Preparation and Evaluation of Ceramic Materials in Wastewater Treatment

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Abstract

Prior to discharge to the environment, domestic wastewater must generally contain not greater than trace levels of various contaminants. This study was conducted touse of naturally avialable ceramic raw materials, without harmful effects on the environment or human and the wastewater brought from Al_Rustamia Location in Baghdad. The efficiency was calculated by evaluating Total Suspended Solid(TSS), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD_5), Phosphat (PO_4), and Nitrite (NO_3). The wastewater treatment done by using pellet filter , six successful manufactured media and the treatment achieved by three stages , one day, five days and ten days. The unit operation of the treatment system done by two ways aerated system with media, and the second aeration without using ceramic media where that treatment with ceramic media with aeration was better than the treatment with aeration only. The results of treatment of ceramic media with aeration show that the two mixtures gives better removal efficiency of the contimanate materials. These mixtures are mix number (3) and mix number (12).The parameters that indicates the removal efficiency for mix number (3) in the first day were (TSS 68%), ($BOD_5$76%), (COD 83%), ($PO_4$96%) and ($NO_3$94%). The mixtures number (12) was (TSS 78%), ($BOD_5$80%), (COD 96%) and ($NO_3$98%).The removal efficiency for wastewater quality parameter using aeration without media was (TSS 70%), ($BOD_5$20%), (COD 77%), ($PO_4$82%), and ($NO_3$100%). The removal for mix number (3) after five days of treatment was (TSS 86%), (BODS 91%),(COD 85%), (PO_4 94%) and for (NO_3 81%).For mix number (12) the removal efficiency was (TSS ,89%),(BOD_5 93%),(COD 85%),($PO_4$94%) and (NO_3 78%). Aeration only gives removal efficiency as (TSS 78%),(BOD_5 86%),(COD 80%),(PO_4 96%) and ($NO_3$74%). After ten days of treatment mix number (3) the removal was (TSS 80%), ($BOD_5$90%), (COD 76%), ($PO_4$96%) and ($NO_3$80%). While the results for mix number (12) was (TSS 84%), ($BOD_5$95%), (COD 81%), ($PO_4$92%) and ($NO_3$80%). The removal efficiency for wastewater quality parameters by aeration only was (TSS 69%), ($BOD_5$92%), (COD 73%), ($PO_4$68%) and ($NO_3$77%).

Keywords: Ceramic raw materials, wastewater, microorganisms, removal efficiency.

Introduction

Since water is such an important resource and there is a strong likelihood that the world will face a fresh water shortage in the near future, It must find ways to more efficiently manage our limited sources of water. One of these ways is to reuse and recycle water by purifying wastewater. To treat wastewater, many wastewater treatment facilities currently use large amounts of energy and chemicals which are harmful to the environment [1].

The health of a community and its water resources must be protected from the harmful effects of inadequately treated wastewater. These harmful effects include waterborne diseases or other illnesses and the pollution of rivers, streams, lakes, groundwater supplies, or other water bodies [2].

In the Arab contries population now exceeding 430 millions unit and total water demand is steadily increasing in most arid and semiarid area of the Arab word. Agriculture consumes in excess of 80% of available water and fresh water balance is negative which means that resources were steadily depleting [3].

The need for sufficient materials, which can be used for enviromental applications, is growing, with increasing manufactured amount of wastewater in the world. Many different technologies have been used for water purification–biological, chemical and physical. Among them adsorption on different types of materials, such as activated carbons, modified clays, zeolites, TiO_2, have been investigated all around the world. However, still the industry searching for new materials. Porous ceramic materials produced from clays show high prosity and specific surface area [4].

Ceramics represent a very wide range of materials, which differ from each other by Ceramics represent a very wide range of materials, which differ from each other by their chemical composition, structure and properties [5].

The use of clay mineral has undoubtedly become more popular and widely used as an adsorbent and ion exchange for water and wastewater treatment applications especially for removing heavy metal, organic pollutants, and nutrients. Clay minerals, such as bentonite and zeolite, are some of the potential alternatives, as they have large specific surface areas with a net negative charge, which can be electrically compensated for by inorganic and organic cations from the enviroment to polyaluminium chloride. Their sorption capabilities come from their high surface areas and exchange capacities. It is a highly effective natural clay mineral, especialy in granular form, used for the purification of wastewater and sludge dewatering [6].

