

THE REUSE OF TREATED WASTEWATER: KORBA (TUNISIA) CASE STUDY

Foufed EL AYN^{1,3}, Semia CHERIF², Amel JRAD¹, Malika TRABESI-AYADI³

- (1) Centre International des Technologies de l'Environnement de Tunis (CITET)
Boulevard du Leader Yasser Arafat, 1080 Tunis, Tunisia. E-mail : unite-
chg@citet.nat.tn
- (2) Centre de Recherche en Sciences des Matériaux, B.P N°95- 2050 Hammam Lif,
Tunisia. E-mail: semiacherif@yahoo.fr
- (3) Laboratoire d'application de la chimie aux ressources et substances naturelles et à
l'environnement. Faculté des Sciences de Bizerte, Tunisia. E-mail:
Malikatrabelsi_ayadi@yahoo.fr

ABSTRACT

The planning and development of water resources in Tunisia integrates the treated wastewater (TWW) reuse. TWW is used in Tunisia since 1965 and is one of the solutions adopted for water scarcity problems intensified by population growth, rising living standards, and accelerated urbanization.

We evaluated the environmental and health impact of the reuse of TWW for crops direct irrigation or for the recharge of the local aquifer in Korba (Tunisia). The investigation of TWW quality showed that in most samples oxygen demands do not exceed the Tunisian standards for TWW used in agriculture (NT 106.03). It was also the case for temperature, electrical conductivity (EC), salinity and pH. While heavy metal concentrations were under the detection limits, the analysis of nutrients revealed relatively low concentrations of nitrates, nitrites and orthophosphate but high potassium and ammonia levels. We did not detect any salmonella and intestinal nematods, whereas high concentrations of total coliforms, thermo-tolerant coliforms, faecal streptococci and E. Coli were found. At the same time we discovered the poor quality of the aquifer unfit for irrigation. These observations led us to conclude that the best use of TWW in this region would be its infiltration for the recharge of the aquifer. It would help at the same time to solve the problems of water scarcity, destruction of the regional aquifer and soils, as well as TWW safe elimination.

1 INTRODUCTION

Tunisia is located in the arid and semi-arid region of the Mediterranean. The reuse of (TWW) has been used in Tunisia since 1965 and considered suitable for non-potable purposes being a solution for water scarcity problems growing with population, rising living standards, and accelerated urbanization (Hamoda 2004). Pollution of water resources increases the scarcity threat and affects all sectors particularly agriculture.

In order to use TWW, physical, chemical and bacteriological water quality should be guaranteed as it can contain high concentrations of heavy metals, organic and

bacteriological compounds but also high salinity levels. In the worse case, instead of being a solution, TWW can cause environmental and health risks (Pescod 1992; Al Salem 1996; Yadav et al. 2002; Da Fonseca et al. 2007; Qadir et al. 2010).

The aim of the present study is to investigate the TWW and the local underground water resource qualities in Korba region (Tunisia) in order to assess the feasibility of a safe use of TWW in irrigation and aquifer recharge and evaluate the impact of TWW on water and soil.

2 MATERIAL AND METHODS

2.1 The study area

The studied area is located in Korba region, in Tunisia (Africa) (Fig.1). The 438 km² Korba coastal aquifer is located in the Northeast of the country. The climate in this region is semi-arid having a 400 mm mean annual precipitation with high variability and 19 °C as a mean temperature (Kallali 2006). Geologically, the region (Pliocene-quaternary) is mainly composed by sandstones, conglomerates and clay. The dominant economic activity is agriculture with some agro-industries, textile industries and tourism. The population of this region is about 100,000 inhabitants (Paniconi 2001). The fertilizers use in the studied area was approached by on site questions asked to five local farmers. It appears that three types of nitrogen fertilizers are used: organic (urea), mineral (ammonium sulphate) or a mixture of both.

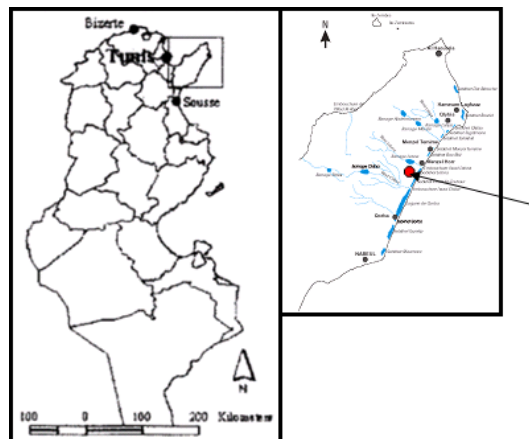


Figure 1. Study area location

2.2 Korba wastewater treatment plant

The treated wastewater plant, with a capacity of 7500 m³ per day, is situated 10 Km North from the Korba city. It actually receives about 5000 m³ used waters per day. It is an urban plant that gathers domestic waters as well as industrial ones coming from 48 industries in various fields like jean washing, fish, steel, slaughterhouse, tomatoes

factories. It is surrounded by agricultural fields and uses a biological activated sludge treatment process. It consists also of a secondary treatment made up of three big anaerobic lagoons basin for removing nitrates. A big part of the TWW is used to feed the sebkha (sea lagoon) close to the plant and classified as a natural park.

