Improvement of the microbiological quality of wastewater using bio-sand filter as a point-of-use water treatment technology

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ABSTRACT

This work purposes to identify the physicochemical and morphological characteristics of three different type of Ouargla sand (South of Algeria) which is dune sand, medium and coarse sand from three different region, Sidi Khouiled, Hassi sayeh and Touggourt respectively and assess its potential use for the improvement of the physicochemical and bacteriological quality of treated wastewater at Said Otba station (Ouargla, South of Algeria) as a Bio-Sand Filter (BSF).

The SEM surface imaging shows the presence of different shapes and sizes of the three types of sand grains. The EDX/XRD of the three types of sand reveals the presence of SiO_2 (α-quartz), Al_2O_3, and others oxides such as Iron, Magnesium and Calcium oxides.

According to the advanced methods which its costs are exorbitant, the results obtained in three types of optimized sand filters conditions were satisfactory, and shows that the rate of abatement for ESM, COD and BOD_5 were 92.54%, 83.72% and 85.54% respectively. The elimination of NO_3^- and NO_2^- were 97.67% and 92.06% respectively. Total germ (GT) elimination rate, total coliforms (CT) and fecal (CF), fecal streptococci (SF) percent.

KEYWORDS: Wastewater, Microbiological quality, Sand filter, Bacterial degradation.

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1. Introduction

Ouargla is an Oasis located in a basin of the Eastern Erg, located in the North-East of Algeria (5° 19' longitude East, 31°57' latitude North), about 800 km from the capital Algiers and covers an area of 163,000 km^2 [1]. Due to its flat topography and hydrogeologically endorheic receiving environment, as well as the wastewater discharge and agricultural drainage water discharge, the Ouargla region (South of Algeria) has experienced a major wastewater excess problem [2]. For protecting the environment and recusing these wastewaters safely in agriculture, these wastewaters must be treated. In agriculture, the price of irrigation rises as agricultural area grows and the height cost of wastewater treatment cause many obstructions [3,4]. The research of a low price and acceptable yield for this process is necessary.

Many researchers have been used sand for water and wastewater treatment [5-8]. This method has been used since 1900 and is now widely used in the treatment of municipal wastewater [9]. Sand filters come in a variety of sizes, from very large municipal water treatment tanks or boxes to small portable vessels used in swimming pools. Water passes through a thick layer of sand or other particle material in open sand filters by gravity [10].

Our investigation is looking into wastewater treatment at the Said Otba station by using three types of Ouargla treated sand from three different regions, Sidi Khouiled, Touggourt and Hassi sayeh. The use of a local material (free cost), such as sand from the dunes, as a biological filter is a promising technique for the treatment of wastewater in southern Algeria as the previous studies shows [11, 12]. The three sand types were physiochemically and morphological characterized. This physical and chemical characterization took into account mean diameter, vacuum index, porosity, and permeability. In addition to pH and salts, the carbonate contents of these sands were determined to characterize it chemically. For that, international standards, scanning electron microscopy (SEM), energy dispersive X-Ray analysis (EDX), X-ray diffraction analysis (XRD) are used at this stage. pH, conductivity, chemical oxygen demand (COD) by colorimetric method, biological oxygen demand (BOD_5), and suspended solids (SS) by filtration method. Nitrate and nitrite testing was performed in all feeding tanks to ensure proper bacteriological quality of the treated water.

2. Materials and methods

2.1 Sampling and analytical methods

The untreated sand specimens for this research were obtained from the three different regions from Ouargla, Algeria (Sidi Khouiled, Touggourt and Hassi sayeh). They were given to the laboratory in 10L plastic boxes, stored at laboratory temperature (24, ±3°C) and far from all chemical products. The wastewater samples were collected from Said Otba discharge effluent in Ouargla, south of Algeria. They were collected in 5 L glass containers and transmitted to the laboratory. They were saved at a temperature below 05±3 °C.

The sand and the wastewater analyses before and after treatment were carried out in compliance with Water and Wastewater Examination Standard Methods.

2.2 Sand treatment on laboratory scale

Three sands samples of different particle sizes were washed many times with distillated water until the wastewater became clean, then dried at 105°C for 24 hours. This objective treatment is to reach the optimum sands quality without any impurities for use it in this research. This sand has been classified in three types based on particle size; coarse sand (C: particle size 4.75 mm -2 mm), medium sand (M: particle size 2 mm - 0.425 mm) and fine sand (F: particle size 0.425 mm - 0.075 mm), using the NFP 49-056 standard method [13].

2.3 Experimental device

Experimental device (Fig. 1) consists of a PVC column with 110 mm in diameter and 150 cm in height. The effective height of the filter bed (HS) varies between 20, 40, 60,80, 100 and 120 cm, it has been used for filtered water (HE) which is kept constant throughout the experiments in order to keep the same hydraulic load on the sand.

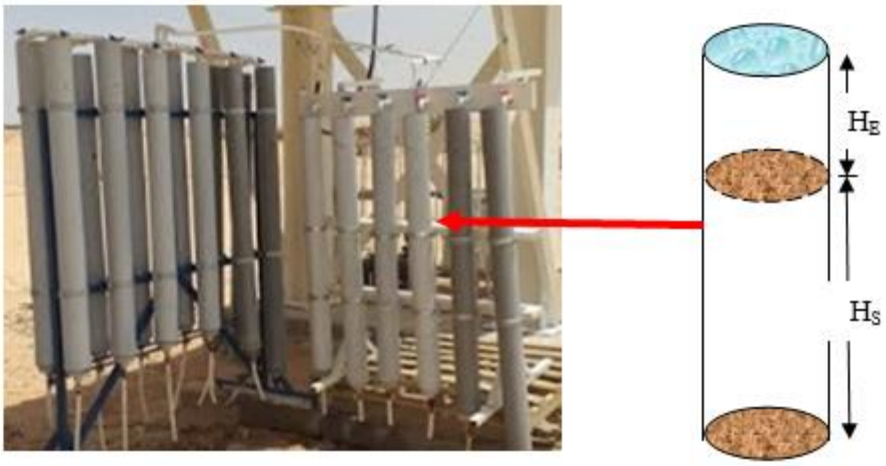


Fig .1: Experimental setup

3. Results and discussion

3.1 Sand and wastewater characterization

3.1.1 Sampling and characterization of Said Otba station effluent

The pH/Temperature of the Said Otba samples wastewater was determined by using a pH 3401 pH meter from WTW company, COD and BDO_5 were determined using a HACH and WTW instruments respectively, nitrate and nitrite were measured using a HACH DR̄ 2800 Spectrophotometer, Total coliforms and E. coli were calculated using the standard membrane filtration method as mentioned in Standard Methods [14]. Total suspended solids (SS) were calculated using a filtration system fitted with a vacuum aspirator through sterile 0.45 mm filters (standard). The results are presented in Table 1

