B−27 CONTROL OF DISINFECTION BY-PRODUCT FORMATION POTENTIALS IN WASTEWATER EFFLUENT TREATED BY SOIL AQUIFER TREATMENT FOR POTABLE PURPOSES

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1. INTRODUCTION

Potable reuse of wastewater effluent is an effective way to ease drinking water shortage. As a natural technology with low energy consumption, soil aquifer treatment (SAT) is often used to purify wastewater effluent. Nevertheless, due to the uncertainty in the quality of SAT effluent, its legitimacy as a safe source of drinking water should be confirmed before practical application.

One of the major concerns in SAT is disinfection by-products (DBPs). Recent studies indicated that compared with surface water, wastewater effluent has higher total DBP formation potential (DBPFP) and higher proportion of nitrogenous DBPFP (N-DBPFP) and brominated DBPFP (Br-DBPFP)[1)] that are toxicologically more important than carbonaceous DBPFP (C-DBPFP) and chlorinated DBPFP (Cl-DBPFP).[2)] SAT is generally considered effective for DBP control since relatively low-levels of dissolved organic carbon (DOC), dissolved organic nitrogen (DON) and total DBPFP were detected in SAT effluent.[3)] However, the increases in DON/DOC and bromide ion (Br^-)/total organic carbon (TOC) ratios after SAT[4,5)] suggested a possibility that SAT will further increase the proportion of N-DBPFP and Br-DBPFP, finally leading to the failure to reduce N-DBPFP and Br-DBPFP down to at least surface water levels in wastewater effluent.

This study aims to clarify the efficiency of SAT mainly on N-DBPFP and Br-DBPFP in wastewater effluent, by providing detailed characteristics of five major DBPFPs including trihalomethanes (THMs), haloacetic acids (HAAs), haloacetonitriles (HANs), chloropicrin, and *N*-nitrosodimethylamine (NDMA).

2. EXPERIMENT METHODS

(1) Material

The general properties and operating conditions of all columns are listed in **Table 1**.

Table 1 Properties and operating conditions of SAT columns

Column	Scale	Soil type	Hydraulic retention time (HRT) (day)	Saturation condition
TS	lab	TS	7	unsaturated
Sa-3.5	lab	Sa	3.5	unsaturated
Sa-7	lab	Sa	7	unsaturated
Sat-sa	lab	Sa	7	saturated
Sa-30	pilot plant	Sa	30	unsaturated

Four lab-scale acrylic columns (i.d., 15 cm; H, 150 cm) and one pilot plant-scale stainless steel column (L, 1.5 m; W, 1.5 m; H, 3.0 m) were adopted in this study. The feed water was an effluent from anaerobic-anoxic-oxic treatment (hereinafter called as A2O water). Toyoura standard sand (TS) represents a soil from an extreme physical environment (low organic content and specific surface area). Sand (Sa) was considered as a typical material commonly used in SAT.

(2) Analytical Methods

In DBPFP test, NaOCl (NH_2Cl for NDMAFP) was added into samples as disinfectant to ensure that after 24 hours the residual concentration would be equivalent to 1mg-Cl_2/L (3mg-Cl_2/L for NDMAFP). After chlorination or chloramination, samples were pretreated by either liquid-liquid extraction (THMs, HAAs, HANs and chloropicrin) or solid-phase extraction (NDMA). The equipments involved while analyzing DBPs were GC/ECD for THMs and HAAs, GC/MS for HANs and chloropicrin, and LC/MS/MS for NDMA.

3. RESULTS AND DISCUSSION

(1) Characteristics of DBPFP in SAT influent and effluents

Figs. 1 and **3** show the detailed data of THMFP, HAAFP, HANFP, chloropicrin FP and NDMAFP in SAT influent (A2O water) and effluents from all the columns. The removal percentages of DBPFP of each column are given in **Table 2**, demonstrating that most DBPs monitored decreased remarkably after SAT, even with a short-term HRT (3.5 days and 7 days).

Table 2 Average removal percentages of DBPFP

DBPFP type	Column				
	TS	Sa-3.5	Sa-7	Sat-sa	Sa-30
THMFP	42	71	76	74	89
HAAFP	54	80	83	82	87
HANFP	52	62	66	67	88
Chloropicrin FP	76	91	94	86	96
NDMAFP	48	67	70	53	71

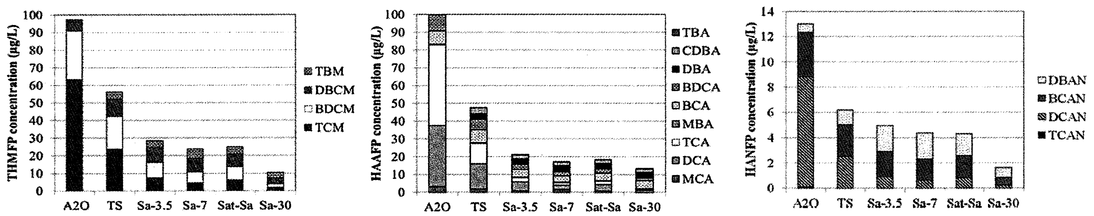

Fig.1 Average THMFP, HAAFP and HANFP in SAT influent and effluents (n=22 for THMFP and HAAFP, n=8 for HANFP)

