Organic micropollutants in the water cycle of a Euro-Mediterranean resort: occurrence and perspectives of decentralised water reuse

G. Buttiglieri[*,1], G. Ferrero[**], Y. Ekowati[**], M. Petrovic[*,***], C. Perez[****], I. Rodriguez-Roda[*,*****]

[*] ICRA, Catalan Institute for Water Research, Parc Científic Tecnològic de la UdG. 17003 Girona, Spain
[1] Gianluigi Buttiglieri; gbuttiglieri@icra.cat; Tel. +34972183380
[**] UNESCO-IHE Institute for Water Education, Westvest 7, 2611 AX Delft, The Netherlands
[***] ICREA - Catalan Institution for Research and Advanced Studies, Passeig Lluís Companys 23, 08010 Barcelona, Spain
[****]LEITAT Technological Center, Environment R&D Departament, C/Innovació 2, E-08225 Terrassa, Spain
[*****] LEQUiA, Institute of the Environment, University of Girona, E-17071 Girona, Spain

Abstract: Touristic facilities located in water scarce areas of the Euro-Mediterranean are simultaneously facing growing incoming numbers of tourists and decreasing availability of water resources. Decentralised water reuse has become one of the most promising practices for insuring dramatic reduction of water consumption in the touristic sector. Different targets in terms of water quality requirements are established by national and international regulations. However, emerging micropollutants have not yet been included in such policies, partially because of the lack of information on their occurrence. This study aimed at comprehensively characterizing the water cycle of a large Euro-Mediterranean resort, during high and low season, in terms of water usage and water quality. Specifically, physicochemical and microbiological parameters analyses were assessed as well as the occurrence of a wide-ranging number of micropollutants.

Keywords: pharmaceuticals; tourism; water scarcity; water reuse.

INTRODUCTION

Global water use has tripled in the last 50 years due to population increase, economic growth, changes in lifestyle, technologies and international trade. Fresh water availability is unevenly distributed between countries and within countries and water scarcity may exist at the regional and local scale. High and concentrated tourism may exceed the levels of consumption of water resources in particular in arid and water-stressed regions, some of which have already needed water transfers to prevent salinization (Cazcarro et al., 2014). Increasing water consumption and intensity as well as tourist numbers and tourism activities standards are expected (UNWTO-UNEP-WMO, 2008). Tourism water consumption is typically below 5 % of domestic water use, but can be as high as 40 % (e.g. Mauritius; Gössling et al., 2012). Additionally, touristic nuclei can have a strong impact on water quality and have been considered as probable source of micropollutants in seawater especially during the high season (Moreno-Gonzalez et al., 2015). Moreover, peaks in micropollutants wastewater contamination have been related to touristic events (Gerrity et al., 2011). However, situations are difficult to analyze because hard data are missing, expensive and/or difficult to obtain (Essex et al., 2010). A thorough assessment of water quantity and quality in the entire water cycle of a large resort has been performed during high and low season with specific emphasis on micropollutants. Decentralized water reuse can decrease water consumption and result in a closed water cycle but (micro)pollutants accumulation needs to be carefully addressed.

MATERIAL AND METHODS

Hotel Samba is located in an extremely touristic area of the North-Eastern Mediterranean coast of Spain, where dramatic water demand increase coincides with water scarcity events during the summer months. Hotel Samba is a large 3 star resort with 441 air conditioned rooms, green areas and exterior pools, conference rooms, bar and restaurant. Water use reported by the hotel ranges from 25,000 to 34,000 m^3/year (100-135 L/person/day). Interventions to reduce water consumption, such as grey water reuse for water closets, were undertaken in the past allowing reuse of 13,500 to 15,000 m^3/year. Two sampling campaigns have been performed in the high season (June, with 76-

This document has been produced with the assistance of the European Union (Grant agreement N° 619116). The contents of this document are the sole responsibility of demEAUmed Consortium and can in no way be taken to reflect the views of the EU.

99% of rooms occupied) and in the low season (November, with 35-67% of rooms occupied). Each sampling campaign took place during three not consecutive days. The sampling points are presented in Figure 1. Different chemical, physical and microbiological parameters were analyzed as well as a broad number of pre-selected micropollutants: 31 pharmaceuticals (18 positive and 13 negative ionization mode) and other 11 micropollutants (endocrine disruptors and flame retardants).

RESULTS AND CONCLUSIONS

It emerged an important seasonal variation in water consumption per use (Figure 1) with a 48% total tap water reduction during low season (128 vs 67 m^3/day in high and low season, respectively).

