DEVELOPEMENT THE PERFORMANCE OF CERAMIC CANDLE FILTERS FOR WATER PURIFICATION USING LOCALLY MATERIALS

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ABSTRACT

This research presents an investigation on the technical feasibility of design and manufacturing the ceramic water candle filters made from Iraqi raw materials to improve the domestic water quality to standards suitable for human consumption in villages and country side, the performance assessment is based on its porosity, turbidity reduction, bacteria removal, ease of flow, hardness and undesired ions reduction, so number of experiments were done by mixing different percent of the raw materials of which activated kaolin clay 15 to 45 wt%,coal 15 to 40 wt%, and porcelanite 15 to 40 wt%, with same grain sizes less than 75 microns. All of these mixtures were molded under constant firing temperature and hydraulic compression pressure (1200 ^0C, and 1325 kg/cm^2). The effect of different feed percent for each material gave the optimum percent of 25%wt activated kaolin clay, 35%wt coal, 40%wt porcelanite reaching to the better tests results, number of tests also is made over the experiments range such as apparent density, porosity, wettability, turbidity, TDS, E Coli, water ions examination tests, the produced filter porosity was 62.3%, water turbidity reduced from 167 NTU to less than 5 NTU.

Keywords: Candle, Filters, Filtration, Ceramic filters.

الخلاصة :

يُقدّمُ هذا البحثِ تحقيقاً على العمليةِ التقنيةِ لتصميمِ وتصْنيعُ مرشحاتَ الماءِ الخزفيةِ الشمعيةِ والمصنعة مِنْ المواد الأوليةِ العراقيةِ لتَحسين نوعيةِ الماءِ المحليةِ إلى المقاييس المناسبةِ للإستهلاكِ البشري في القُرى والمناطق النائيه، تقييم الأداءَ للمرشحات الخزفيةِ الشمعيةِ المصنعة أستند على المسامية، تخفيض مستوى العكورةِ، إزالة البكتيريا المرضية، تحقيق سهولة في التدفقِ والجريان، تخفيض آيوناتِ العسرة والغير مرغوب فيها، أعتمد عدد من التجاربِ بخَلْط نسب مختلفةِ من المواد الأوليةِ الداخلة ومنها طينَ الكاولينِ المنشط والمفعل بنسبة وزنية تتراوح بين 15 إلى 45 %، فحم الخشب بنسبة 15 إلى 40 %، ومادة البورسيلينات من 15 إلى 40 wt %، بحجومِ حبيبية ثابتة أقل مِنْ 75 ميكرونِ. كُلّ هذه الخلطاتِ شكلت تحت درجةِ حرارةِ حرق ثابتةِ 1200 درجةِ مئوية وضغطِ هيدروليكيِ ثابت قدرة 1325 كيلوغرام / سنتيمتر مربع. ان مع أختلاف النسب المئوية تم تحديد أفضل النسب للمواد الداخلة في أستخدام الطين المفعل بنسبة 25 % ، الفحم بنسبة 35 % ، البورسيلينات بنسبة 40 % للوصِول إلى نَتائِجِ الإختباراتِ الأفضلِ، كذلك تم أجراء عدد من الفحوصات اللازمة لجميع التجارب مثل فحص الكثافةِ الظاهريةِ، فحص المسامية ، فحص الامتصاصية، فحص العكورة، فحص المواد الصلبة الذائبة الكلية، فحص البكتيريا البرازية، فحص آيوناتِ ماءِ السالبة والموجبة. كان نموذج المرشح المثالي الناتج بمساميةَ 62.3 %، أما درجة عكورةِ الماءِ فقد أنخفّضتْ مِنْ 167 إلى أقل مِنْ وحدة عكورة قياسية.

