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Performance of Urban Wastewater Treatment of Four Activate Sludge Treatment Plants in Tunisia

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Abstract

In water-scarce regions, such as Tunisia which is known by the vulnerability of its water resources, national policy encourages and imposes laws opting for environmental sustainability and the preservation of water resources. The current study aims to determine the occurrence and removal of protozoan cysts, helminthes eggs, fecal bacteria, organic load and chemical pollution in the urban wastewater of activated sludge plants in Tunisia. The results show that the absence of primary sedimentation and operation of organic and fluid overload appears to be the main causes of the poor quality of the treated wastewater. The presence of protozoan cysts, helminthes eggs and bacteria as well as the high content of organic matter and nutrient elements greatly limits the reuse of wastewater in agriculture, in particular.

Keywords: Activated sludge; Wastewater; Constraints reuse; Protozoan cysts; Helminthes eggs; Fecal bacteria

Introduction

Tunisia belongs to the category of the least developed countries endowed with water resources in the Mediterranean Sea [1]. The Tunisian strategy in the medium term is to use non-conventional water resources such as the reuse of the treated wastewater, desalination of brackish water and artificial recharge of groundwater [2].

The National Sanitation Utility (ONAS) [3] collects on 2010, 246 Mm^3 of wastewater and manages 109 wastewater treatment plants (WWTPs) that can handle a volume of 240 million m^3 of which 28% is used for irrigation of 8065 hectare of irrigated agricultural schemes, 1040 hectare of golf courses, and about 450 hectare of green spaces, in addition to the recharge of aquifers and wetlands.

Almost all WWTPs treat wastewater to a secondary biological stage. For urban WWTPs, there are about 82 activated sludge mainly at low load, 13 lagoons and 2 WWTPs trickling filter. It is worthwhile to note that treated wastewater has to meet Tunisian standard published in 1989: NT 106.02 and 106.03 before discharging it into the receiving environment and before reusing it in agriculture, respectively. Although the use of water and sludge in agriculture is an interesting alternative in water poor countries, public health risks associated with microbiological, organic and mineral burden can be relatively high [4,5].

The World Health Organization considers the presence of helminth eggs, especially intestinal nematodes as the main constraint for the reuse of wastewater in agriculture due to their higher resistance in the environment, simple life cycle, and low minimal infective doses [6,7]. As for the content of micropollutants in domestic waters, it is rather random because it is derived from daily household activities, originating, on the one hand, from the corrosion of drinking water pipes and, on the other hand, the use of metals in household activities and household products [5].

Metals can be a significant health risk to humans and animals and can also affect, in the long term, irrigated by the accumulation in the soil [8,9]. Nutrients not only are found in large quantities in the wastewater, but they are also important quality parameters that enrich these waters in agriculture and landscape management [10].

The current study aims to determine the occurrence and removal of protozoan cysts, helminthes eggs, fecal bacteria, organic load and chemical pollution in the urban wastewater in four activated sludge plants under the semi-arid climate of Tunisia. Therefore, the evaluation of purification yield gives an idea about the health risks for the population during its reuse in agriculture.

Materials and Methods

Physicochemical analyses

The pH and electrical conductivity of wastewater were determined according to the protocols of AFNOR (NF T 90-008 and NF EN 27888) using a pH meter and a conductivity-type Meter Toledo HANNA INSTRUMENTS HI type 9900. The chemical oxygen demand (COD), suspended solids (SS) and biochemical oxygen demand (BOD) were measured according to the protocols of AFNOR (NFT 90-018, NF T 90-103, NF EN 1189). The concentrations of nitrite, ammonium nitrate and orthophosphate were measured by a colorimetric method using Nessler reagent, sulfamilic acid, and sodium salicylate and ammonium molybdate, respectively. Regarding metal determination, it was performed by atomic emission spectroscopy with inductive current plasma (ICP-AES).