2.3 Sampling, preparation and analyses

The samples of underground water are taken in August from 4 piezometers close to the treatment plant. The TWW is sampled directly from the outlet of the treatment plant by an auto-sampler. In order to study the change occurring during a single day, TWW is sampled each 30 minutes during 24 hours in June 2008. The other samples are taken instantly in January, March, April, August and September 2008. Samples from TWW outlet and from the piezometers and wells intended for bacteriological analysis are taken in sterile flasks and transported in a cooling box (4 °C) to the laboratory. The analyses are conducted the same day. The samples intended for chemical analyses are stored in plastic bottles and analysed the same day.

Chemical and bacteriological analyses are performed in the laboratory of the International Center for Environmental Technologies of Tunis- CITET (accredited ISO 17025 since 2001) according to the ISO and NF standards as described in Table 1.

Total coliform (TC) and thermo-tolerant coliform (TTC) concentrations were determined according to the multiple-tube fermentation technique, with positive tubes confirmed for TC in brilliant green lactose bile broth 2% (48 h at 37°C) and for TTC (24 h at 44°C). In the TTC tubes, the presence of *Escherichia Coli* was confirmed with the indole test.

Table 1 Method and reference of the analysis of each parameter

Parameters	Method	Reference
pH	Electrochemistry	NF T 90-008
Electrical Conductivity	Electrochemistry	NF EN 27-888
Chemical Oxygen Demand (COD)	Titrimetry	NF T 90-101
Biochemical Oxygen Demand during 5 days (BOD ₅)	Electrochemistry	NF EN 1899-2
Al, Cd, Cu, Fe, Pb, Cr, Mn, Ni ^c	Atomic Emission ICP ^a	NF EN ISO 11885
Mg, Ca, Na, K ^d	Atomic Emission ICP ^a	NF EN ISO 11885
Ammonia	Colorimetry	NF T 90-015-2
Bicarbonates	Titrimetry	NF EN ISO 9963-1
Chloride	Ionic chromatography	NF EN ISO 10304-2
Nitrate	Ionic Chromatography	NF EN ISO 10304-1
Nitrite	Colorimetry	NF EN 26777- ISO 6777
Orthophosphate	Colorimetry	NF EN 1189
Sulfate	Ionic Chromatography	NF EN ISO 10304-1
Total Suspended Solids (TSS)	Filtration	NF EN 872
Total coliform	MPN ^b multiple-tube fermentation	NF T 90 - 413

Table 1. (Continue)

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Thermo-tolerant Coliform	MPN ^b multiple-tube fermentation	NF T 90 - 413
Escherichia Coli	MPN ^b multiple-tube fermentation	NF T 90 - 413
Faecal Streptococcus	MPN ^b multiple-tube fermentation	NF T 90 - 413
Salmonella	-	ISO 6340
Intestinal nematods	Microscopic observation	-

^a ICP (Inductively Coupled Plasma), ^b MPN (most-probable-number), ^c Al (Aluminium), Cd (Cadmium), Cu (Copper), Fe (Iron), Pb (Lead), Cr (Chromium), Mn (Manganese), Ni (Nickel), ^d Mg (Magnesium), Ca (Calcium), Na (Sodium), K (Potassium).

3 RESULTS AND DISCUSSION

3.1 Aquifer quality

The groundwater quality of the studied region shows a high contamination with nitrate and bacteria respectively from 81 to 332 mg L⁻¹ and from 30 to more than 11,000 bacteria per 100mL (faecal streptococci, thermo-tolerant coliforms, total coliforms and Escherichia Coli). Additionally, high concentrations of salts were observed reaching 8.50 g L⁻¹ in some wells. They can be classified from “saline” to “extremely saline” according to *Mulla* (2008). Trace metal pollutant concentrations (Aluminium, Cadmium, Copper, Iron, Lead, Zinc, Chromium, Manganese and Nickel) are lower than their detection limits while the nitrite, ammonia and orthophosphate levels are quite low. All the SAR (Sodium Adsorption Ratio) levels (*Richards* 1954) are higher than 9, if the underground water is used for irrigation, it surely would cause severe damage to crops, according to FAO report (1985). These waters are not suitable for drinking nor for irrigation.

