

ABSTRACT

In recent years, research has indicated the presence of pharmaceutically active ingredients (PAIs) as emerging water contaminants. The presence of these compounds in surface waters is of great environmental concern due to the toxicological effects of these compounds on organisms in the aquatic environment. Conventional wastewater treatment approaches have been shown to be ineffective in eliminating PAIs from influent wastewater. Among the ecotoxicological PAIs detected in effluents from a typical Kenyan municipal wastewater treatment plant (WWTP) in Bungoma include sulfonamides such as sulfachloropyridazine (SCP) and sulfadimethoxine (SDM). Furthermore, recovery of suspended adsorbent in a continuous flowing system still remains an unresolved challenge. There is therefore an urgent need to investigate and evaluate efficient and cost-effective wastewater treatment alternatives. Iron modified adsorbents have been demonstrated to be economical and efficient adsorbents for removal of various pollutants with adsorbent recovery achievable through external magnetic field. Iron-oxide modified clays, therefore, present a potentially efficient and sustainable alternative due to the natural occurrence and abundance of clay and low cost of iron, hence reduced capital investment. However, the sorption and interaction mechanisms of clays and iron-oxide modified clay for sulfachloropyridazine (SCP) and Sulfadimethoxine (SDM), as model sulfonamides, are not well understood. The objective of this study was to evaluate the sorption characteristics of natural untreated kaolinite clay and iron modified clay (Fe-MC) for SCP and SDM, in single and binary solutions. The effects of initial concentration (0.25 – 1.25 mg L⁻¹), contact time (15- 360 min) and temperature (303 – 323 K) were investigated. Langmuir model satisfactorily described the sorption of both adsorbates onto the raw and Fe-MC clays. Notably; the raw clay had higher sorption capacity than Fe-MC. In binary solute solutions, an antagonistic sorption process of SDM ($R_{q,SCP} = 0.453$) in the presence of SCP ($R_{q,SDM} = 0.915$) was observed for the raw clay. However, for the Fe-MC clay, an antagonistic sorption process of SCP ($R_{q,SCP} = 0.625$) in the presence of SDM ($R_{q,SDM} = 1.032$) was noted. The antagonisms suggest replacement sorption. For each compound, the sorption reactions obeyed follow a pseudo-second order kinetic law for both clays. However, half-life values depict SDM exhibited faster sorption kinetics over SCP onto the untreated clay while the opposite phenomenon occurred for sorption onto Fe-MC. The calculated thermodynamic parameters, ΔG , ΔH , ΔS and ΔE_a indicate that SCP and SDM sorption on both untreated and Fe-MC clays are spontaneous, exothermic and physical in nature. Intraparticle diffusion model showed that the sorption of the processes followed multiple phases and were not solely controlled by pore diffusion. The proposed sorption mechanisms were found to be consistent with cation bridging and negative charge-assisted H-bonding. The results show the tested clay may be used as a low-cost material for removal of