Bacteriological analysis

Bacteriological analysis is the germ count of fecal pollution indicators: thermo tolerant fecal coliforms and *Escherichia coli*. Thermo tolerant coliforms are commonly used to control the relative quality of water.

The numeration was performed using the static method of seeding in liquid medium (MPN). The sample preparation was performed according to the technique of suspension-dilution (ISO9308-2 and ISO 7899-1, 1990).

Parasitological analyses

Samples were examined for parasites according to the modified Bailenger method [11]. Briefly, each sample was allowed to settle over 24 h in the laboratory at room temperature. Then, the recovered sediment was centrifuged for 15 minutes. The resulting pellet was mixed with an equal volume of buffer-acetic acid pH 4.5. Besides, one equivalent volume of ether twice the volume of the resulting solution was then stirred for 10 minutes. The sample was then centrifuged at 1000 g for 6 minutes. The obtained sediment was resuspended with approximately 5 mL of a solution of zinc sulphate (33% density 1.18). The volume V of the product was measured. P a volume of 0.3 mL was collected on the surface after flotation microscopic observation.

Different types of samples collected from each sampling station always include raw sewage collection and wastewater treatment. The samples were collected during the rainy season from November to March 2010, with two samples per month. The samples under investigation were collected from the WWTPs of Beja, Bizerte, Nabeul and Menzel Bourguiba. The characteristics of the four stations operating at Activated Sledges are shown in Table 1.

Results and Discussions

Determining the abundance of parasitic forms of resistance in treated and untreated wastewater from the cities of Bizerte, Beja, Menzel Bourguiba and Nabeul (Table 2) showed that all the raw wastewater samples were positive for helminthes eggs and protozoan cysts (*Giardia* sp, *Entamoeba coli* and *Entamoeba histolytica* cysts), which is in accordance with the research work of Ben Ayed et al. [12].

Moreover, helminthes eggs are predominant protozoan cysts. The average concentration of protozoan cysts is close to 2164 cysts/L against 705 eggs/L.

Entamoeba coli cysts are the most abundant (Table 3), their concentration varies from 741 to 1680 cysts/L, followed by Giardia cysts from 400 to 921/L and finally cysts of *Entamoeba Histolytica* (390-817 cysts/L). Regarding helminthes, two major classes were identified, the nematodes class represented by the *Ascaris* sp and pinworm and the cestodes one represented by *Hymenolepis nana* (Table 3). The scale of abundance of helminthes eggs ranges according to the following order: *Ascaris* sp (49.50 to 68.42%) >*Enterobius vermicularis* (21.15 to 44.55%) >*Hymenolepis nana* (0 to 11.50%).

In addition, the evaluation of the bacterial load of raw sewage at the studied WWTPs showed the presence of fecal coliforms and *Escherichia coli*, with concentrations ranging from 2.5 10^6 to 2.5 10^7/100 mL and from 4.10^4 to 5.10^5/100 mL (Table 2), respectively. However, the concentration of fecal coliforms in treated wastewater ranges from 4.5 10^3 to 1.1 10^5/100 mL.

Table 4 presents an overview of the mean physicochemical characterization of raw and treated wastewater. It appears that the WWTPs of Nabeul and Beja currently operate in organic overload (COD, BOD_5 and SS) which are not compliant to Tunisian standard of ONAS gathering network estimated at 1000, 400 and 400 mg/L, respectively. After treatment, the organic quality of Beja and Menzel Bourguiba wastewater met the Tunisian standard of irrigation and may be discharged/ thrown out into the receiving environment set at 90 mg O_2/L for COD, 30 mg O_2/L for SS and 30 mg/L for BOD_5 (NT 106 002-1989).

The determination of nutrients (NH_4^+, NO_2^-, NO_3^- and PO_4^{3-}) at the outlet of the studied treatment plants shows that the oxidized forms of nitrogen does not cause problems while ammonia nitrogen and orthophosphate concentrations, estimated at 1 and 0.005 mg/L respectively, exceed by far the Tunisian standards for the discharge into the receiving set.

