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Differences in dissolved organic matter between reclaimed water source and drinking water source

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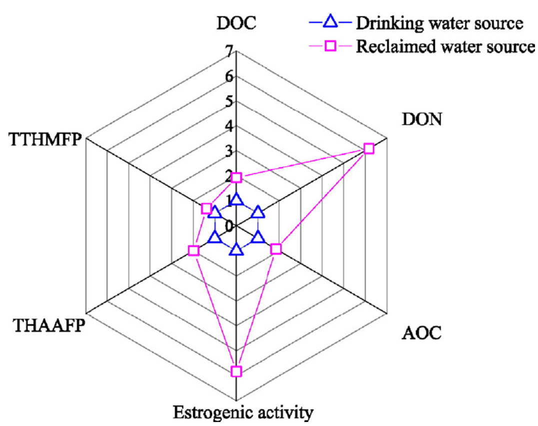
HIGHLIGHTS

- Higher DOC and DON level of rDOM compared with dDOM.
- Higher proportion of hydrophilic fractions and low-molecular weight compounds in rDOM
- rDOM is less biostable than dDOM.
- rDOM presents greater toxic effects on human health than dDOM.

GRAPHICAL ABSTRACT



Comparison of normalized composition and potential risk of DOM in drinking water source and reclaimed water source

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ABSTRACT

Dissolved organic matter (DOM) significantly affects the quality of reclaimed water and drinking water. Reclaimed water potable reuse is an effective way to augment drinking water source and de facto reuse exists worldwide. Hence, when reclaimed water source (namely secondary effluent) is blended with drinking water source, understanding the difference in DOM between drinking water source (dDOM) and reclaimed water source (rDOM) is essential. In this study, composition, transformation, and potential risk of dDOM from drinking water source and rDOM from secondary effluent were compared. Generally, the DOC concentration of rDOM and dissolved organic nitrogen (DON) content in reclaimed water source were higher but rDOM exhibited a lower aromaticity. Besides, rDOM comprises a higher proportion of hydrophilic fractions and more low-molecular weight compounds, which are difficult to be removed during coagulation. Although dDOM exhibited higher specific disinfection byproducts formation potential (SDBPFP), rDOM formed more total disinfection byproducts (DBPs) during chlorination including halomethanes (THMs) and haloacetic acids (HAAs) due to high DOC concentration. Likewise, in consideration of DOC basis, rDOM contained more absolute assimilable organic carbon (AOC) despite showing a lower specific AOC (normalized AOC per unit of DOC). Besides, rDOM exhibited higher

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biotoxicity including genotoxicity and endocrine disruption. Therefore, rDOM presents a greater potential risk than dDOM does. Reclaimed water source needs to be treated carefully when it is blended with drinking water source.

Contents

1. Introduction

Dissolved organic matter (DOM), found in aquatic environments, is a heterogeneous mixture of complex organic materials including humic substances, proteins, lipids, polysaccharides, and amino acids, among others (Leenheer and Croué, 2003); it plays a key role in influencing the quality of both reclaimed water and drinking water. Besides, with population growth, anthropogenic activity and, thus, water pollution increase. Traditional water sources are finding it difficult to meet the demand on drinking water supplies and reclaimed water potable reuse has been considered an effective way to augment drinking water sources (Du Pisani, 2006; Rice and Westerhoff, 2014). Among different ways of reclaimed water potable reuse, de facto (unplanned) potable reuse exists worldwide, such as in Yangtze River Basin in China, Mississippi Valley in America and Rhine Valley in Europe (Gerrity et al., 2013). During de facto potable reuse, it is possible that a substantial portion of drinking water source could be derived from upstream secondary effluent, namely reclaimed water source (National Research Council, 2012; Rice et al., 2013). Hence, when reclaimed water source is used for drinking in the case of de facto reuse, close attention must be paid to DOM and understanding the differences between DOM in drinking water source (dDOM) and DOM in reclaimed water source (rDOM) is important.

DOM can form toxic byproducts during oxidation and disinfection. It is a major precursor of disinfection by-products (DBPs), including carbonaceous DBPs (C-DBPs) and nitrogenous DBPs (N-DBPs) (Krasner et al., 2009). DOM also affects advanced treatment. One obvious impact is that the reagent dose in the advanced treatment depends on DOM concentration (Bond et al., 2011). Moreover, advanced treatment performance is also influenced by DOM. Coagulation favors the removal of hydrophobic, high-molecular weight DOM over the hydrophilic, low-molecular weight one (Edzwald and Tobiason, 1999; Matilainen et al., 2010). Besides, biologically assimilable organic carbon (AOC) provided by DOM can cause membrane fouling during advanced treatment and water quality deterioration during storage and distribution (Zhao et al., 2013; Zhao et al., 2014a). Therefore, water quality and treatment performance are substantially impacted by DOM.

A number of studies have demonstrated that dDOM and rDOM originate from different sources: dDOM comes from soils, sediments, plankton, and bacteria (McKnight et al., 2001; Hudson et al., 2007), whereas rDOM consists of four major classes of organic matter: refractory DOM retained in treated drinking water, soluble microbial products (SMPs) during biological treatment, transformation products derived from biotic and abiotic treatment, and contaminants of emerging concern discharged by anthropogenic activity, e.g., endocrine disrupting chemicals (EDCs), pharmaceuticals and personal care products (PPCPs) (Drewes et al., 2003; Michael-Kordatou et al., 2015). Different sources lead to great variation in the composition and property of dDOM and rDOM. Transformation characteristics and the potential risk posed by rDOM during treatment processes could, therefore, differ from those in dDOM.

Consequently, to improve treatment process performance and guarantee water quality safety when reclaimed water is blended with drinking water source, understanding the differences in composition, transformation and potential risk between dDOM and rDOM is important. During the last decades, tremendous effort has been made to give insight into the characteristics of DOM. Generally, dissolved organic carbon (DOC) was considered the most comprehensive surrogate parameter to quantify DOM concentration and specific ultraviolet absorbance (SUVA) was widely used to characterize DOM aromaticity