

# Occurrence, composition and risk assessment of antibiotics in soils from Kenya, Africa

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**Abstract** Antibiotics can accumulate in soils via different ways, which may pose serious threat to ecological environment of soil and quality of agricultural products. In this study, the occurrence of 12 antibiotics including four sulfonamides (SAs), four tetracyclines (TETs) and four fluoroquinolones (FQs) was investigated in soils from four sampling sites of Kenya (Mai Mahiu, Narok, Mount Suswa Conservancy, and Juja), Africa. The soils in suburban area of Narok had the highest average concentrations of total 12 antibiotics with an average value of  $43.64 \mu\text{g kg}^{-1}$  dw (dry weight), followed by Mai Mahiu ( $26.70 \mu\text{g kg}^{-1}$  dw), Juja ( $24.41 \mu\text{g kg}^{-1}$  dw) and Mount Suswa Conservancy ( $12.21 \mu\text{g kg}^{-1}$  dw). Sulfamethoxazole, sulfamethazine, oxytetracycline, and enrofloxacin were identified as the main antibiotics polluted in soils. Total organic carbon may influence the distribution of SAs in Narok and FQs in Juja. Ecological risk analysis based on the risk quotient showed that SAs detected in soils have higher risk compared to TETs and FQs.

**Keywords** Kenya · Soils · Sulfonamides · Tetracyclines · Fluoroquinolones · Risk assessment

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## Introduction

Antibiotics are not only widely used in medicine to save human lives or to control disease in factory farming (Durso and Cook 2014; Gothwal and Shashidhar 2015), resulting in lots of antibiotics in wastewater treatment plant (Michael et al. 2013; Zhou et al. 2013) and livestock manure (Ho et al. 2014, 2015; Prosser and Sibley 2015). However, conventional sewage treatment facilities were never designed to deal with pharmaceutical compounds, so the removal efficiency of antibiotics was not stable and lots of antibiotics were discharged into the environment (Michael et al. 2013). Soil is also regarded as one of the important media for existence and transformation of antibiotics (Tolls 2001; Zhang et al. 2011). Antibiotics entered into the soil via sewage irrigation and manure fertilizer, and so on. Antibiotics in soils has showed toxic effect on soil microorganism (Liu et al. 2015; Reichel et al. 2015) and plant (Du and Liu 2012; Jin et al. 2009). So, it is critical to assess the levels of antibiotics in soils to avoid potential health risk via plant (Li et al. 2014; Prosser and Sibley 2015). Degradation and adsorption were the two main environmental behaviors of antibiotics in soil. Adsorption mechanism of antibiotics in soil was mainly due to charge transfer and ion interactions, and was significantly influenced by the pH of the soil (Thiele-Bruhn 2003; Tolls 2001). Antibiotics were susceptible to microbial degradation under aerobic conditions (Pan and Chu 2016).

In Africa, no adequately enforced legislations regarding antibiotic use in food-producing animals as well as monitoring and control of their residues are carried out (Nonga et al. 2010). Hence, lots of antibiotics in Africa are not only discharged into the environment, but also found in the food which may threaten the human health. For example, all analyzed chicken eggs contained sulfadiazine (SD) and