INTRODUCTION

Ceramic filtration is the use of porous ceramic to filter microbes or other contaminants from drinking water, the primary materials used in manufacturing of ceramic candle filters are clay, combustible, and siliceous materials or grog as a non plastic material used to reduced the shrinkage and control the porosity, the clay being used as a plastic when wet and hard when fired, fine Particles have a unique property of being plastic when saturated with water since their plasticity allows to form shape before firing [Dies, W.R., 2001]. Clay originates from chemical and physical weathering of igneous rocks over long period of time [Shepard, A., 1968]. The kaolin has a distinct crystalline structure that resembles platy sheets stacked on top of each other. The chemical composition consists of hydrous aluminum silicates combined with traces amounts of minimal impurities like iron which give distinct reddish color [Kenneth, L.Barbalace., 2005], the structure of kaolinite is a tetrahedral silica sheet alternating with an octahedral alumina sheet. These sheets are arranged so that the tips of the silica tetrahedrons and the adjacent layers of the octahedral sheet form a common layer, the charges within the structural unit are balanced, the molecular formula that is common for the kaolinite group is Al2Si2O5(OH)4 [Grim, R.E., 1968]. The acid activation of kaolin clay resulted in release of clay octahedral layer cations from the interstice clay structure to optimize increased surface area, porosity, surface acidity [Lambert, J.F., 1997],[Suraj, G., 1998], [Komadel, P., 2003], removal of octahedral cations (aluminum ions) lead to increase of microspore volume by creating large numbers of micro channels and increasing of surface area [Myriam, M., 1998], also the acid activation forms additional bonds by forming (OH) groups by proton attacking on the unsaturated and broken bonds that occur at the layers edges [Lambert, J.F., 1997],[Suraj, G., 1998], this mean increasing number of weakly acidic functional group at the surface [Jozefaciuk, G., 2002]. The white kaolin clay is finer than the red and black clays trend to be purer than red clays and have fine pore structure than typical red clay, the combustible materials are used to increase the porosity of filter media by creating voids within internal structure after the material has been sintered during firing [Harvey, A.R., 2003]. The third complement forming material is described as non plastic material often mixed with the clay to help control shrinkage and to avoid cracking [Shepard, A., 1968], and used as a major element in the filtration and filters industry, has a perfect adsorption efficiency with low grain size if used alone [Serry, M.A., 1979]. These materials require processing such as grinding and sieving before they can be mixed together into uniform mixture then pressed or molded into final shape, the size of these materials influence the final pore size in ceramic filters; to large particle size makes filter become to porous and fragile, too small makes the filter chalky [Potters for Peace, 2003]. The firing temperature range from 1000-3000 ^{0}C for period 2-3 hours for removing the combustible materials to create pores needed to flow the water through filter channels, ceramic filters have a variety of shapes involving hollow candle filters, disk, and pot filters [Franz, A., 2005]. The filter flow rate can be developed so for increasing without modification of filter configuration is to place three ceramic candle filters in container to increase water filtered volume twice than disk filter flow per hour [Dies, W.R., 2001]. Results from the previous studies revealed that the ceramic candle filters which were used by different countries along the world has the most effective reduction of turbidity with range (88-97)% to be considered well below the specified value 5 NTU of the world health organization (WHO) guidelines for drinking water [Franz, A., 2005],[Sagara, J., 2000], for microbial removal such as E.Coli bacteria the percent removal ranged from (92-100)% and (0.14-0.55) L/hr for flow rate. According to the world health organization guidelines the minimum necessary volume of water required for one person per day for consumption and food preparation is (7.5) Liter [Howard, G., 2004], however the flow rates were unacceptabley low at (0.2-0.3)L/hr [Low, C.S., 2002], so not all of the filters used by the world fullfill the requirements of world health organization standards.

MATERIALS AND EXPERIMENTAL METHOD

The primary materials used in this research for production and manufacturing of ceramic candle filters are an Iraqi raw materials used by the state company of geological survey of these; Kaolin, and Porecelanite all of them obtained from the western desert, besides to coal provided from local markets. The Porecelanite basically used as a skeletal chemically inactive material with grain size (-75) micron represent non plastic material used to reduce the shrinkage of filter element during firing stage and control of porosity, white Kaolin used in grain size (-75) micron at different feed percent by weight because of having a unique property of being plastic when saturated with water, since its plasticity enables from making shape before firing, it can be activated by heat or acid treatment for increasing of adsorption capacity [Essa.M.J., 2008], therefore and before materials addition it has been activated with diluted solution of 5 % hydrochloric acid and heated to 105 ^{0}C with 12 hours of contenious mixing then leaved to cool at room temperature and putted in the oven for drying, the acid treatment will substitute aluminum ions in the clay space layers structure with hydrogen ions later for draw or adsorb the water ions as hardness ions [Siddiqui,M.K.H.,1968], wood coal used as a combustible material with grain size (-75) micron to increase the porosity when it bur off during firing leaving behind voids internal pores through which water will flow, all of these feed materials were in equal uniform size to achieve the homogeneity. **Table 1.** explains the chemical composition for the inlet raw materials in manufacturing of ceramic candle filters [GCGSM, 2008]. After materials processing (grinding and sieving) into smaller grain size mixed together properly to form cohesive mixture at different percent using mixing machine, compounded in wet method using 10% wt of water from the total mixture weight [Hamilton, D., 1982] then molded using cylindrical steel mold with diameter and height (42 ,75) mm as shown in **Fig.1.** and compressed hydraulically by press machine up to 1325 kg/cm^2 to compact materials into the desired shape since filter press machine offer number of important advantages over manually pressing, the molded filters then dried to placed in drying oven subjected to temperature (110 ^{0}C) for 24 hours and fired to a high elevated temperature (1200 ^{0}C) in furnace (nabertherm) 30 to 1300 ^{0}C temperature range with heating average of 10 ^{0}C per minute and burning time (2-3) hours to avoid the sudden shrinkage that could occurred by the action of clay or even the silica.

Table 1. Raw materials chemical analysis [GCGSM, 2008].