Table 1: Physicochemical and biological characterization of Said Otba station effluent

	DCO (mgO_2/l)	DBO5 (mgO2/l)	TSS (mg/l)	NO_2^- (mg/l)	NO_3^- (mg/l)	pH	T (°C)	EC (ms/cm)	Total coliforms (N/100ml)	Fecal coliforms	E.Coli (cfu/100m)
est method	ISO 6060	ISO 5815	ISO 11923	ISO 13395		ISO 10532		ISO 7888	ISO 9308		
alues	118	48.5	268	0.52	11	7.89	24	12.43	1400000	460000	4600
imited alue	120	35	35	3.0	50	6.5<pH<8.5	30	0.7	400	1000	126
ef.	[15]			[16]			[15]	[17]	[18]	[16]	[19]

3.1.2 Physical parameters of sand

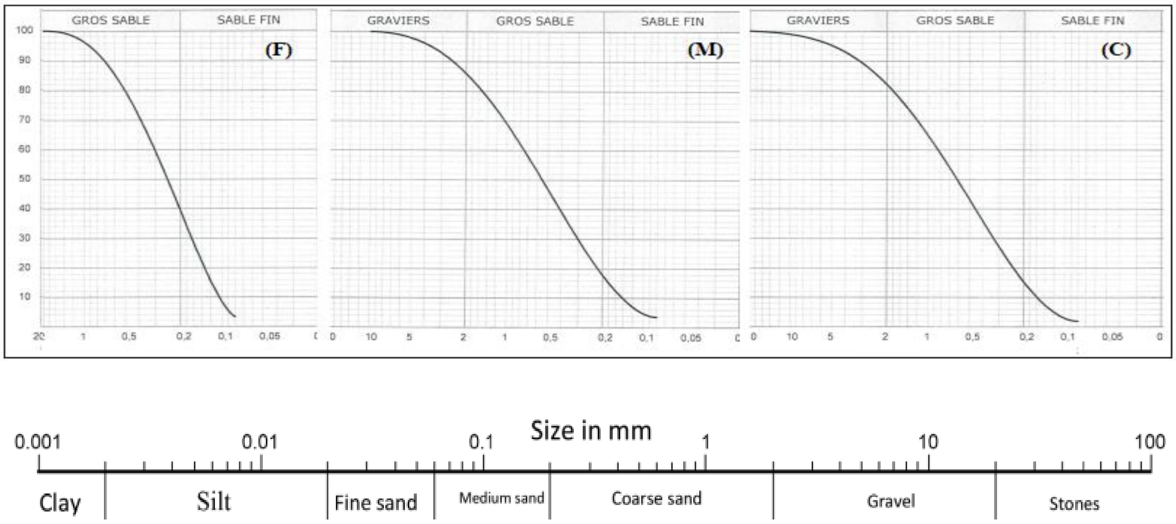


Fig. 2: Granulometric analysis of the three types of Sand (F: fine, M: medium, C: coarse) (cumulative) and the distribution of grain size of soil carried out according to NF P18-560 and NF P 94-57 standard [20].

Figure 2 shows the granulometric curves of the three types of sands resulting from the granulometric adjustment where the sands passing through sieve columns, this adjustment was established by the standard method NF P 18-560 [20, 21].

As depicted, for the dune sand (Sidi Khouiled sand), 40% of the sample were a fine sand, while only 60% of the sample were a coarse sand. For Touggourt and Hassi sayeh sand, 17 and 15% of the sample were a fine sand, 69 and 67% of the sample were a coarse sand and 14, 18% were a gravel sand respectively.

Through the particle size curve, we have drawn the values, which are presented in the following table (**Table 2)** where UC is the uniformity coefficient which calculated as the rapport between D_{60} and D_{10}, D_{10} and D_{60} represent the size fractions finer than 10%, and 60%, respectively [22, 23]. The results shows that the three types of sand belong to the category of fine sand, medium sand and coarse sand. This is well confirmed by their permeability, 0.41 for fine sand, 0.43 for medium sand and 0.051 (m/s) for coarse sand, as well as the particle size results.

Table 2: Physical parameters of sand

Type of sand	D_{10}	D_{60}	UC	Permeability K (m/s)	Porosity n	Vacuum index e
Fine sand	0.125	0.275	2.21	0.019	0.41	0.7
Medium sand	0.175	0.580	3.14	0.035	0.43	0.65
Coarse sand	0.180	0.750	4.16	0.051	0.45	0.53

3.1.3 Chemical parameters of sand

The table 3 shows the values of the chemical and mineral parameters of the three types of sand used on this study. Is shows that the salt is a medium basic and the values of salts are very low, these results indicate that all three types of sand do not contain a height concentration of salts and calcites ($CaCO_3$).

Table 3: Values of the chemical parameters of our sands

Type of sand	pH	Salts %	$CaCO_3$ %
Fine sand	8.0	0.290	0.240
Medium Sand	8.6	0.020	0.150
Coarse sand	8.63	0.010	2. 470

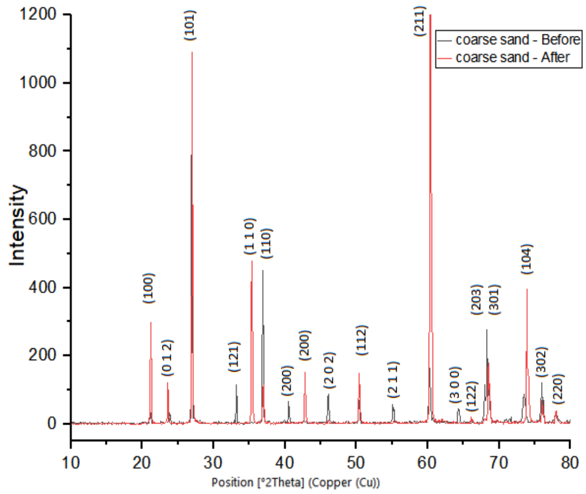
Chemical and mineralogical analyses indicate that all three sand samples do not contain salts.

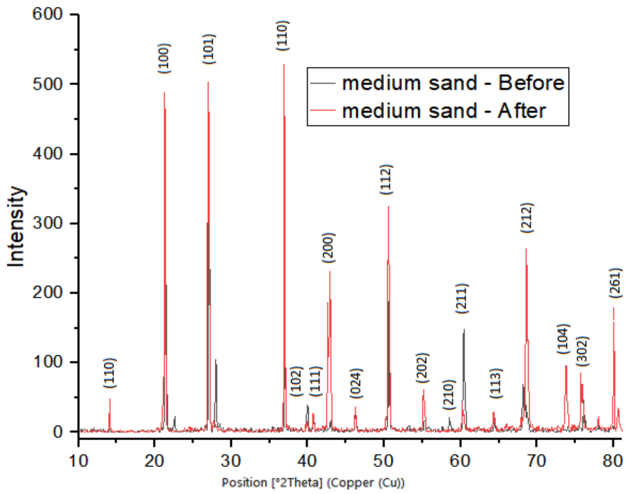
3.1.4 Mineralogy analysis

The three types of sand phase identification were carried out with the help of a PROTO BENCHTOP X-ray diffractometer that uses Cu-Kα radiation. The X-ray generator was set to 40 kV and 30 mA, and all scans were performed at a rate of 2° per minute, ranging from 10° to 80°, with a continuous scale factor of 0.02.

