DBP Control by Intermediate Chlorination in Water Treatment plant: laboratory and full-scale studies

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Abstract Chlorine has been widely used as a disinfectant for surface water treatment in most countries. But chlorine reacts with natural organic matters in waters and forms halogenated by-products. In this study, we evaluated the reduction efficiencies of DBPs formation by intermediate chlorination through jar test and full-scale test. The results of this study showed that intermediate chlorination is not only more efficient in reduction of DBPs formation but also more economical than prechlorination.

Keywords: Prechlorination; Intermediate chlorination; Postchlorinaion; DBPs.

Introduction

Chlorination has been used for inactivation of microorganisms and oxidation of organic and inorganic materials. In the 1970's, it was proved that the disinfection by-products (DBPs) formed by reaction between chlorine and organic matter in the water, are harmful to human health. Existence of disinfection by-products (DBPs) in drinking water is one of primary concerns in drinking water treatment now(Reckhow *et al*, 1990). In spite of advantages, chlorination needs to be revaluated and concerned because of serious risks of DBPs to human health (Van Steenderen *et al*, 1991). So many water supplies began modifying existing treatment processes. But water treatment plants in Seoul were not initially designed to control the formation of trihalomethanes and haloacetics by modifying existing disinfection practice.

Therefore new methods are needed to meet Treatment Technique (TT) Regulations for trihalomethanes, haloacetic acids. In solving this problem, intermediate chlorination might be one of methods that can control disinfection by-products (DBPs) without modifying existing treatment processes (Yu *et al*, 1999). The purpose of this study is evaluating effect of intermediate chlorination for DBPs reduction.

Methods

Experimental Procedure

To evaluate of DBPFP, jar test was conducted for the raw water and settled water of 20min settling of Kyung-an river water.

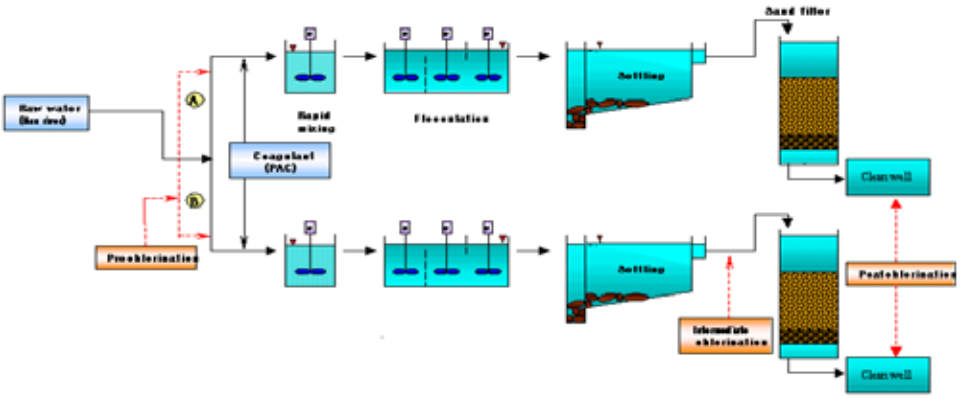

Figure 1. Schematic diagram of chlorination system in Dukdo water treatment plant

Full-scale test was conducted at Dukdo water treatment plant where the Han river water is used as raw water. Schematic diagram of each process is shown in Figure 1. As shown in the figure, the effluent water of settling basin was divided into two lines. One line was connected to sand filtration before postchlorination and another line was connected to sand filtration after intermediate chlorination. Disinfectant (liquid chlorine) dose was based on three times the dissolved organic carbon concentration as Cl_2 and 7.6 times ammonia-nitrogen demand. Samples were quenched using Ascorbic acid or NH_4Cl and carried to the laboratory for the analysis of DBPs

Analycal method

Thihalomethanes (four THMs ; $CHCl_3$, $CHCl_2Br$, $CHClBr_2$, $CHBr_3$) were analysed using a GC according to USEPA 502.2 head space method.