Experimental part

Ceramic Media Preparation, Raw Materials and Methods

All raw materials used were brought from the Ministry of Industry and Minerals Geological Survery as rocks (White Kaolin, Porcelanite and Flint) but as powder for (Bentonite). Grinding these raw materials (the rocks) to a very fine particles was achieved by Porcelain ball mill several mixtures in different proportions were prepared from these raw materials as shown in Table (1) to be used as a physical media in the treatment of wastewater and then choose the best mix according to their physical properties. First a mixed powder was prepared from White Kaoline Clay, Flint, and Porcelanite in different proportions. Then these powders mixed with Bentonite in ratio's (70:30), (80:20), (60:40) as shown in Table (1). The sintring temperature was 1200˚C for two hours. Chemical composition of Porcelanite, Flint, White kaolin and Bentonite shown in Table (2, 3, 4 and 5) respectively.

Table (1)
Mixing ratios of raw materials.

Patch N0.	*description*	*Percentage (Wt %)*
1	*Prepared Mixture:Bentonite Porcelanite:kaoline:flint	70 :30 30: 60:10
2	Prepared Mixture:Bentonite* Porcelanite:kaoline:Flint	70 :30 10: 60:30
3	Prepared Mixture:Bentonite* Porcelanite:kaoline:Flint	80 : 20 20: 60: 20
4	Prepared Mixture:Bentonite* Porcelanite:kaoline:Flint	60 :40 20: 60: 20
5	* Prepared Mixture:Bentonite Porcelanite:kaoline:Flint	80 : 20 10: 60: 30
6	Prepared Mixture:Bentonite* Porcelanite:kaoline:Flint	60 :40 10: 60: 30
7	* Prepared Mixture:Bentonite Porcelanite:kaoline:Flint	70 :30 20: 60: 20
8	Prepared Mixture:Bentonite* Porcelanite:kaoline:Flint	80 : 20 30: 60: 10
9	Prepared Mixture:Bentonite* Porcelanite:kaoline:Flint	60 :40 30: 60: 10
10	Porcelanite:Bentonite	60 :40
11	Porcelanite:Bentonite	70 :30
12	Porcelanite:Bentonite	80 : 20

** Prepared mixture was Flint، White Kaolin, and Porcelanite with different proportions.*

Table (2)
Chemical composition of the Porcelanite.

Material	MgO %	Fe_2O_3 %	Al_2O_3 %	SiO_2 %	CaO %
Porclanite	7.2	0.87	2.71	62.02	11.55

Table (3)
Chemical composition of the Flint.

Material	TiO_2 %	Fe_2O_3 %	SiO_2 %	Al_2O_3 %
Flint	0.92	1	46	38

Table (4)
Chemical composition of the White Kaolin.

Material	Al_2O_3 %	Fe_2O_3 %	Si_2O %	TiO_2 %
Kaolin	35	1.4	48	0.92

Table (5)
Chemical composition of the Bentonite.

Material	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %	SO_3%	Na_2O%	K_2O%
Bentonite	50.05	6.26	16	7.94	3.14	0.85	1.01	0.47

Wastewater Treating System Bulit Up

Glassy system consist of a Pyrex tube with 6 holes each hole with (1cm) diameter. The hole No.1 and No.4 for return wastewater in order to increase the treatment efficiency. The hole No.2 for the aeration passage, the hole No.3 for input wastewater. The hole No.5 for sludge discharge and at last the hole No.6 for outlet the treated water. The system consist of the following items:

1-Ceramic piece for air distridution which contain hunders of holes that allow the passage of air stream through it, and one slot from the side for the air stream.

2- Electric motor provides the system with oxygen through water.

Wastewater characteristics

The prepared media (best properties samples) were used for wastewater (sewage), treatment brought from Al-Rustamia location, the treatment done over a certain periods of time (1 day, 5 days and 10 days). The Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD_5), Total Suspended Solid (TSS), Nitrite (NO_3) and Phosphate (PO_4), were detected before any treatment it order to compare these parameters values with that after treatment (only aeration and aeration with media).

Results and Discussions

Table (6) shows the concentrations of quality parameters for raw samples of wastewater.

Table (6)
Raw wastewater characteristics before treatment.

