EVALUATING THE EFFECTS OF DISSOLVED ORGANIC CARBON (DOC) AND pH ON POSSIBLE TRIHALOMETHANE (THM) FORMATION IN TEXTILE LIQIUD EFFLUENTS AFTER TREATING WITH CHLORINE

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ABSTRACT
The chlorination leads to the formation of disinfection by products. Any process that uses chlorine gas directly or chlorine liberating chemicals or where chlorine is produced in the process, formation of chloro-organo compounds is a real possibility if alkanes, alkenes etc. are available. The trihalomethanes (THMs) and haloacetic acids (HAAs) are the two most prevalent classes of disinfection byproducts. Chlorine reacts with natural organic matter (NOM) to form a number of carcinogenic byproducts. Treated effluents from ten chlorine based textile effluent treatment plants (ETPs) were assessed for trihalomethanes (THM). The presence of THMs in the outlet stream was confirmed in this study. The concentration of THMs was found below the WHO concentration where the effluents contain a lower value of dissolved organic carbon (DOC). Trihalomethanes (THMs) formation increases significantly with the increase concentration of DOC and increasing pH. But THM concentration is independent of pH at concentration above 150ppb. The pH value is 8.5 at 150 ppb concentration of THM. Curves have been generated in Matlab software to find out the concentration of THM for different chlorine dose, pH and DOC values. The concentrations of THM in the outlet stream of different ETPs can be found out using these curves. The results are very close to the practical measured values.

Keywords: THM; DOC; ETP; DBP

INTRODUCTION

The rise in the number of textile industries in Bangladesh has seriously increased water pollution in the country (Sultana et al., 2013). Effluent from the textile industry is often a major source of environmental pollution, especially water pollution. Among the various stages of textile production, the operations in the dyeing plant, which include pre-treatments, dyeing and finishing, unused or partially used organic compounds and have a high biochemical oxygen demand (BOD) and chemical oxygen demand (COD). They are often of strong color and may also be of high temperature. When disposed into water bodies or onto land these effluents can result in the deterioration of ecology and damage to the aquatic life. (Khan F., 2014)

In Bangladesh chlorine is cheap or available as an otherwise unusable product from chlor–alkali plants (Quader, 2010). Chlorination of textile wastewater achieves all the objectives of textile liquid waste treatment (Quader, 2010) but chlorination leads to the formation of carcinogenic disinfection by products (WHO, 2005). Chlorine reacts with natural organic matter (NOM) to form a number of carcinogenic byproducts. These include but are not limited to trihalomethanes (THMs), haloacetic acids (HAAs), haloacetonitriles, haloketones, haloaldehydes, chloropicrin, cyanogens chloride, and chlorophenols. The THMs and HAAs occur most frequently and generally represent the highest concentrations of the organic contaminants. Chloramines react with NOM to form byproducts similar to those formed by chlorination but at lower concentrations (U.S. EPA, 1995).

Trihalomethanes (THMs) are the major category of disinfection by-products in chlorinated water and dissolved organic carbon is the major precursor of THM formation (Mac Crehan et al., 2005). The maximum contaminant level (MCL) set by USEPA for the concentration of total THMs in drinking water is 80 µg L-1. The concentration of total THMs regulated by the European Union in drinking water is 100 µg L-1 (EPA, 1998). WHO guideline values for $CHCl_3$, $CHCl_2Br$, $CHClBr_2$ and $CHBr_3$ are 200, 60, 100 and 100 µg L^{-1} respectively. The formation of disinfection byproducts (DBPs) is a function of many factors. The formation of DBPs during the chlorination process is very important and needs to be monitored. The prediction model for DBPs has proved to be a very useful approach in controlling and monitoring the formation of DBPs (Chowdhury et al., 2009.)

The use of chlorine in the treatment of textile wastewater can be a desirable option if the THM level is kept below WHO standard. This study is aimed to investigate the presence of THMs in chlorinated treated water and evaluate the effect of dissolved organic carbon (DOC) and pH on the concentration of THMs.

