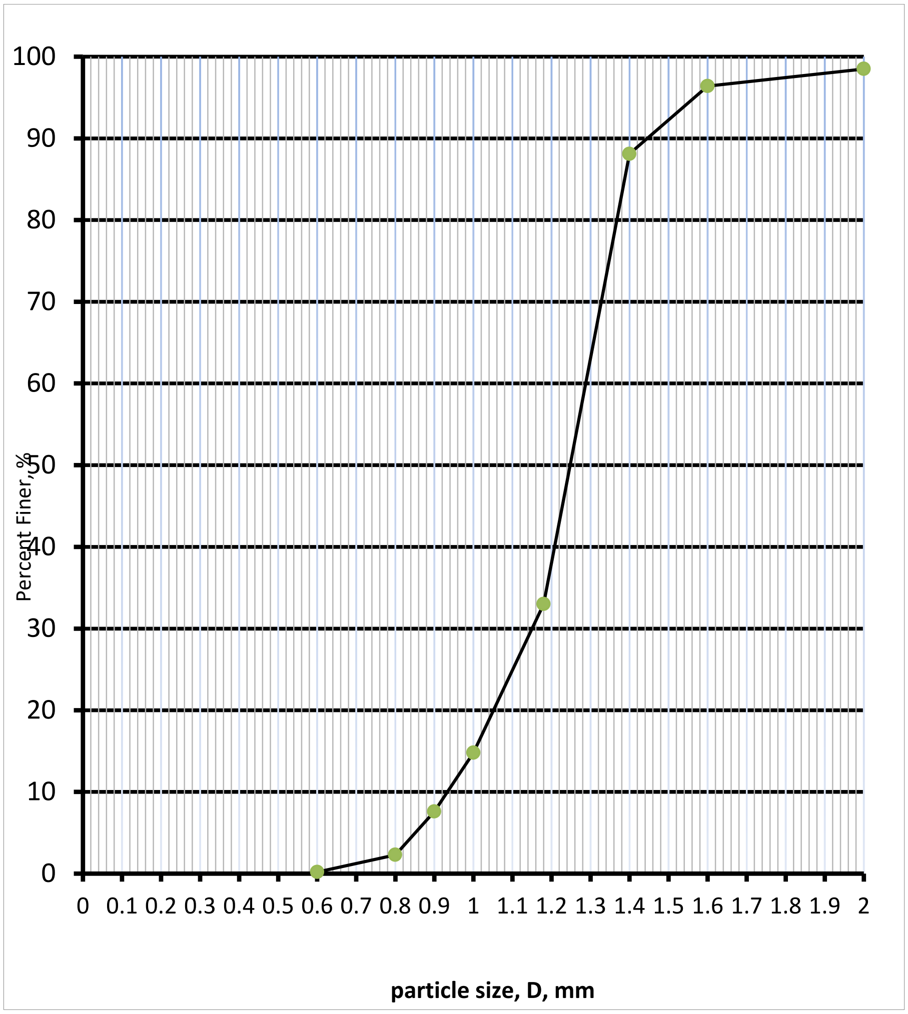


Figure (13) sieve curve of sand.

Results of surface water analysis

Filter outflow turbidity and pH will give a good indication of overall process performance of medium, and there are many factors affecting the performance of filter among them ROF, highet of medium and turbidity of influent water. Runs of filtration process were conducted to explore the effect of these factors on performance.

Turbidity Test:

Table (6) showed the values of the turbidity after filtration using filtration media of sand, crushed glass and crushed ceramics with three different feeding raw water samples turbidity (2.9 ,4.8 and 6.5 NTU) at different flow rate (4 , 6 and 8 m^2/h). Results showed that all samples of feeding raw water turbidity are reduced after filtration using conventional sand, crushed glass and crushed ceramics mediums.

Table (6). Turbidity after filtration using conventional Sand, crushed glass and crushed ceramics at different flow rate.