(*For DBP acronyms & abbreviations refer to Appendix)

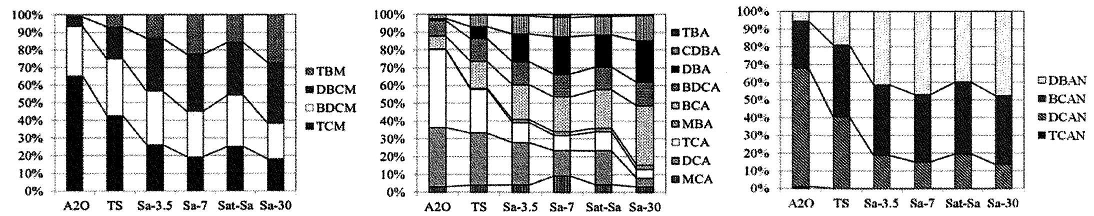

Fig.2 Average percentages of THMFP, HAAFP and HANFP in SAT influent and effluents

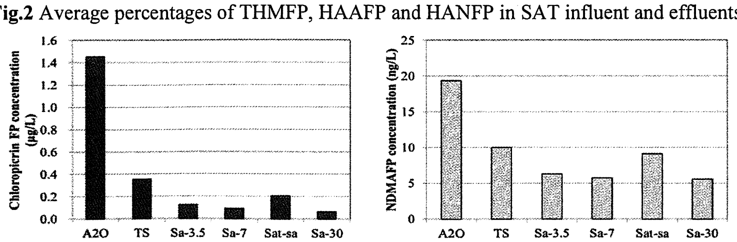

Fig.3 Average chloropicrin FP and NDMAFP in SAT influent and effluents (n=2)

In addition, from **Fig. 2** it can be learned that after SAT, the proportions of Br-THMFP, Br-HAAFP and Br-HANFP significantly increased. Actually, the concentrations themselves of some species of Br-DBPFP including DBCMFP, TBMFP, DBAFP and DBANFP were found to increase, showing that SAT has poor ability to control Br-DBPFP levels.

(2) N-DBPFP/C-DBPFP

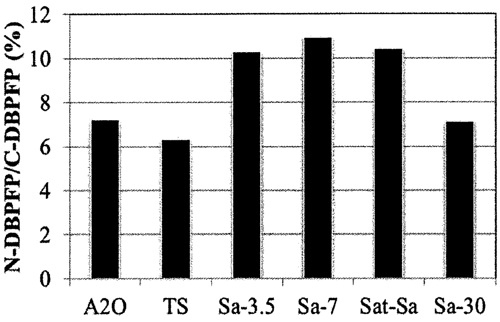

Fig.4 Average N-DBPFP/C-DBPFP ratios (%)

In **Fig.4**, the N-DBPFP (the sum of average HANFP, chloropicrin FP and NDMAFP)/C-DBPFP (the sum of average THMFP and HAAFP) ratios are calculated. A growing trend is found in samples after SAT, suggesting that the precursors of N-DBPs (DON) might not be effectively removed compared to those of C-DBPs (DOC).

4. CONCLUSIONS

The major findings from this study are listed below:

(1) Apparent removal efficiency (at least 42%) of all DBPFP by SAT was found under all conditions, even in short-term HRT columns (3.5 days and 7 days). After SAT, all DBPFP (except NDMAFP) could be reduced by approximately 90% at most (Sa-30).

(2) Compared with Cl-DBPFP and C-DBPFP, Br-DBPFP and N-DBPFP were removed by SAT inefficiently, which offered a hint that the precursors of Br-DBPFP and N-DBPFP were not removed efficiently as those of Cl-DBPFP and C-DBPFP.

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APPENDIX LIST OF DBP ACRONYMS & ABBREVIATIONS

TBM	Bromoform
DBCM	Dibromochloromethane
BDCM	Bromodichloromethane
TCM	Chloroform
MCA	Monochloroacetic acid
MBA	Monobromoacetic acid
DCA	Dichloroacetic acid
TCA	Trichloroacetic acid
BCA	Bromochloroacetic acid
BDCA	Bromodichloroacetic acid
DBA	Dibromoacetic acid
CDBA	Dibromochloroacetic acid
TBA	Tribromoacetic acid
TCAN	Trichloroacetonitrile
DCAN	Dichloroacetonitrile
BCAN	Bromochloroacetonitrile
DBAN	Dibromoacetonitrile

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