Compound	SiO_2%	Al_2O_3%	Fe_2O_3%	CaO%	TiO_2%	MgO%	Na_2O%	K_2O%	L.O.I%
Kaolinite	47.86	33.49	1.17	0.25	2.2	0.44	0.44	0.43	12.99
Porecelanite	75.73	2.78	0.91	9.39	0.25	9.85	0.16	0.22	0.45

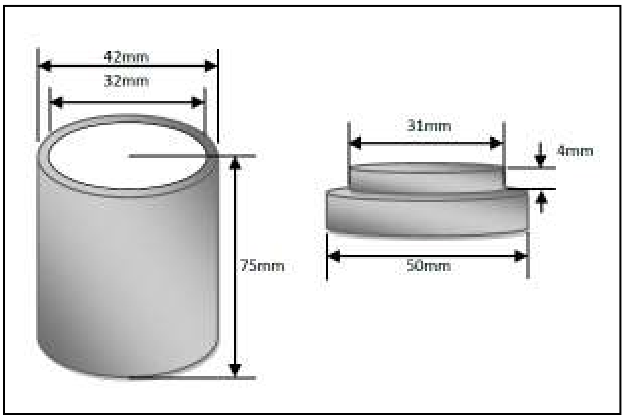

Fig.1. Candle filter mold

FILTRATION PROCESS

Fig.2. below show the general description for water filtration device which consist of water supply vessel to deliver the raw water for filtration vessel with dimension 300mm diameter and 350mm height, the three candle filters has been arranged with triangular configuration and fixed on the base with silicon adhesive material to prevent water passage through unsealed regions between the filtration vessel and candle filters since there is a hole under each filter to allow the filtrated water from flowing upon the gathering vessel and then measuring the volume of filtered water. Water level controller has installed inside the filtration vessel to achieve constant water head continuously on the filters for giving a lot of accuracy in determination of average water flow rate, the candle filters has manufactured with constant dimension for all as shown in **Fig.3.**

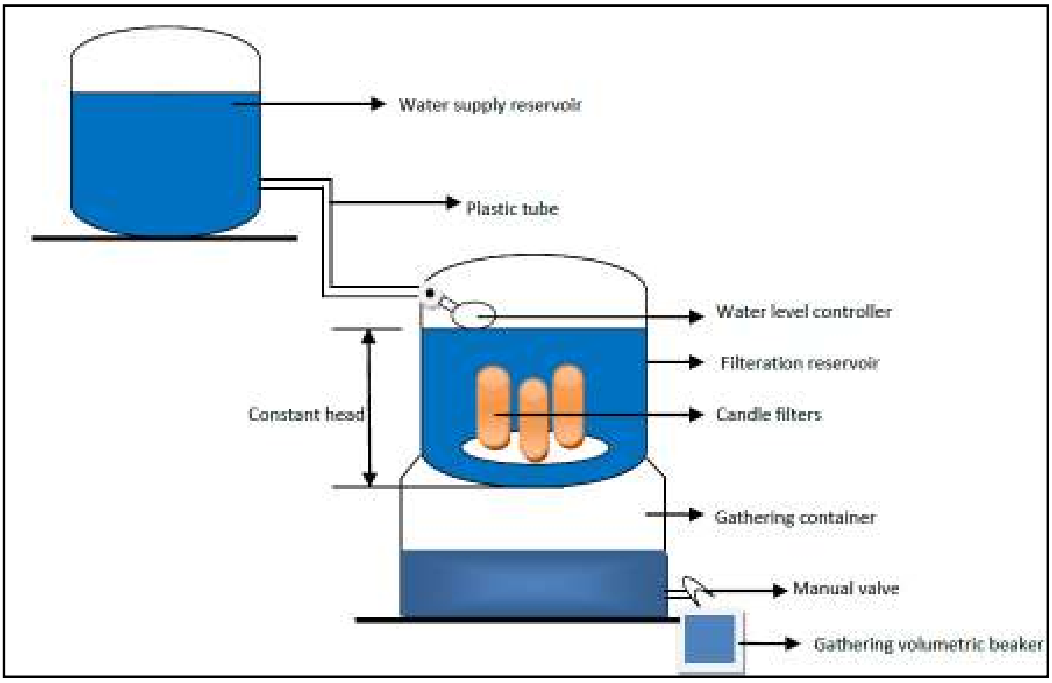

Fig. 2. Filtration process by using candle filters

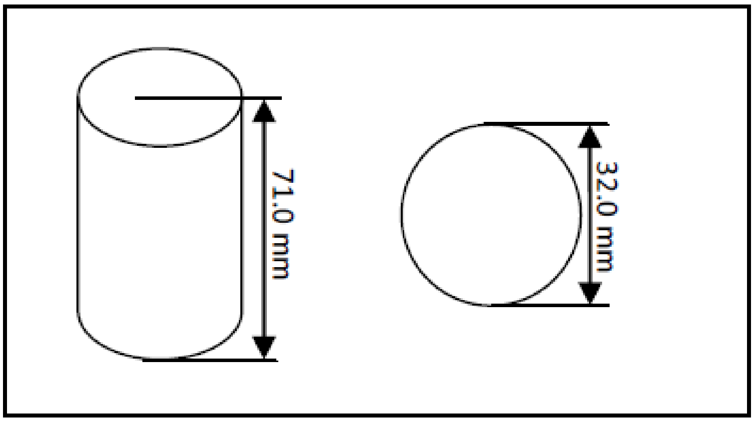

Fig. 3. Candle Filter Dimension

TESTS AND MEASURMENTS

1. Mechanical Tests:

Several mechanical tests were carried on the produced research filters using hydraulic press machine toni pact one thousands with fixation of the two main parameters of compression pressure and burning temperature each other as shown in the tables below.

