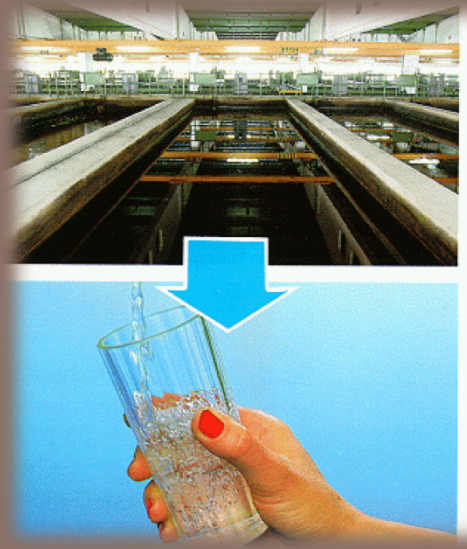
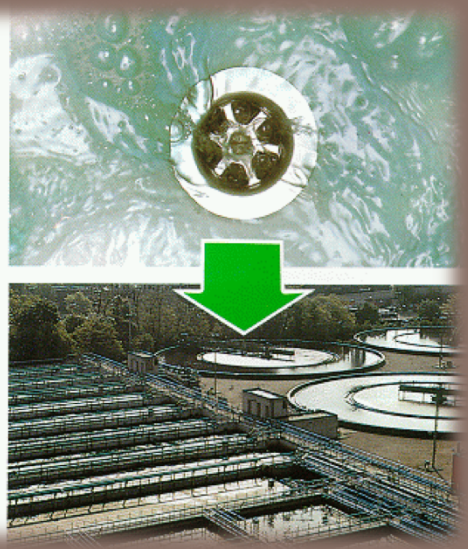
MONITORING TRIHALOMETHANES (THMs) IN WATER DISTRIBUTION NETWORK IN HO CHI MINH CITY AND APPLICATION OF LOW COST METHODS FOR THM REMOVAL AT HOUSEHOLD SCALE