X-Ray Diffraction analysis, displaying the constituent phases of the fine, medium and coarse sand before and after wastewater treatment tests are shown against Figs. 1, 2, and 3 respectively.

As the figures shown, the three types of sand samples have a high crystalline character, as seen by the strong peaks of the diffraction patterns [24]. The peaks values for the three types of sand are nearly the same composition and for deducing the crystal structures in multiphasic materials we used the X'pert HighScore Plus software and Match! software V3.15 for XRD analysis.





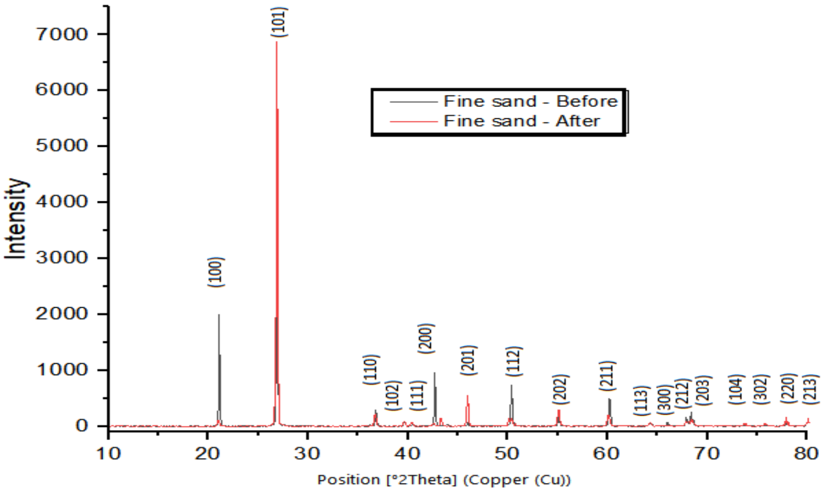


Fig. 3. The representative XRD pattern of the three types of sand samples.

The most intense peak for these samples of sand was in 2θ = 26.50~27° and represent the (101) orientation, indicating that orientation is the preferred orientation of α-quartz (SiO_2) mineral with a hexagonal crystalline structure in these types of sand patterns [25], also the presence of peaks at 2θ = 50.5~51° where represent the (112) orientation confirmed the presence of α-quartz [24]. This result confirms the increased crystallinity of the samples, similar to that found by previous research [26-28]. Other observed peaks as shown in the diffractogram with their orientations (hkl) illustrate the presence of other menials such as the calcite mineral ($CaCO_3$), Berlinite, Bazzite, Barrosite, monoclinic, iron oxyde, periclase, Albite mineral and gypsum ($CaSO_4 2(H_2O)$). These results are agreed with the reults obtin by Hadjadj et Naouia [27, 29].

3.1.5 SEM and EDX analysis

The Surface morphology of the three types of sand before and after tests, shown in Figs. 4 and 5, show that the medium and coarse sand grains are not uniform in shape, with noticeable surface abrasive particles. Fine grains of sand, on the other hand, have a spherical and rounder shape, which distinguishes dune erosion and deposition grain sand [13, 30-31]. These figures shown some pores or cavities in their surfaces which dictate the surface of three types of sand is heterogeneous and can act as a bio-adsorbent of may type of pollutants [32]. The Energy Dispersive X-ray Spectroscopy (EDX) results showings the same chemical elements contained in the three types of sands (before and after tests) where the samples reveal a high content of silicon and oxygen that represent the SiO_2, with the lower content of Aluminum, Magnesium, Potassium and iron. The results of the EDX confirm the results given by XRD of the presence quartz mineral in the three sand samples [24]. The results are illustrated in Table 4 and fig.6.

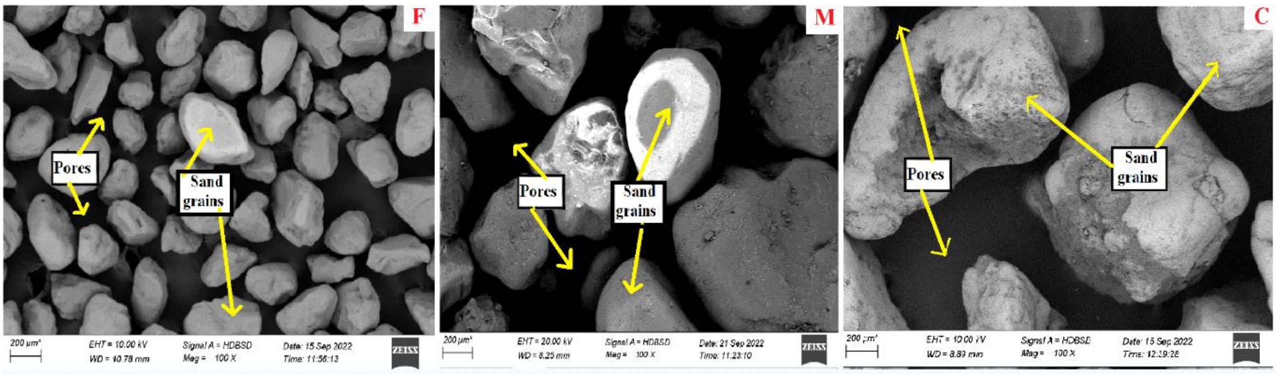


Fig.4 – (F, fine; M, medium; C, coarse) SEM image of the used sand particles on this work before tests.