Highet of filtration medium (cm)	Rate of filtration (RoF) (m^3/h)	Feeding raw water turbidity (NTU)								
		2.9 NTU			4.8 NTU			6.5 NTU		
		S	G	C	S	G	C	S	G	C
30 cm	4 m^3/h	0.81	0.84	1.0	1.11	1.15	1.33	1.33	1.39	1.65
45 cm		0.55	0.56	0.79	0.68	0.69	1.0	0.88	0.90	1.20
60 cm		0.48	0.51	0.69	0.55	0.61	0.98	0.69	0.70	0.90
30 cm	6 m^3/h	0.92	0.95	1.12	1.22	1.27	1.41	1.50	1.52	1.74
45 cm		0.65	0.65	0.89	0.77	0.80	1.12	0.91	0.92	1.32
60 cm		0.55	0.58	0.75	0.71	0.72	0.87	0.77	0.80	1.0
30 cm	8 m^3/h	1.18	1.21	1.55	1.41	1.48	1.87	1.86	1.88	2.11
45 cm		0.88	0.89	1.11	1.24	1.30	1.68	1.32	1.33	1.75
60 cm		0.75	0.77	0.91	0.98	0.95	1.21	1.0	1.12	1.35

(Sand (S), Crushed glass (G) and crushed ceramics (C))

Effect of height of medium.

To investigate the effect of height of medium on filtration performance using sand, crushed glass and crushed ceramics mediums, turbidity is maintained at constant level at the entrance of feeding filter through fixed level of rate of filtration in each medium.

The performance of filtration using sand, crushed glass and crushed ceramics at different height medium is summarized in table (6).

- The efficiency of removal of turbidity increased by increasing of height of medium of sand, crushed glass and crushed ceramics.
- The turbidity values after filtration were recorded the minimum values at height 60 cm at flow rate 4 m^3/h at all levels of feeding raw water when sand used as filtration medium and these results are converge with the results of turbidity after filtration using crushed glass.
- The turbidity values after filtration were recorded the greatest values at height 30 cm when crushed ceramics was used as a filtration medium.

Effect of Rate of filtration (RoF).

To investigate the effect of rate of filtration on filtration performance using sand, crushed glass and crushed ceramics mediums, rate of filtration is maintained at constant level at the entrance of raw water feeding filter through fixed level raw water feeding turbidity as shown in Figures 14, 15, 16, 17, 18, 19, 20, 21,22, 23, 24, and 25.

The performance of filtration using sand, crushed glass and crushed ceramics at different rate of filtration is summarized in table (6).

- Turbidity removal increased by decreasing rate of filtration by using sand or crushed glass or crushed ceramics as filtration mediums.
- Turbidity removal efficiency was recorded the maximum at rate of filtration 4 m3/h at different raw water feeding levels (2.9, 4.8 and 6.5 NTU) with sand , crushed glass and crushed ceramics filtration mediums.

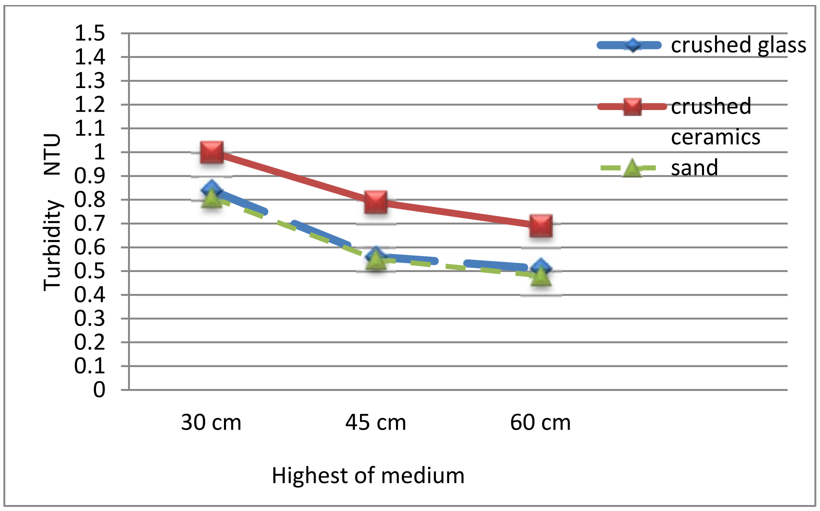


Figure (14) Results of turbidity after filtration with raw water 2.9 NTU at flow rate 4 m^3 / h