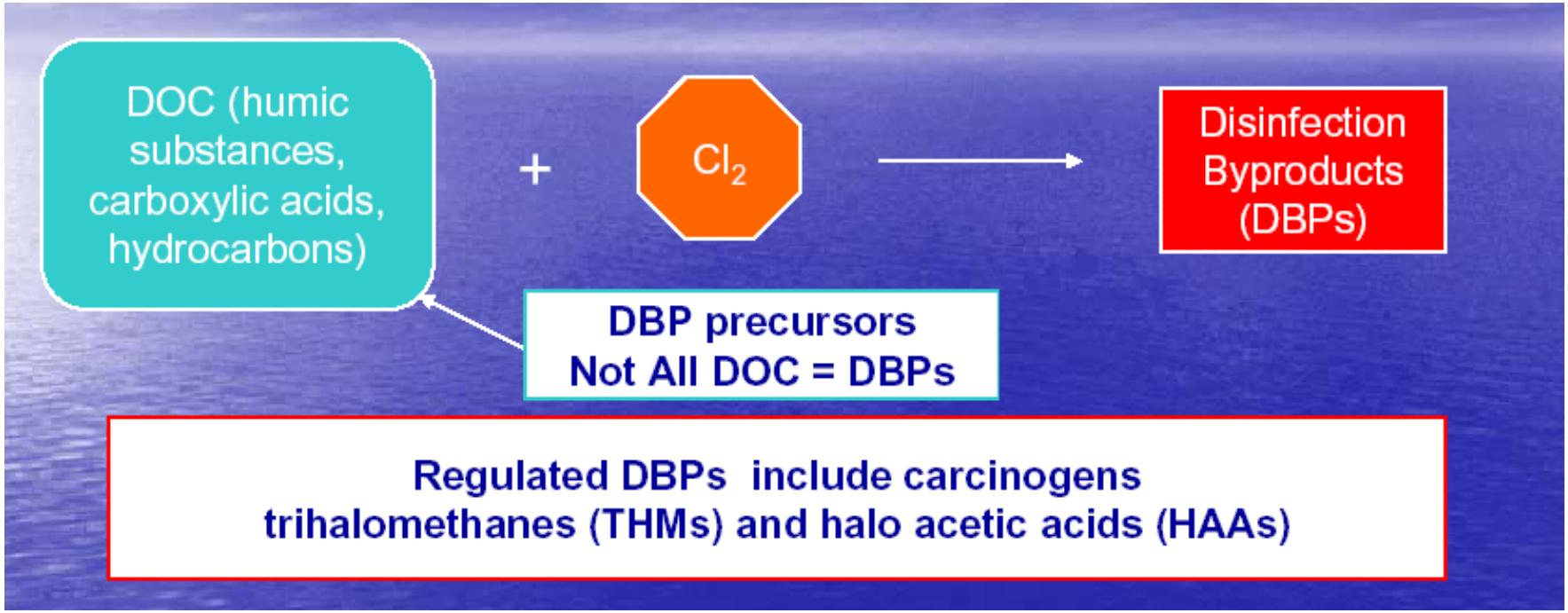




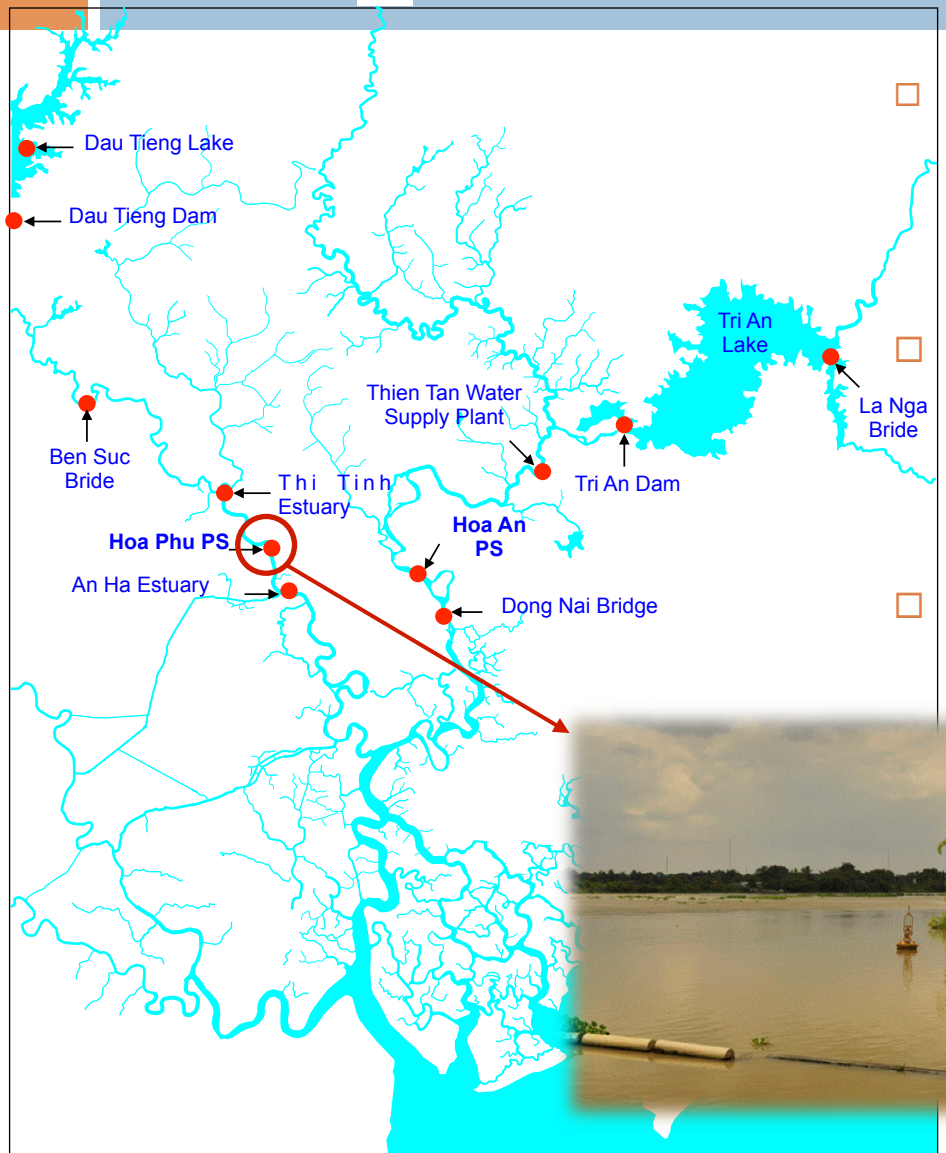
Authors: Thanh L.T.T, Quynh NTN, Phuong LD and N.P.Dan

INTRODUCTION

- Pre-chlorination and disinfection are the key processes in water treatment plants.
- Chlorine is the most common disinfectant used in WTPs in Vietnam due to its low cost and high reactivity.