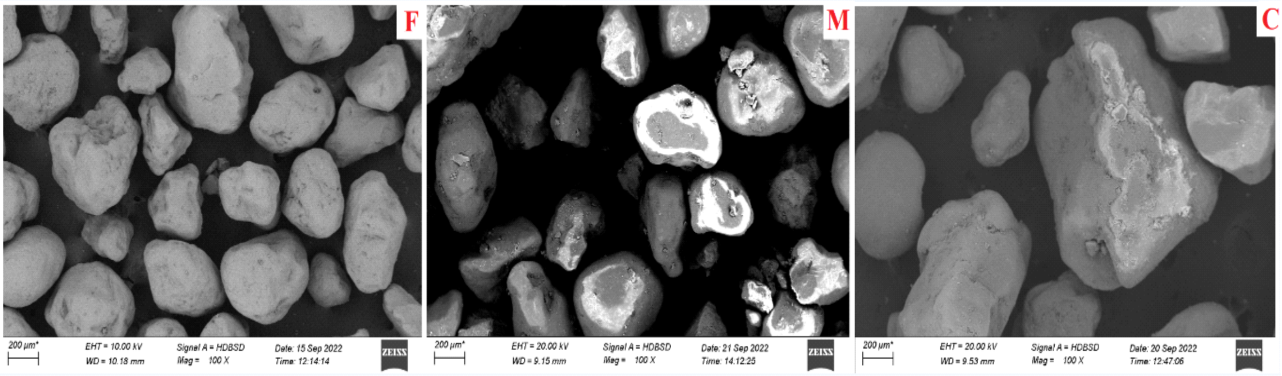


Fig.5 – (F, fine; M, medium; C, coarse) SEM image of the used sand particles on this work after tests.

Table 4 The elemental composition of the three type of sand

Sand Elements	Fine sand (Weight %)		Medium sand (Weight %)		Coarse sand (Weight %)	
	Before	After	Before	After	Before	After
Oxygen	70.29	57.19	61.36	61.32	69.97	47.07
Magnesium	2.20	1.57	1.17	1.86	1.46	1.19
Aluminum	1.24	11.44	5.34	5.90	4.07	16.27
Silicon	23.33	20.88	25.48	25.42	21.80	24.71
Calcium	2.56	3.13	3.76	3.06	1.45	6.70
Potassium	0.08	0.63	1.25	.62	0.30	1.20
Iron	0.31	5.17	1.64	1.83	0.94	2.96

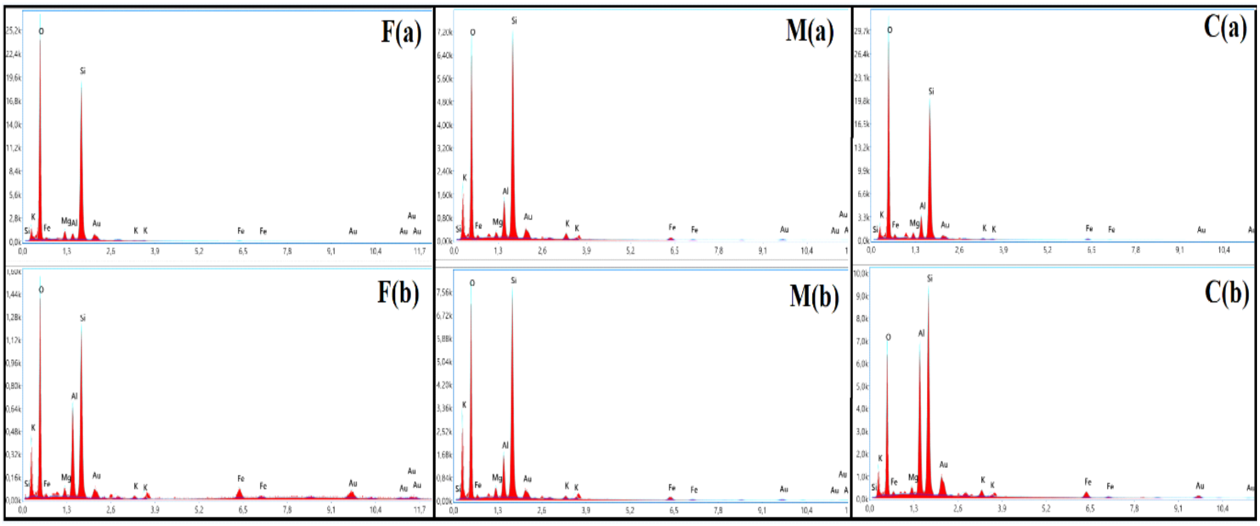


Fig.6 - (F, fine; M, medium; C, coarse) EDX spectrum of the used sand particles on this work before (b) and after (a) tests.

3.2 Analysis of experimental results

3.2.1 Effect of the sand types and its thickness on the inflow discharge

The effect of the sand type and its thickness on the inflow discharge and the filtration speed has been investigated. The figures 7.a and 7.b show the relevance between sand thickness and the filtration rate and the inflow discharge respectively, for the three sand types. The thickness of the sands was evaluated with six values (0.2, 0.4, 0.6 ,0.8, 1.0 and 1.2m) to choose the best yield,

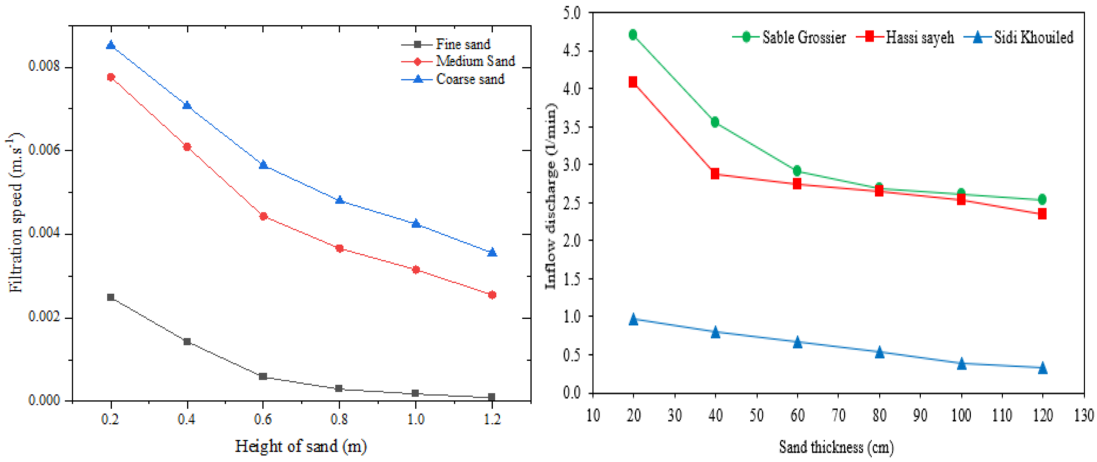


Fig. 7: Relevance between sand thickness and the flow Rate (A) and inflow discharge (B).

The results shows that the inflow discharge reduces as the sand thickness increases and the addition of the input flow rate (wastewater volume) or thick sand (20-120 cm) will influence the filtration processes and the outflow discharge [23]. As the fig.7.a illustrated, Touggourt an Hassi sayeh sands inflow discharge decreased and then it remained approximately constant at 60 cm of sand thickness. Sidi khouiled sand has a lower permeability and porosity, compared with Touggourt an Hassi sayeh sands and shows the lower inflow discharge.

