Impacts of agricultural reuse of treated wastewater on the microbiological quality of groundwater in Ouargla basin (Northern Algerian Sahara)

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Abstract: The objective of our work is to highlight the impacts of the agricultural reuse of treated wastewater on the microbiological quality of groundwater in the Ouargla basin. A comparative study was carried out between the bacterial densities of four germs (total and faecal coliforms, total and faecal streptococci), at the level of nine piezometers installed in plots irrigated by unconventional treated, conventionally irrigated and non-irrigated water. Our main results from this research show that irrigation with treated wastewater affects the increase in bacterial concentrations in groundwater. The average load of total and faecal coliforms recorded in piezometers irrigated by treated water is estimated successively at 2433±31 germs/100ml and 1210±26 germs/100ml .

Keywords: treated wastewater, agricultural reuse, groundwater, microbiological load, Ouargla, Algerian Sahara.

I. Introduction

The reuse of treated water, beyond its positive effect, can also have unfavorable impacts on public health and the environment, depending mainly on the characteristics of the treated water, the degree of purification, the method and the place of use, among the potential disadvantages the pollution of soil and groundwater and the most important surfaces of the use of treated wastewater [1] [2] -[3]-[4]-[5].

According to [6] [7] these discharges may contain many substances, in solid or dissolved form, as well as many pathogenic micro-organisms. In the framework of this study, we will be particularly interested by the characterization of the microbiological quality of conventional irrigation water from wells and non-conventional treated wastewater at an agricultural development perimeter located at north of the Ouargla's wastewater treatment plant, as well as the characterization of the impacts of this agricultural reuse of treated wastewater on the spatial variability of the microbial flora of groundwater in the targeted area.

II. Materials and methods

II.1. Study Area

The Ouargla basin (Fig 1), a morphological context favorable to water stagnation, the study area has an area of 99,000 ha, it is one of the main oases of the Algerian Sahara, located in the extension of the great basin of the north-eastern part of the Sahara. It is approximately 750 km from Algiers. It is part of the quaternary river Oued M'ya, currently covered is hidden under sediments [8]- [9]. The limits of the Ouargla basin are: Northern limit Sebkhet Safioune, Southern limit Through the Sedrata dunes, Western boundary the eastern slope of the M'Zab Ridge and Eastern limit linen by Ergs Touil and Arfidji.

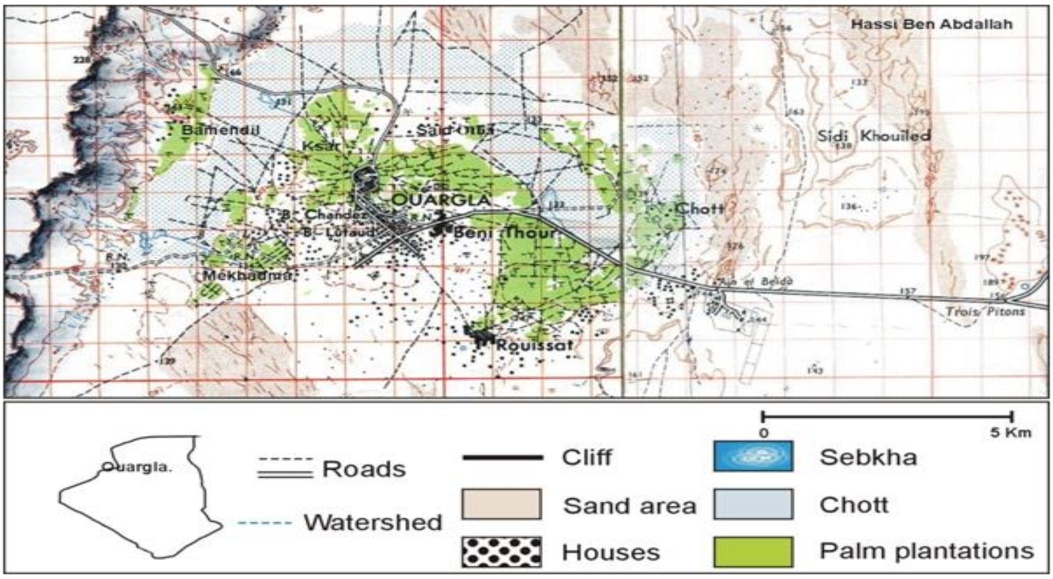
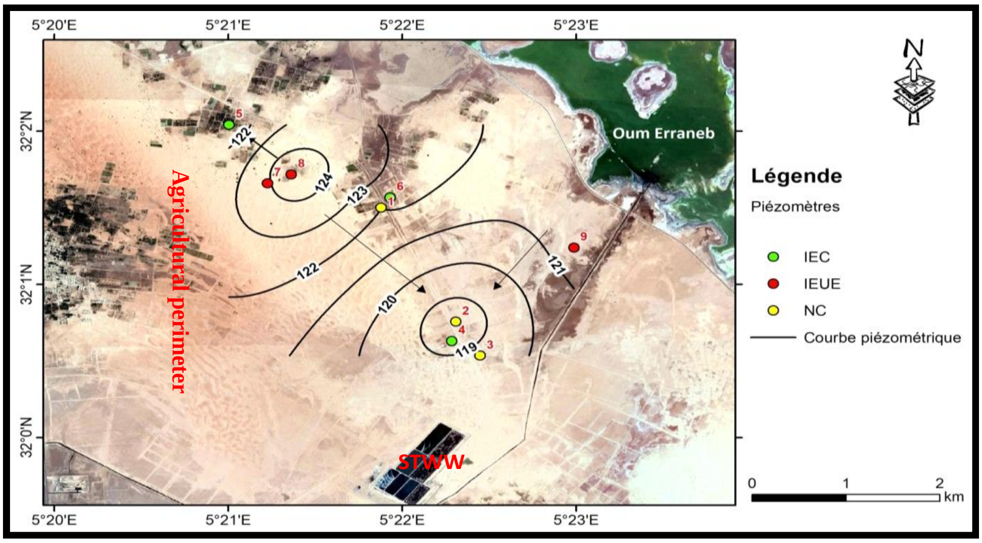