Table 1.1 Show the effect of compression pressure

COAL%	ACT. KAOLINE %	PORCELANITE %	COMPRESION PRESURE (KG/CM^2)	MECHANICAL STRESS (MPa)	BURN TEMP ^{0}C
35	15	50	400	3.41	1200
35	15	50	700	7.44	1200
35	15	50	1000	9.60	1200
35	15	50	1325	13.37	1200

Table 1.2 Show the effect of burning temperature

COAL%	ACT. KAOLINE %	PORCELANITE %	BURN TEMP ^{0}C	MECHANICAL STRESS (MPa)	COMPRESION PRESURE (KG/CM^2)
35	15	50	1000	11.02	1325
35	15	50	1100	13.78	1325
35	15	50	1200	16,54	1325
35	15	50	1300	14.68	1325

2. Physical properties:

Ninety test has been implemented to measure the physical properties of all the ten produced candle filters and the average was taken for three filters of each experiments with once repitition,of these tests the apparent density, volume porosity, and wettaility or water absorption. The apparent density depend on the burnning temperature, raw materials gradient used, water content in the prepared mixture and compression pressure [Serry, M.A., 1979] and can be represented by the following equation [ASTM C373-88]:

$$\rho_a = [(m_d)/(m_{sa} - m_s)] \times \rho_w \quad (2.1)$$

The volume porosity reffered to the volume of pores or the paths that connect with each other's inside the filter body to open evantually at the external surface [Rayon, W., 1978], and it can be determined by the following equation [Doi, Y., 1980]:

$$P\ \% = V_P / V_T \times 100 \quad (2.2)$$

The pores volume (v_p) can be represented as:

$$V_P = (m_w - m_d)/\rho_w \quad (2.3)$$

The total external volume can be represented as:

$$V_T = (m_{sa} - m_s)/\rho_w \quad (2.4)$$

for the wettability (water absorption) it was determined by applying the following equation [ASTM C373-88]

$$W_a = (m_w - m_d)/(m_d) \times 100 \quad (2.5)$$

Where:
m_w = wettewd mass (g)
m_d = dry mass (g)
m_{sa} = saturated mass (g)
m_s = suspended mass (g)
ρ_w = water density (g/cm^3).

2. Water purification tests:

Several tests were examined for the ten produced candle filters in this research at the central Baghdad laboratories for water tests of which turbidity using turbidity meter (Hanna instruments HI 93703, portable) in NTU units, TDS [ASTM D5907-10], E.Coli test [Lenores, C., 1998], inorganic ions such as hardness ions calcium and magnesium [ASTM D511-09], total hardness [ASTM D1126], sulfate ion [ASTM D516-07], nitrate ion [ASTM D3867-09] and chloride ion [Belcher, R., 1957], the results compared to the raw water and the standard Iraqi specification for drinking water [The Standard Specification No.417; 2001] as shown in **Table 3.1** and **Table 3.2**.

Table 3.1 Pollutants concentrations in raw water and according to the Iraqi specification

Water quality parameter	Concentrations in untreated water	Allowable concentrations of Iraqi spesification
EC, MPN	2960	NA
TDS, mg/l	1245	1000
Turbidity, NTU	167	5
Ca^{+2}, mg/l	156	200
Mg^{+2}, mg/l	98	150
NO_3^{-1}, mg/l	6.3	45
SO_4^{-2}, mg/l	243	400
Cl^{-1}, mg/l	68	200

Table 3.2 Show the arrangement of research produced water candle filters experiments with final tests results

Candle filter no.	COAL %	ACT. KAOLINE %	PORCELANITE %	Apt. density(gm/cm^3]	POROSITY%	Wettability%	AVERAGE HR.FLOW RATE (ml/hr)	TURBIDITY (NTU)	Removal %	E.COLI MPN	Removal %	TDS (mg/L)	Removal %	Cl- (mg/L)	Removal %	Ca^+ mg/L)	Removal %	$Mg^{=2}$ (mg/L)	Removal %	T.Hardness (mg/L)	SO_4^- (mg/L)	Removal 5	NO_3^- (mg/L)	Removal %
CF1	15	45	40	1.38	49.1	42.70	275	33.5	79.94	680	77.03	405	67.47	49	27.94	27	82.69	19	80.61	145.6	74	69.55	5.1	19.05
CF2	20	40	40	1.26	51.1	48.92	350	19.2	88.50	745	74.83	310	75.10	39	42.65	24	84.61	25	74.49	138	92	62.14	4.3	31.75
CF3	25	35	40	1.18	50.8	57.54	475	28	83.23	615	79.22	390	68.67	42	38.23	31	80.13	27	72.45	188.5	67	72.43	4.6	26.98
CF4	30	30	40	1.09	54.3	68.83	540	11.1	93.35	485	83.61	245	80.32	24	64.71	39	75	36	63.27	245.5	42	82.72	2.3	63.49
CF5	35	25	40	1.05	60.90	76.84	650	4.3	97.42	280	90.54	220	82.33	17	75	34	78.20	31	68.37	212.5	49	79.83	2.6	58.73
CF6	40	20	40	0.91	78.25	87.37	745	4.6	97.24	310	89.53	285	77.11	20	70.59	42	73.08	37	62.24	257	52	78.60	3.1	50.79
Candle filter no.	**COAL %**	**ACT. KAOLINE %**	**PORCELANITE %**	**Apt. density (gm/cm^3)**	**POROSITY%**	**Wettability%**	**AVERAGE HR.FLOW RATE (ml/hr)**	**TURBIDITY (NTU)**	**Removal %**	**E.COLI MPN**	**Removal %**	**TDS (mg/L)**	**Removal %**	**Cl- mg/L)**	**Removal %**	**Ca^+ (mg/L)**	**Removal %**	**$Mg^{=2}$ (mg/L)**	**Removal %**	**T.Hardness (mg/L)**	**SO_4^- (mg/L)**	**Removal 5**	**NO_3^- (mg/L)**	**Removal %**
CF5-10%PC	35	35	30	1.10	60.2	64.92	510	10.7	93.59	580	80.40	340	72.69	34	50	31	80.13	14	85.71	135	53	78.19	3.4	46.03
CF5-5%PC	35	30	35	1.03	57.2	72.53	575	6.2	96.29	415	85.98	255	79.52	23	66.18	29	81.41	12	87.76	121.8	62	74.48	4.0	36.51
CF5	35	25	40	1.05	60.9	76.13	650	4.3	97.42	280	90.54	220	82.33	17	75	34	78.20	31	68.37	212.5	49	79.83	2.6	58.73
CF5+5%PC	35	20	45	0.98	62.3	79.25	685	1.4	99.16	200	93.24	120	90.36	15	77.94	53	66.03	37	62.24	284.6	42	82.72	1.7	73.02
CF5+10%PC	35	15	50	0.96	65.7	76.88	725	2.8	98.32	235	92.06	170	86.34	18	73.53	58	62.82	41	58.16	313.5	35	85.60	1.9	69.84