Parameters	TSS	BOD_5	COD	PO_4	NO_3
Concentration mg/l	165	180	300	30	22.4

Wastewater sample feed to the treatment system, aerated and the dissolved Oxygen concentration was controlled by D.O meter. Also the ambient should be maintained at the range of temperatures (20˚C-25˚C).The results of water quality parameters were given in mg/l concentration. After one day (24hrs) of operation these parameters becomes as shown in Table (7) below.

Table (7)
Characteristics in (mg/l) of treated water at the 1st day.

No	*TSS*	*BOD_5*	*COD*	*PO_4*	*NO_3*
3	52	42	50	1.1	1.2
4	65	45	52	4.3	1.5
5	70	60	51	2.3	2.3
8	82	62	57	2.5	3.3
11	60	50	50	1.4	1.6
12	35	35	58	1.0	0.4
Treatment by aeration	48	90	68	5.4	nil

From the first glance, it is clear from results shown in Table (7) that there is a wide range of differences, also, it is clear that media number (3) and number (12) achieved the best treatment. For example, the removal efficiency formedia No.3 was (TSS 68%), ($BOD_5$76%), (COD 83%), ($PO_4$96%) and ($NO_3$94%). While the removal efficiency for media number (12) was (TSS 78%), (BOD_5 80%), (COD 96%) and (NO_3 98%). The removal efficiency for wastewater usingaeration without media was (TSS 70%), ($BOD_5$20%), (COD 77%), ($PO_4$82%), and ($NO_3$100%). At the fifth day.

Table (8)
Characteristics in (mg/l) of treated water of the 5th day.

No	TSS	BOD_5	COD	PO_4	NO_3
3	22	16	45	1.8	4.2
4	25	18	42	2.3	4.9
5	32	20	46	2.2	5
8	27	19	46	3	5.2
11	20	14	50	1.9	4.9
12	18	12	45	1.8	4.8
Treatment by aeration	36	24	58	1.2	5.8

As shown in the previouse Table (8) the removal for media number (3) was (TSS 86%), (BOD5 91%),(COD 85%), (PO_4 94%) and for (NO_3 81%) and for mix number (12) the removal efficiency was (TSS 89%),(BOD_5 93%),(COD 85%),(PO_4 94%) and ($NO_3$78%). While for aeration only case the removal was (TSS 78%), (BOD_5 86%), (COD 80%), (PO_4 96%) and (NO_3 74%). At the tenth day (240 hrs) the removal was not differ from that at the fifth day. Table (9) shows the results of the tenth day.

Table (9)
Characteristics in (mg/l) of water after 10 th day treatments.

No	TSS	BOD_5	COD	PO_4	NH_3
3	33	18	72	1.1	4.3
4	30	19	75	3.3	4.4
5	31	22	83	3.7	5.2
8	35	20	82	2.5	4.8
11	28	19	84	2.4	3.5
12	26	8	57	2.2	3.2
Treatment by aeration	51	14	80	9.6	5.1

The removal efficiency at the tenth days results for media number (3) was (TSS 80%), ($BOD_5$90%), (COD 76%), ($PO_4$96%), ($NO_3$80%). While the results for mix No.12 was (TSS 84%), ($BOD_5$95%), (COD 81%), ($PO_4$92%), ($NO_3$80%). The removal efficiency for wastewater quality parameters using aeration without media was (TSS 69%), (BOD_5 92%), (COD 73%), (PO_4 68%), (NO_3 77%). It is appeared that the color of water and odor nominated it for domestic use but not drinking. Also that means whenever the porcelanite execeed 80% in the media it will improve the removal efficiency due to the increase in porosity and water absorption and the result of the removal efficiency of the (NO3) at the first day for the aeration was (100%) and for media with aeration was between (94% and 98% for mix number (3) and (12), thus because the ceramic media has a normal oxides and salts in its contain and that effect on the removal of Nitrite. From Table (9) for tenth day results shows that the results not differ so much between the result for treatment for the first day or the fifth day that mean the treating operation must stop at the fifth day and the discharged treated water does not has any contanite from the ceramic materials that has been used in the treatment. Figs. (1), (2), (3), (4) and (5) explain and shows the removal efficiency in TSS, BOD_5, COD, PO_4 and NO_3 respectively. Thus the media) allow to passage of water and the contaminations in the wastewater was traped in the voids.