Figure 1. The environment of Ouargla basin

II.2. Experimental station

Our experimental study was carried out in the Ouargla basin, in a development area located to the north of the Ouargla's wastewater treatment plant (Fig.2), where a new attempt to use treated water for agricultural purposes has begun in recent years. This perimeter stretching over an area of sixty hectares.

This new development area where farmers are responsible for testing the reusability of treated wastewater in agriculture is considered as an experimental interval, especially for EUE irrigated phoeniculture, which is advised by the National Sanitation Office.



IEC; Piezometers located at stations irrigated by conventional waters

IEUE; Piezometers located at stations irrigated by non-conventional water

NC; Piezometers located at non-irrigated stations

STWW; Ouargla's wastewater treatment plant

Figure 2. Piezometric card of the study area produced on ArcGIS 10.3

II.3. Installation of piezometers

Nine stations are selected for this study (Fig 2), three of which are irrigated by treated wastewater, three by well water and three by uncultivated water. At the level of the latter, the installation of piezometers at fixed points, which will allow us to carry out measurements on the state of groundwater. For this, profiles are dug at the selected stations, This operation aims to bring the water closer to the surface to facilitate the digging of piezometers. At the end of the holes with the basement are made at the levels of the profiles previously made to allow the water to this collected.

cooler and stored at a temperature of approximately 4°C, then transported directly to the laboratory. The bacteriological analyses were carried out in the laboratory of the Etablissement Public de la Santé Proximité Ouargla (EPSP). Water withdrawals are made during the winter period between December and February 2017. During our work we searched for the following pollution indicator germs: total and faecal coliforms (thermotolerant), total and faecal streptococci. The statistical interpretation of the results and performed by the NPP method (Mac Grady table).

Table I. Average bacterial density results for the studied waters

Studied water		Total Coliforms (T.C.) (sprouts/100ml)	Coliforms Fecals (C.T) (sprouts/100ml)	Streptococci. Total (S.T) (sprouts/100ml)	Streptococci Faeces (S.F) (sprouts/100m
Conventional well water		9,4x10²	6,4x10²	2,3x10²	0,30 x10²
Treated wastewater (non-conventional waters)		43x10²	27x10²	15x10²	7,50 x10²
Groundwater from non-irrigated stations	**P 1**	11x10²	2,7x10²	7,5x10²	1,1x10²
	P 2	9,3x10²	2,5x10²	6,4x10²	0,92x10²
	P 3	7,5x10²	1,5x10²	3,8x10²	0,74x10²
	Means	9,27 x10²	2,23 x10²	5,9 x10²	**0**,92 x10²
Groundwater from stations irrigated by conventional waters	**P 4**	11x10²	6,4x10²	7,5x10²	2x10²
	P 5	12x10²	7,5x10²	9,3x10²	3,4x10²
	P 6	14x10²	11x10²	12x10²	4,3x10²
	Means	12,33 x10²	8,30 x10²	9,60 x10²	3,23 x10²
Groundwater from treated wastewater irrigated plants	**P 7**	23x10²	11x10²	11x10²	3,8x10²
	P 8	21x10²	9,3x10²	9,4x10²	3,6x10²
	P 9	29x10²	16x10²	14x10²	6,4x10²
	Means	24,33 x10²	12,10 x10²	11,46 x10²	4,60 x10²