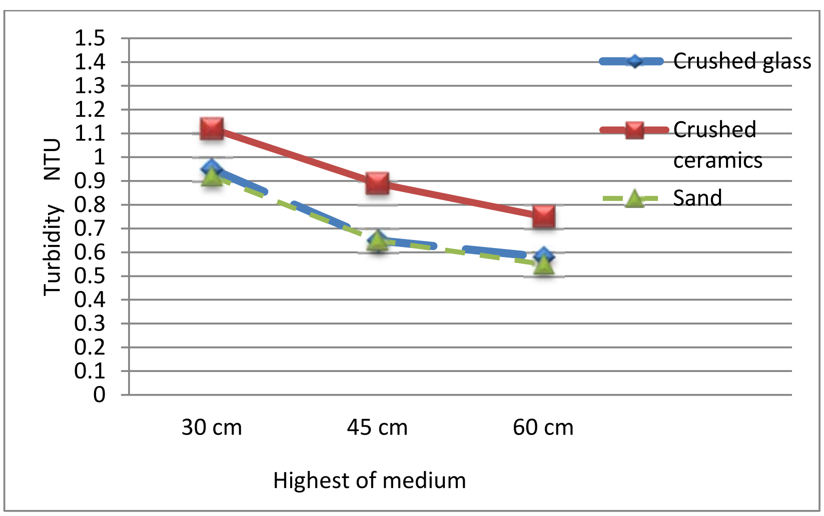


Figure (15) Results of turbidity after filtration with raw water 2.9 NTU at flow rate 6 m^3 / h

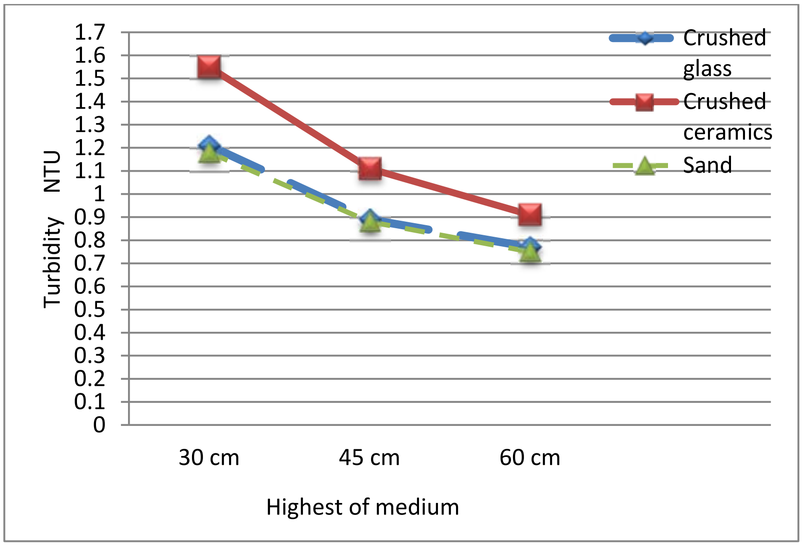


Figure (16) Results of turbidity after filtration with raw water 2.9 NTU at flow rate 8 m^3 / h