PROBLEMS



- Triet, L.M, 2008 and Ha, N.T.V. 2009: the water quality of Sai Gon River has been degraded in terms of increase in OMs and ammonia
- Surface WTPs in Saigon river have used a large amount of chlorine for pre-chlorination, iron/manganese removal and disinfection.
- ➔ increase high risks of DBP formation in the drinking water.

Hoa Phu Water pump station at Ben Than Cu Chi

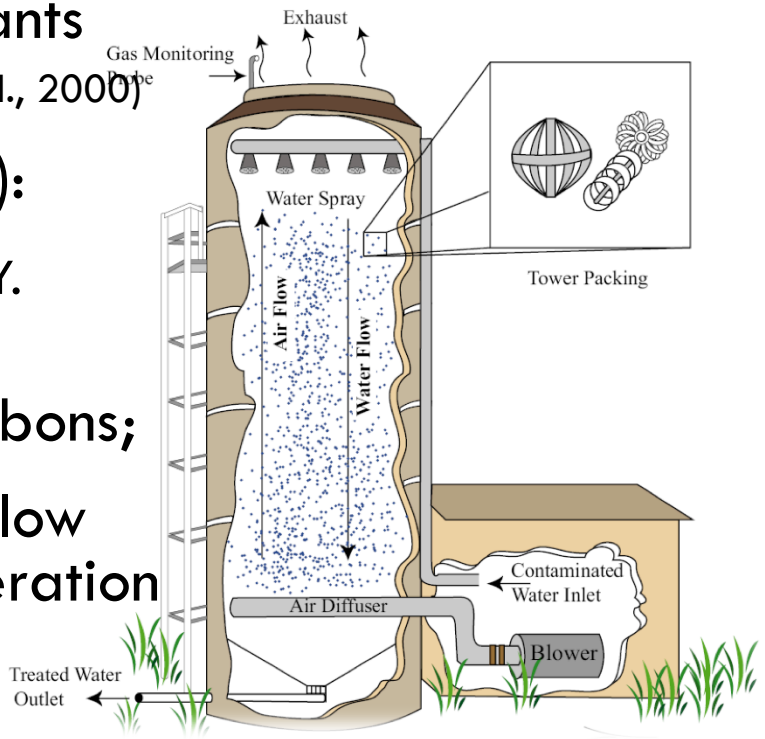
PROBLEMS

- Trang et al. (2012): the THMs formation potential of produced water from TH-WTP had 118 µg THM/mg DOC,
- Average total THM after disinfection was 156 µg/L
- DOC of tap water more or less 5 mg/l (Trang, *et al.*) ➔ THM may exist in the piped water

THM Removals

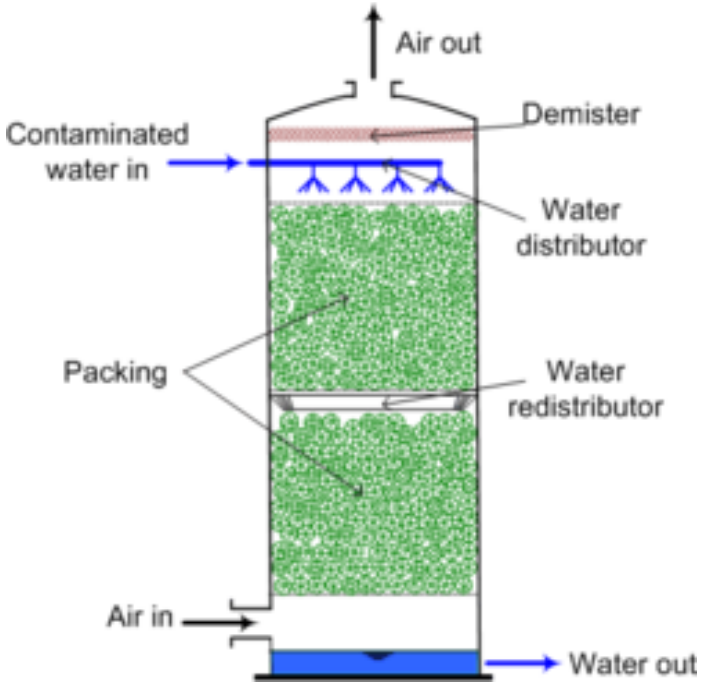
- Removal of precursors before chlorination,
- Use of alternative oxidants/disinfectants such as ozone, UV (Reid Crowther & Partners Ltd., 2000)
- Advanced oxidation processes (AOPs):
- BAC treatment combined with AOPs (Y. Takeuchi et al., 1997).
- Adsorption by granular activated carbons;
- **Air stripping** (Fangtong & Shujuan, 2009): low cost and simple maintenance and operation
- Thermal methods ➔ efficient volatile organic matters

