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Removal of fluorescence and ultraviolet absorbance of dissolved organic matter in reclaimed water by solar light

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ABSTRACT

Storing reclaimed water in lakes is a widely used method of accommodating changes in the consumption of reclaimed water during wastewater reclamation and reuse. Solar light serves as an important function in degrading pollutants during storage, and its effect on dissolved organic matter (DOM) was investigated in this study. Solar light significantly decreased the UV_{254} absorbance and fluorescence (FLU) intensity of reclaimed water. However, its effect on the dissolved organic carbon (DOC) value of reclaimed water was very limited. The decrease in the UV_{254} absorbance intensity and FLU excitation–emission matrix regional integration volume (FLU volume) of reclaimed water during solar light irradiation was fit with pseudo-first order reaction kinetics. The decrease of UV_{254} absorbance was much slower than that of the FLU volume. Ultraviolet light in solar light had a key role in decreasing the UV_{254} absorbance and FLU intensity during solar light irradiation. The light fluence-based removal kinetic constants of the UV_{254} and FLU intensity were independent of light intensity. The peaks of the UV_{254} absorbance and FLU intensity with an apparent molecular weight (AMW) of 100 Da to 2000 Da decreased after solar irradiation, whereas the DOC value of the major peaks did not significantly change.

Introduction

Wastewater reclamation and reuse plays an important role in solving water shortage problems in cities of many countries, including China. Storing reclaimed water in lakes is an important method of accommodating changes in the consumption of reclaimed water during the reclamation and reuse of wastewater (Marks, 2006; Taigbenu and Ncube, 2005).

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Water quality may change during storage; for example, suspended solids in reclaimed water may settle, and nutrients, including nitrogen and phosphorus, may induce algae growth in the lake (Hernández et al., 2006; Ma et al., 2005). As such, the changes in water quality during storage are important considerations for the final use of reclaimed water.

The photodegradation of pollutants by solar light is an important method of controlling pollutants during the storage of reclaimed water. Light plays an important role in transforming some micro-pollutants, including fluoroquinolone antibiotics and triclosan (Buth et al., 2010; Amine-Khodja et al., 2006; Liu and Guan, 2012). The half-life time of the photodegradation of fluoroquinolone during solar light irradiation in pure water even ranges from 1.25 to 58 min (Ge et al., 2010). Solar light can transform triclosan in surface water into harmful dioxin-like pollutants, which are then concentrated in sediments (Buth et al., 2010). The experiments on the fates of micro-pollutants during solar light irradiation indicate that solar light serves as an important function in transforming pollutants in surface water.

Dissolved organic matter (DOM) is an important component in reclaimed water; it contributes to the formation of the precursors of disinfection byproducts, assimilable organic carbon, and membrane-fouling pollutants (Tang et al., 2010; Wu et al., 2009; Liang and Song, 2007; Lin et al., 2009). Solar light degrades natural humic acid, including Elliott soil fulvic acid (Halladja et al., 2009). During solar light irradiation, some organic nitrogen pollutants are transformed into ammonium and nitrate, which are associated with the eutrophication of water environments (Bronk et al., 2010). The composition of DOM in reclaimed water is very complex, and soluble microbial products and undegradable pollutants are present in reclaimed water (Barker and Stuckey, 1999). Therefore, the effects of solar light on DOM in reclaimed water may be very complex.

The spectrum, hydrophobicity, and molecular weight of DOM have been used to characterize the potential risk changes of reclaimed water, such as the formation of disinfection byproducts and increase in toxicity (Henderson et al., 2011). Ultraviolet (UV) absorbance and fluorescence excitation-emission matrix regional integration volume (FLU volume) are correlated with the chlorination anti-estrogenic activity formation potential and the formation of disinfection byproducts (Tang et al., 2010, 2014). Research on the precursors of disinfection byproducts shows that during chlorination, DOM with molecular weights of lower than 1 kDa play a major role in the formation of N-nitrosodimethylamine and increase of genotoxicity (Mitch and Sedlak, 2004; Wu et al., 2010). This finding indicates that the molecular weight of DOM is also an important factor that is associated with the formation of disinfection byproducts. However, research on the effects of solar light on UV absorbance, FLU spectra, and DOC in reclaimed water remains limited. The changes in

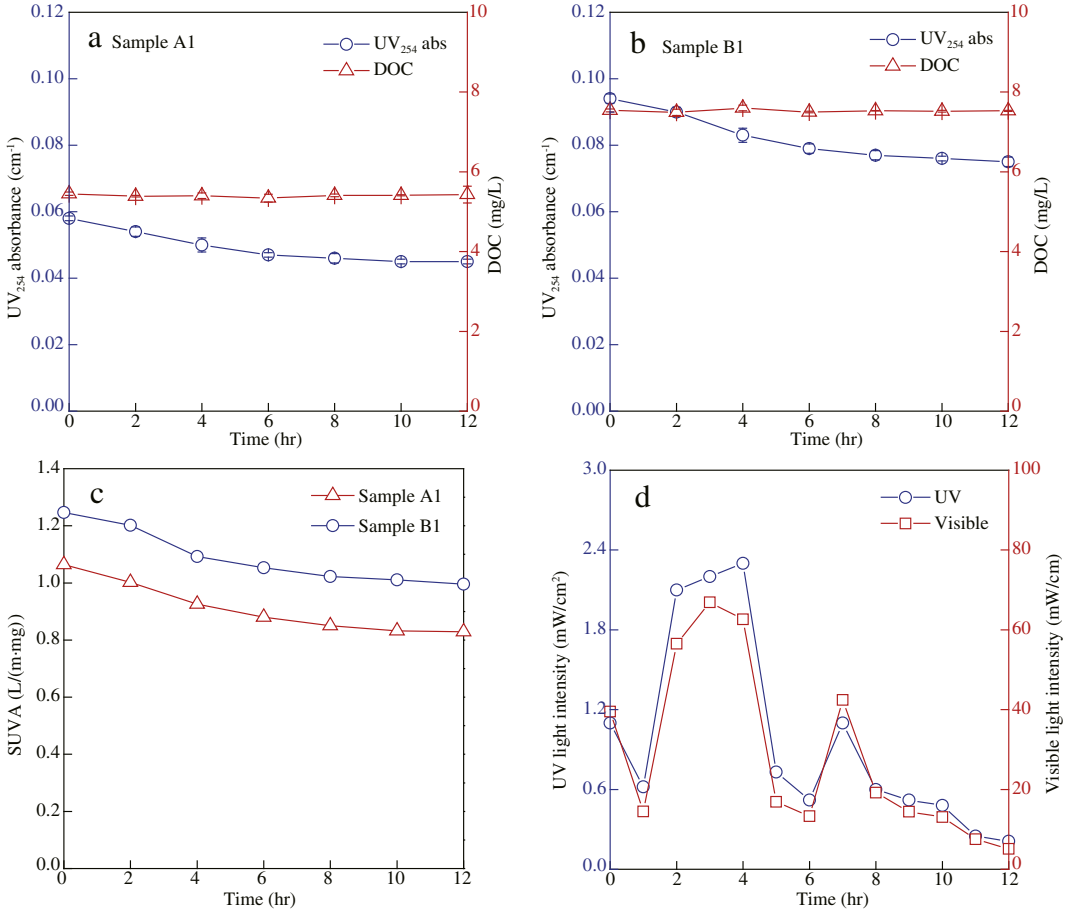

Fig. 1 – Changes of UV_{254} absorbance, dissolved organic carbon (DOC) values, and Specific ultraviolet absorbance (SUVA) values in the reclaimed water samples during natural solar light irradiation.