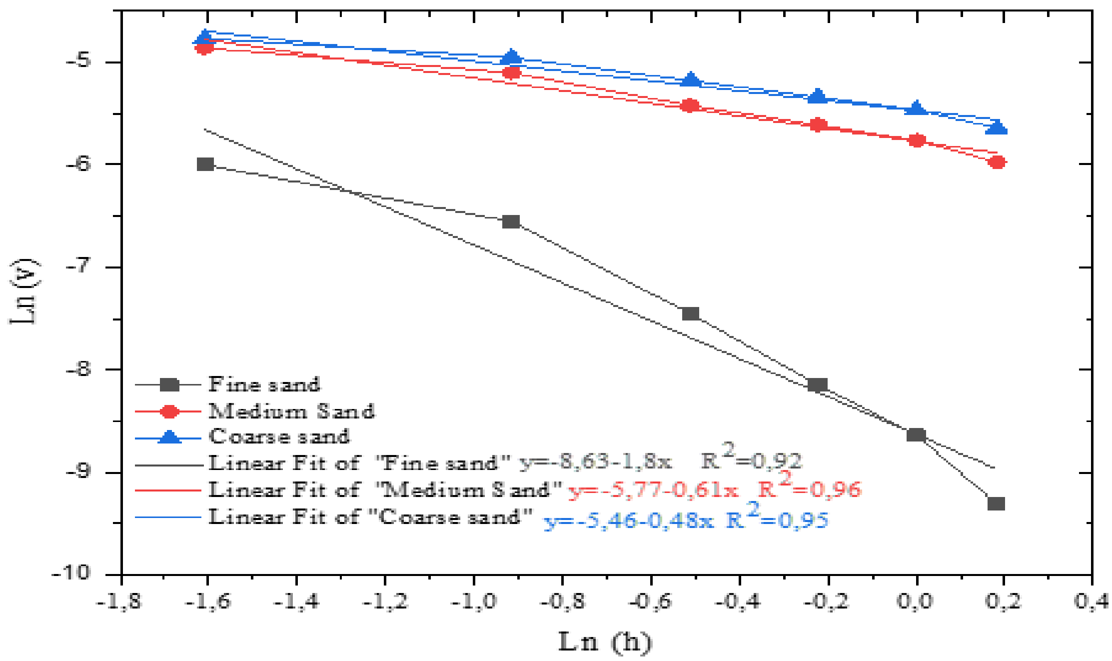


Fig.8 Variation of filtration speed depending on the height of sand / Ln (filtration speed) = f (Ln (sand thickness))

The adjustment of the experimental measurements showed that the variation of the ratio (v) as a function of the thickness of the sand layer follows a power law of the form:

$$v = a\, h^{-b} \quad (1)$$

$$\ln v = \ln a - b \ln h \quad (2)$$

The table (3) represents the values of parameters “a” and “b” of equation (2)

Table 5: The values of the parameters 'a' and 'b' for three types of sand.

Type of sand	K (cm/s)	has	b	R^2
Fine sand	0.018	0.016	0.514	0.92
Medium Sand	0.035	0.311	1.566	0.96
Coarse sand	0.051	0.421	1.990	0.95

3.2.2 Effect of the sand types and its thickness on the temperature and the pH in the filtration processes

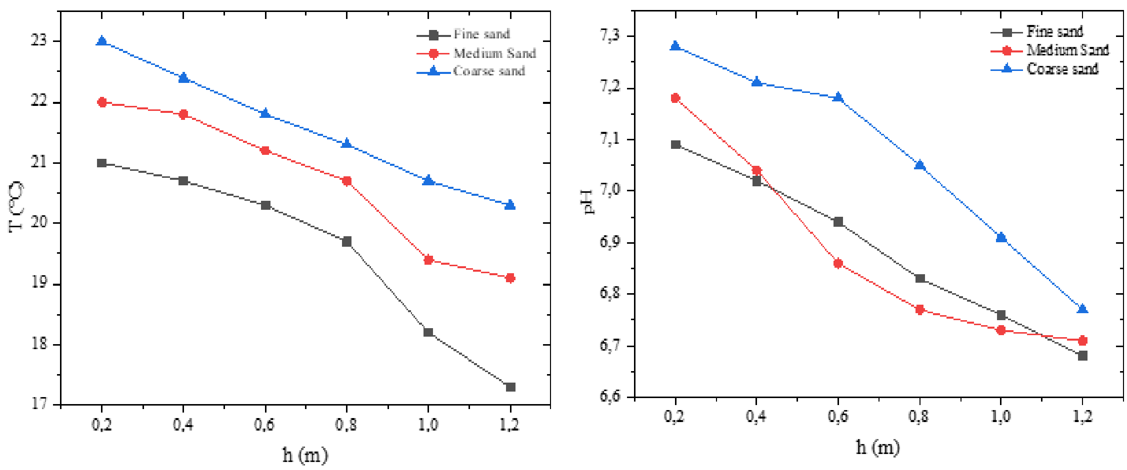


Fig. 9: The effect of sand thickness on the temperature and pH in the filtration processes.

There are several things that have an impact on biological treatment of wastewater, but temperature is the main one. Unfortunately, despite the fact that numerous research has produced a wealth of data regarding biological treatment of wastewater, they have not specifically examined how temperature affects biological treatment [33]. The wastewater matrix and medium surface properties may alter as a result of pH changes in the wastewater, which could have an impact on aggregation and deposition during the wastewater filtration process. So, the safe release or reuse of wastewater requires the provision of an acidic or basic treatment system [34, 35]. Given the part it plays in the solubility of gases, the dissociation of dissolved beneath salts, sedimentation, influence the chemical and biochemical reactions and the corrosion in pipes of sewage treatment plants, for that calculation of pH, it's a crucial.

Starting from temperature of 24°C, the temperature values of the different samples are decreased by 1, 2 and 3°C for Touggourt, Hassi sayeh and Sidi Khouiled sand respectively at 0.2m and decreased by 3.7, 5.1 and 6.83°C for Touggourt, Hassi sayeh and Sidi Khouiled sand respectively at 1.2m. As a result, the discharge of wastewater into the wild are safe and it is in the optimum temperature range of sewage 15–25°C [36].

The pH parameter values for the three types of sand decreased from pH= 7.89 and revolve around a pH standard of 7±0.3, as shown in figure 9. Therefore, all filter pH values satisfy WHO quality criteria. These circumstances show that wastewater's pH quality level is steady and healthy [37].

3.2.3 Effect of sands filter types and its thickness on COD Removal

Chemical oxygen demand (COD) is a parameter that is frequently used to quantify the level of pollution brought on by contaminants while evaluating water contamination. The COD is a calculation that determines how much oxygen is needed to oxidize the organic substances in wastewater as well as how much oxygen is used by organic matters in boiling acid potassium dichromate solution. COD is a metric for measuring the biological activity of compounds in water, including bacteria, as well as the quantity of biologically inert organic materials in the water [38, 39]. The COD in the wastewater of Said Otba station was slightly high, 118 mg O_2/L and the value should be less than 90 mg O_2/L.