➔ to select to study.



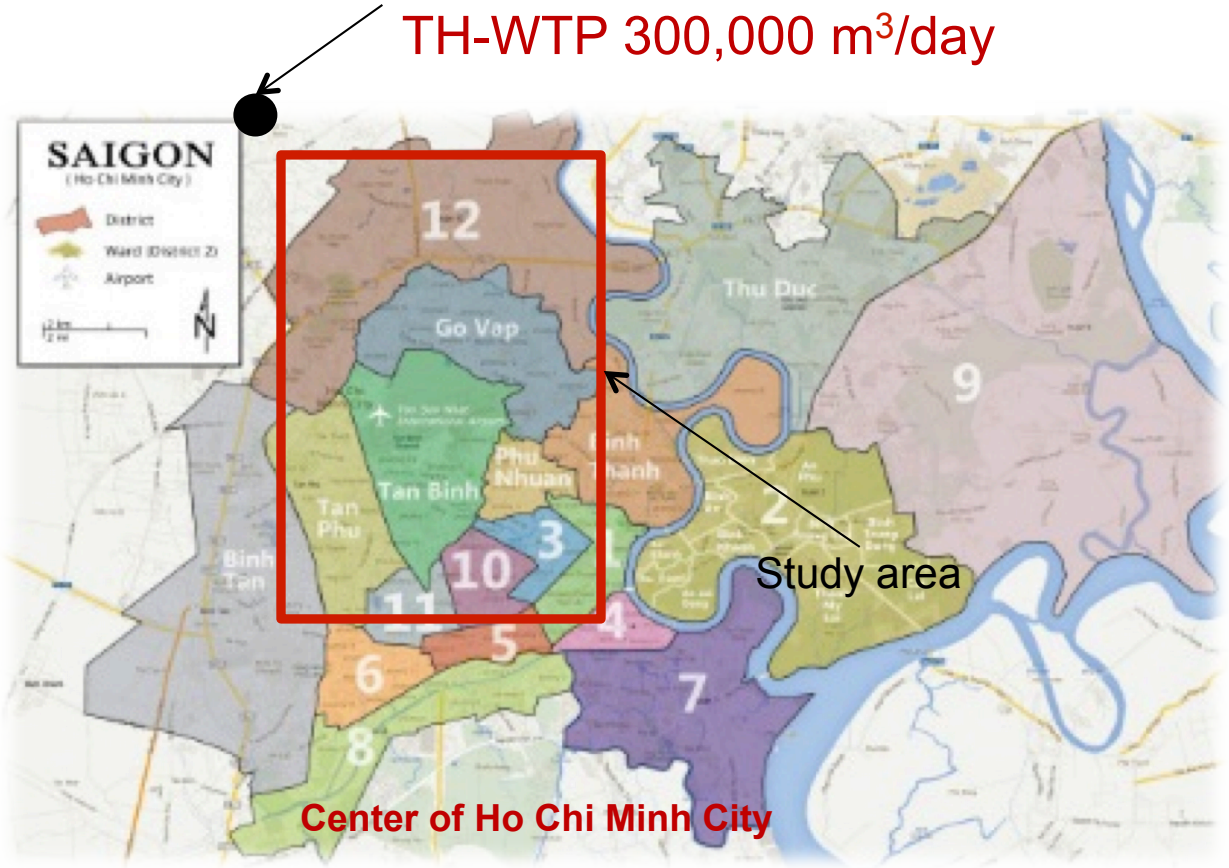
Objectives

- Study on the THMs monitoring in the water distribution network supplied from Tan Hiep WTP,
- Investigate THM removal by (i) air stripping columns and (ii) boiling.



