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Contribution of Constructed Wetlands for Reclaimed Water Production: A Review

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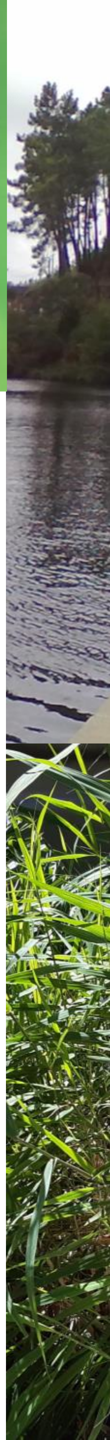


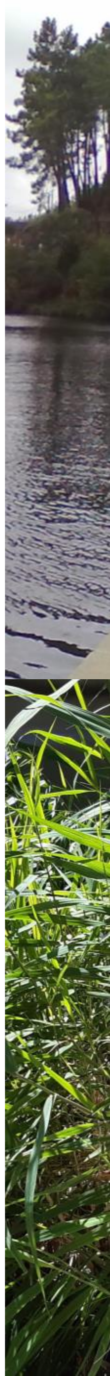
Contribution of Constructed Wetlands for Reclaimed Water Production: A Review

Goal

The purpose of this work is to evaluate the potential of constructed wetlands for the production of reclaimed water, based on a critical review of published research.

Presentation structure

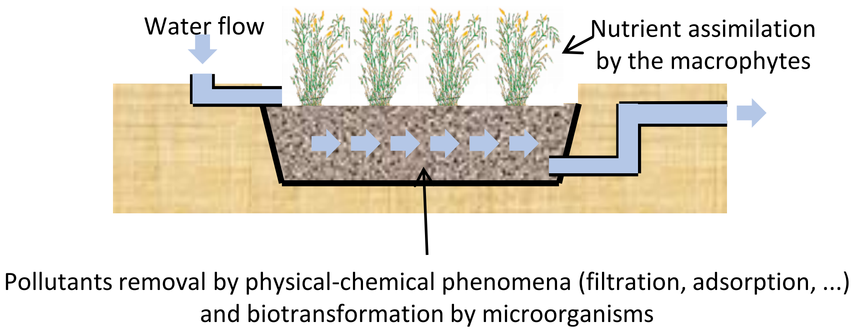
Introduction → Methods → Results → Discussion → Perspectives for the future → Conclusions

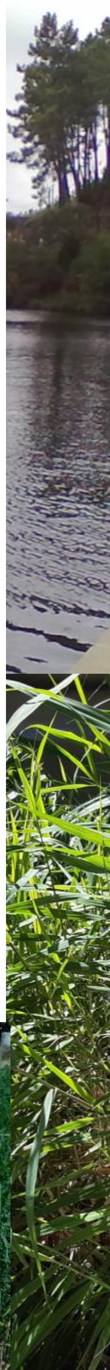


Introduction

Reclaimed water consists of wastewater treated by adequate processes that ensure water quality and absence of risk, qualifying the water to be used for some purpose, replacing or decreasing the consumption of freshwater.

Constructed wetlands (CWs) consist of an eco-efficient, green and low-cost technology for wastewater treatment, most suitable for tertiary and advanced treatment but also applied to secondary and even primary steps.



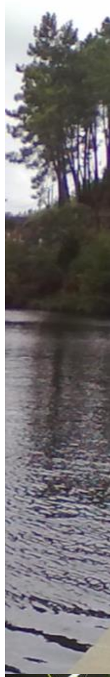


Introduction

Reclaimed water production and use contribute to mitigating the scarcity of freshwater.

Agriculture and related activities consist in the main abstraction of freshwater reserves, but several other human activities present relevant contributions.

Most of the water uses imply the generation of resultant wastewater.



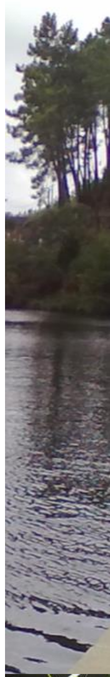
Introduction

The conventional wastewater primary and secondary treatment technologies do not allow to obtain of treated water with the quality required for its reuse.

Main reclaimed water end uses require advanced treatments, which may include disinfection.

Examples of advanced treatments are additional settling or filtration, coagulation-flocculation, desalination, maturation lagoons, and CWs.

Due to its low CAPEX and OPEX, CWs may potentiate the dissemination of reclaimed water production and reuse.