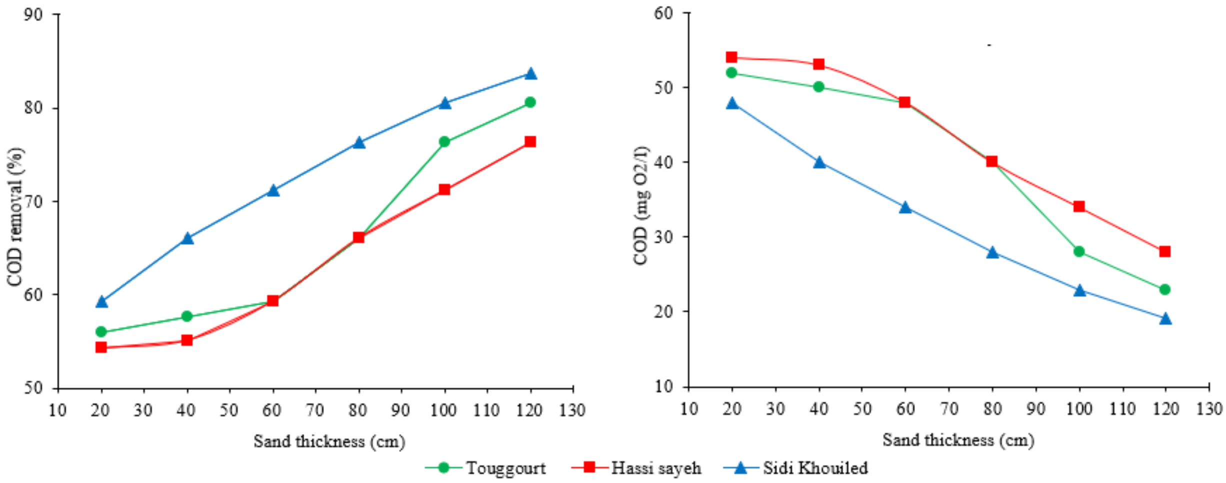


Fig .10: Variation of COD concentration and its removal (%) as a function of the Sand thickness

Fig. 10 shows the COD concentration and its removal (%). The results shows that the removal (%) of COD increase with the increasing of the sand thickness for the three types of sand. The sand filter system achieved a maximum COD removal efficiency of 80.51, 76.27 and 83.90, for Touggourt, Hassi sayeh and Sidi Khouiled sand respectively.

The decrease in COD concentration (increasing in its removal (%)) could be attributed to suspended solids filtration. This may also be attributable to the biological layer maturing in the sand medium. Antiseptic bacteria (microbial degradation) become well established after the development of this layer and play a crucial role in the biological treatment during filtering [40, 41].

3.2.4 Effect of sands filter types and its thickness on BOD Removal

The quantity of dissolved oxygen required (i.e., demanded) by aerobic biological organisms to decompose the organic substances present in a given sample of water at a specified temperature during a specific timespan is known as the biochemical (biological) oxygen demand. BOD is a water pollution index which makes it possible to evaluate the biodegradable fraction of the carbonaceous polluting load of wastewater. The technique is based on measuring the amount of dissolved oxygen before and after samples are incubated for a certain period of time which it is generally 5 days (we then speak of BOD_5) at a set temperature (20°C). The mass of oxygen per unit volume (mg/L) is used to describe the net change in oxygen concentration [42, 43]. In our work, the measuring of BOD_5 for the Said Otba wastewater on the three types of sand filter with different sand thickness was obtained by using OxiTop IS6, WTW, Weilheim from Germany.

Fig.11 represents the evolution of the BOD_5 concentration and its removal % as a function of sand type and its thickness. The BOD_5 of the Said Otba wastewater was 48.5 mg O_2/L and the value should be less than 30 mg O_2/L. After the Said Otba wastewater passing throw the three sand types, the measuring of the BOD_5 shows that with the increasing of the sand thickness, the removal increases and the results obtained indicated an important improvement, at 83.51, 77.32 and 85.57%, for Touggourt, Hassi sayeh and Sidi Khouiled sand respectively in removal by the three types of sand filter at 120 cm of thickness. These results could be explained by that at the long with the collected filtrate, pollutants that affect BOD concentration are washed away [44]. The decrease in BOD could also be related to aerobic heterotrophic bacteria. These organisms employ oxygen as an electron acceptor (aerobic) and organic substances as both a carbon source and an electron giver (heterotroph) [45].

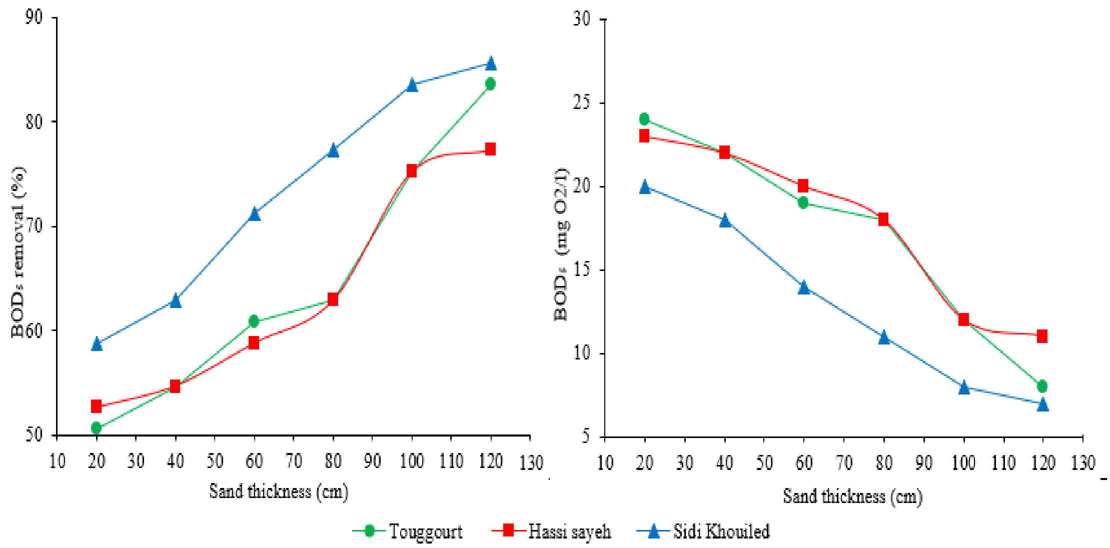


Fig .11: Variation of BOD_5 concentration and its removal (%) as a function of the Sand thickness

3.2.5 Effect of sands filter types and its thickness on Total Suspended Solids Removal

Total suspended solids (TSS) are known as solid particles in water that are able to trapped by a filter. Sand filters are frequently used in water treatment and remove suspended matter through diverse mechanism [41, 46]. Our investigation into this part of the research was about the effect of the type and thickness of sand on reducing TSS by throwing wastewater through the three types of sand mentioned above.