DISCUSSION

From **Figs.D1,D2.** the mechanical tests results revealed that with fixation of burning temperature at 1200 ^{0}C and varying the compression pressure between (400 to 1325) Kg/cm^2 the maximum mechanical stress was (13,37) MPa at (1325) Kg/cm^2, conversely when the burning temperature has been varied between (1000 to 1300) ^{0}C at fixed compression pressure (1325) Kg/cm^2 the maximum mechanical stress was (16,54) MPa, so from these tests results the compression pressure of (1325) Kg/cm^2 and burning temperature of (1200) ^{0}C has adopted for all the produced research filters later.

From **Table 3.2** the research ceramic candle filters tests results showed with increasing the feed filler material of coal directly in the first set reducing of the apparent density from 1.38 to 0.91(gm/cm^3) , increasing the volume porosity from 49.1 to 78.25 % and consequently the wettability to the filter product noticeably to pass the water upon the filters easily with increased the average flow rate from 275 to reach 745 (ml/hr), on the other hand as explained in the second set of **Table 3.2** for studying the effect of fixed coal feed percent with varying to the other materials it has developed one of the first set mixtures (35,25,40)% by weight of coal, kaolin, and porcelanite which gave better of average tests results, and from discussion the second set tests results explained reducing the apparent density from 1.10 to 0.96 (gm/cm^3) , increasing the volume porosity from (57.2 to 65.70) % , wettability from (64.92 to 79.25) %, and the average flow rate from 510 to reach 725 (ml/hr), so the results behavior for both set can be seen in **Figs. D3, D4.** of apparent density, **Figs.D5,D6.** of porosity and wettability, **Figs. D7,D8.** of the average flow rate .

The direct increment of coal filler feed percent in the first set lead to create large numbers of interior, interstices channels that has small enough diameter even being not uniformed distribution along the entire channel length which could open with each other's between the silica feed particles that control and organize on the degree of internal porosity, either with the second set the channels diameter will be expected to be more uniformed besides increasing the chance of existence internal adsorption surfaces because increasing silica source since porcelanite is the best type of silica form for adsorption capacity and this referred to its final mineral structure involve tridoymite and low cristobalite with perforated crystal structure to make it posses high surface area, porous, low dense, involved on vacant internal channels which draw or adsorb the ions from its solutions [Oefiler, J.H.,1973],consequently a lot of channels that has small enough diameter to achieve enhanced results such as turbidity for both set as shown in **Figs. D9, D10.**, total dissolved solids (TDS) in **Figs. D11, D12.**, E.Coli bacteria retention in **Figs. D13,D14.**, efficiently. On the other hand the average distribution of internal channels also depended on mixing efficiency with inlet materials distributions so it regards as effective parameters of increasing ions adsorption capacity.

From **Table 3.2** and as shown in **Figs. D15,D16**. for both sets the hardness ions adsorption begin to be improved and this referred to the efficiency of activated clay for hardness ions withdrawal caused by occurring number of changes at the internal clay structure of which neutralizing the negative charges of hydroxyl groups connected with silicon atoms as a result of hydrothermal treatment [Linsen,B.G.,1970],[Siddiqui,M.K.H.,1968], dehydration of water molecules connected with octahedral layer which leaves behind convenient spaces for positive ions accommodation when the filters dried by heating at elevated temperature 1200 ^{0}C, removal of cations from octahedral layers besides to the positives ions at the clay surfaces sites to be substituted with another positive ions later. Either for the partial clay efficiency for sulfate ions adsorption as explained in **Figs. D15,D16**. may referred to the remaining hydroxyl groups after acid activation that connected with silicon, aluminum atoms at the neutralized sites [Rao, S. M., 1984]. The main roll of silica addition is represented clearly by reduction of negative ions as shown for both sets in **Figs. D15,D16**. for chloride and sulfate, **Figs. D17,D18**. for nitrate ions respectively, due to the presence of excellent physical morphology as mentioned above, either for others ions such as hardness ions (Ca^{++} Mg^{+}) the porcelanite showed good ability to reduce the concentration but slightly low if it is compared with activated clay, therefore, this may referred to the decreasing of internal adsorption surfaces to the activated feed clay.