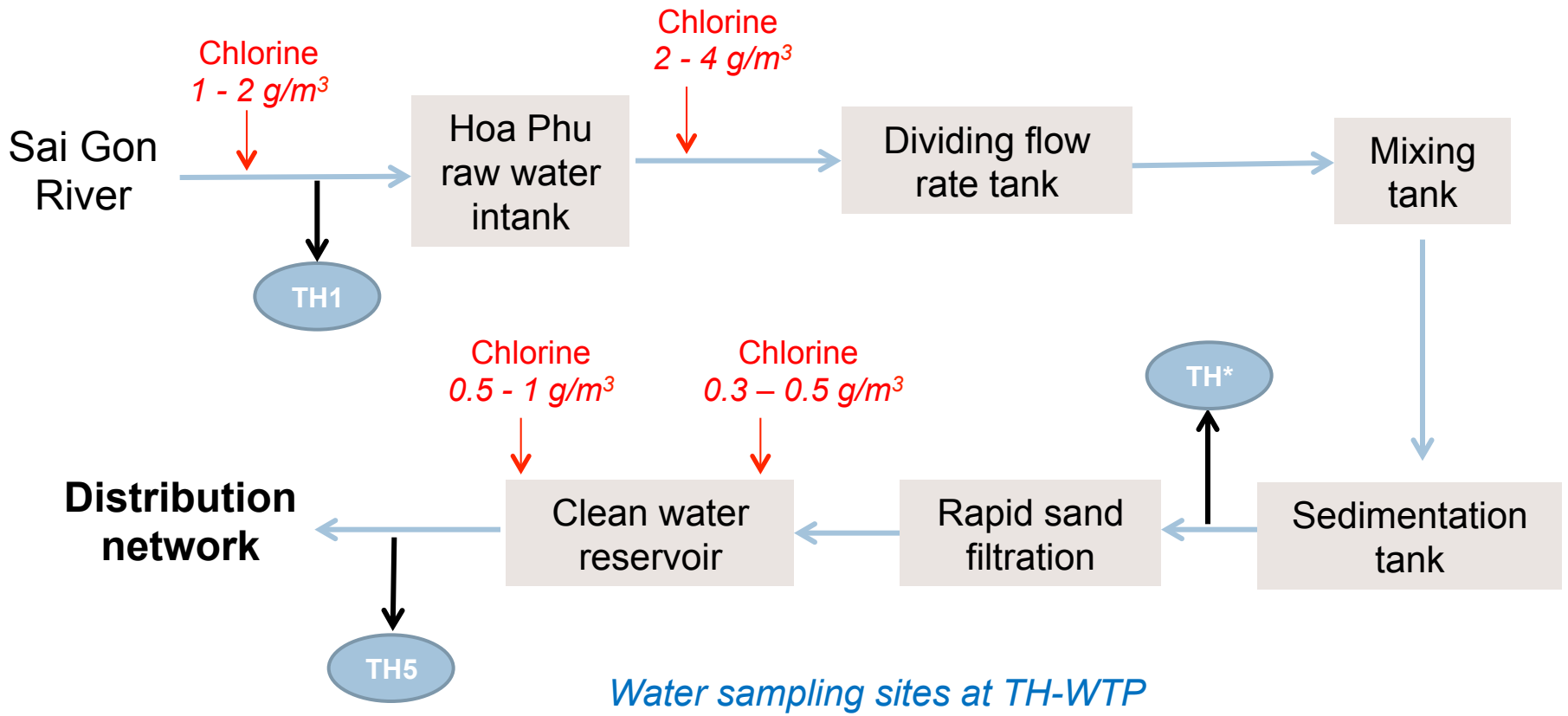
MATERIALS AND METHOD

Sampling



- August - November 2012
- Once a month
- **17** sampling sites: **3** sites at TH-WTP and **14** sites in Water network

