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Retention of *Escherichia coli*, *Giardia lamblia* cysts and *Ascaris lumbricoides* eggs in agricultural soils irrigated by untreated wastewater

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ABSTRACT

In central Mexico, agricultural irrigation reusing Mexico City's municipal wastewater has been occurring for the last century, resulting in the recharge of the local aquifer. However, groundwater of this zone is of good quality, indicating that the microorganisms contained in wastewater are retained by soil after infiltration. This study aims to assess the capacity of three agricultural soils to retain three microorganisms frequently found in wastewater, namely *Escherichia coli* (*E. coli*), *Giardia lamblia* (*G. lamblia*) cysts and *Ascaris lumbricoides* (*A. lumbricoides*) eggs, through batch sorption–desorption assays. The tested soils were: an organic-clayey soil (C-OM), a clayey soil (C-om) and a sandy soil (c-om). For the three soils, sorption equilibrium of *E. coli* was reached before 1 h, while for *G. lamblia* cysts and *A. lumbricoides* eggs, sorption equilibrium took 2.5 h. Sorption of *E. coli* was better described by the Freundlich model than by the Langmuir one. Higher retention of bacteria was observed in the C-om soil ($K_F = 4340$) than in the C-OM and c-om ones ($K_F = 1821$ and 0.01, respectively). Regarding *G. lamblia* cysts and *A. lumbricoides* eggs, data could not be fitted to the tested sorption models. For both organisms, retention was lower in the C-OM soil than in the C-om and c-om ones. In the desorption tests, a sudden liberation of *E. coli* from soils was observed, probably due to bacterial re-growth. Desorption of *G. lamblia* was higher in the sandy soil than in the clayey ones; desorption was not increased when a surfactant was applied to the soil, suggesting that hydrophobic interactions are not necessarily responsible for retention of the cysts onto the tested soils. For *A. lumbricoides* eggs, desorption using NaOCl solution suggested that retention was caused by interactions between the mineral fraction of the soil and the external walls of eggs. This study showed that the three target microorganisms are retained by the tested soils and that mineral domain of soil has an important role in such retention.

1. Introduction

Currently, changes in global climate have brought new concerns about water availability. The main hydrological variations predicted, such as modification of annual average rainfall, reduction of groundwater recharge, increase of evapotranspiration and changes in river flow patterns will impact water accessibility for agricultural activities (Falloon and Betts, 2010). In this sense, wastewater reuse for irrigation purposes attempts to relieve the pressure over the fresh water resources, at the same time it carries other benefits such as improving crop yields and soil fertility (Jun-Feng et al., 2007; Xu et al., 2010; Singh et al., 2012) by increasing the content of organic matter and other nutrients in soil (Mohammad-Rusan et al., 2007; Singh et al., 2012). Even with these advantages, there is concern regarding the reuse of wastewater in agriculture due to the presence of pathogen bacteria, protozoa and helminth eggs in reclaimed or untreated wastewater (Cifuentes et al., 2000; Gupta et al., 2009; Forslund et al., 2010; Levantesi et al., 2010). Fortunately, the capacity of some soils to remove pathogens while wastewater infiltrates through soil seems to be high. Some studies have found the presence of coliforms (Candela et al., 2007; Palese et al., 2009; Forslund et al., 2010), helminth eggs (Gupta et al., 2009) and other protozoa in soils that have been irrigated with

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