Current Situation of Treated Wastewater Reuse in Golf Courses in Marrakesh (Morocco): Problems and Solutions

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Morocco is suffering from water scarcity. Water resources are estimated to be 700 m$^3$/year/capitata.

Moroccan government initiated in 2006 the National Plan for Sanitation which aims partly to:

- Treat 80% of sewage in 2020 and 100% in 2030.
- Reduce pollution by 60%.
- Use 35% of reclaimed wastewater in irrigation of green spaces and golf courses.
INTRODUCTION
As a part of the National Tourism Strategy, Marrakech has developed its golf sector. The city comprises nowadays 11 running golf courses and 7 under construction.

- TOURISTIC POTENTIAL
- ECONOMY

A project of treatment and reuse of reclaimed wastewater in the irrigation of golf courses has been initiated in 2008.

Our study presents the results of a survey carried out in 2015 in Marrakesh, in order to assess the current situation of this reuse.
STUDY AREA CHARACTERISTICS

- Climate: Arid continental

- Maximum precipitations occur in April and November while minimum rainfall is recorded in summer (June, July, August and September).

- Monthly average temperature: from 4.4°C to 38.3°C.

- Monthly evapotranspiration: from 1.76 to 7.01 mm/day (average of 4.13 mm/day).

<table>
<thead>
<tr>
<th>Table 1: Climatic data for Marrakesh (ClimWat, 2015)</th>
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<tr>
<td><strong>Rain</strong> mm</td>
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<tr>
<td>-------------</td>
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<tr>
<td><strong>Min T°</strong> °C</td>
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<tr>
<td><strong>Max T°</strong> °C</td>
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<td><strong>ETo</strong> mm/day</td>
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MATERIALS AND METHODS

INVESTIGATION (July/August 2015)

-RADEEMA offices:
  - Political, financial, regulatory and technical frameworks

-75% golf courses irrigating with reclaimed wastewater in Marrakech (Self administrated questionnaire/Answers obtained on site)
  - Areas, water consumption, water storage structures, soil types, irrigation systems, turfgrass varieties, and hygienic measures taken to protect public and employees
CURRENT STATE OF THE TREATMENT AND REUSE OF RECLAIMED WASTEWATER IN MARRAKESH

- Construction of a wastewater treatment plant (33 million m³/year)
- Construction of a distribution network (80 km)
CURRENT STATE OF THE TREATMENT AND REUSE OF RECLAIMED WASTEWATER IN MARRAKESH

- **Pre-treatment**: grit and grease removal.
- **Primary treatment**: water decanting.
- **Secondary treatment**: Biological activation.
- **Tertiary treatment**: Coagulation and flocculation, sand filtration and disinfection by ultraviolet lamps and chlorine.
• Total water consumption from April 2012 till August 2015: 11.3 Mm³
• Average Reclaimed wastewater consumption in surveyed golf courses: 16 000 m³/ha/year (ranging from 5,945 to 28,836 m³/ha.year).
• Reclaimed wastewater consumption in surveyed golf courses in Spain: 8 200 m³/ha.year).

Figure 2: Golf courses monthly consumption of reclaimed wastewater (2012, 2013, 2014)
WATER MANAGEMENT OF GOLF COURSES UNDER IRRIGATION WITH RECLAIMED WASTEWATER IN MARRAKESH

GENERAL DATA (water consumption)

- Golf courses equipped with irrigation Centralized management system: 100%
- Golf courses equipped with Agro-meteorological station: 67%
- Golf courses equipped with soil humidity sensor: 33%
WATER MANAGEMENT OF GOLF COURSES UNDER IRRIGATION WITH RECLAIMED WASTEWATER IN MARRAKESH

IRRIGATION SYSTEM MANAGEMENT

- **Storage facilities**: Lakes (50,000 to 92,400 m³).

- **Pumping system**: 5 to 6 pumps with different flow rate.

- **Filtration system**: Screen filtration (83%).
  Disc filtration (17%).
Figure: Percentage of golf courses surveyed facing negative impacts of reclaimed wastewater on storage lakes and irrigation system in Marrakesh.
WATER MANAGEMENT OF GOLF COURSES UNDER IRRIGATION WITH RECLAIMED WASTEWATER IN MARRAKESH

IRRIGATION SYSTEM MANAGEMENT

Undetaken treatments (%)

<table>
<thead>
<tr>
<th>Cleaning</th>
<th>Aeration</th>
<th>Filtration system</th>
<th>Pumping station</th>
<th>Lake</th>
<th>Ultrasound system</th>
<th>Fogger treatment</th>
<th>Lakes depth increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
<td>80</td>
<td>60</td>
<td>40</td>
<td>20</td>
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Other treatments:
- Ultrasound system
- Fogger treatment
- Lakes depth increase
RECOMMENDED MEASURES FOR WASTEWATER REUSE IN GOLF IRRIGATION

**Efficient filtration system**

1. Sand and gravel filters are recommended before screen or disc filtration in order to remove suspended inorganic and organic fines.

2. Automatic flushing for filter cleaning (Used by only 50% of golf courses)

**Improvement of water quality**

1. Acid injection

**Improvement of Reclaimed wastewater storage**

1. Aeration (reduces odors and increases dissolved oxygen)
2. Storage in covered tank (high costs of constructing but low costs of maintenance)
3. Chemical treatment for algae.
WATER MANAGEMENT OF GOLF COURSES UNDER IRRIGATION WITH RECLAIMED WASTEWATER IN MARRAKESH

SOIL MANAGEMENT

- Soil: clayey in fairways, and sandy in greens.

Figure 5: Responses of golf courses managers to negative impacts of reclaimed wastewater in golf courses in Marrakesh
Figure 6: Actions undertaken to overcome soil problems caused by irrigation with reclaimed wastewater in surveyed golf courses in Marrakesh.
All golf courses use *Agrostis stolonifera*. The use of *Agrostis stolonifera* was chosen for its tolerance to various stresses, including drought, heat, frost and withstanding low mowing heights (3 mm). 50% of respondents stated that reclaimed wastewater did not affect directly *Agrostis stolonifera*. Others claim it causes longer germination periods, fungal diseases, and rooting issues.
Generally, respondents claimed RWW didn’t have any direct effects on turf.
ISSUES FACED BY THE GOLF COURSES REUSING RECLAIMED WASTEWATER

HYGIENE MANAGEMENT

- Apart from signs that prohibit swimming in lakes without mentioning the source of the water and irrigation during closure time, no hygienic measures are taken by golf courses to protect clients.
- 33% of respondents asked workers to put protection when they are in contact with reclaimed wastewater, but no hygienic measures were undertaken by employees.
Reuse of reclaimed wastewater offers multiple benefits but presents also some limits that need appropriate management. As the golf industry tends to expand in Morocco, and more golf courses will have to switch to reclaimed wastewater for irrigation, more investigations must be undertaken in order to have a national guidelines and best practices of reusing reclaimed wastewater in the golf industry.
Thanks for your attention!

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