Giardia sp, *Entameaba coli*, and *Entameaba histolytica* cysts were detected in all the treatment plants, suggesting endemic levels of these parasites in the concerned Tunisian population. Together with epidemiological investigations [13,14], the order of frequency of protozoan cysts and helminthes eggs in wastewater corroborate the research work undertaken in Tunisia [15,16] and in the world in this field [17,18]. Generally, the concentration of nematode was higher than that of cestodes, and the abundance of protozoa cysts was higher than that of helminthes eggs [19].

	Commissioning	Sizing			Composition Eq. Hab connected (100%)
		Capacity (equivalent habitant)	Discharge (m^3/day)	BOD_5 (kg/day)	
Bizerte	1997	250 000	26600	10740	Domestic 96.7%, 2.9% industrial and 0.6% touristic
Beja	1979	144000	14000	7800	60% domestic and 40% industrial
Menzel Bourguiba	1997	91000	11065	4700	85.5%domestic,12.76% industrial and 1.7% touristic
Nabeul (SE4)	1994	81400	9585	5870	83% domestic,12.2% industrial and 4.44% touristic

Table 1: Main characteristics of the different treatment plants

	Bizerte		Menzel Bourguiba		Beja		Nabeul (SE4)	
	I	E	I	E	I	E	I	E
Helminthes eggs/L	1010 ± 300	0	520 ± 70	0	200 ± 80	0	1089 ± 180	13 ± 8
Protozoa cysts/L	3417 ± 600	0	2190 ± 450	50 ±10	1676 ± 240	0	2873 ± 360	236 ± 150
FC/100 ml	2.5 ± 0.4 10^7	1.4 ±0.5 10^4	2.5 ± 0.7 10^6	9.0 ± 0.4 10^4	2.0 ± 0.7 10^5	4.5 ± 0.6 10^3	2.2 ± 0.8 10^6	1.1 ± 0.3 10^5
EC/100 ml	4.0 ± 0.5 10^4	2.0 ± 0.3 10^2	2.0 ± 0.3 10^5	9.0 ± 0.8 10^4	1.8 ± 0.2 10^4	1.4 ± 0.6 10^2	5.0 ± 0.7 10^5	2.9 ± 0.2 10^4

Table 2: Microbiological characterization of raw and treated sewages

I: Influent Station, E: Effluent the station, CF: fecal coliforms, EC: *Escherichia coli*

		Helminthes/L (100%)			Cysts/L (100%)		
		Ascaris	Oxyure	Hym. Nana	Giardia	E. Coli	E. Hyst
Bizerte	I	500 (49.50%)	450 (44.55%)	60 (5.90%)	920 (26.90%)	1680 (49.16%)	817 (23.90%)
	E	0	0	0	0	0	0
Menzel Bourguiba	I	350 (76.30%)	110 (21.15%)	60 (11.50%)	730 (33.41%)	1070 (48.85%)	390 (17.50%)
	E	0	0	0	0	50 (100%)	0
Beja	I	390 (68.42%)	180 (31.57%)	0 (0%)	400(23.85%)	741 (44.2%)	536 (32%)
	E	0	0	0	0	0	0
Nabeul	I	546 (50.13%)	543(49.86%)	0 (0%)	760 (26.45%)	1345 (46.81%)	768 (26.73 %)
	E	0 (0%)	13.0 (4.65%)	0 (0%)	40 (14.34%)	32 (11.50%)	164 (58.78%)

Table 3: Composition and abundance of parasitic elements

I: Influent, E: Effluent, Hym. nana: Hymenolepis nana *E. coli : Entamoeba coli*, *E.Hyst* : *Entamoeba coli*.