The studied filters in this present work and if they compared with the performance of these filters used by the world, then they would be closer in turbidity reduction and give more flow rate than utilized by the world in spite of ability of the latter on bacteria removal more

slightly. So from the physical point of view the tests of the ceramic candle filters in this work meet with the standards Iraqi specification and the world health organization for drinking water.

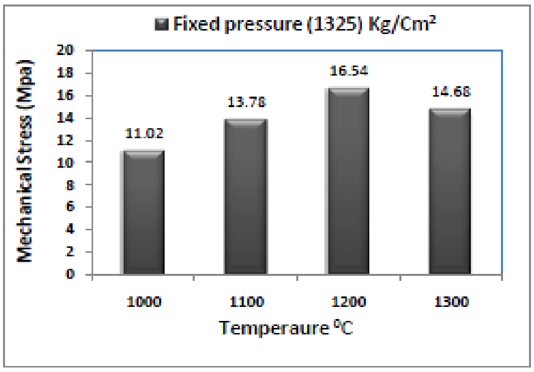

Fig.D1. The effect of filters burning temperature on the final mechanical stress.

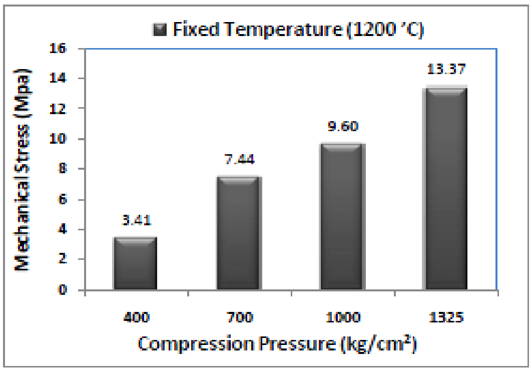

Fig.D2. The effect of filters compression pressure on the final mechanical stress.

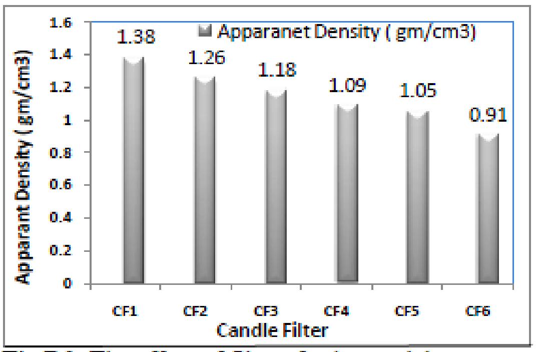

Fig.D3. The effect of filters feed materials composition on the Apparent density.

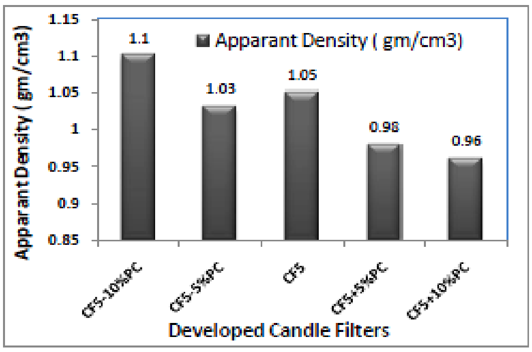

Fig.D4. The effect of filters feed materials composition on the Apparent density.

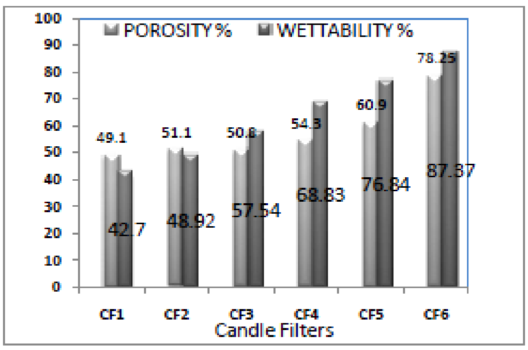

Fig.D5. The effect of filters feed materials composition on the filters physical properties.

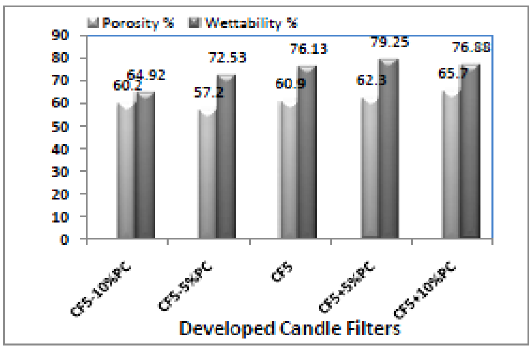

Fig.D6. The effect of filters feed materials composition on the filters physical properties.