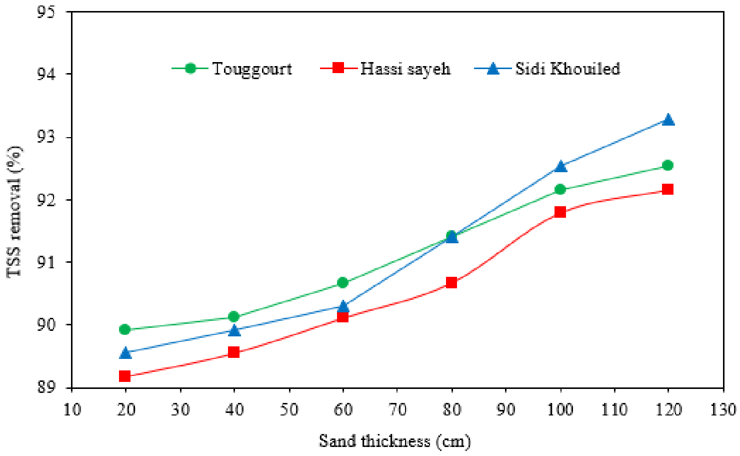


Fig. 12: Removal of TSS as a function of sand thickness.

Fig. 12 shows the TSS removal in the three different sands filter from the three regions versus different thickness. The concentration of suspended solids in the wastewater of Said Otba station was significantly high 268 mg/L and the acceptable value was 30 mg/L, so it's more than 8.9 times higher. The TSS removal efficiency results show height efficiency with the three sand types, 91±1.5, 91±1.5 and 91±1.8, for Touggourt, Hassi sayeh and Sidi Khouiled sand respectively. The observation suggests that the use of different thickness for TSS removal has not an important values case 120 cm of sand thickness give us 3% more efficiency of 20 cm, this result is due to the fact that the diameter of the residual TSS is smaller than the voids between the sand grains of the three types of sand.

The results obtained indicated important improvements, at higher than 91% significance levels, in TSS removal by the three sand types. So, sand filter is a promising method for improvement the quality of Said Otba wastewater station.

3.2.6 Effect of sands filter types and its thickness on Nitrites and Nitrates removal.

Indirect human consumption of the dissolved nitrates and nitrites in groundwater results in adverse health effects. One of the most common side effects are a reduction in thyroid gland mechanism, a low vitamin A storage, the production of nitrosamines which cause the cancer and the decrease in blood oxygen transport capacity [47]. The WHO recommends limit values for nitrite and nitrate in drinking water of 50 mg/l for nitrate and 3.0 mg/l for nitrite [16]. The comparison of nitrate and nitrite results with WHO guidelines according to the relation given below, and combined nitrate-nitrite guideline value should be ≤ 1 [48].

$$\frac{C_{nitrate}}{GV_{nitrate}} + \frac{C_{nitrite}}{GV_{nitrite}} \leq 1$$

where: C is the concentration and GV is guideline value (50 mg/l for nitrate and 3.0 mg/l for nitrite)

As the Fig.1 and the table 44 are shown, the concentrations of nitrate and nitrite were accepted values before the tests according to the nitrate-nitrite guideline value, and excellent at the end of the filtering experiments where the nitrate-nitrite guideline value are <<< 1 and the removal was higher than 85% for nitrite for the three types of sand and higher than 93, 77 and 97% for Touggourt sand, Hassi sayeh sand and Sidi Khouiled sand respectively for nitrate removal.

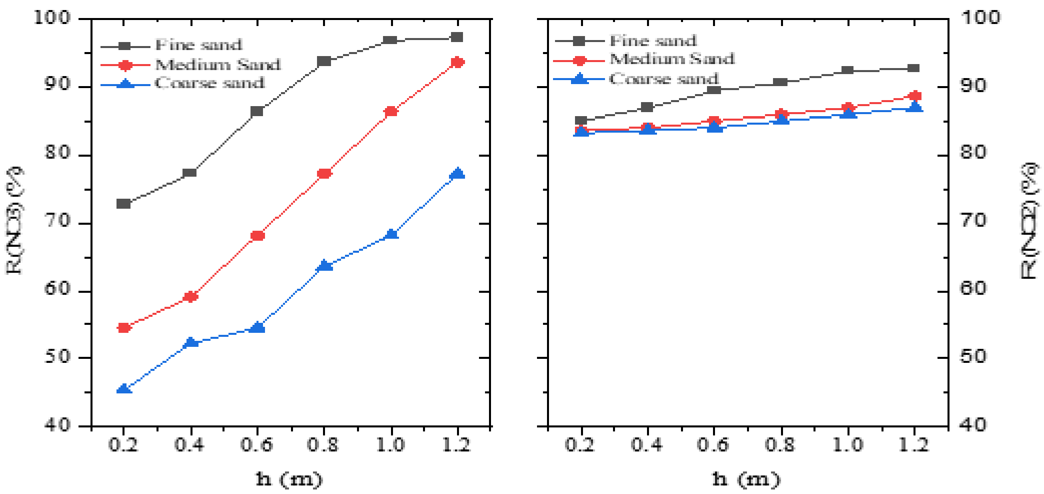


Fig. 13: Variation in yield of Nitrites (NO_2^-) AND (NO_3^-) as a function of sand height

Fig.13 shows that the removal rate of nitrites and nitrates has decreased considerably at the level of water coming out of the filter compared to the incoming water but remains below the Algerian standards (50 mg/l).

Table 6: Nitrate-nitrite guideline value for the Said Otba wastewater and after filtering by the three types of sand.

Sand	Said Otba wastewater	Touggourt	Hassi sayeh	Sidi Khouiled
$\frac{C_{nitrate}}{GV_{nitrate}} + \frac{C_{nitrite}}{GV_{nitrite}}$	0.393	0.072	0.021	0.018

3.2.7 BACTERIOLOGICAL QUALITY MONITORING

The monitoring of the bacteriological quality of the water consists in the research and enumeration of the following germs: total germs (GT), total coliforms (CT) and fecal (CF), fecal streptococci (SF) sand filter outlet. The results obtained are grouped in figure 8.