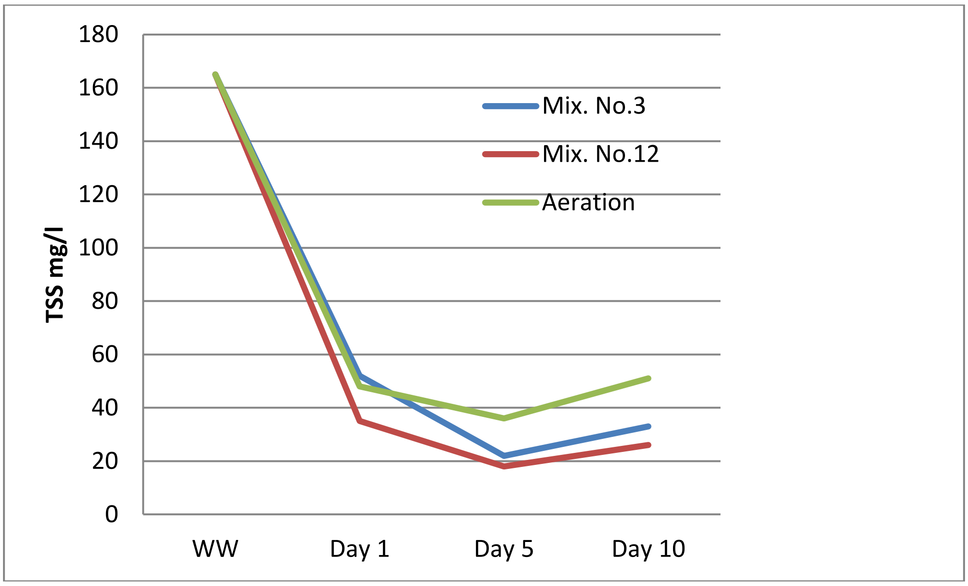

Fig. (1) Removal efficiency of TSS in days.

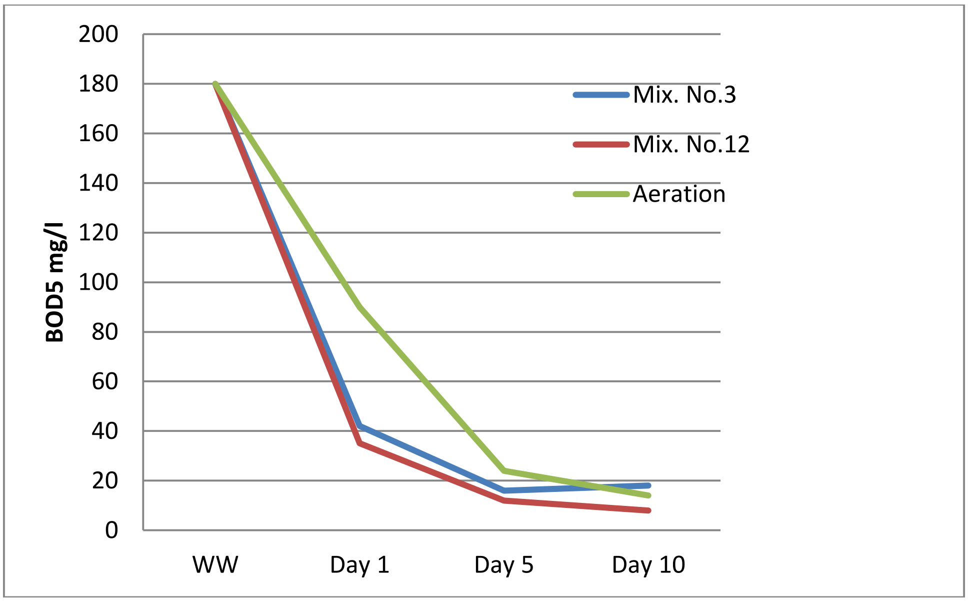

Fig. (2) Removal efficiency of BOD_5in days.

