Trihalomethanes (THMs) Formation in Groundwater and Surface Water Using Chlorine and Chlorine Dioxide as Disinfectants

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**Keywords:** trihalomenthanes; chlorine; chlorine dioxide; disinfectants

Introduction

Chemical disinfection is used to destroy or control the growth microorganisms present in water that would otherwise cause fouling, corrosion of equipment, or lead to disease from microbial activity (Pandit & Kumar, 2013). Chlorine has always been the most popular choice as a disinfectant in Malaysia due to its low cost and effectiveness. However, disinfectants, when reacting with organic matters present in the water, can produce disinfection by-products (DBPs) which can be harmful to human health (Al-Otoum et al., 2016). The most prevalent species of DBPs associated with chlorine is trihalomethanes (THMs) and haloacetics acids (HAAs). The four THM compounds are currently regulated in Malaysia (MOH, 2010), however there were some cases of elevated THM fromation reported in Malaysia (Abdullah et al., 2003).

The application of alternative disinfectant for Malaysian drinking water can be relevant in the future. Thus, this study aims to compare THMs formation level using chlorine and chlorine dioxide as disinfectants. Compared to chlorine (Cl2), chlorine dioxide (ClO2) produced lower levels of THMs (Al-Otoum et al., 2016).

Material and Methods

Samplings were carried out at two sites for one round of sampling; borehole in Nibong Tebal, Penang (groundwater) and Jalan Baru, Perak (river). For THM formation, the raw water collected was filtered before disinfected using either chlorine or chlorine dioxide at 5mg/L. For each disinfectant, three pH (6, 7, and 8) and four contact times (1, 3, 6 and 24 hr) were applied. All conditions were carried out in duplicates. After the contact time ended, each sample will be immediately extracted as per modified US EPA Method 551.1, using methyltertiary-butyl ether (MTBE) as extraction solvent. The extracts were then analysed by using gas chromatography – mass spectrophotometer (GC-MS) to determine the four THM coumpounds; chloroform (CF), dichlorobromomethane (DCBM), dibromochloromethane (DBCM), and bromoform (BF).

Results and Conclusions

From the samplings carried out at both sites, the organic contents of both waters were slightly different. As shown in Table 1.1, specific UV absorbance (SUVA) value for groundwater was higher. This indicates higher organic content that might act as precursor for THM formation.

**Table 1.1** Organic content parameters of both sampling sites.

|  |  |  |  |
| --- | --- | --- | --- |
| Sources | DOC (mg/L) | UV254  (cm-1) | SUVA  (L/mg-m) |
| Groundwater | 9.103 – 9.174 | 1.311 – 1.328 | 14.345 – 14.531 |
| Surface Water | 1.573 – 9.889 | 0.093 – 0.099 | 0.940 – 1.001 |

Out of the four THM compounds, only BDCM was found in all samples. The discussion in this part will be in term of total THM (TTHM) so that it can better reflect a parameter in the Malaysia Drinking Water Standard that is being constantly monitored. As illustrated in Figure 1.1 and 1.2, THM formation from both sampling sites show the same trend where THM formed higher in water disinfected using chlorine compared to chlorine dioxide. The maximum THM formation for groundwater and surface water were both formed when using chlorine at 49.4 µg/L (at pH 7) and 43.2 µg/L (at pH 6), respectively.

With respect to contact time, for groundwater (Figure 1.1), TTHM formation level at pH 6 when applying Cl2 as disinfectant obviously shows that the TTHM increased as contact time increased. However, compared to ClO2 at pH 6, the formation level of TTHM increased gradually until 6 hours and later decreased until the 24 hours. For both water sources, at pH 7 using Cl2, TTHM level dropped drastically at 3 hours before continuing a gradual increase until 24 hours. For surface water a straight gradual increase can also be seen when using Cl2 at pH 8. However no such trend was found when using ClO2 for both groundwater and surface water.

With respect to pH, pH 7 formed higher TTHM compared to other pH, except when using ClO2 for groundwater. The lowest TTHM levels were also at pH 7, at 3 hours contact time, for Cl2 and ClO2 at concentrations of 7.7 µg/L and 5.4 µg/L, respectively.

**Figure 1.1** TTHM formations in groundwater

**Figure 1.2** TTHM formations in surface water

References

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