Chapter 9
Groundwater Treatment via Ozonation

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ABSTRACT

Groundwater is the source of drinking water that needs to be maintained from pollution. Groundwater pollution is a major problem caused by human activities that are invaluable to human health. When high levels of organic and inorganic substances do not exceed the standard of drinking water, various studies have been made by researchers to overcome the problem. Various alternatives such as in-situ and ex-situ treatment have been carried out to eliminate pollutants from groundwater. Among the treatment, ozone becomes a major alternative because of its effectiveness in treating raw water. Ozone treatment has several advantages such as disinfectants, oxidize of organic and inorganic pollutant, and remove taste and color from groundwater. The performance of ozonation process becomes better when combined with other treatments. Therefore, application of ozone can replace chlorine because of its good potential to improve quality of groundwater effluent and comply drinking water standard adopted by World Health Organization.

INTRODUCTION

This chapter consist of two (2) main topics. Topic 2 is divided into five (5) sub-topics which includes drinking water governance in Malaysia, groundwater characteristics, groundwater issues, groundwater pollutants and various techniques of remediate pollutant in groundwater. The topic also identifies the causes and problems of groundwater pollution which affects the quality of drinking water. Moreover, several case studies on groundwater pollution problems throughout the world are also discussed in this topic.

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The second topic also explores the application of ozone in in water. The ozone functions in water treatment are also described in this topic. The mechanism and oxidation reaction between ozone and pollutant are also explained here. Previous studies on ozone application in water treatment are also reported to support the use of ozone later. Comparisons between ozone alone and a combination with other water treatments is also presented in this chapter. Overall, this topic helps to give a thorough understanding on the potential use of ozonation in groundwater.

GROUNDWATER

Groundwater occurs naturally through the hydrologic cycle by an aerial recharge and losses from surface water. Precipitation is the source of an aerial recharge. As aerial recharge occurrences are over a broad area, the amount of rainfall received are proportional to the formation of groundwater. Water bodies such as rivers, lakes, wetlands, ocean, coast and estuaries are main sources of groundwater recharge from water losses (Li et al., 2016). However, as almost all surface water interacts with groundwater continuously, the formation is reversible (Stahn & Tomini, 2017).

Globally, groundwater is the most extracted raw material with an average extraction of 600 to 700 km^3 annually (Pandey et al., 2011). On the contrary, groundwater contributes less than 10% of total water usage in Malaysia. Most of the groundwater supply are for domestic usage largely at remote or rural areas. 40% of the water supply particularly in rural areas are provided by groundwater (Nazaruddin, 2017). Furthermore, this sourcing method is also found to be commonly used to support the demand from industrial sectors as well as population growth. Nazarudin et al. (2017) also stated that newly opened housing development areas that are remote and where water supply is limited or at over-populated area would benefit from this groundwater harvesting method. Meanwhile, the state of Kelantan has been drilling tube well in coarse sand aquifers since the past 40 years. 624,389 people living in Kota Bharu and Bachok extract groundwater for their daily usage (Sefie et al., 2015).

The failure in distinguishing the boundless potentials of the resources are the main cause for the limited exploitation of groundwater in Malaysia. As Malaysia is blessed with an abundance of rainfall, the principal in water sustainability and resources primarily in groundwater management will benefit the country in the snowballing demand of water (Ayob & Rahmat, 2017).

Drinking Water Governance in Malaysia

The quality of drinking water in Malaysia is ruled by the National Standard for Drinking Water Quality and WHO Guidelines for Drinking Water Quality (Ambu et al., 2014). Water quality index is used to assess the suitability of water for a variety of uses. Table 1 and Table 2 shows the water quality index and water quality classification respectively as proposed by the Department of Environment (DOE), Malaysia. The water quality can be classified based on several parameters such as Ammonical Nitrogen (AN), BOD, COD, DO, pH and TSS. In Malaysia, water supply can be classified from Class I to Class V, from clean to the worst quality of water.

Groundwater quality are characterised by criteria such as contents of microbiological, physical, chemical and radioactive constituents. Drinking water quality standard is provided for water to be used for human consumptions. It must be clear without unpleasant taste, colour and odour (EPA, 2012). Table 3 shows the comparison standard for microbiological parameters in Malaysia and other countries for