

Research Article

# Micropollutants in wastewater irrigation systems: Impacts and perspectives

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## Introduction

Climate change and the increasing global population pose a severe threat to the availability of freshwater in the world. Over consumption of water and deteriorating water quality are problems that should be addressed in order to ensure water availability for the coming decades. In this context, the increasing presence of micropollutants in water has shown to cause detrimental impact on water quality, given the negative disturbances that they can cause on human health and on the environment. Thus, it is important to study and quantify the presence of micropollutants in water bodies and also in regenerated wastewater based irrigation systems.

Micropollutants are defined as pollutants present at low concentrations in the water (ranging from pg to ng) and they can be pharmaceuticals, hormones, personal care products (PPCPs), pesticides, etc. [4]. Their massive production and their low removal capacity from water in conventional wastewater treatment plants (WWTPs) has led to its high persistence in the environment. As a result, they accumulate in soil, plants, and living beings, causing well documented harmful impacts. Some examples are their effect as endocrine disruptors on aquatic organisms, and the carcinogenic effect that polycyclic aromatic hydrocarbons (PAHs) cause in humans. In addition, the presence of antibiotics in the environment has made bacteria to gain resistance against antibiotics.

Regenerated wastewater usage in agriculture is a widespread practice in countries that face water scarcity, because it is a feasible solution to save and manage the available water resources [2]. However, the increasing presence of micropollutants in wastewater is a relevant impediment for this practice, as they accumulate on the plantations, on the soil, and they can even reach the groundwater by percolation. For example, in the Beijing area, the treated water from the WWTPs is discharged into the Wenyu River and their tributaries. This water is used for irrigation purposes in the agriculture fields.

## More Information

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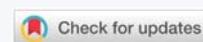
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In order to quantify the discharge of organic micropollutants [3], calculated the annual load of each organic micropollutant and their sources (wastewater treatment plants, agriculture practices, etc). The total annual load of organic micropollutants was found to be  $13.140 \pm 620$  kg/year ( $\pm$ standard deviation). Among this load,  $5930 \pm 440$  kg/year corresponded to pharmaceuticals and metabolites,  $1550 \pm 140$  kg/year to pesticides and metabolites, and  $5660 \pm 350$  kg/year to household chemicals, respectively. According to this study, urban households and other establishments were identified as the main sources of organic micropollutants in the studied area.

Finally, the authors compared the micropollutants concentration in this fluvial system with the average and maximum concentrations of these chemicals reported in the literature (e.g. Europe and the USA), in order to evaluate their eco-toxicological effects, and to gather useful information for further decision-making. In order to achieve this, the concentrations of micropollutants causing chronic and acute effects stipulated by the Technical Guidance Document for Environmental Quality Standards (EU) were referred for the purpose of comparison. In this sense, the maximum allowable concentrations were used to evaluate the risk of presenting acute effects, while the annual average values was considered for evaluating the chronic effects. However, regarding the 62 identified micropollutants, data was available for only 16 pollutants. However, the results showed that these values had exceeded for carbendazim, clarithromycin, diclorofenac, and diuron.

## Practical applications

The most important practical application of initiating such studies will be to evaluate the eco-toxicological risk of the micropollutants with respect to their annual loads, in order to evaluate their possible detrimental effects on human health

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and the natural environment. Literatures relevant to the established chronic and acute effect concentrations of these substances (European Environmental Quality Standards) should be referred. However, in some instances, a complete toxicological and risk evaluation will not be possible due to the lack of information for the majority of the chemicals.

Conventional WWTPs that employ both primary and secondary treatment processes have low efficiency for the removal of micropollutants, as they aim to eliminate particulates, carbonaceous substances, nutrients and pathogens present in the water. Some reasons why micropollutants are difficult to treat is their low concentration and their wide range of physico-chemical and biological properties (e.g., biodegradability and hydrophobicity) [5]. In Beijing's case study, the results revealed that the major source of organic micropollutants is from the urban city of Beijing. The reason is that WWTPs are equipped with conventional treatment systems, showing an insufficient removal efficiency of these substances (from -27% to 65%) [3].

