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Analysis of multiclass antibiotic residues in urban wastewater in Tunisia

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ABSTRACT

The present work describes the occurrence of antibiotic residues in urban wastewaters discharged into southern Sfax wastewater treatment plant (WWTP). Thirteen out of the fifty-six antimicrobial compounds analyzed were detected in the wastewater samples with concentration ranging from 23.30 (for cefalexin) to 690.50 ng/L (for spiramycin) in WWTP influent and from 7.50 (for cefalexin) to 370.04 ng/L (for spiramycin) in WWTP effluent. The highest removal efficiency was observed for trimethoprim (88%), while the lowest one was observed for sulfapyridine (33%).The potential impact of the regenerated waters in the environment and pubic health is also discussed.

1. Introduction

Antibiotics are a group of pharmaceuticals extensively used in human medicine (Schwartz et al., 2003). A global increase in antibiotic consumption from current 63.2 to 105.3 thousand tons by 2030 is foreseen by World Health Organization (INC, 2016). In Tunisia, the consumption of antibiotics increased by 38% between 2005 and 2013, and further rise is foreseen in the next years (The MSI Data Base "SIAMED") (INC, 2016). This increase of antibiotic consumption has been reported to be alligned with an increment in their irrational use, from 28 to 65% in the last few years (Erbay et al., 2005; Tünger et al., 2000). In this regard, a study recently performed in Tunisia showed that 61% of consumers were obtaining antibiotics directly from the pharmacist, without a medical prescription (INC, 2016). This uncontrolled use of antibiotics can have a direct effect on the health of consumers because human body becomes resistant to antibiotics (Carlet et al., 2012) and indirect problems also on the environment. The later is related to the considerable quantities of antibiotics that enter into the ecosystem through effluent from urban wastewater treatment plants. Several studies have shown that wastewater from municipal conventional WWTPs could be a significant source of contamination of aquatic environment by antibiotics from human consumption since WWTPs are not designed to remove them (Adams et al., 2002; Gobel et al., 2007; Rodriguez-Mozaz et al., 2015; Vieno et al., 2007; Watkinson et al., 2009). Therefore, antibiotics have been detected in the natural environment, namely ground water (Batt and Aga, 2005; Negreanu et al., 2012), surface water (Proia et al., 2016; Schwartz et al., 2003), soil and sediment samples (Gobel et al., 2007; Kim and Carlson, 2007) as well as in aquatic organisms (Álvarez-Muñoz et al., 2015; Homem and Santos, 2011; Serra-Compte et al., 2017). Furthermore, applying treated wastewater to agricultural fields for irrigation may contaminate agricultural soils (Negreanu et al., 2012) and lead to uptake of antibiotics by plants (Wu et al., 2015). In summary, antibiotics show pseudo-persistent behavior in the environment (Hernando et al., 2006; Richardson et al., 2005) and their accumulation in different environmental compartments can threaten aquatic and terrestrial ecosystems and may have an impact on human and animal health (Homem and Santos, 2011). In fact, antibiotic residues present in the ecosystem provide an ideal setting for the acquisition and spread of antibiotic resistance genes, resulting in serious environmental problems (Pruneau et al., 2011; Rodriguez-Mozaz et al., 2015).

The objective of this study was to monitor the presence of 56 antibiotics in wastewater effluents in a WWTP located in a highly industralized area of southern Sfax, Tunisia (Fig. 1). So far there is only a study in Tunisia that evaluated the presence of 14 aminoglycosides and phenicol antibiotics in municipal wastewater, sea water and in a pharmaceutical company effluents (Tahrani et al., 2016). Removal efficiencies of antibiotics in Sfax WWTP were evaluated and discussed. To the authors' knowledge, our work is the first study on the presence and elimination of such broad set of antibiotics in Tunisia.