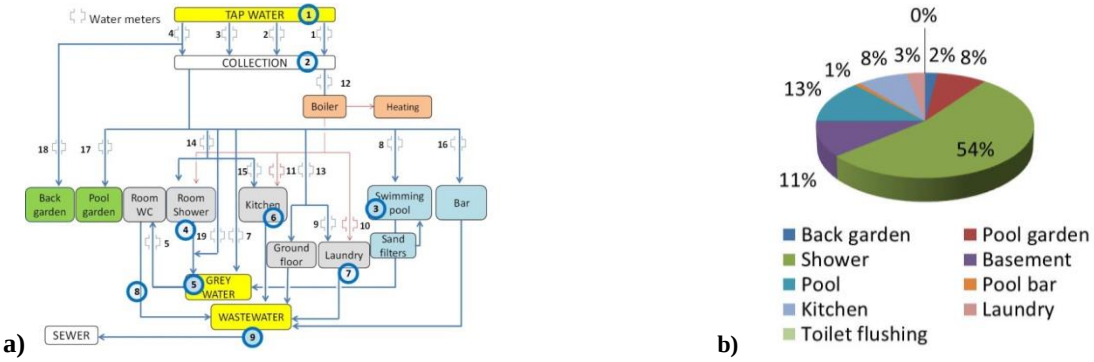

Figure 1. a) Sampling points. 1: tap; 2: tap water deposit (Cl_2 addition); 3: swimming pool; 4: shower effluent; 5: grey water tank; 6: kitchen effluent; 7: laundry effluent; 8: hotel room black water effluent, 9: hotel wastewater effluent. b) Tap water consumption divided by use during the high season sampling campaign.

A comprehensive physicochemical characterization, including a broad overview of micropollutants, was performed by use and by season. In some cases limited differences were observed (e.g. tap and pool water) while different patterns in consumption and contamination were detected in greywater and wastewater during high and low season. Extremely high micropollutants concentrations, up to 240 μg/L, were detected in greywater, kitchen effluent and wastewater (Figure 2), at levels higher than wastewater treatment plant influent average concentrations. Loads of micropollutants (ng/person/day) were calculated and compared.

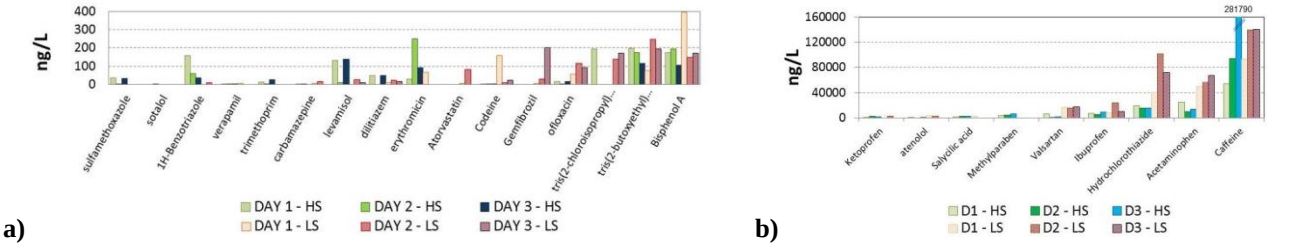

Figure 2. Occurrence of a selection of micropollutants in the hotel water cycle (HS: high season; LS: low season; a) greywater, b) wastewater).

REFERENCES

Cazcarro I., Hoekstra A.Y., Sánchez Chóliz J. (2014), The water footprint of tourism in Spain. *Tourism Management*, **40**, 90-101.

Essex S., Kent M., Newnham R. (2010), Tourism Development in Mallorca: Is Water Supply a Constraint? *J. Sustainable Tour.* **12**(1), 4-28.

Gerrity D., Trenholm R.A., Snyder S.A. (2011), Temporal variability of pharmaceuticals and illicit drugs in wastewater and the effects of a major sporting event. *Water Res.* **45**, 5399-5411.

Moreno-González R., Rodriguez-Mozaz S., Gros M., Barceló D., León V.M. (2015), Seasonal distribution of pharmaceuticals in marine water and sediment from a mediterranean coastal lagoon. *Environ. Res.* **13,** 326-344.

Scoullos, M. J. (2003), Impact of anthropogenic activities in the coastal region of the Mediterranean Sea. In: Int. Conf. on the Sustainable Development of the Mediterranean and Black Sea Environment, May, Thessaloniki, Greece.

UNWTO, UNEP and WMO (UN World Tourism Organization, United Nations Environment Programme and World Meteorological Organization). (2008), Climate change and tourism: Responding to global challenges. Paris & Madrid.

This document has been produced with the assistance of the European Union (Grant agreement N° 619116). The contents of this document are the sole responsibility of demEAUmed Consortium and can in no way be taken to reflect the views of the EU.