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Efficiency of two sewage treatment systems (activated sludge and natural lagoons) for helminth egg removal in Morocco

Sana Chaoua[a,*], Samia Boussaa[a,b,*], Ahmed Khadra[a], Ali Boumezzough[a]

[a] Laboratory Ecology and Environment (L2E), URAC 32, Faculty of Sciences Semlalia, Cadi Ayyad University, BP 2390-4008 Marrakesh, Morocco
[b] ISPITS-Higher Institute of Nursing and Health Techniques, Ministry of Health, Marrakesh, Morocco

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ABSTRACT

Morocco is a country known for its vulnerability of water resources because of its arid and semi-arid climate. Thus, recycled wastewater has been suggested for agricultural activities, but contamination of these wastewaters is a major concern.

The current study aims to determine the occurrence of helminth eggs in urban wastewater and to evaluate the removal of these pathogens by two sewage treatment systems: activated sludge and natural lagoons. The samples of wastewater and sludge were collected from two wastewater treatment plants (WWTP) located in Marrakech and Chichaoua, Morocco.

Parasitological identification, according to the Bailenger technique, showed the presence of Nematodes and Cestodes, which are pathogenic to humans and animals and are responsible for helminthiasis. The wastewater and sewage sludge samples from Marrakech carried *Ascaris lumbricoïdes*, *Ancylostoma duodenale*, *Trichuris trichiura*, *Capillaria* spp., *Taenia* spp. and *Hymenolepis* spp., while the samples from Chichaoua carried *Ascaris lumbricoïdes*, *Ancylostoma duodenale*, *Trichuris trichiura* and *Capillaria* spp.

The overall removal efficiency of eggs in the treatment plants ranged from 100% in the WWTP of Marrakech using activate sludge to 94.97% in the WWTP of Chichaoua using natural lagoons. These results were discussed according to health risk and the cost-effectiveness of both wastewater treatment techniques.

Introduction

Water shortage in arid and semi-arid regions of the Middle East and North Africa, including Morocco, is a major issue [1]. Water quality degradation is quickly joining water scarcity in most countries of these regions.

In Morocco, using treated wastewater and sludge in agriculture is a widespread practice as an official strategy against quantitative and qualitative threats to water resources. However, these unconventional resources (treated wastewater and sludge) contain significant concentrations of fertilizing elements, such as nitrogen and phosphate. Many authors have noted the positive correlation between the metabolic activity of soil microorganisms and sewage effluent in irrigation [2,3].

In addition, wastewater is a major vehicle of biological infectious agents, especially bacteria, viruses and protozoa, which can be transmitted by direct contact with polluted sludge or wastewater or indirectly through ingestion of contaminated crops [4]. The helminth eggs, helminthiasis infective agents, are extremely resistant to environmental stress and persist for several years in the soil [5,6], while bacteria can survive in water for several weeks depending on its temperature, physio-chemical conditions and sunlight [7–9].

The persistence of helminth eggs, especially intestinal Nematodes, is the main constraint for the reuse of wastewater in agriculture. Because of their high resistance in the environment, their simple life cycle and low minimal infective doses, helminth eggs have been considered indicator organisms [10].

Part of the control strategy for helminthiasis is to remove eggs from wastewater and to later inactivate them in the sludge produced from wastewater treatment. However, these pathogens cannot be completely removed by conventional disinfection processes because of their resistance [11]. In sewage treatment systems, the elimination of suspended particles by separating

* Corresponding authors at: Laboratory Ecology and Environment (L2E), URAC 32, Faculty of Sciences Semlalia, Cadi Ayyad University, BP 2390-4008 Marrakesh, Morocco.
E-mail addresses: sana.chaoua@gmail.com (S. Chaoua), samiaboussaa@gmail.com (S. Boussaa).