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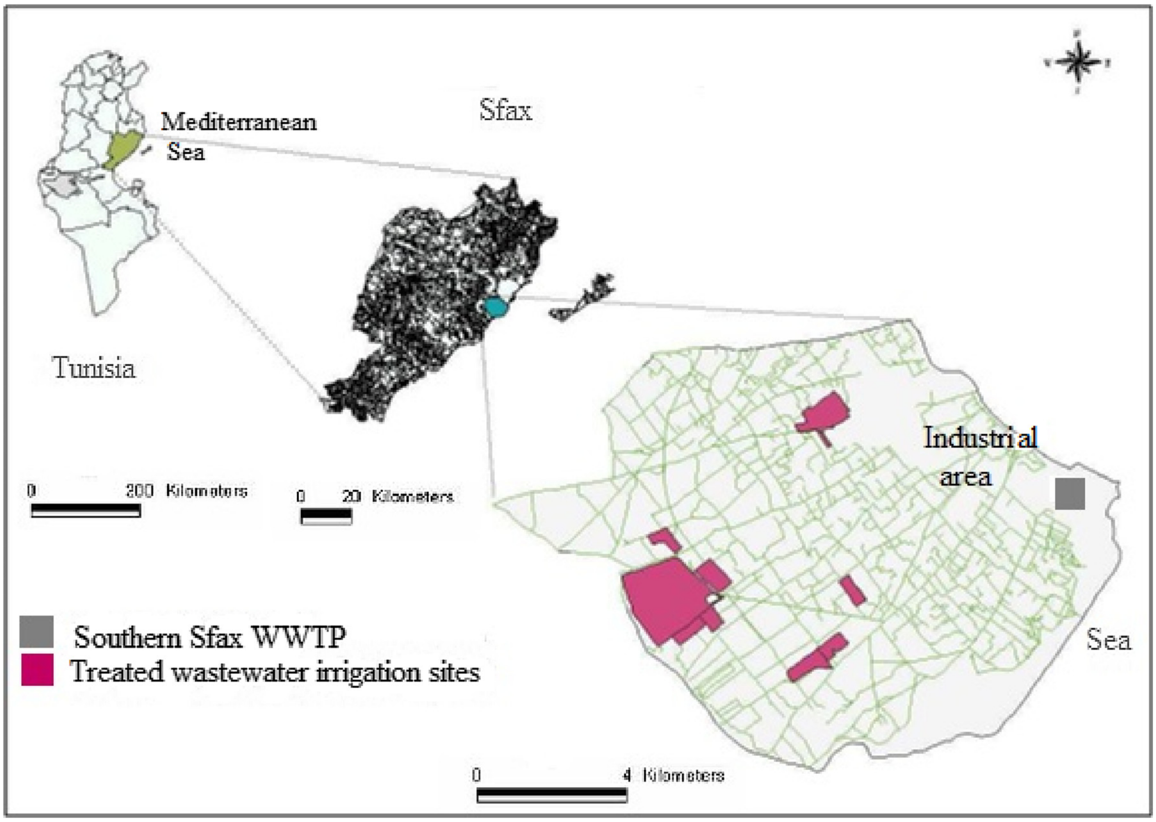

Fig. 1. Southern SFAX WWTP location.

2. Materials and methods

2.1. Sampling site and sample collection

Southern Sfax WWTP is located in a industrialized area (Fig. 1) and receives both domestic and treated industrial wastewater. Domestic source accounts for approximately 75% of influent while industrial sources account for 25%. The WWTP serves a population of 526.800 inhabitants and is designed to purify urban wastewater with a daily average flow rate of 49.500 $m^3 d^{-1}$, with an hydraulic retention time (HRT) of 48 h and a sludge retention time (SRT) of 22 days (Belhaj et al., 2015). The treatment process of the plant are outlined in Fig. 2. Raw wastewater passes first through the mechanical screen and the aerated grit chamber and is further evacuated into the primary sedimentation tanks. Secondary treatment consists of three alternative anoxic/aerobic bioreactors aimed at the elimination of nitrogen and phosphorus. After settling in the secondary sedimentation tanks final effluent is either discharged into the sea or used to irrigate plants and trees. Decanted sludge is recirculated to the bioreactors and the remaining portion is pumped into the sludge storage tank.

Three different sampling campaigns were executed during March 2016 in dry weather conditions, (average temperature was 28 °C). Although the collection of 24 h composite samples is recommended in order to take representative samples, due to instrumental limitations (no autosampler available), composite samples were manually collected during a 6 hour period at the WWTP: one sample every hour, from 7 h to 13 h, which is the daytime when the WWTP the receives the highest load of wastewater at an average flow rate of 50 L/s (personal communication of the staff at Sfax WWTP). The influent sample was collected before the primary treatment (influent) and the effluent sample

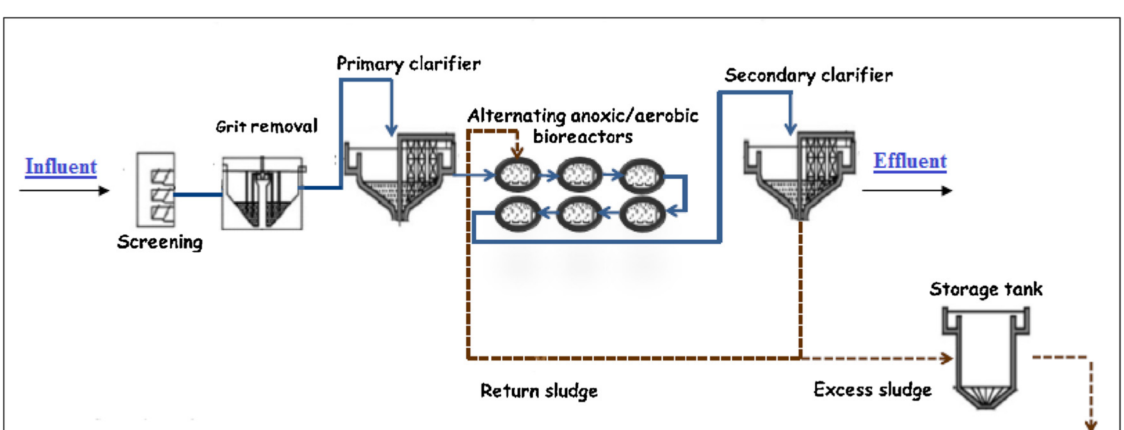

Fig. 2. Wastewater treatment steps in southern SFAX WWTP.