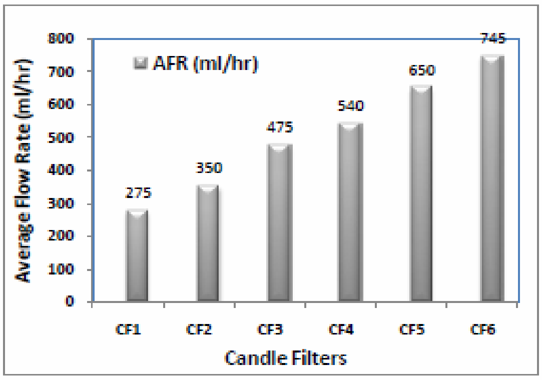

Fig.D7. The effect of filters feed materials composition on the filters water flowbility.

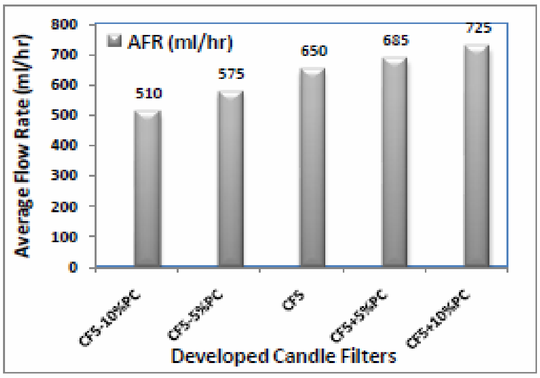

Fig.D8. The effect of filters feed materials composition on the filters water flowbility.

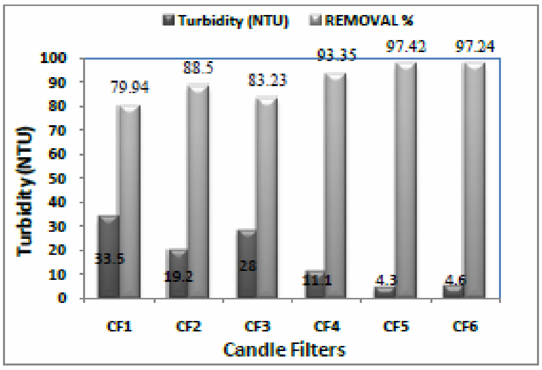

Fig.D9. The effect of filters feed materials composition on the filters turbidity.

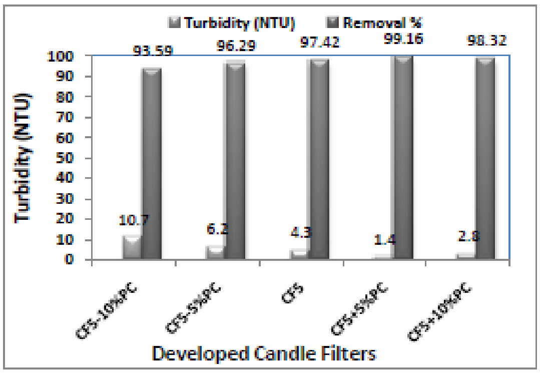

Fig.D10. The effect of filters feed materials composition on the filters turbidity.

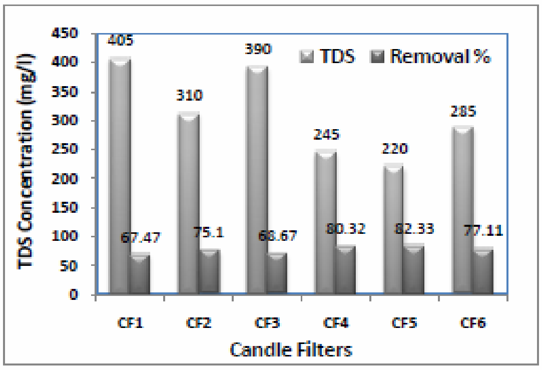

Fig.D11. The effect of filters feed materials composition on the filters water purity.

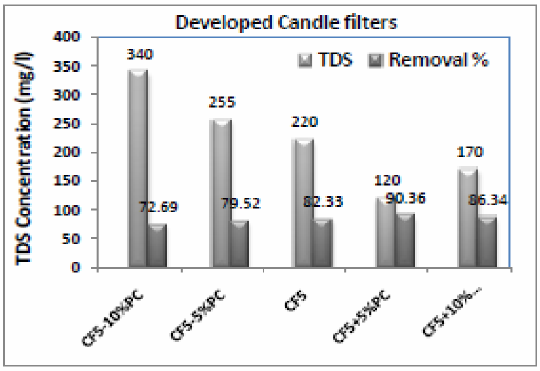

Fig.D12. The effect of filters feed materials composition on the filters water purity.

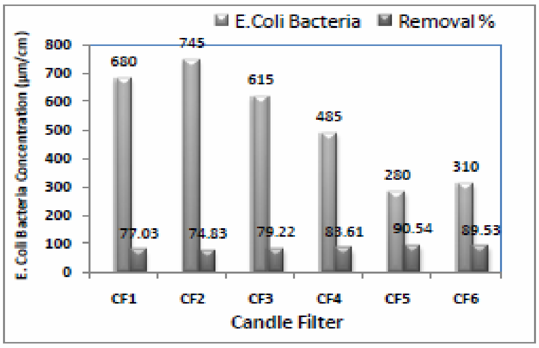

Fig.D13. The effect of filters feed materials composition on the bacteria retention efficiency.