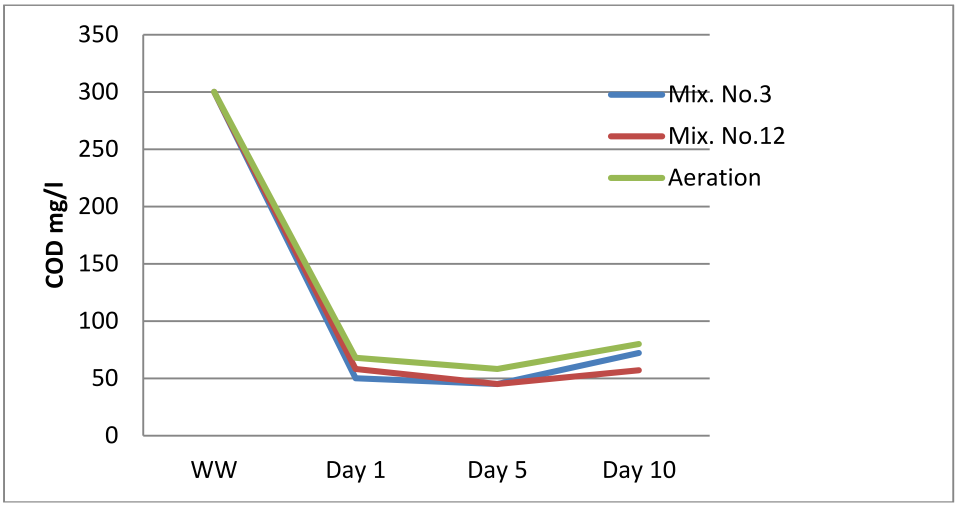

Fig. (3) Removal efficiency of CODin days.

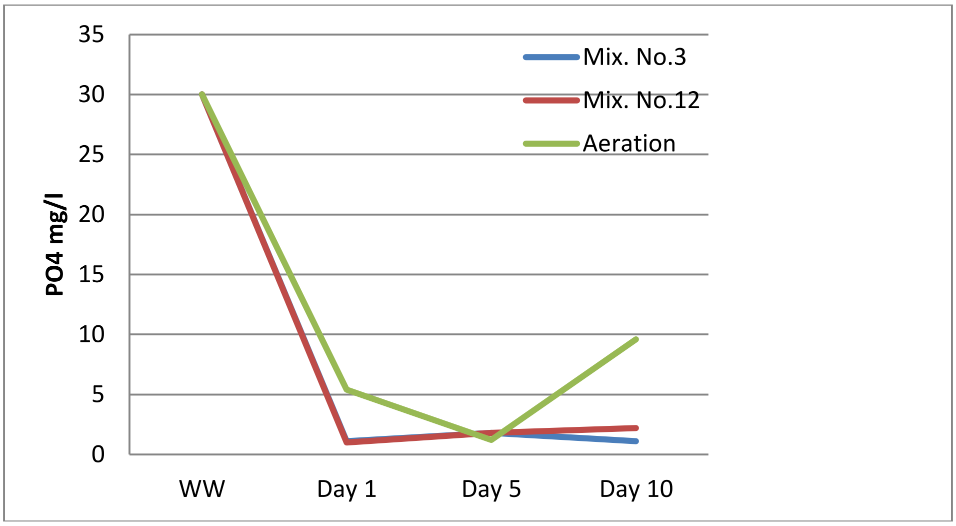

Fig. (4) Removal efficiency of PO_4 in days.

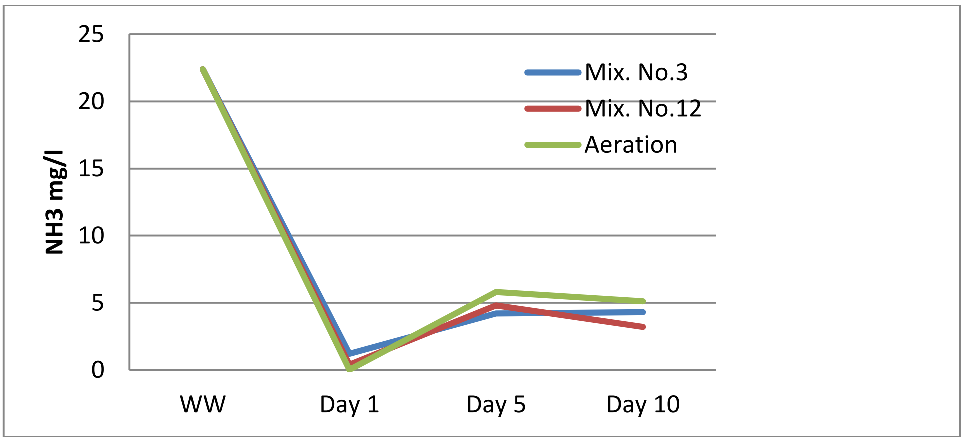

Fig. (5) Removal efficiency of NO_3in days.