	Bizerte		Menzel Bourguiba		Beja		Nabeul	
	I	E	I	E	I	E	I	E
pH	7.38	7.65	7.42	7.78	7.64	7.85	7.55	7.79
CE (µS/cm)	4680	4620	2106	2349	1562	1252	3569	3281
DCO (mg/L)	648	73	368	72	1500	76	1626	148
DBO_5 (mg/L)	289	25	258	25	537	21	353	36.5
SS (mg/ L)	338	34	135	23	479	19	1310	50
NO_3^- (mg/L)	-	0.56	-	-	2.25	1.1	<0.04	0.1
NO_2^- (mg/L)	-	0.05	-	-	0.165	0.011	<0.01	0.08
NH_4^+ (mg/L)	-	34.50	-	-	-	10.3	69.6	44.5
P (mg/L)	-	5.40	-	-	14.86	1.56	11.0	3.60
Zn (mg/L)	0.6	0.20	-	-	0.9	<0.05	1.6	0.08
Ni (mg/L)	0.05	<0.03	-	-	<0.005	<0.05	<0.1	<0.1
Cr (mg/L)	0.08	0.03	-	-	<0.05	<0.05	<0.01	<0.01
Cd (mg/L)	0.004	0.004	-	-	<0.05	<0.005	<0.005	<0.005
Cu (mg/L)	0.05	0.01	-	-	0.1	<0.05	0.43	<0.1
Pb (mg/L)	<0.03	<0.03	-	-	0.05	<0.05	1.7	<0.05
Hg (mg/L)	<0.02	<0.02	-	-	<0.001	0.0006	<0.001	<0.001

Table 4: Physicochemical characterization of the average raw and treated wastewater

I: Influent, E: Effluent, Hym. nana : Hymenolepis nana *E. coli : Entamoeba coli, E.Hyst : Entamoeba coli.*

- : data not available, BOD_5: Biological Oxygen Demand, COD: chemical oxygen demand, SS: suspended solids, NO_3^- : nitrate, NO_2^-: nitrite, PO_4^{3-} : orthophosphate

Otherwise, the microscopic counting and recognition of eggs and cysts of parasites could be influenced by the following factors: the limitations of the Bailenger technique [11], the presence of impurities in the samples to be analyzed and the morphological characteristics of some forms of parasites and their low abundance.

Moreover, it appears that the activated sludge treatment is more effective in the removal of helminthes eggs. Indeed, the average reduction of cysts and eggs are 99.70 and 95.36%, respectively (Table 5). Treated wastewater from sewage treatment plants (Menzel Bourguiba and Nabeul) remains partly contaminated by protozoan cysts. However, helminthes eggs were detected only at the effluent of the WWTP Nabeul SE4.

Pollution in this context [12,15], found that more than half of the parasites are eliminated during the primary settling with a greater reduction of helminthes eggs compared to cysts protozoa because of their large size and hence their high settling velocity. It was reported a settling velocity of 0.01 and 0.65 m/hour for *Giardia* cyst and *Ascaris* ova, respectively [20]. In our case, the WWTP of Bizerte and of Beja are not equipped with a primary clarifier.

With respect to the bacteria of fecal pollution, the best reduction rate of fecal coliforms and *Escherichia coli* were recorded at the WWTP Bizerte with the reduction rate of approximately 99.94 and 99 50% corresponding to 3.25 and 2.3 log unit, respectively. Nevertheless, the removal efficiency of WWTP of Nabeul, reduces fecal coliforms and Escherichia coli which did not exceed 95.11% and 94.20 (1.44 and 1.23 log unit).

The presence of these concentrations of bacteria in treated wastewater leads to the probability of the existence of pathogens for humans and animals [21].

Monitoring the evolution of the organic load (COD, BOD_5, SS) in wastewater before and after treatment showed a reduction exceeding 80% (Table 5). The best treatment efficiency was observed at the WWTP of Beja.