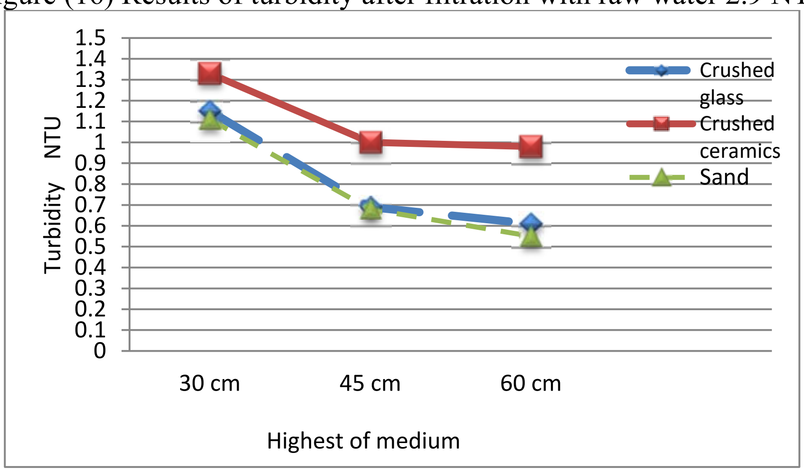


Figure (17) Results of turbidity after filtration with raw water 4.8 NTU at flow rate 4 m^3 / h

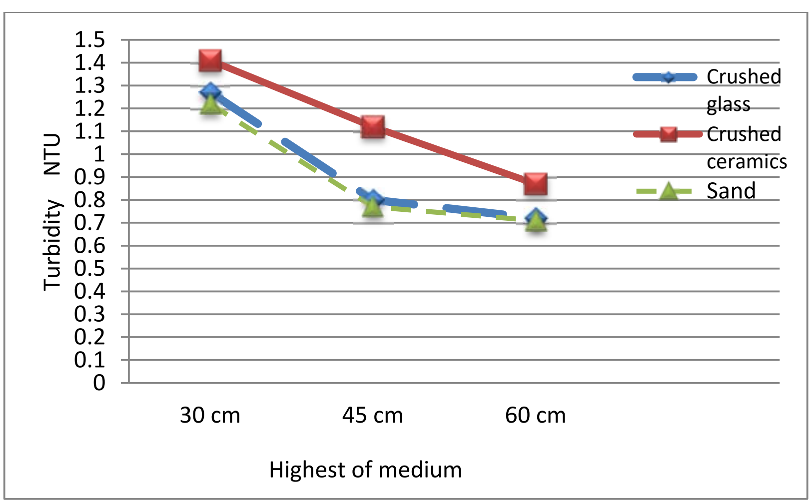


Figure (18) Results of turbidity after filtration with raw water 4.8 NTU at flow rate 6 m^3 / h

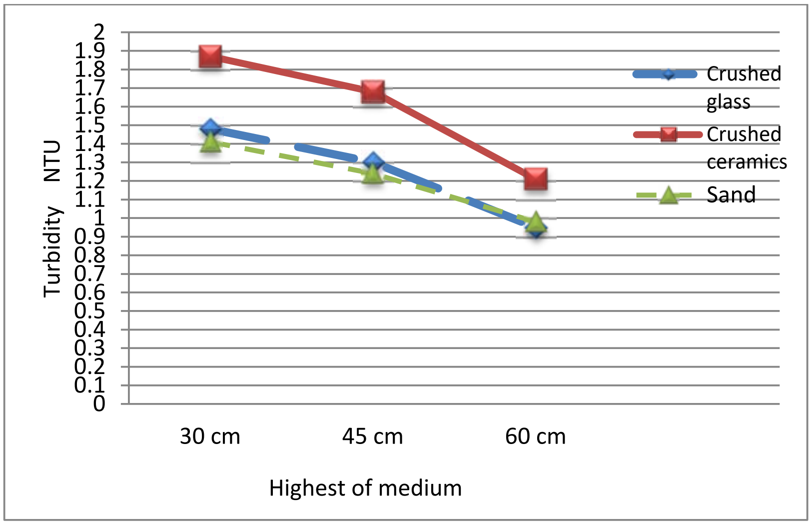


Figure (19) Results of turbidity after filtration with raw water 4.8 NTU at flow rate 8 m^3 / h