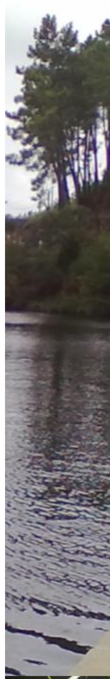


Methods

The present work aims to extend some previous review works, such as the work of Tao et al. (2017)*, which proposed a set of design orientations for using CWs to produce reclaimed water, based on the available data from 31 full-scale CWs.

The present work is intended to include published work on studies carried out with pilot-scale CWs in the last decade, and full-scale data not covered by the referred previous review. <u>The data gathered was organized according to</u> the wastewater and CW types, end uses, water quality analysis and experiments carried out to validate the end-use quality criteria.

* Tao W, Sauba K, Fattah K and Smith J 2017 *Rev. Environ. Sci. Biotechnol.* **16** 37–57

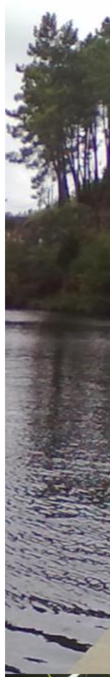


Methods

The kinds of wastewater considered were Domestic, Urban, Industrial, and Others, like greywater and stormwater. When not indicated by the authors, domestic wastewater was considered as urban, and irrigation end-use was classified as for agriculture purposes.

There are several types of CW depending on the construction design and operation mode and can be set in combinations of that. Three main types are common and classified according to the flow arrangement of the water under treatment:

- subsurface vertical flow CWs, SSVF, abbreviated as VF;
- subsurface horizontal flow CWs, SSHF, abbreviated as HF;
- and free surface flow CWs, FSF.



Methods

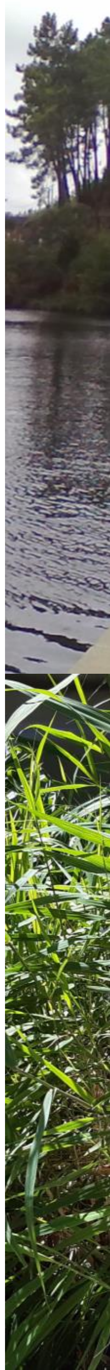
Reclaimed water end-uses were organized in:

(i) Potable Uses - direct or indirect;

(ii) Non-potable Uses - irrigation of animal feeding, food crops, non-food plantations or woodlands, aquaculture production, and urban and residential uses that may include green spaces irrigation, urban lakes, ponds, fountains and recreative spaces, cleaning of urban areas and roads, fire protection, air conditioning, toilet flushing, and washing of cars and clothes, among other urban uses;

(iii) Groundwater and Environment - groundwater replenishment, streams recovery and augmentation, seawater intrusion barrier;

(iv) and Industrial Uses - such as process water, cooling water, boiler make-up water, and washing of spaces and equipment.

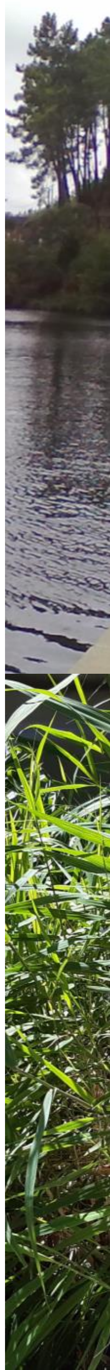


Methods

A search in Scopus database was conducted, and the contents of the extracted documents were evaluated for the focus on the end uses of the reclaimed water produced by CWs.