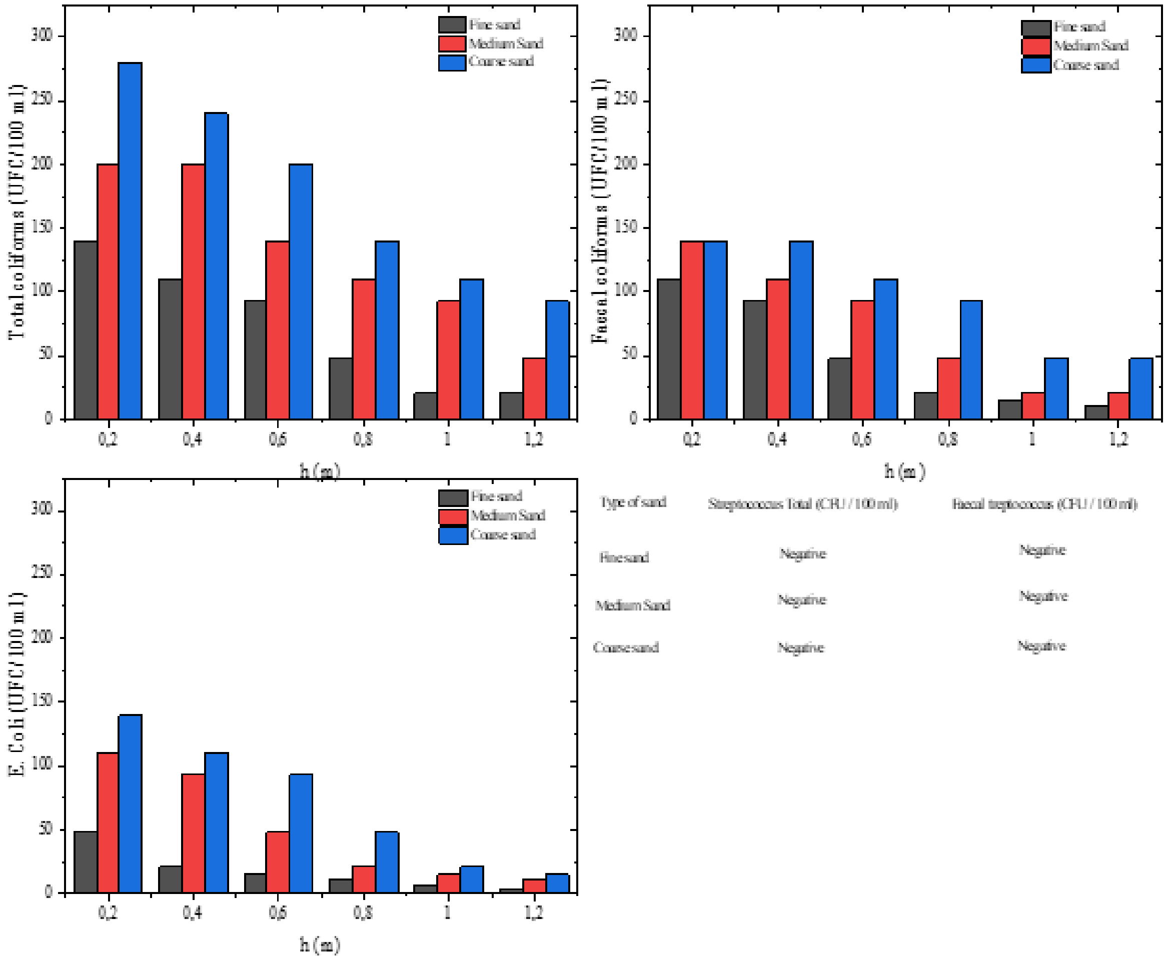


Fig. 14 Results of bacteriological analyses of raw and purified wastewater from the city of Ouargla.

As the results shown in the picture 10, the sand filters can effectively reduce total coliform bacteria in water by trapping and removing the bacteria as water passes through the filters. The sand particles in the filters act as a physical barrier, trapping the bacteria, and the action of water passing through the sand also helps to physically remove the bacteria. The process of filtration and the accumulation of trapped bacteria within the filter can also create conditions that are unfavorable for the growth and survival of bacteria, leading to a decrease in total coliform bacteria levels [49].

The decrease in total fecal matter in the water after using a sand filter is likely due to the removal of this type of organic matter. Sand filters work by passing water through a bed of sand, which acts as a physical barrier to trap and remove impurities. Additionally, the bacteria present in the sand may help to break down some of the organic matter, further improving water quality [50].

The three type sand filters can effectively remove E. coli bacteria from water by physical filtration and biological degradation processes. Water travels through the sand layer and particles, including bacteria, are caught in the gaps between the sand grains, resulting in physical filtering. The trapped bacteria can then be degraded by naturally occurring microorganisms in the filter, such as heterotrophic bacteria, which feed on organic matter and can break down E. coli. Additionally, the sand filter helps to maintain a stable environment for the bacteria-degrading microorganisms, providing them with the nutrients and conditions they need to thrive [51].

POSSIBILITY OF USING WASTE WATER IMPROVED BY SAND FILTER

We compared the maximum values of the results of the bacteriological parameters of these waters (worst case during the analysis period). The Regulation of the Official Journal of the Republic of Algeria No. 41 dated 15 July 2012; The purpose of this Order is to set out the specifications for wastewater Treated for irrigation purposes in accordance with the attached table.

Table 7: Bacteriological parameters of treated water compared to Algerian standards

Parameter	Treated water	Algerian standards
Total coliforms (CFU/100 ml)	280-21	-
Fecal coliforms (CFU/100 ml)	140-15	<100
Total Streptococcus (CFU/100 ml)	Negative	-

, it can be seen from Table 4 that the microbiological parameters of water improved by sand filtration remain below Algerian standards. According to these standards, the sanitary quality of these waters would then be acceptable in the case of reuse.

CONCLUSION

The filtration method used in this work produced a good water quality using a low-cost sands filter. Although this study's solution appears to be quite beneficial from an ecological standpoint, there may be health dangers associated with using untreated wastewater in Ouargla, Algeria.

The study allowed the experimental analysis of three types of sand: coarse sand, medium sand and fine sand. In fact, empirical relationships have been found for the three configurations of the sands, allowing the dimensioning of the rate of elimination of the polluting charge and the speed of filtration on one side, on the other side the height of sand. A comparative study was carried out between these three types of sand and it appears that for the same height of sand, the rate of charge elimination, the concentration of pollutant are more reduced in the soft sand compared to the medium and coarse sand. The study then addressed, microbiological analysis confirms the presence of various germs such as total germs, total and fecal coliforms, fecal streptococci. This can be explained by the sand filtration. The comparison of the physicochemical and microbiological quality of this water with Algerian standards has shown the suitability of this water for irrigation without major negative impacts on the environment

Declaration of competing interest

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work; there is no professional or other personal interest of any nature or kind in any product, service, and/or company that could be construed as influencing the position presented in, or the review of, the manuscript entitled.

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