METHODOLOGY

Textile liquid waste samples were collected from the equalization tank of ten chlorine based effluent treatment plants. All possible efforts were made to minimize the time lag between collection and analysis so that no significant change may occur in the quality of the samples. The collected samples were transported to the laboratory quickly and then samples were preserved in the refrigerator in accordance with the standard Methods. To determine the THM in the treated effluent THM Plus method (Method 10132) was used with Hach DR/2010 Spectrophotometer. The effect of free residual chlorine, pH, and temperature on THM was assessed using the correlation developed by Rodrigue (2000).

The model developed by Rodriguez et al. (2000) has been used to find out the concentration of DOC in the outlet stream. The model is, $\mathbf{TTHM = 0.044(DOC)^{1.030}(t)^{0.262}\ pH^{1.149}(D)^{0.277}(T)^{0.968}}$ **(1)**
Parameters TTHM= Total Trihalomethane (ppb), DOC= dissolved organic carbon (mg/l), t= contact time (min), D= Chlorine dose (mg/l), T= outlet stream Temperature (^oC). The temperature, pH and chlorine dosing data were collected from the ETPs and contact time was taken as 48 hours.

Curves have been generated using MATLAB software. Here two parameters contact time (t), and temperature (T) have been kept constant. Contact time was taken as 48 hour and temperature was fixed at 50^0 C as the average textile outlet stream temperature is 50^0C (Babu et al, 2007) and no significant increases in THMs beyond 48 hours of chlorination (Chowdhury et al.2009)

RESULTS AND DISCUSSIONS

The presence of THMs in all treated samples was confirmed in this study. However, the concentration of THMs in treated samples was found below the WHO guide line (180ppb) values. Increase in DOC generally led to increase in THMs formation (Muller, 1998). Figure 1 illustrates the correlation between DOC and THMs of different treated sample of different ETPs. Figure shows that strong correlation between DOC and THMs (r^2 =0.86). It may be observed that textile liquid wastes content a lower value of DOC ranged 0.6 to 2 mg/l approximately.

The study identified pH, chlorine dose as significant for THMs formation. The effect of pH on THMs formation of treated textile waste water samples is presented in figure 2. The pH has been found to be correlated with THMs formation. 30% to 50% increase in THMs formation was noted when the pH was increased from 6 to 11(Chowdhury et al., 2009). It is observed in figure 2 that trihalomethanes formation increase significantly with increasing pH which corresponds to results noted in previous studies (Khan. F., 2014).