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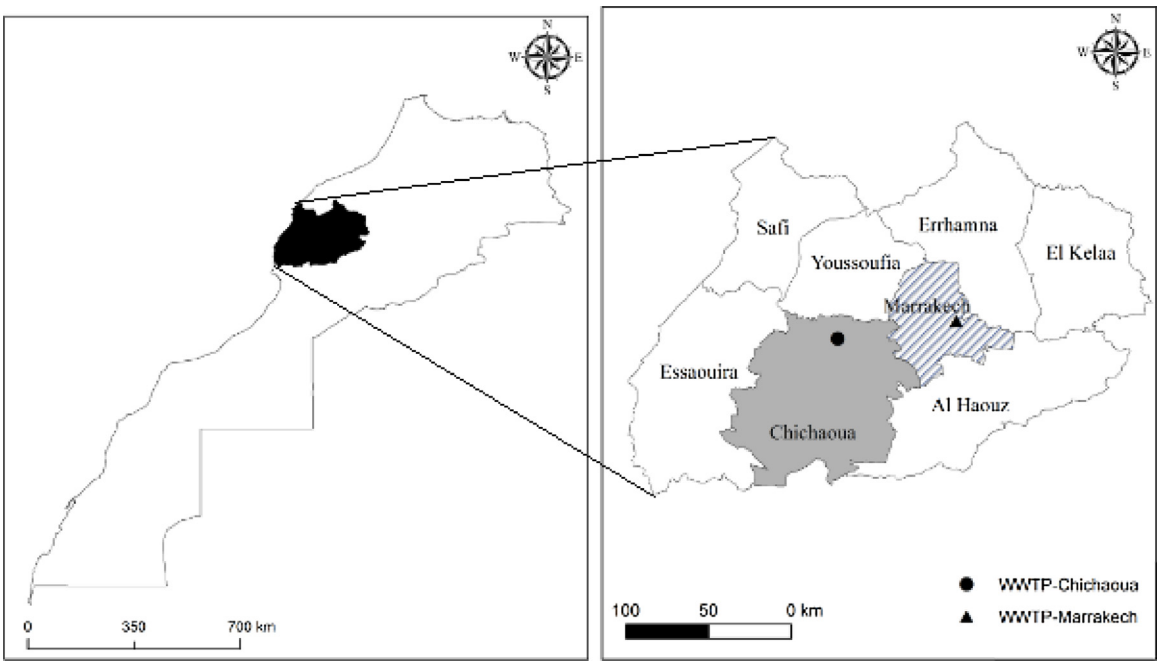

Fig. 1. Map of Morocco with study area localization.

Table 1
Presentation of study area [19].

Region	Habitant	Superficies (km²)	Urbanization rate (%)
Marrakech	1330468	6872	51
Chichaoua	369955	2625	4

processes (sedimentation, filtration, flocculation and coagulation) is accompanied by an abatement of the concentration of helminth eggs [12]. Many authors have highlighted the ability to reduce these resistant microorganisms as indicator of the disinfection capacities of wastewater treatment systems [13–15]. Therefore, the evaluation of purification yield gives information regarding the health risk of wastewater reuse for the human population. The effectiveness of wastewater treatment systems against helminth eggs has been demonstrated for activated sludge, sand filtration [16] and lagoon ponds [17,18].

In the same way, we aimed to investigate the presence of intestinal parasites (as helminth eggs) in wastewater and sewage sludge for the first time in our study area and to evaluate and compare the effectiveness of two sewage treatment systems (activate sludge and natural lagoons) in the elimination of helminth eggs.

Materials and methods

Study area

Sampling was carried out at two wastewater treatment plants in central Morocco (Fig. 1), with two different treatment systems. The activated sludge station of Marrakech and the natural lagoons station of Chichaoua were included in this study (Table 1).

Wastewater treatment plant (WWTP) of Marrakech

Marrakech has a WWTP with a capacity of 1.3 million of population equivalents. The WWTP (31°41′42.56″N; 08°03′34.01″W) is located on a lot of 17 ha in the Tensift Wadi riverbed, downstream of the dam that allows the N7 (Road Safi) to cross the river [20].

The mechanical treatment of the Wastewater Treatment Plant of Marrakech was enhanced by a biological treatment stage in 2010–2012. This biological stage includes 4 activated sludge tanks (70,000 m^3), 4 clarifiers (Ø 56.7 m), rapid sand filtration (20 filters), UV-disinfection, chlorination, mechanical excess sludge thickening (DAF), two digesters, sludge dewatering, biogas cleaning and CHP biogas plant.

All the sludge produced in the water system is recovered and thickened by gravitation for the primary sludge and by flotation for the secondary sludge. The thickened sludge is returned to four digesters for the production of biogas by biomethanization [20].

Wastewater treatment plant of Chichaoua

The WWTP of Chichaoua (31°32′38″N; 8°45′58″W) has a capacity of 22,000 equivalent inhabitants. It will allow a treatment flow of 2.000 m^3 per day. The treatment of raw water adopted for the station is natural lagoons. The first step is screening, and then the ponds are arranged and operated in series, with anaerobic ponds preceding the facultative ponds, which then feed into several maturation ponds. Sludge is collected and treated by the composting process byONEP (National Office for Potable Water) in collaboration with the Ecology and Environment Laboratory (L2E), Faculty of Sciences Semlalia [21].

Sample collection

Wastewater and sewage sludge were collected from the two wastewater treatment plants during the spring season from April to June 2016 with two samples per month.

The wastewater samples were collected from different stages of the two treatment systems. A sample of 10 l was taken [22] approximately 11 am, when the parasite load is closely related to human activity [23]. For the primary sludge, we collected samples of 100 g from each station. Samples were conserved in formaldehyde 10% (2 ml/l) for parasitological analysis [24] and transported to the Laboratory of Ecology and Environment (L2E) for treatment.

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