The haloacetic acids (five haloacetic acids; MCAA, DCAA, TCAA, MBAA, DBAA) were analysed using a GC according to modified USEPA 552.2 micro extraction method.

Total organic halide was analysed using a TOX analyser (Dohrmann DX-2000) with SM 5320.

Results and Discussion

Reduction of DBPs formation by intermediate chlorination

Jar-test results using Kyung-an river water showed that settled water forms far less DBPs than raw water. THMFP, HAAFP, TOXFP were 11.56㎍/L, 30.9㎍/L, 240.21㎍/L for the settled water, but 61.06㎍/L, 92.7㎍/L and 317.64㎍/L for the raw water, respectively. Therefore THMFP, HAAFP, TOXFP were reduced by 81.07 %, 66.7% and 24.4%, respectively in settled water. This is ascribed to removal of DBP precursors in water through coagulation and settling process(Jiang *et al*, 1992).

Full-scale test results in differing dosages of prechlorinaiton and intermediate chlorination show that the less prechlorine is used the less DBPs is formed.

Water qualities in each process are shown in Table 1. It shows that DBPs concentrations through prechlorination-postchlorination are higher than intermediate chlorination-postchlorination. Also prechlorination-intermediate chlorination combined process has the lowest formation of THMs and TOXs. THMs and HAA5 in prechlorination-intermediate chlorination-postchlorination were reduced by 28% and 48%, respectively than prechlorination- postchlorination.

Table 1. Concentration of DBPs through water treatment processes at the water treatment plant

step	concentration(㎍/L)		
	THMs	HAAs	TOXs
Pre-chlorination(2.8mg/L)			
coagulation & sedimentaion	14.3	21.7	-
sand filtration	21.6	10.7	-
post-chlorination	25.0	17.5	80.4
Pre-chlorination(0.5mg/L) + intermediate chlorination(1.5mg/L)			
coagulation & sedimentaion	13.0	8.4	-
sand filtration	18.3	10.3	-
post-chlorination	22.5	9.2	73.2
Pre-chlorination(1.0mg/L) + intermediate chlorination(1.0mg/L)			
coagulation & sedimentaion	15.0	13.2	-
sand filtration	20.0	17.3	-
post-chlorination	19.0	15.2	65.8
Intermediate chlorination(2.0mg/L)			
coagulation & sedimentaion	0.2	0.5	-
sand filtration	18.0	5.3	-
post-chlorination	21.5	11.3	67.0

These results are explainable by the fact that DBPs formation was restricted by low prechlorine concentration in raw water, and intermediate chlorine reacts with reduced precursors after coagulation settling

Economic effect

In the Full-scale test conducted at Dukdo water treatment plant, average chlorine dosage to achieve chlorine goal concentration (0.90.1mg/L) of transmitted water was 4.29mg/L in

prechlorination-postchlorination and 3.44mg/L in intermediate chlorination-postchlorination.

Therefore the study showed that intermediate chlorination is not only more efficient in removal of DBPs but also more economical than prechlorination.

Conclusions

Prechlorination is the important step for inactivation of microorganisms and the removal of algae, unpleasant taste. But this study showed that the more prechlorine is used, the more DBPs formed (Kim, 2002). Also, prechlorination-intermediate chlorination-postchlorination is more effective than intermediate chlorination-post chlorination for reduction of DBP formation. It is thought that step dosing of required chlorine demand is more effective than dosing at one point in reducing DBPs formation.

The conclusions that can be obtained from this study are as follows:

To minimize DBPs, low prechlorine concentration (at least 40 to 50 percent of chlorine demand) should be applied in raw water and intermediate chlorine (0.4 to 0.6 mg/L as free chlorine concentration) reacted with reduced precursor after coagulation settling

Introducing intermediate chlorination is not only more efficient in reduction of DBPs(15 to 30 percent) but also more economical(19.8 percent) than prechlorination alone.

According to raw water conditions (e.g., high turbidity, high concentration of organic matter, increasing algae, decreasing pH et al.), intermittent transition from prechlorination to pre and intermediate chlorination would allow to meet the TT for DBPs.

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