Considering these practical limitations, the implementation of tertiary treatment systems at the main WWTPs of Beijing is required in order to increase the removal efficiency of these micropollutants. Such advanced treatment systems are very versatile, as they can be composed of many different technologies, such as advanced oxidation processes, nanofiltration, powdered activated carbon (PAC), reverse osmosis, and membrane bioreactors. The selection of a particular treatment technology is governed by the characteristics and nature of the target substances to be treated, for example, by considering the polarity, refractory nature and molecular size of the pollutants. In this sense, given the organic nature of the micropollutants and their low concentrations, PAC could be considered as an efficient adsorbent for treating persistent and non-biodegradable organic compounds [1], carried out a study to assess the removal efficiency of micropollutants by PAC addition in WWTP, obtaining an overall removal higher than 80%. The results showed that the performance of PAC depends on the dose and contact time, the molecular structure and behavior of the substances to be treated, as well as the water and wastewater composition. For full-scale applications, all these factors should be studied and tested during pilot scale tests before implementation at the WWTPs in order to verify its effectiveness.

### Future research

After identifying the major micropollutants present in wastewater and from previous knowledge on the advantages and limitations of various advanced treatment technologies, future research should be focused on the identification of the most suitable technology to eliminate the characterized micropollutants. For this reason, the micropollutants loads in wastewater need to be considered just as an orientation towards the design of future tertiary treatment systems. In any developing country, the use of pharmaceutical compounds will

always increase in the upcoming years. In this sense, there is a need to develop studies oriented towards the quantification of the future usage of these chemicals in the country, in order to adapt the WWTP design for the removal of micropollutants. Moreover, financial assessments studies can also be developed in order to assess the required investments for the implementation of tertiary treatment system at WWTPs, as well as the obtainment of financial return by different means.

More studies should also be carried out to envisage the fate of the micropollutants after their release from WWTP. The use of regenerated wastewater for irrigation purposes can cause the accumulation of micropollutants in soils and crops. Moreover, these substances can even reach the groundwater due to percolation. However, there is a lack of information about the behaviour and fate of micropollutants in the soil and in the subsurface environment. Moreover, previous results have also suggested that diffuse agriculture sources are also important contributors to micropollutants release due to the extensive use of pesticides. In this sense, research pertaining to alternative agriculture practices that use less amount of pesticides need to be carried out. For example, replacing pesticides by the use of natural predators against frequent pests or by cultivating more pest-resistant varieties of crops.

Finally, there is still a lack of information in order to establish the presence of acceptable levels of these substances in drinkable water and food. For this reason, research on toxicological effects is crucial in order to develop strict regulations regarding these pollutants.

### Perspectives and outlook

The use of regenerated wastewater for irrigation purposes is a valuable solution for fighting against climate change effects and achieving a more circular economy. As a result of the growing world population, this practice is crucial in order to ensure food security, especially in water scarcity areas. Taking into consideration the risks involved for the society and the environment due to the presence of micropollutants, different stakeholders (including governmental sectors) have to play an essential role by tackling this problem. In this sense, governments should seek for citizens and nature well-being by promoting the implementation of tertiary treatment systems at existing WWTPs in order to obtain higher efficiencies of micropollutants removal. Additionally, more restrict legislation concerning environmental conservation needs to be developed in order to control and restrict the usage of detrimental chemicals. For example, the government needs to regulate the quantity of pesticides used per area of land, ensuring that farmers work under the allowed/prescribed limits. In order to achieve this, regular inspections and laboratory analysis of the produced crops are required. Moreover, given the financial revenue that the population of this area obtain as a result of the agriculture, upgrading existing WWTPs is crucial in order to maintain prosperous economy and ensure economic stability of a country.



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