Sampling in Tan Hiep WTP



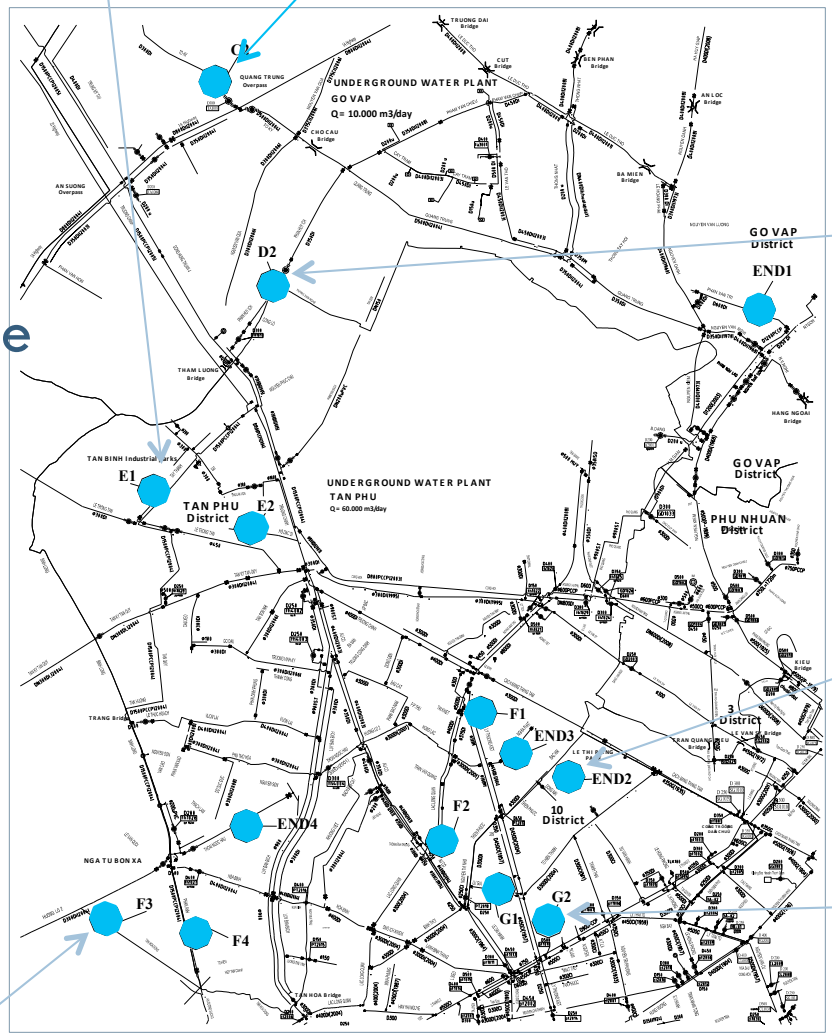
Water sampling sites at TH-WTP

TH - WTP used a large amount of chorine in pre-chlorination and desinfection

Sampling

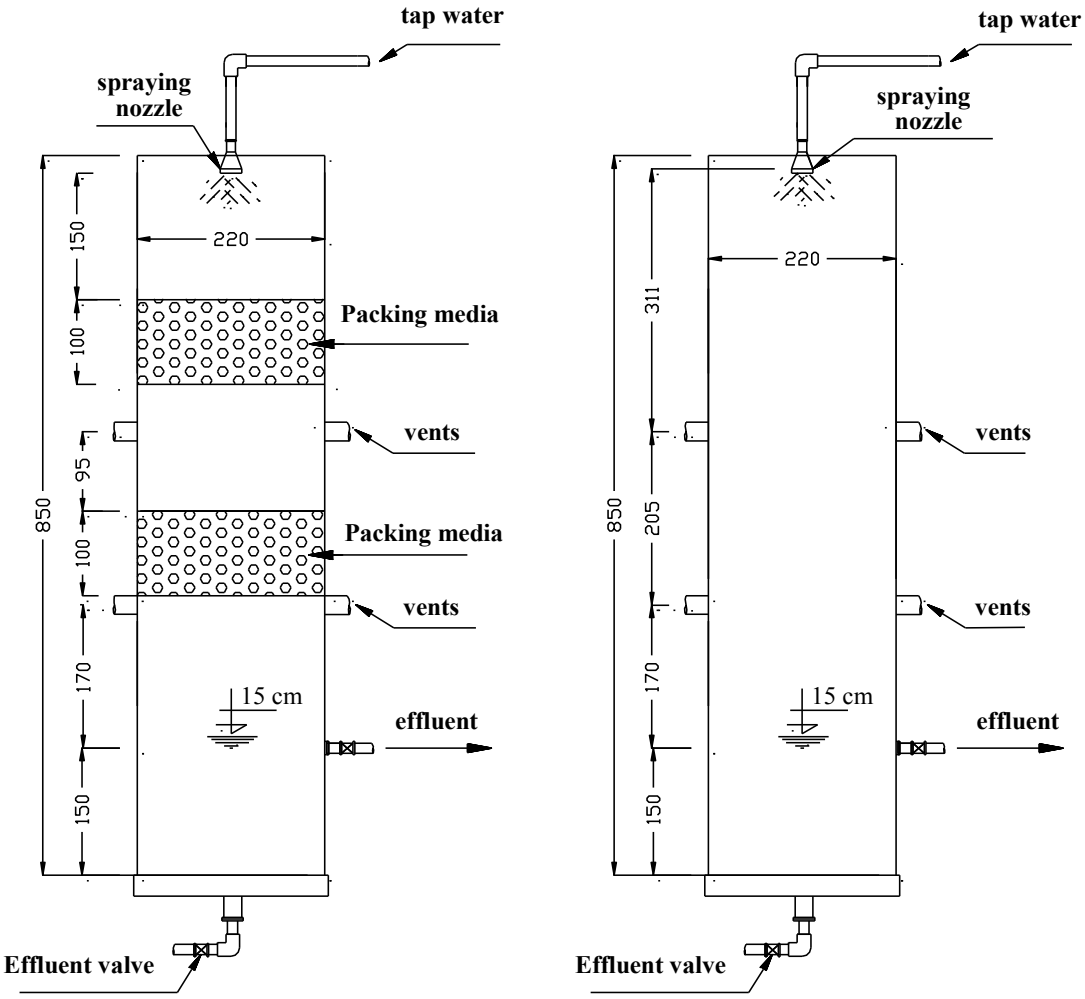
Sites within distribution network in North-westhern area of HCMC:

- Those households use water provided from TH-WTP
- The faucet for collecting sample must be connect directly to the distribution network.
- 1ml $Na_2S_2O_3$(10%) was added to samples



Pipe network of the selected study area

Air stripping column (ASC)



Air stripping column (AS)

- ✓ Feed water was the tap water of Lab which does not pass through any on-site treatment facilities or storage.

- ✓ This tap water may be mixture of produced waters from TH-WTP and Hoc Mon underground water treatment plant.

The feed water used in the AS experiment

Parameter	Unit	Value
Cl_2 (F)	mg/l	0.41 ± 0.1
Cl_2 (T)	mg/l	0.53 ± 0.09
pH	-	7.06 ± 0.14
Water temperature	^0C	31 ± 0.3
Ambient temperature	^0C	32 ± 0.2

Air stripping column (ASC)

- Air stripping experiment was conducted at hydraulic loading rates of 7, 12 and 18 $m^3/m^2/h$.
- The experiment at each hydraulic loading rate was run continuously for 2 weeks (8 hours/day).

Specific surface area: 110 m^2/m^3
Porosity = 85%
Diameter = 18 mm
Length = 25 mm

Boiling test

A stainless steel pot with glass cover was used. Its working volume is 800 mL.

The heat was provided by an electric stove.

The tested waters included:
(i) piped water, and
(ii) the effluent of ASC experiment.

Boiling test

The water after 5, 10 and 15 minutes of boiling was taken, since the bubbles and steam happened in the pot,
Analysis of THMs was done as soon as samples were cooled down to room temperature (about 30 to 45 min).