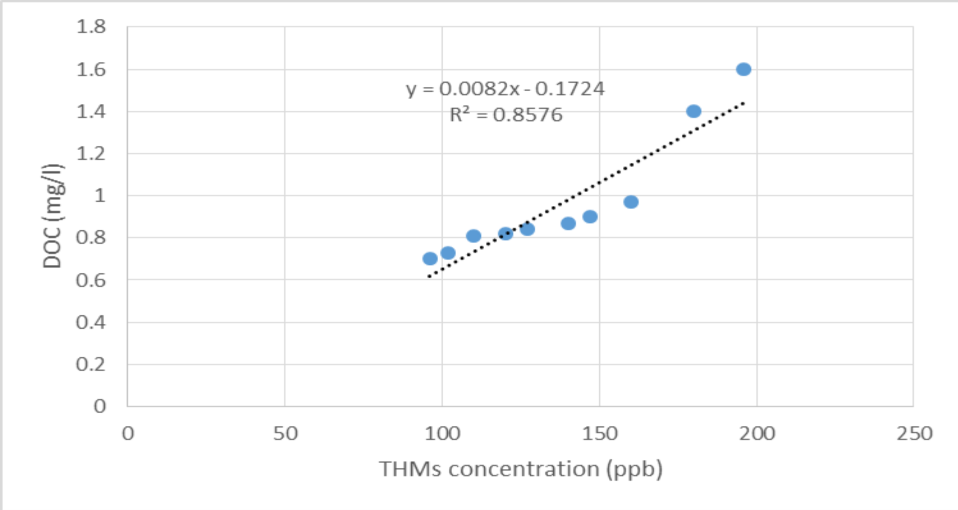

Fig.1: Effect of DOC on THMs formation

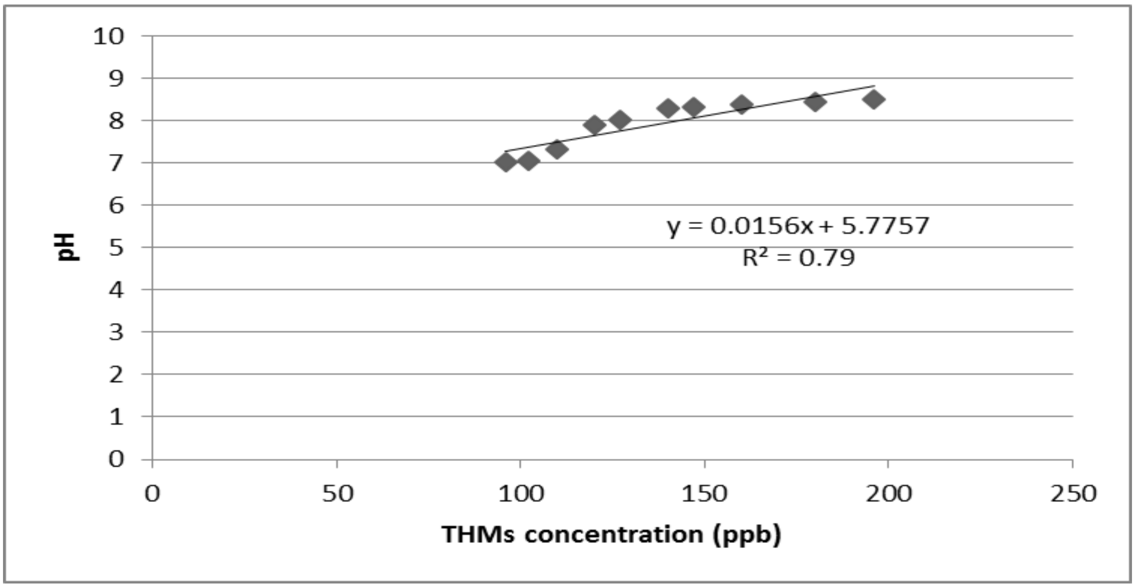

Fig.2: Effect of pH on THMs formation

The effects of reaction time on THMs formation is illustrated in the figures exposed to different pH and chlorine doses. Chlorine dose is affected by the amount and type of organic matter (Chowdhury et al., 2009.). The amount of chlorine used for disinfection is referred to as the chlorine dose. [Fig] 3 to 6 shows the effect of chlorine dose on THMs formation. For these Figures, seven chlorine doses were administered It can be seen that, at the lowest chlorine dosages, the THMs concentrations were less than those found at intermediate chlorine dosages. However, THMs formation was not found to increase significantly when the chlorine doses were increased further. This may be due to the fact that the chlorines beyond breakpoints had insignificant amount of organics to react.

CONCLUSIONS

THM Plus method (Method 10132) was used with Hach DR/2010 Spectrophotometer to investigate the formation of disinfection byproduct, trihalomethane (THM) in the treated effluent since these disinfection byproducts are suspected to cause cancer, liver and kidney damage, related fetus growth. The concentration of THM was found ranged between 62-130 ppb shows that no significant amount of THM was formed in the chlorinated.However, the concentration of THMs in treated samples was found