3.2 TWW quality

The samples were analyzed for their pH, temperature and electrical conductivity (EC). pH values of all samples are basic without exceeding the maximum allowed concentration of 8.5 as stated in the NT 106.03 Tunisian standards for TWW reused in agriculture. The temperature of the collected TWW varies from 16.4 (January) to 26.1 °C (August) depending on the seasonal temperature. Some fluctuations are observed in EC with variations from 4230 to as high as 9510 µS cm⁻¹ (August). The latter value is the only to exceed the NT 106.03 standards set at 7000 µS cm⁻¹. There is quality instability of the TWW generated by this treatment plant represented by the EC fluctuations. The evaporation phenomena taking place in summer especially in the anaerobic lagoons for tertiary treatment is probably an explanation of this phenomenon, besides the seasonal summer industrial activities of the region mainly tomatoes

conservation factories.

As for organic pollution, we observe COD variations from 33 to 139 mg O₂ L⁻¹ through the sampling period while the BOD₅ varies from 3.5 to 34 mg O₂ L⁻¹. The maximum allowed concentrations by the Tunisian standard (NT 106.03) respectively for COD (50 mg O₂ L⁻¹) and BOD₅ (30 mg O₂ L⁻¹) are exceeded only in August for both parameters. Total suspended solids (TSS) are high in all samples, varying from 9 to 20 mg L⁻¹. This could cause the clogging of the irrigation systems and prevents direct drip irrigation. Regarding organic quality and by referring to NT 106.03 standard, the TWW can be used for irrigation and aquifer recharge except in summer.

Nine trace metal pollutants are searched for, in January, March, April and June 2008, in the TWW samples: aluminium, cadmium, copper, iron, lead, zinc, chromium, manganese and nickel. All metals concentrations are below their detection limits (0.050 mg L⁻¹) except for two occurrences: in January for aluminium (3.5 mg L⁻¹) and June for iron (0.154 mg L⁻¹),

Investigating nutrient quality, we analysed phosphate, nitrates, nitrites, ammonia, and potassium. Quite high, up to 0.92 mg L⁻¹, phosphate concentrations are found. In summer, nitrates and nitrites levels are high with respective maxima at 6.6 mg L⁻¹ and 5.6 mg L⁻¹. The ammonia levels are very high in all samples varying from 23.4 up to 61 mg L⁻¹. There is probably a lack of conversion in the oxidation stage of the treatment of the ammonium into nitrates and nitrites, all over the year. At the same time, there is the possibility that the anaerobic final treatment, converting nitrite into gaseous nitrogen, does not work optimally in summer.

The SAR for the samples collected in March, June and September varies from 11.9 to 15.8 with an average of 13.8 (Table 2). This value is very high and, according to *FAO report* (1985), can cause severe damage to the soil irrigated with this TWW.

Table 2 TWW water sodicity.

Date of sampling	Calcium mmole L ⁻¹	Magnesium mmole L ⁻¹	Sodium mmole L ⁻¹	SAR
13 March	3.6	2.92	30	11.9
27 June (24 h average sample)	3.6	1.95	37	15.8
14 September	3.5	2.97	35	13.7
Average	3.6	2.61	34	13.8

*Sodium Adsorption Ration (Richards 1954)

Bacteriological TWW analyses (Table 3) show a high level of contamination by faecal streptococci, coliforms and *Escherichia coli* (*E. coli*) but no occurrence of salmonella or intestinal nematodes in any sample. This high bacterial contamination reflects the domestic origin of the treated waters. This is a health risk in using this TWW even for irrigation.

Table 3 Bacteriological contamination of the TWW.

Date of sampling	Faecal streptococci	Thermo-tolerant coliforms	Total coliforms	E. coli*
	/100 mL	/100 mL	/100 mL	/100 mL
28 January	360	4300	9300	360
27 June (24 h average sample)	**	240000	240000	23000
14 August	360	93000	93000	"
14 September	93000	>110000	110000	15000

*Escherichia coli

4 CONCLUSION

There is a poor underground water quality in this region especially because of its high salinity and bacteriological contamination.

The TWW of the local treatment plant shows, all over the year, levels exceeding the maximum allowed standards for potassium, phosphate and faecal coliforms. Parameters like TSS, COD, BOD₅, nitrites and faecal streptococcus exceed the maximum values only in some period of the year. Altogether, the best solution is to avoid the rejection of this TWW in the environment, as it is presently the case, and not to use it directly for irrigation. It would be wiser to use infiltration basins for the whole quantity of TWW for an indirect recharge of the aquifer.

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