The result indicates that in wastewater microorganisms need nutrients to decompose organic material operating time can lead to a large reduction of COD treat waste causing greater reduction in concentrations of COD. Similar results were also reported by Suhendrayatna et al. the decrease in BOD_5concentration for several time. After (5) days exposing to the wastewater, BOD concentration decreased to (12) mg/L due to the absorption of organic compound in wastewater by prepared media which have a best physical poperties.

Conclusions

From six mixes used only two shows success in the removal operation of treatment thus the ceramic media with aeration shows high removal efficiency in removal of the contamination that use aeration only.

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الخلاصة

سمح التقدم التكنولوجي في تحقيق نظم معالجة مياه الصرف الصحي المتقدمه قبل تصريفها الى البيئه يجب ان لايحتوي الماء على ملوثات أكبر من مستويات ضئيله مسموح بها. تعتمد هذه المعالجه على استعمال مواد طبيعيه متوفره في الطبيعه لاعتماد اعلى مستوى من الازاله بدون طرح اي مؤثرات جانبيه من هذه المواد المستعمله وهذه المواد هي مواد اوليه سيراميكيه. العمل الحالي يقدم معالجه تعتمد على استخدام مواد خام سيراميكيه متوفره بشكل طبيعي، من دون اثار ضاره على البيئه او الانسان. ان المعالجه قد تمت بأستعمال هذه الخلطات الستة حيث تمت المعالجه على ثلاث مديات زمنيه الاولى ليوم واحد والثاني لخمسة ايام والثالث على مدى عشرة ايام وذلك لغرض معرفة مدى تأثر عملية المعالجه بالتغيير الزمني كما ان عملية المعالجه للمنظومه تمت بطريقتين الطريقه الاولى بأستعمال المواد السيراميكيه مع التهويه والطريقه الثانيه بأستعمال التهويه فقط وملاحظة الفرق بينهما والافضل كفأة في ازالة الملوثات. ان نتائج المعامله بأستعمال المعالجه بالمواد السيراميكيه مع التهويه اظهرت افضل فعاليه في ازالة الملوثات ومن بين الخلطات التي استعملت اظهرت الخلطه رقم (3) والخلطه رقم (12) افضل النتائج حيث لمدى يوم واحد من المعالجه تضمنت النتائج التاليه: (TSS 68%), ($BOD_5$76%), (COD 83%), (PO_4 96%), ($NO_3$94%). بينما الخلطه رقم (12) اظهرت النتائج التاليه (TSS 78%), ($BOD_5$80%), (COD 96%), (PO4 82%), (NO_3 98%) بينما التهويه اظهرت النتائج التاليه (TSS 70%), (BOD_5 20%), (COD 77%), (PO_4 82%) (NO_3 100%). وكانت نتائج اليوم الخامس للخلطه رقم (3) كالتالي: (TSS 86%), (BOD5 91%),(COD 85%), (PO_4 94%) (NO_3 81%) بينما الخلطه رقم 12 اظهرت النتائج التاليه: (TSS 89%),(BOD_5 93%),(COD 85%), (PO_4 94%) and (NO_3 78%)). واخيرا التهويه كانت لها النتائج التاليه: (TSS 78%),(BOD_5 86%), (COD 80%),(PO_4 96%) and ($NO_3$74%) بينما المعالجه على مدى عشرة ايام وللخلطه رقم (3) اظهرت النتائج التاليه: (TSS 80%), (BOD_5 90%), (COD 76%), (PO_4 96%), (NO_3 80%) وللخلطه رقم 12 كالتالي: (TSS 84%), (BOD_5 95%), (COD 81%), (PO_4 92%), (NO_3 80%). وللتهويه كانت النتائج التاليه (TSS 69%), (BOD_5 92%), (COD 73%), (PO_4 68%) and (NO_3 77%).