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Emerging Contaminants (CECs) Content In Soil Irrigated With Treated Wastewater

Anna Gagliardi[1], Federica Carucci[1], Marcella Michela Giuliani[1], Michele Perniola[2], Michele Denora[2], Gennaro Brunetti[3], Francesco De Mastro[3], Carlo Salerno[4], Giovanni Berardi[4], Giuseppe Gatta[1]

[1] Dep. DAFNE, Univ. Foggia, IT, giuseppe.gatta@unifg.it, anna.gagliardi@unifg.it; federica.carucci@unifg.it; marcella.giuliani@unifg.it
[2] Dep. DICEM, Univ. Basilicata, IT, michele.denora@unibas.it; michele.perniola@unibas.it
[3] Dep. DiSSPA, Univ. Bari, IT, francesco.demastro@uniba.it; gennaro.brunetti@uniba.it
[4] IRSA CNR, Ist. Ric. Acque. Bari, IT, carlo.salerno@ba.irsa.cnr.it; giovanni.berardi@ba.irsa.cnr.it

Introduction

In the last years, the trace of emerging contaminants (CECs) in treated wastewater effluents used for crops irrigation, such as personal care products, plasticizers, surfactants, pesticides, food additives, pharmaceutical products, industrial additives, herbicides, has attracted considerable attention of scientific communities (Xu et al., 2009). Furthermore, the accumulation of CECs in the soil, depending on its physicochemical properties (Rimienschneider et al., 2017), and in the edible parts of food crops and their subsequent entry into the human food chain have been gaining prominence over the last decade (Christou et al., 2017).

This research aimed to evaluate the accumulation of selected CECs in soil irrigated with treated municipal wastewater (TWW) during one processing tomato crop cycle. According to international literature, the CECs were selected for this type of effluent based on previous analytical investigations conducted on the treated effluent used during our experimental trial.

Materials and Methods

The experimental trial was conducted in the Apulia region of Italy (Trinitapoli, 41°21' N; 16° 03' E; altitude 10 m a.s.l.) in a loam soil with the following physical and chemical characteristics: sand, 43.9%; silt, 35.9%; clay, 20.2; bulk density of 1.45 Mg m^{-3}; organic matter 1.8%; available phosphorus 203.0 mg kg^{-1}; total potassium 1.27 g kg^{-1}; total nitrogen 0.91‰. During the experimental period (2020), processing tomato (cv Taylor) was grown. The experimental field was arranged according to a complete randomized block design with the irrigation treatments (freshwater, FW, and treated wastewater, TWW) replicated three times. Samples of the irrigation water sources (FW and TWW) were taken four times during the processing tomato crop cycle, and the soil samples were collected at the beginning and the end of the crop cycle at three different depths (0-30, 30-60 and 60-90 cm).

The extraction of CECs in the soil samples was obtained with QueEChERS method, followed by determination using gas chromatography-tandem mass spectrometry (GC-MS/MS). Next, soil and water samples were analyzed to determine the CECs levels by online solid-phase extraction/liquid chromatography/high-resolution mass spectrometry (SPE/LC/HRMS).

Results

The concentrations of CECs in water sources (FW and TWW) are shown in Table 1. All selected CECs were not detected in FW, and the antibiotics Trimethoprim and Sulfamethoxazole, selected according to international literature, were not detected in TWW.

In irrigated soil, only eight CECs (Clarithromycin, Carbamazepine, Fluconazole, Climbazole, Sitagliptin, Telmisartan, Venlafaxine, Flecainide) were found with respect to 15 CEC_S detected in irrigated waters. However, only Clarithromycin, Fluconazole, and Telmisartan showed a significant difference in the concentrations between FW and TWW irrigated water (Figure 1).

Table 1. Mean values (± standard error) of the CECs concentration in irrigation water sources (freshwater, FW and treated wastewater, TWW). nd, non detected)

CECs	**Category**	**Irrigation Water**	
		FW	TWW
Selected Target		μg/L	μg/L
Clarithromycin	antibiotic	nd	0.02±0.02
Sulfamethoxazole	antibiotic	nd	nd
Trimethoprim	antibiotic	nd	nd
Ketoprofen	anti-inflam.	nd	0.11±0.11
Diclofenac	anti-inflam.	nd	0.81±0.10
Naproxen	anti-inflam	nd	0.00±0.00
Carbamazepine	antiepileptics	nd	0.30±0.02
Metoprolol	beta-blocker	nd	0.07±0.02
Fluconazole	antimicotic	nd	0.17±0.07
Climbazole	antimicotic	nd	0.05±0.02
Flecainide	antiarrhythmic	nd	1.56±0.34
Gabapentin	antiepileptics	nd	0.18±0.05
Sitagliptin	antidiabetic	nd	0.21±0.02
Telmisartan	antihypertensive	nd	0.32±0.13
Venlafaxine	antidepressant	nd	0.25±0.02

At the end of the tomato cycle, the concentration of these CECs (average values of the three depths) detected in the soil irrigated by TWW was significantly higher than in control (FW): 2.02 ng/g *vs*. 2.54 ng/g, 1.17 ng/g *vs.* 1.98 ng/g and 0.39 ng/g *vs*. 1.12 ng/g, for Clarithromycin, Fluconazole, and Telmisartan, respectively. The CECs content found in soil irrigated with FW is probably due to the type of irrigation water (treated wastewater) used in the experimental area over the past few years.

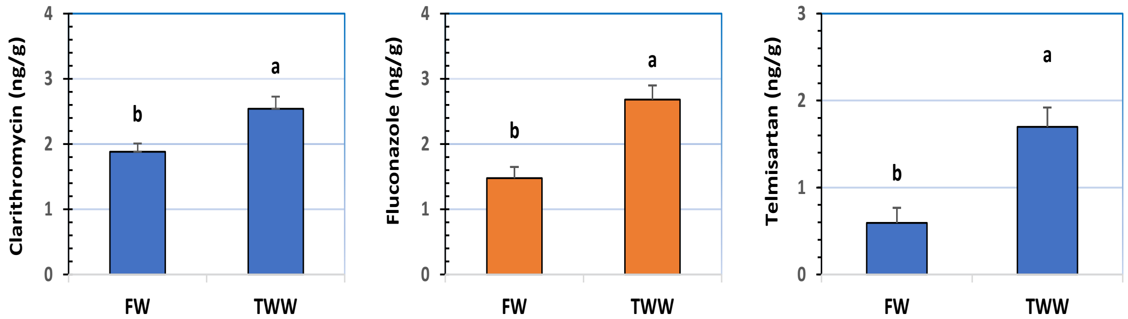

Figure 1 - Content of the Clarithromycin, Fluconazole and Telmisartan detected in irrigated-soil at the end of the processing tomato crop.

Conclusions

The results showed that not all selected CECs present in TWW were found in the soil. Evaluating CECs content in the soil system, it has highlighted the selective presence closely related to their physicochemical properties and soil characteristics. Indeed, these aspects can affect the degradation of pharmaceuticals and, therefore, their bioavailability. The problem related to the degradation of these CECs could be the formation of by-products, which are not necessarily less toxic with respect to the starting compounds. Future studies will be carried out to investigate CECs fate in soil irrigated by TWW.

Literature

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