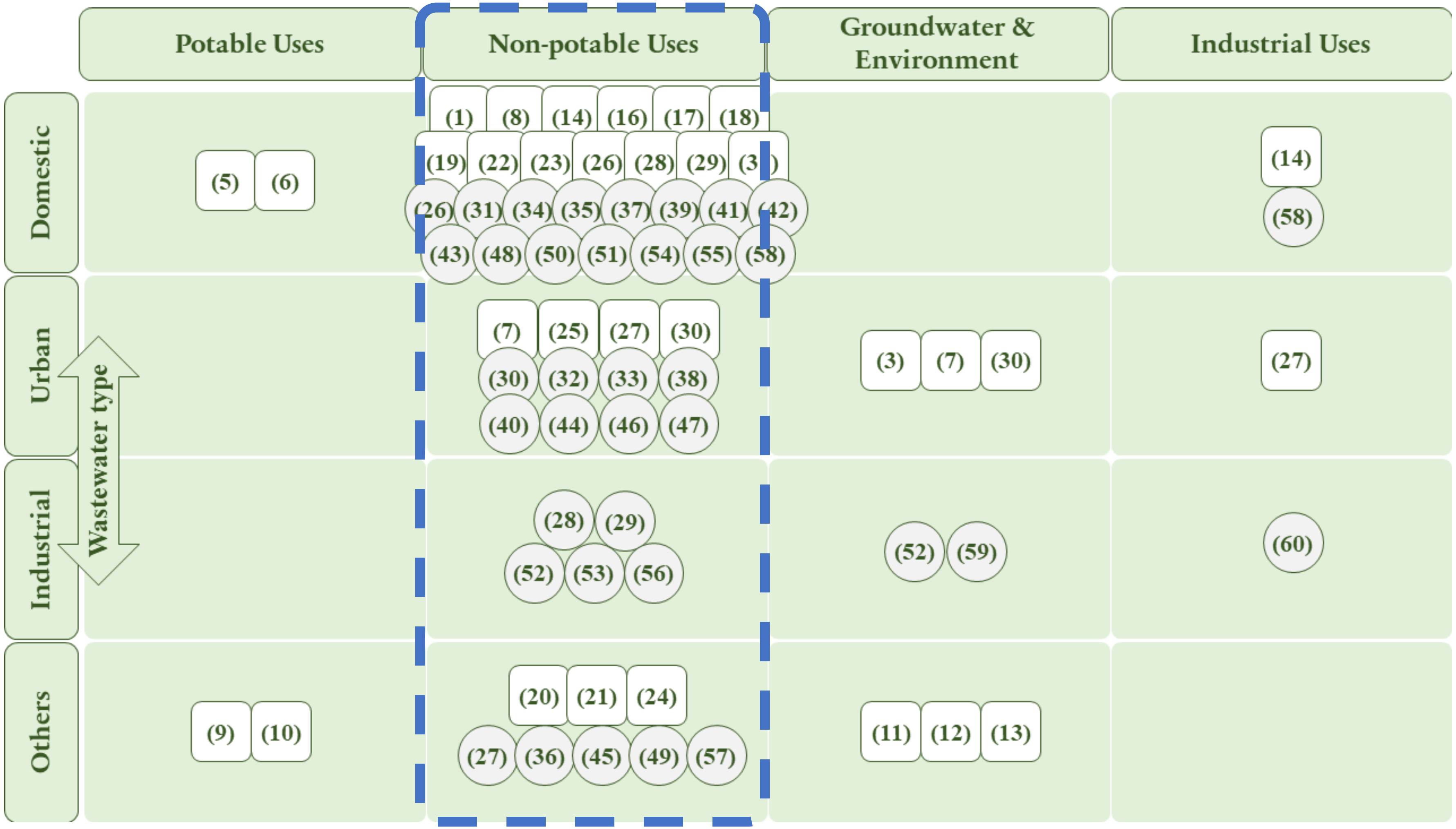
The documents published from 2010 onwards and providing the characteristics of the CWs, wastewater type, analysis performed and water end-use were selected, and then organized according to an adaptation of the end uses of reclaimed water classification following and the main types of wastewater.

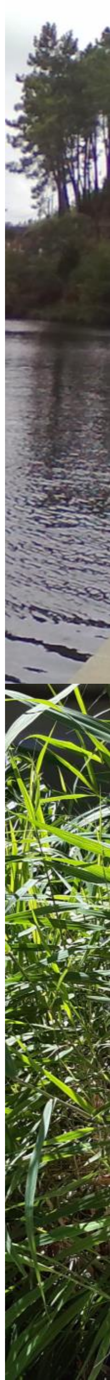
The search and selection procedure resulted in the analysis of 33 documents.



Results

Distribution of the 31 works referred by Tao and co-workers (squares) and the retrieved 33 published works (circles).





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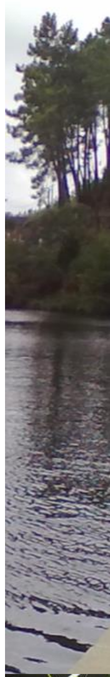
Discussion

It was observed that 70% of the identified works propose the use of reclaimed water for irrigation in agriculture, but most of this end-use applicability is based on a theoretical comparison of the treated water quality with the current legislation.
This result was expected because agriculture and related activities consist in the main abstraction of freshwater reserves.