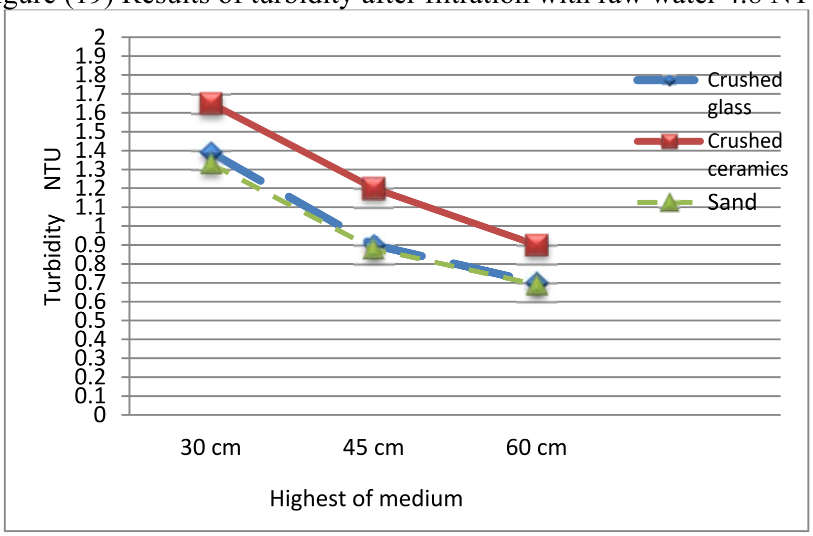


Figure (20) Results of turbidity after filtration with raw water 6.5 NTU at flow rate 4 m^3 / h

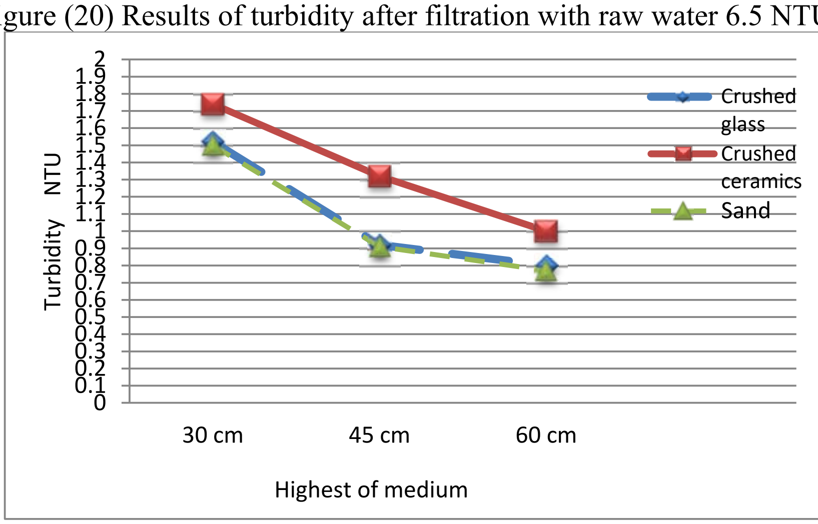


Figure (21) Results of turbidity after filtration with raw water 6.5 NTU at flow rate 6 m^3 / h

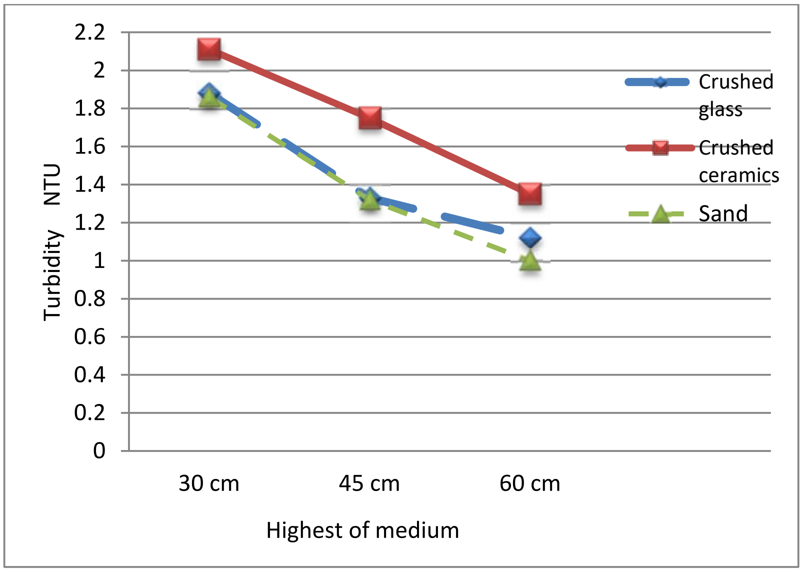


Figure (22) Results of turbidity after filtration with raw water 6.5 NTU at flow rate 8 m^3 / h

Turbidity removal efficiency.