Concerning parasitic and organic load, the WWTP of Nabeul is the least efficient one. It is manifested in the research work of Robertson et al. [22], which demonstrated a positive correlation between the elimination of parasites and the reduction of suspended solids due to the adhesion of the greater part of the microorganisms contained with the suspended matter.

Besides, the average concentration of NH_4^+ and PO_4^{3-} in the treated wastewater of all studied stations are 29.76 and 3.52 mg/L, respectively. The rejection of these waters rich in eutrophying components into a receiving site could disrupt the ecological balance [8].

The evaluation of the chemical toxicity of both raw and treated wastewater via the analysis of heavy metals has shown a low concentration that does not exceed the Tunisian standards.

	Bizerte	Menzel Bourguiba	Beja	Nabeul	Average
Total Eggs	100	100	100	98.80	99.70
Total cysts	100	97.71	100	84.82	95.63
Fecal coliforms	99.94	96.40	97.75	95.11	97.30
Escherichia coli	99.50	55.0	99.22	94.20	86.98
COD	86	80.5	95	92	88.37
BOD_5	89.96	90.31	96	90	91.56
SS	89.94	82.96	96	96	91.22

Table 5: Performance purifying (%) related to the microbiological and organic load

BOD_5: Biological Oxygen Demand, COD: chemical oxygen demand, SS: suspended solids

The WWTP of Beja (Table 1) assures the treatment for 40% of the industrial waters, coming from a plant of yeast in the region [23] which is characterized by a COD concentration of 27 g/L and a BOD_5 of 3.2 g/L [24].

It appears that most microbiologically contaminated raw sewage (helminthes eggs, protozoan cysts, fecal coliforms, and *Escherichia Coli*) are those of the WWTP of Bizerte and Nabeul, while the least contaminated ones are those of the station of Beja. This quality influent could be explained by the characteristics of the treatment plant (Table 1).

In fact, although the WWTP of Bizerte is the largest among the four plants, which is sized for 250 000 Eq. inhabitants, it works in organic overload during seasonal peaks [16]. The same thing is to Beja plant that operates in organic overload, however 40% of the collected industrial wastewater is lightly loaded microbiologically [25]. The poor quality of Nabeul plant treated wastewater is attributed, as shown by the research work of Maamri [26] not only to a fluid overload that sometimes attains 153% and 197%, but also to an organic overload in which SS can exceed 4 g/day in some conditions.

Conclusion

Monitoring the treatment efficiency of urban wastewater at four active-sludge stations shows that the quality of the treated wastewater exceeds the Tunisian standards for a possible reuse or a release into the environment without risk. Besides, it may have, in certain cases, some human health and ecological risks and perturbation of the ecological balance following the presence of high nutrient concentration, organic load and parasitic elements observed in the functioning of the overloaded plants.

However, the microbiological quality of all treated wastewater does not meet the standard of irrigation or discharge into a natural environment that is 2000 units of fecal bacteria per 100 mL.

Rehabilitation treatment plants are becoming increasingly necessary to solve the problems such as the lack of primary sedimentation and operation fluid and organic overload. The poor quality of the treated wastewater suggests greater caution management of water potential so as to preserve the safety of the population as well as the environment.

