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Seasonal variations of trihalomethanes (THMs) in water distribution networks of Istanbul City

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Abstract

Seasonal variations of trihalomethane (THM) concentrations were investigated within distribution systems of the Buyukcekmece water treatment plant in Istanbul City (Turkey). The investigation was based on an intensive 30-week sampling program, undertaken during the spring, summer and fall of the year 2003. THMs and other water quality and operational parameters were monitored at points along the distribution system between the treatment plant and the system's extremity. The results showed that THM concentrations vary significantly between finished waters and water at the distribution network. When water temperature exceeds 24°C in summer, the THM levels are 1.2–1.8 times higher than finished water, while when water temperature is below 15°C in the spring and fall, the measured THM concentrations at the system's extremity were very rarely higher than 100 μg/L. Finally, THM levels were measured at sampling points representing progressively greater travel times from the plant to the extremity of the distribution system. Multiple regression analysis was also conducted in order to estimate THMs from total organic carbon, temperature, and chlorine dose parameters. The regression model resulted in a R^2 value of 0.827.

Keywords: Trihalomethanes; Chlorination; Distribution systems; Regression analysis

1. Introduction

The disinfection of water using chlorine is a common practice in Turkey. Chlorine is used to treat water in order to destroy microorganisms and/or to ensure residual concentrations in distribution systems, thus protecting water from microorganism regrowth [1]. Chlorine is a widely used disinfectant because it is extremely efficient

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and relatively inexpensive [2]. Although chlorination worked well, it was discovered in the 1970s that the use of chlorine as an oxidant or disinfectant posed potential health risks due to the formation of disinfection by-products (DBPs) in drinking water [2,3]. Chlorine reacts with the natural organic matters contained in water to generate DBPs. The focus on the formation of DBPs in drinking water distribution systems has increased in recent years [1]. Among DBPs found in chlorinated water, special attention has been paid to the concentration of trihalomethanes [THMs: chloroform ($CHCl_3$), bromodichloromethane ($CHCl_2Br$), chlorodibromomethane ($CHBr_2Cl$) and bromoform ($CHBr_3$)] because of their potential carcinogenic effects [4]. The Government of Turkey recently has recently been preparing to establish a maximum contami-nant level (MCL) of THMs of 100 μg/L to comply with European Union criteria.

It was stated in the literature that THM occurrence in chlorinated water may vary significantly based on season and geographical location in the distribution system [5–9]. These variations are due to changes in raw and treated water quality as well as in operational parameters related to chlorination [10]. The operational parameters that influence THM occurrence in the distribution systems are chlorine dose, water temperature, pH and travel time of water within the system. It has been concluded that, in terms of water quality, the fulvic and humic fraction of organic matter constitute important precursors for THMs [11]. Besides, total organic carbon (TOC) and ultraviolet absorbance at 254 nm (UV_{254}) have been used as indicators for the presence of organic matter in drinking water [12]. Several laboratory and field research studies have shown that the higher the values for these parameters, the higher the concentrations of THMs formed [1,6,13–15].

On the other hand, at this time there is a lack of information concerning THM occurrence in Istanbul water distribution systems, as well as about the capacity of the Istanbul city water treatment utilities for compliance with 100 μg/L of the EU and 80 μg/L of US Environmental Protection Agency (EPA) THM standards [16, 17]. Because the EU and EPA standards for THMS take into account the seasonal averages of THM concentrations in representative locations of the distribution systems instead of single values of the finished water, there is an increasing interest in investigating locational and temporal variations of these chlorination by-products in distributed water [1].

Recently, several researchers have investigated and modeled the occurrence of THMs in distribution systems, based on single-sample surveys [1]. The aim of this paper is to study the seasonal variations of THMs in the treated water of the Buyukcekmece water treatment plant in Istanbul. This plant receives raw water from Buyukcekmece Lake (BL). The study also tries to investigate the effects of water quality and operational parameters on THM occurrence in distribution systems. Multiple regression analysis was carried out in order to estimate THMs from a set of parameters.

2. Materials and methods

2.1. Description of treatment plants

The water utility taken as a case study is the Buyukcekmece water treatment plant (BWTP). The plant takes water from BL; its capacity is 400,000 m^3/d and serves nearly 2 million people living on the European side of Istanbul City (Fig. 1). A conventional treatment scheme is applied in the plant and consists of aeration, prechlorination, coagulation, flocculation–sedimentation, filtration, and postchlorination. Prechlorination is adapted at the coagulation stage with an average chlorine dose of 2 mg/L; alum is used as the coagulant at a typical dose of 30 mg/L. The coagulated water is filtered in conventional rapid-sand filters, and chlorine is used