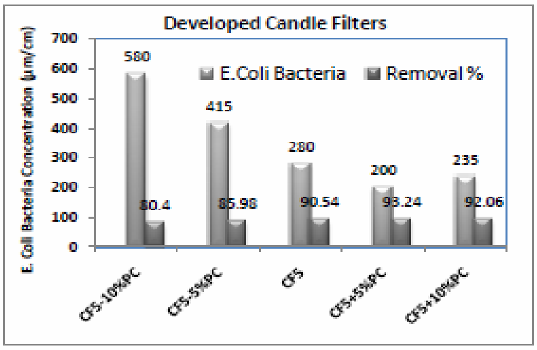

Fig.D14. The effect of filters feed materials composition on the bacteria retention efficiency.

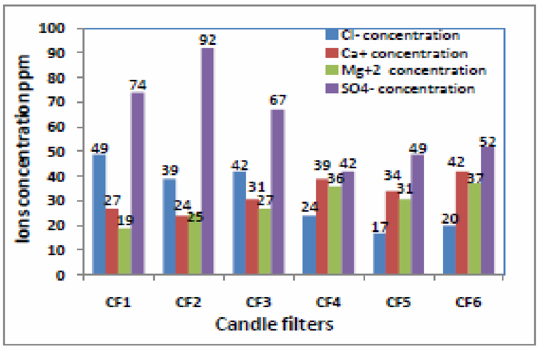

Fig.D15. The effect of filters feed materials composition on the water ions concentrations.

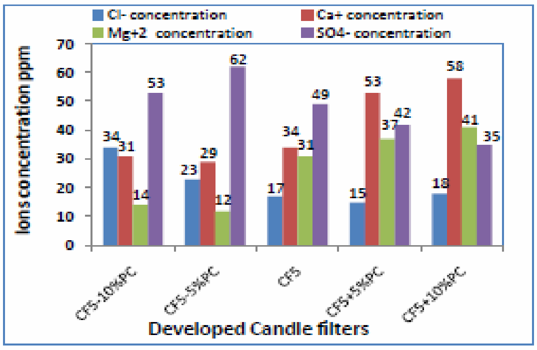

Fig.D16. The effect of filters feed materials composition on the water ions concentrations.

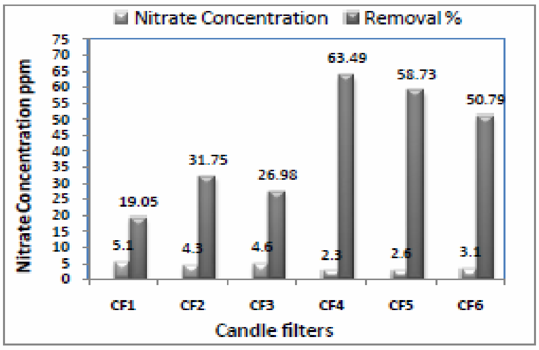

Fig.D17. The effect of filters feed materials composition on the water ions concentrations.

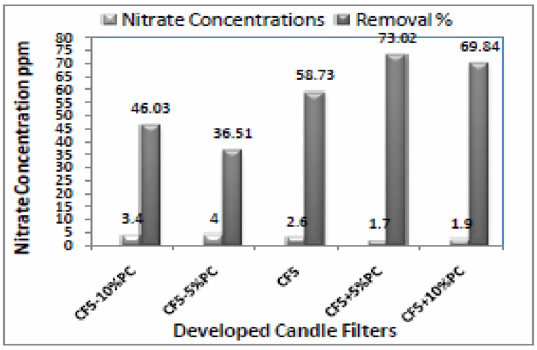

Fig.D18. The effect of filters feed materials composition on the water ions concentrations.

CONCLUSIONS

1. Coal has been used to increase the volume or apparent porosity of filter media but doesn't increase over 40 wt. % at low clay content because it lead to filter weakness and cracks at mechanical test.

2. The clay existence in the filter materials mixture resulted in little bulky shrinkage to the final product which increased with increasing of clay feed percent at fixation or even decreasing of silica feed material.
3. The increased activated clay feed percent the best the removal of hardness ions (adsorption efficiency enhancement) but on the account of water filtration difficulty.
4. It has been noticed that siliceous material (porcelanite) control on filter shrinkage average through heating stage and its increasing at fixation or decreasing to the other filter feed materials resulted in limited porosity increasing besides to the other physical properties, best performance to the ionic reduction efficiency, and crack occurs due to quartz inversion at cooling stage if the feed weight percent exceed 50 %.
5. The burning temperature ($1200C^0$) and compression pressure (1325 kg/cm^3) gave best mechanical stress at minimum clay feed percent which represent the filter ceramic material and its increments lead to more filter strengthening.
6. The best feed materials percent by which obtained on the best performance of physical properties more acceptable tests results for turbidity, TDS, E.Coli , and ions concentrations reduction is that of (coal 35%, activated kaolinite clay 25%, and porcelanite 40%) among others.

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