Table (7). Results of turbidity removal ratio.

Highet of filtration medium (cm)	Rate of filtration (RoF) (m^3/h)	Feeding raw water turbidity (NTU)								
		2.9 NTU			4.8 NTU			6.5 NTU		
		S	G	C	S	G	C	S	G	C
30 cm	4 m^3/h	72%	71%	65%	76%	76%	72%	79%	78%	74%
45 cm		81%	80%	72%	85%	85%	79%	86%	86%	81%
60 cm		83%	82%	76%	88%	87%	80%	89%	89%	86%
30 cm	6 m^3/h	68%	67%	61%	74%	73%	70%	76%	76%	73%
45 cm		77%	77%	69%	83%	83%	76%	86%	85%	80%
60 cm		81%	80%	74%	85%	85%	81%	88%	87%	84%
30 cm	8 m^3/h	60%	59%	47%	70%	69%	61%	71%	71%	67%
45 cm		69%	69%	62%	74%	72%	65%	79%	79%	73%
60 cm		74%	73%	68%	79%	80%	74%	84%	82%	80%

The following observation can be concluded from table

- Turbidity removal efficiency of crushed glass media is greater than turbidity removal efficiency of crushed ceramic.
- Turbidity removal efficiency of crushed glass media and sand media are similar.
- Turbidity removal efficiency increase with increasing the height of media.
- Turbidity removal efficiency is directly proportional to rate of filtration.

- Crushed glass media was achieved maximum efficiency of turbidity removal (80% - 89%) at height of media 60 cm and rate of filtration 4 m^3/ h. And was achieved minimum efficiency (73%-82%) at height of media 30 cm and rate of filtration 8 m^3/h.
- Crushed ceramic media was achieved maximum efficiency of turbidity removal (76% - 86%) at height of media 60 cm and rate of filtration 4 m^3 / h. And was achieved minimum efficiency (68%-80%) at height of media 30 cm and rate of filtration 8 m^3/h.

pH Test:

The tables (8) shows the values of the pH of filtrated water using filtration media of sand, crushed glass and crushed ceramics with three different raw water samples of pH (7.38, 7.42, 7.48) at different flow rate (4, 6 and 8 m^2/h).The pH measurements showed that the pH values of three water sample of feeding water were almost the same before and after filtration using sand and crushed glasses and pH values slightly increased after filtration when crushed ceramics was used as a filtration medium.

Table (8). Results of pH after filtration using sand, crushed glass and crushed ceramics with different raw water samples pH at rate of filtration 4, 6 and 8 m^3/h .

Highet of filtration medium	pH Feeding raw water								
	7.38			7.42			7.48		
	S	G	C	S	G	C	S	G	C
30 cm	7.38	7.38	7.42	7.42	7.42	7.48	7.48	7.48	7.53
45 cm	7.38	7.38	7.48	7.42	7.42	7.53	7.48	7.48	7.58
60 cm	7.38	7.38	7.51	7.42	7.42	7.57	7.48	7.48	7.61

Effect of height of medium.

To investigate the effect of height of medium on filtration performance using sand, crushed glass and crushed ceramics mediums, pH is maintained constant at the entrance of feeding filter through fixed rate of filtration in each medium.

The performance of different height medium is summarized in table (7).

- pH was recoding the same values before and after filtration at different height when sand and crushed glass each used as single filtration medium.
- pH values was record small increasing when crushed ceramics used as a single filtration medium and increased by increasing the height of crushed ceramics medium.