Within this end-use, only 23% of works attempted evaluating the effects of the reclaimed water by some kind of irrigation experiment.
Using the theoretical or practical approaches, 48% of the works either identified some risk or had lacking data in the experiments that impeded the risk evaluation.



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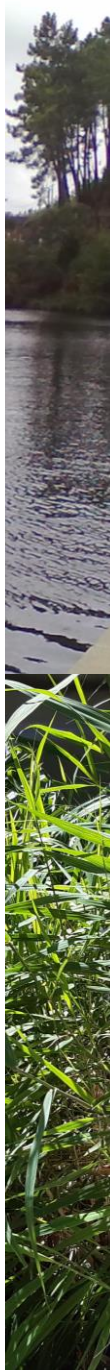
Discussion

The most reported data refers to the use of reclaimed water for non-potable uses (near 77% of total cases), and almost all cases within non-potable uses report to irrigation purposes (more than 95%).

Few recent works are focusing on the use of CWs to produce reclaimed water for applications other than non-potable uses in the last decade. These works consider the use of reclaimed water to:

- Restore surface water quality;
- Feed coastal wetlands;
- Combine irrigation of green spaces and microalgae production;
- Reuse in the automotive industry.

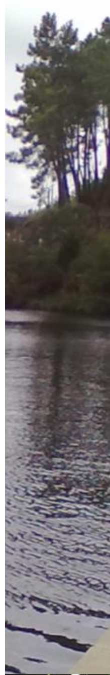


Perspectives for the future

Potable and Industrial uses of reclaimed water produced by CWs are less explored in the reviewed literature.

Although the standards for use in potable applications are stringent, this end-use may represent a relevant market to foster the production of reclaimed water, in which the contribution of CWs can be considered.

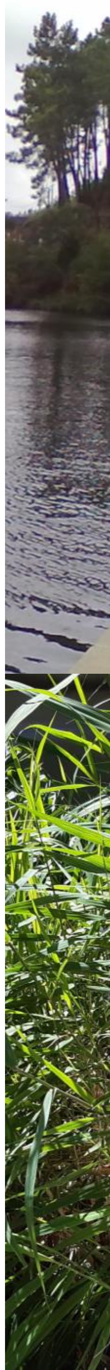
Some other potential uses seem to be less explored, such as the use of reclaimed water for firefighting, and industrial applications (such as process water, washing, and cooling).



Perspectives for the future

There are also few reports on the use of CWs to reclaim greywater and stormwater, which can be a potential use of CWs since this technology works well with low-strength wastewaters and is very resilient to non-conventional pollutants.

A particular strength of CWs, the multiple modes of design and operation, and the consequent adaptability to different wastewaters and reclaimed water applications is also a barrier to the spread of this technology.
A shorter set of design and operation schemes may foster the spread of the technology, by presenting a set of fewer complex scenarios to the stakeholders.

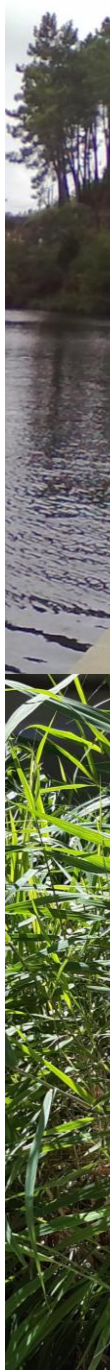


Conclusions

Reclaiming wastewater has a special role in the mitigation of the growing water scarcity threat.

CWs may contribute to that goal due to their eco-efficiency, low-cost implementation and operation, flexibility, and link to sustainable development and circular economy.

The present work showed that most research and fieldwork focus on CWs application is for irrigation or environmental applications, and, mainly, in reclaiming domestic and urban wastewaters.

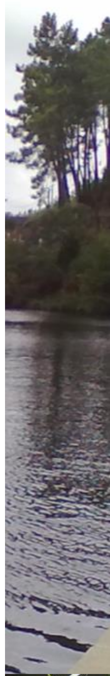


Conclusions

Using other types of wastewaters, such as greywater, stormwater, and industrial wastewaters, may represent an opportunity to explore CWs contribution to reclaiming wastewater.

There is still also a need to focus the research on the treated water quality on each kind of end-uses, and a need to standardize reclaimed water regulations and CWs design and operation.

Thank you for your attention.



Acknowledgments

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