References

1. EURONET Consortium (2012) Profil environnemental de la Tunisie.
2. ANPE (2014) Les indicateurs de développement durable de la Tunisie. Agence national de protection de l'environnement.
3. ONAS (2010). Office national de l'assainissement, Tunisia. Rapport annuel.
4. Védry B (2004) Problems of sewage sludge. L'Eau Indust Nuis 272: 49-54.
5. Belaid N (2010) Assessment of impacts of irrigation by treated wastewater on plants and soils of the irrigated perimeter of El Hajeb-Sfax: salinization, accumulation and metal elements phytoabsorption. PhD in Environmental Sciences. Water Soil Environmental Chemistry and Water Microbiology.
6. International Reference Centre for Waste Disposal (1985) Health aspects of waste water and excreta use in agriculture and aquaculture. IRCWD News 23.
7. Keffala C, Harerimana C,Vasel JL (2012) Helminth eggs in wastewater and sludge from treatment plants: Sanitary stakes and importance of waste stabilization ponds. Env Risque santé 11: 511-520.
8. FAO (2003) l'insécurité alimentaire dans le monde. Organisation des nations unis pour l'alimentation et l'agriculture pour l'Afrique du Nord.
9. Rattan RK, Datta SP, Chhonkar PK, Suribabu K, Singh AK (2005) Long-term impact of irrigation with sewage effluents on heavy metal content in soils, crops and groundwater-a case study. Agr Ecos Env 109: 310-320.
10. Hamoda MF (2004) Water strategies and potential of water reuse in the south Mediterranean countries. Desalination 165: 31-41.
11. Alouini Z (1993) Fate of parasites in five wastewater treatment plants in Tunisia. Rev Sci Eau 6: 453-462.
12. Ben Ayed L, Schijven J, Alouini Z, Jemli M, Sabbahi S (2009) Presence of parasitic protozoa and helminth in sewage and efficiency of sewage treatment in Tunisia. Parasitol Res 105: 393-406.
13. Bouratbine A, Aoun K, Siala E, Chahed MK, Ben Hassine L, et al. (2000) For a better estimation of the prevalence of intestinal parasitism in the Tunis region. Bull Soc Pathol Exot 93: 353-355.
14. Bouratbine A, Maamouri N, Ben Abdallah RR, Aoun K, Haouet S, et al. (2003) Epidemiological, clinical and parasitological data concerning intestinal amebiasis in northern Tunisia. Tunisie Méd 81: 318-322.
15. Alouini Z (1998) Eau: ressources, aménagements, environnement - Devenir des oeufs et kistes de parasites au cours d'un cycle d'épuration de la station Cherguia à Tunis. Houille Blanche 7: 60-64.
16. Jemli M, Louati A, Sabbahi S (2012) Devenir de la pollution chimique et biologique au cours d'un cycle d'épuration de la station de Bizerte. R Fac Sci Biz X 27.
17. Robertson LJ, Smith PG, Grimason AT, Smith HV (1999) Removal and destruction of intestinal parasitic protozoans by sewage treatment processes. Int J Env Health Res 9: 85-96.
18. Jimenez B (2007) Helminth ova removal from wastewater for agriculture and aquaculture reuse. Water Sci Technol 55: 485-93.
19. Stien JL, Schwartzbrod J (1988) Flow of helminth eggs in activated sludge wastewater treatment plants. Tech Sci Methods 83: 495-498.
20. Konaté Y, Maiga AH, Basset D, Picot B, Casellas C (2013) Occurrence, removal and accumulation in sludge of protozoan cysts and helminth eggs in a full-scale anaerobic pond in Burkina Faso. Water Sci Tech 67: 193-200.
21. Neubert S, Benabdallah S (2003) The re-utilization of treated wastewater in Tunisia. Etudes rapports expertise, German development institute.
22. Robertson LJ, Paton CA, Campbell AT, Smith PG, Jaackson MH, et al. (2000) Giardia cysts and Cryptosporidium oocysts at sewage treatment works in Scotland, UK. Water Res 8: 2310-2322.
23. ONAS (2010) Office national de l'assainissement, STEP Béja, Tunis. Elaboration des manuels d'exploitation des STEP : STEP Béja.
24. ODNO (2011) Office de Développement du Nord-Ouest, Gouvernorat de Béja en chiffres, Tunis.
25. Hedhli N (2012) Evaluation de l'efficacité du traitement des eaux usées au niveau de la station de Béja. Mastère d'hydrobiologie, Fac Sci Bizerte.
26. Maamri S (2011) Mastère d'hydrobiologie, Treatment of urban waste water by activated sludge at the city level Bordj Bou Arreridj made by thewastewater treatment plant wastewater ONA. Fac Sci Bizerte.

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