Effect of Rate of filtration (RoF).

To investigate the effect of rate of filtration on filtration performance using sand, crushed glass and crushed ceramics mediums, pH is maintained constant at the entrance of feeding filter through fixed height of medium in sand, crushed glass and crushed ceramics mediums.

The performance of different flow rate is summarized in table (7).

- pH was recorded constant values after filtration at different rate of filtration using sand, crushed glass and crushed ceramics mediums.

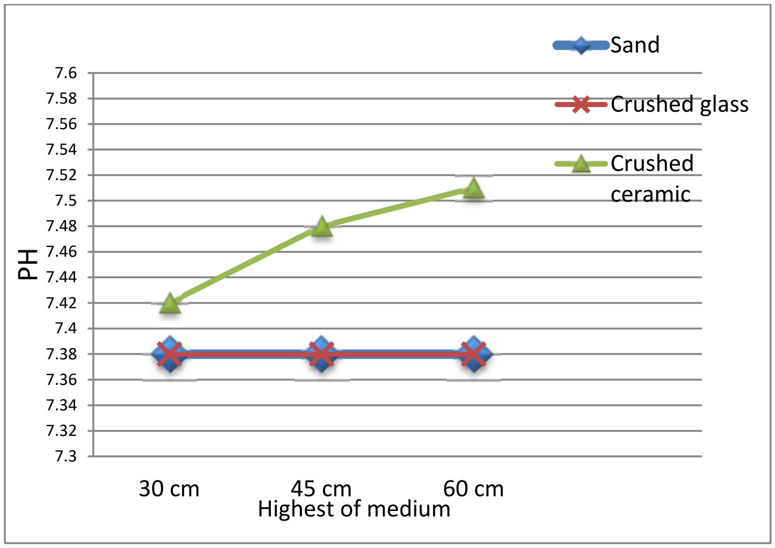


Figure (23). Values of pH of filtrated water after filtration with raw water of pH 7.38.

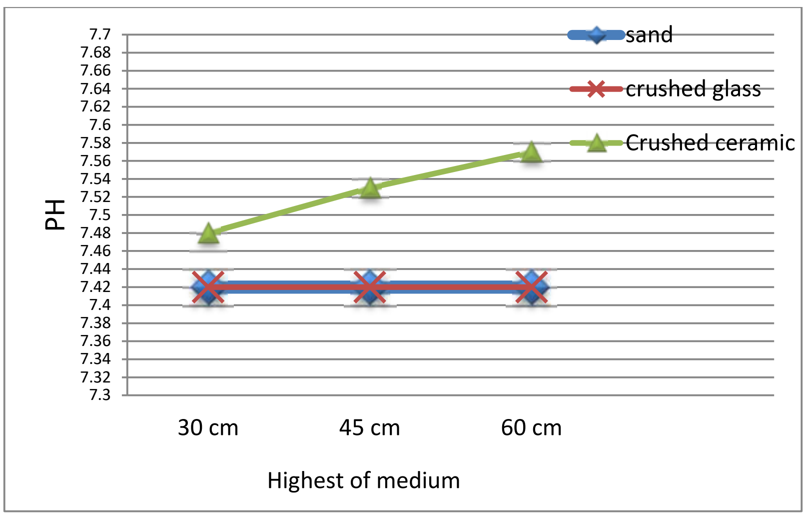


Figure (24). Values of pH of filtrated water after filtration with raw water of pH 7.42.