This operation is followed by the installation of piezometers. For sampling, a glass sample bottles were cleaned, sterilised in an oven at 180°C for 2 hours were respected; they were only open at the time of sampling. After sampling, the vials were labelled, placed in a

III. Results and discussion

The Analysis of the results presented in Table 1 indicates that conventional irrigation water is unpolluted (940 C.F and 640 C.T/100ml), compared with Algerian irrigation water standards (1000 coliforms/100 ml) [10]. On the other hand, the bacterial density of treated water (4300 C.T and 2700 C.F/100ml) far exceeds the above standard. So these are considered polluted waters. At the same time, the concentration of total and faecal streptococci in the irrigation water studied remains below the standards (1000 germ/100ml [10] estimated at the level of piezometers located in treated water reuse sites, this result is much higher than the groundwater standard declared by the Official Journal of the Algerian Republic.

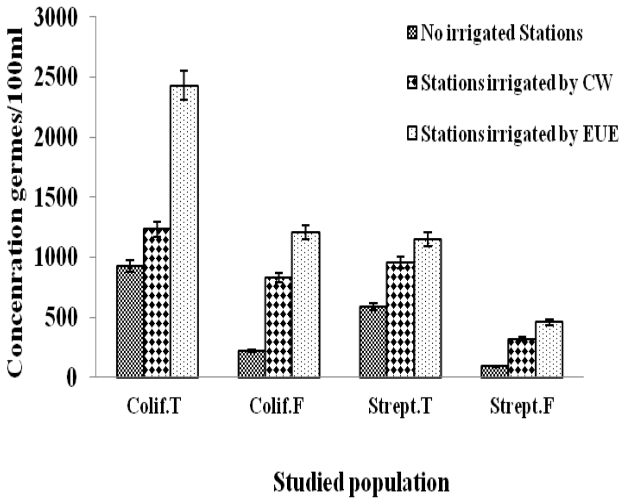


Figure 3. Average bacterial density results for groundwater

On the other hand, the density of total and faecal coliform bacteria as well as total and faecal streptococci in conventional and non-conventional irrigation water is much higher in groundwater than in all the stations studied (Fig. 3). The results of the microbiological analyses showed that the groundwater studied was all contaminated by most of the germs sought with differences in concentrations between control sites (P1, P2, P3, P4, P5, P6) and agricultural reuse sites for treated water (P7, P8, P9).

The average concentration of total coliforms (TC), is about 1531 g/ml for all piezometers studied during the measurement period, whose minimum average value is 926 g/ml is recorded at piezometers located in non-irrigated stations, whereas the maximum average value is around 2433 germs/100ml,

The faecal coliform (FC) count shows that the piezometer waters at the treated water reuse sites contain an average concentration of about 1210germ/100 ml. The maximum fecal coliform mean is recorded at P9 level (1600germ/100ml). At the same time, piezometers located at non-irrigated stations have the lowest concentrations (223 germs/100ml). With regard to total streptococci (ST), we noted that the average concentration of groundwater in the study area is in the order of 898 germs/100ml, with a maximum mean value recorded at the P9 level (1400 germs/100ml) and a minimum mean value recorded at the P3 level (380 germs/100ml). For fecal streptococci (FS), the recorded bacterial density ranges from 74 to 640 germs/100mL. The minimum and maximum average concentrations are recorded at the P3 and P9 piezometers. Our results obtained show that the high concentration of microbial germs studied in the various piezometers located in the agricultural reuse sites of treated water could be explained by the quality of the latter loaded with germs, as well as the nature of sandy subsoils which facilitate water infiltration towards the shallow water table (depths in the study area vary between 0.5m to 2m). In contrast, this shallow aquifer contains high densities of total and fecal coliforms, which are considered indicators of fecal contamination.

In addition, the direction of groundwater flow in our study area is from north to south (Fig 2), which explains the bacterial contamination of the waters of the control stations (non-irrigated station as well as those irrigated by conventional water), it is due to the dynamics of the water table following the direction of flow. Our results obtained are consistent with those presented by [11]-[4] the authors reported that groundwater is highly contaminated with microbial germs.

IV. Conclusion

The urban and infrastructural development of the city of Ouargla (Northern Algerian Sahara) and the increase in the volumes of liquid effluents discharged without precautions into the agricultural perimeters seems to have had a harmful effect on the microbiological quality of the aquifer of the zone, despite this aquifer is not usable by the population but their microbial contamination at agricultural sites can affect the quality of crops. To remedy the current situation and the safe agricultural reuse of treated water, advanced treatment of these non-conventional waters must be exploited in the study area.

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