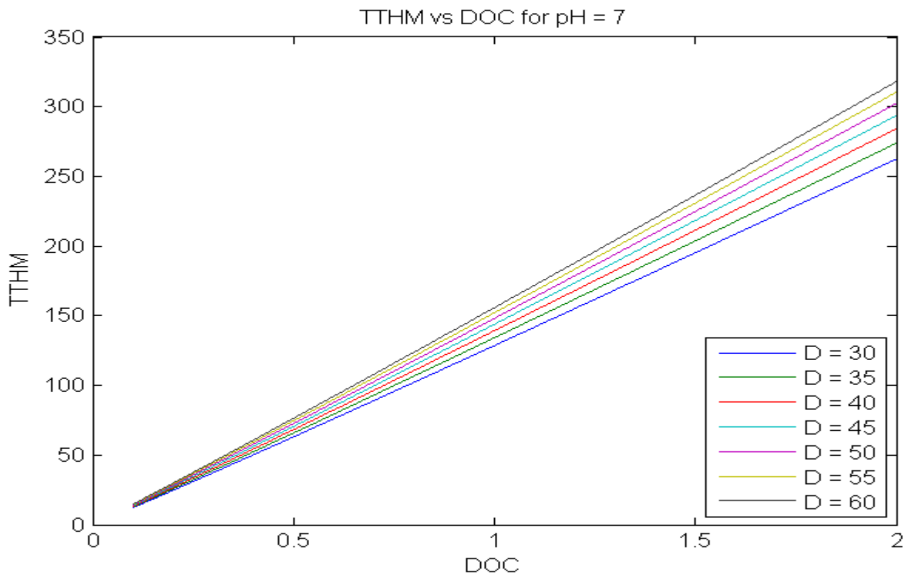

Fig.3: Effect of DOC and Chlorine dose on THMs formation at pH=7

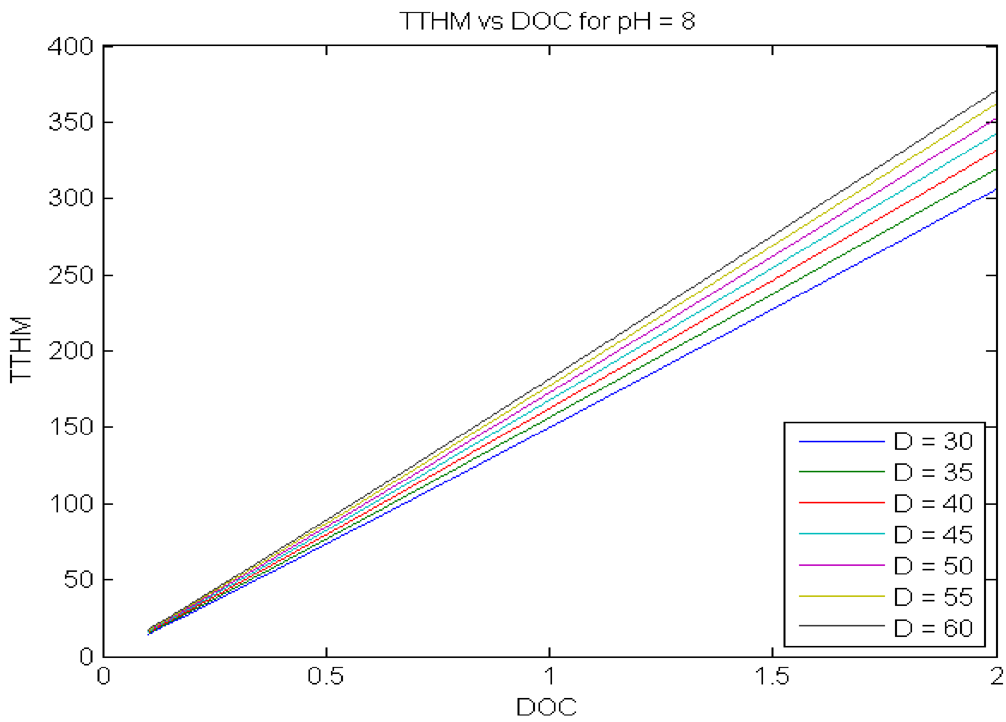

Fig. 4: Effect of DOC and Chlorine dose on THMs formation at pH=8

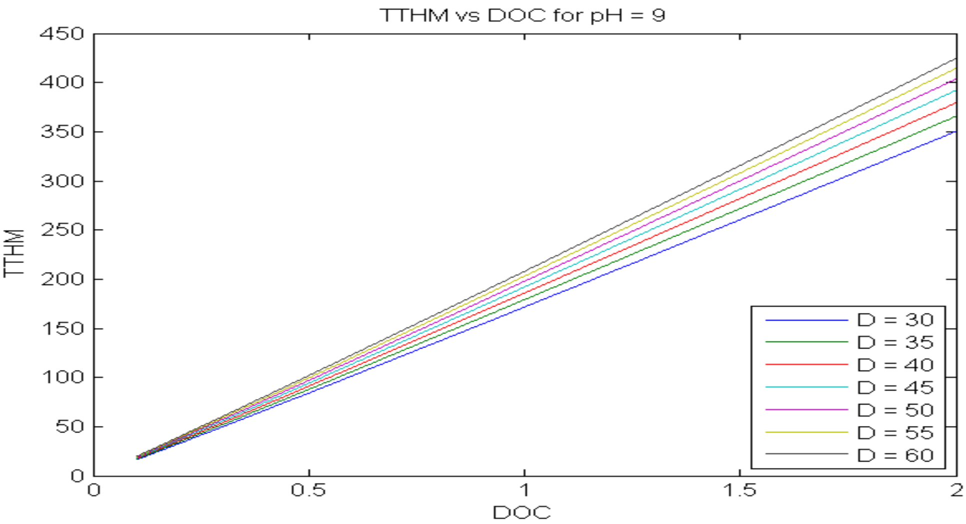

Fig.5: Effect of DOC and Chlorine dose on THMs formation at pH=9

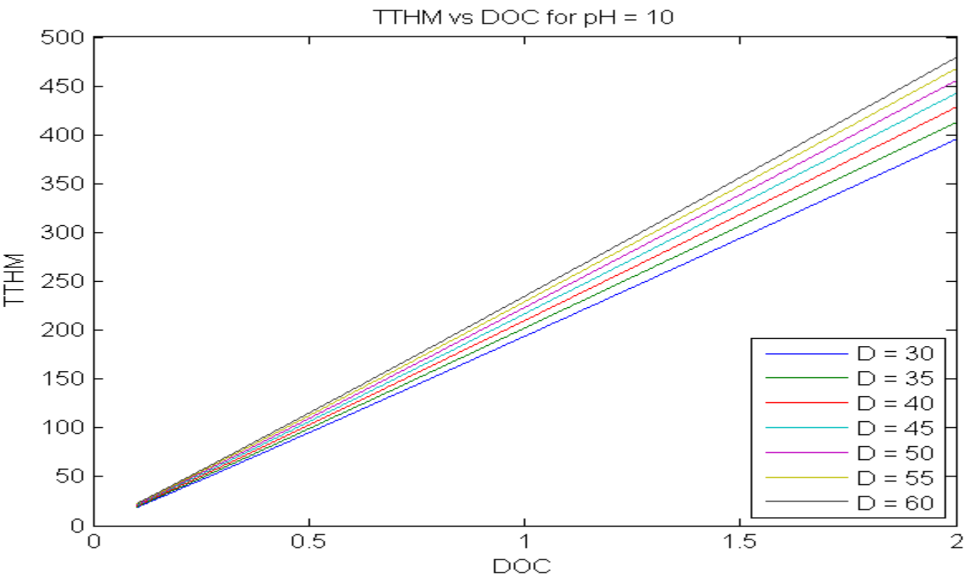

Fig.6: Effect of DOC and Chlorine dose on THMs formation at pH=10

below the WHO guide line (180ppb) values. Figure shows that strong correlation between DOC and THMs (r^2 =0.86). It may be observed that textile liquid wastes content a lower value of DOC ranged 0.6 to 2 mg/l approximately. Trihalomethanes (THMs) formation increases significantly with the increase concentration of DOC and increasing pH. But THM concentration is independent of pH at concentration above 150ppb. The pH value is 8.5 at 150 ppb concentration of THM. Curves have been generated in Matlab software to find out the concentration of THM for different chlorine dose, pH and DOC values. The concentrations of THM in the outlet stream of different ETPs can be found out using these curves. The results are very close to the practical measured values.

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