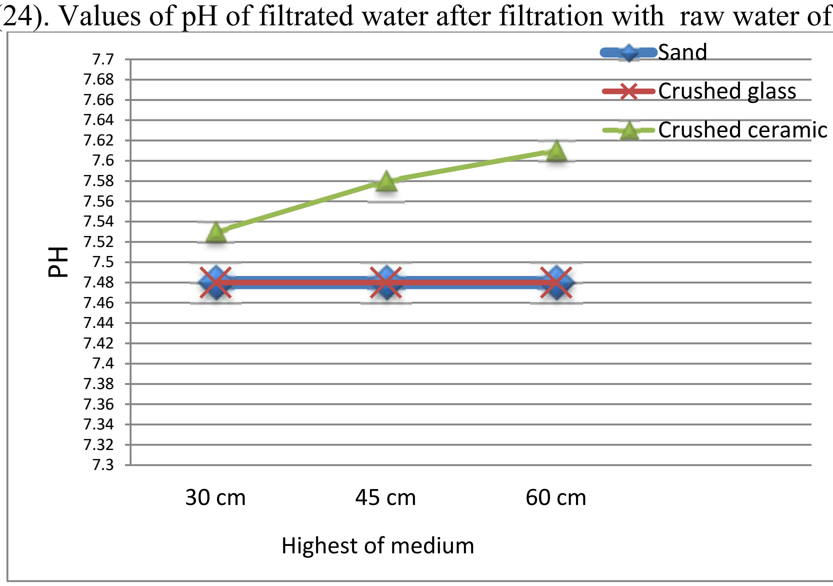


Figure (25). Values of pH of filtrated water after filtration with raw water of pH 7.48

Results of analysis of raw water and filtrated water

Table (9) showed analysis of raw water (after coagulation) feeding filter column and filtrated water using conventional sand, crushed glass and crushed ceramic as a filtration medium at feeding raw water turbidity 4.8 and height of medium 60 Cm during rate of filtration 6 $m^3/m^2/h$.

Table (9). Results of analysis of raw water and filtrated water

Analysis	Maximum allowable for drinking water	Raw water	Filtrated water		
			Sand	Crushed glass	Crushed ceramic
Silica	250 mg/L	4.2	3.9	3.8	3.5
Iron	0.3 mg/L	0.05	0.01	0.05	0.07
Aluminium	0.2 mg/L	0.18	0.13	0.15	0.18
Manganese	0.4 mg/L	UDL	UDL	UDL	UDL
Calcium	350 Mg/L	37	36	42	74
Magnesium	150 mg/L	14.4	14.4	19.8	16.4
Sodium	200 mg/L	12.6	12.8	22.3	16.8
alkalinity	500 mg/L	140	136	138	168

Conclusions

The use of crushed glass or crushed ceramic as a filter medium for rapid filters in the process of treated water has been very successful in reducing water turbidity. They have the ability to remove turbidity and provide high quality wastewater that complies with international specifications (less than 1 NTU). The turbidity value is reduced by increasing the height of the medium in the case of two media. The pH value of the filtered water using crushed glass as the filtration medium is within the allowable range than the pH value of the filtered water using crushed ceramic. The process of waste glass recycling and ceramic recycling has been successful as a water treatment component. Therefore, the process of recycling waste glass and recycling waste ceramics is an important method, and saving energy reduces acid rain, global warming, air pollution, protects the environment from waste glass and ceramics, and much more. There are advantages of. One filter consisted of recycled glass and a crushed layer of anthracite, while the other filter contained silica sand and anthracite. Both filters contained a layer of anthracite at a depth of 60 cm on top of 40 cm of glass or silica sand. The filtration rate was 5 m / h. The authors reported that glass filter turbidity removal was slightly inferior to sand filter turbidity removal. Additional testing was recommended. One explanation for the slightly inferior performance of crushed glass in their study is as follows. The effective size of sand was 0.33 mm, while the effective size of glass was 0.59 mm.

Filtration theory suggests that finer medium sizes lead to better particle removal with faster filters. In order to isolate the effects of using different types of filter media (ie glass instead of sand), it is desirable that the two media being compared are about the same size. The effective size of sand is 0.95 mm, the effective size of crushed glass is 0.96 mm, the effective size of crushed ceramic is 1.05, the filtration rate is 4, 6, 8 m2 / h, and the depth is 30 cm, 45 cm, 60 cm. was. The results showed that the turbidity removal efficiency of the crushed glass medium was higher than the turbidity removal efficiency of the crushed ceramic. The turbidity removal efficiency of crushed glass medium and sand medium is similar.

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