Analytical methods

	Standard	Machine	Method	Reagent
Free chlorine	Method 10069	HACH DR 890	Colorimeter	± 0.01mg/L
Total chlorine				
pH	Method 4500-H^+	HANNA HI8314		± 0.01
Color	Method 2120 & 7045	HACH DR 890	colorimeter	± 0.01mg/L
Turbudity				
Alkalinity	Method 2320	Titration with the combined color indicator	H_2SO_4 0.02N	
DN	Method 5310C	Shimadzu Total organic carbon Analyser TOC-V CPH with auto Sampler ASI -V		
DOC				
THMs	Method 6232	GC-MS plus QP 2010 Shimadzu		Pentane (C_5H_{12})

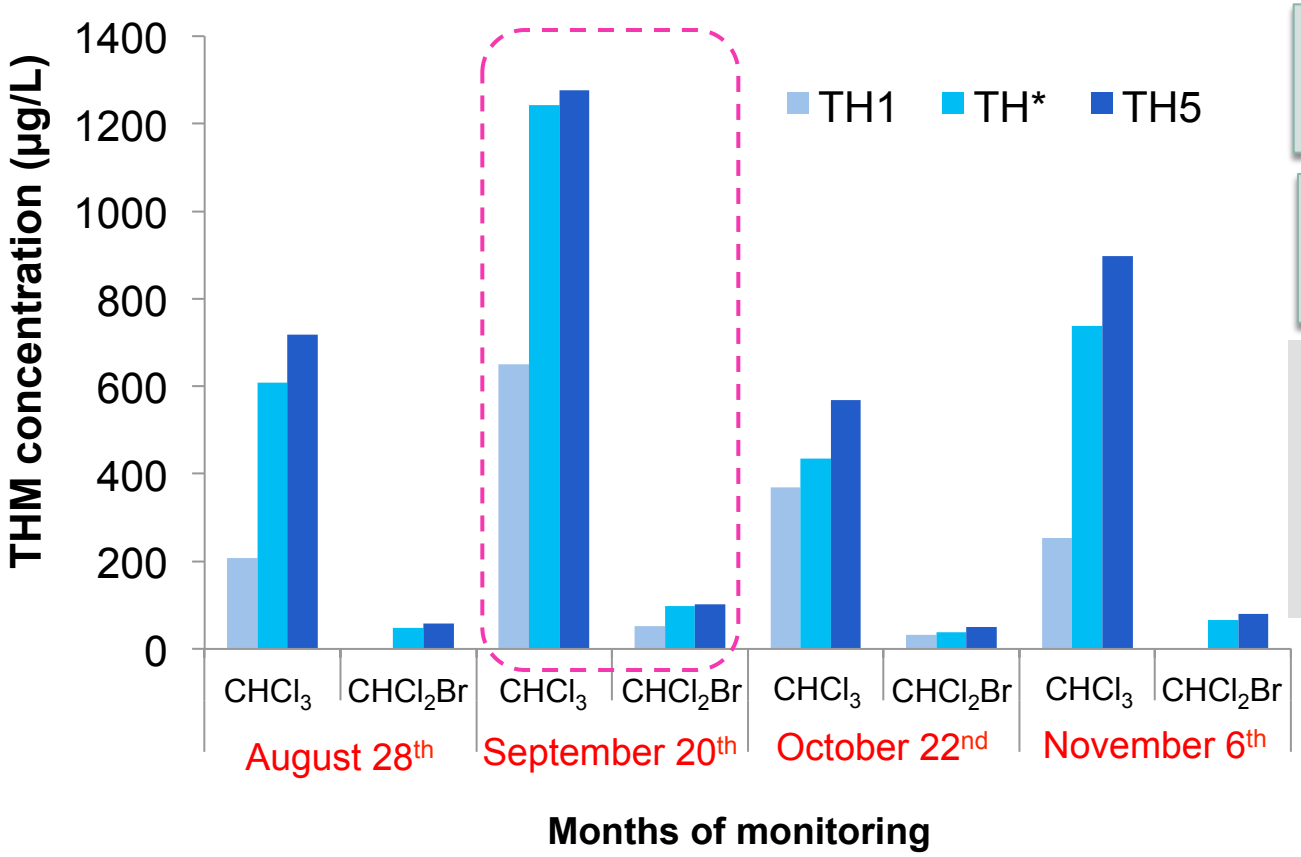
Analytical methods

GC – MS plus QP 2010 Shimadzu

HACH DR890 Colorimeter

Shimadzu Total organic carbon Analyser TOC-V

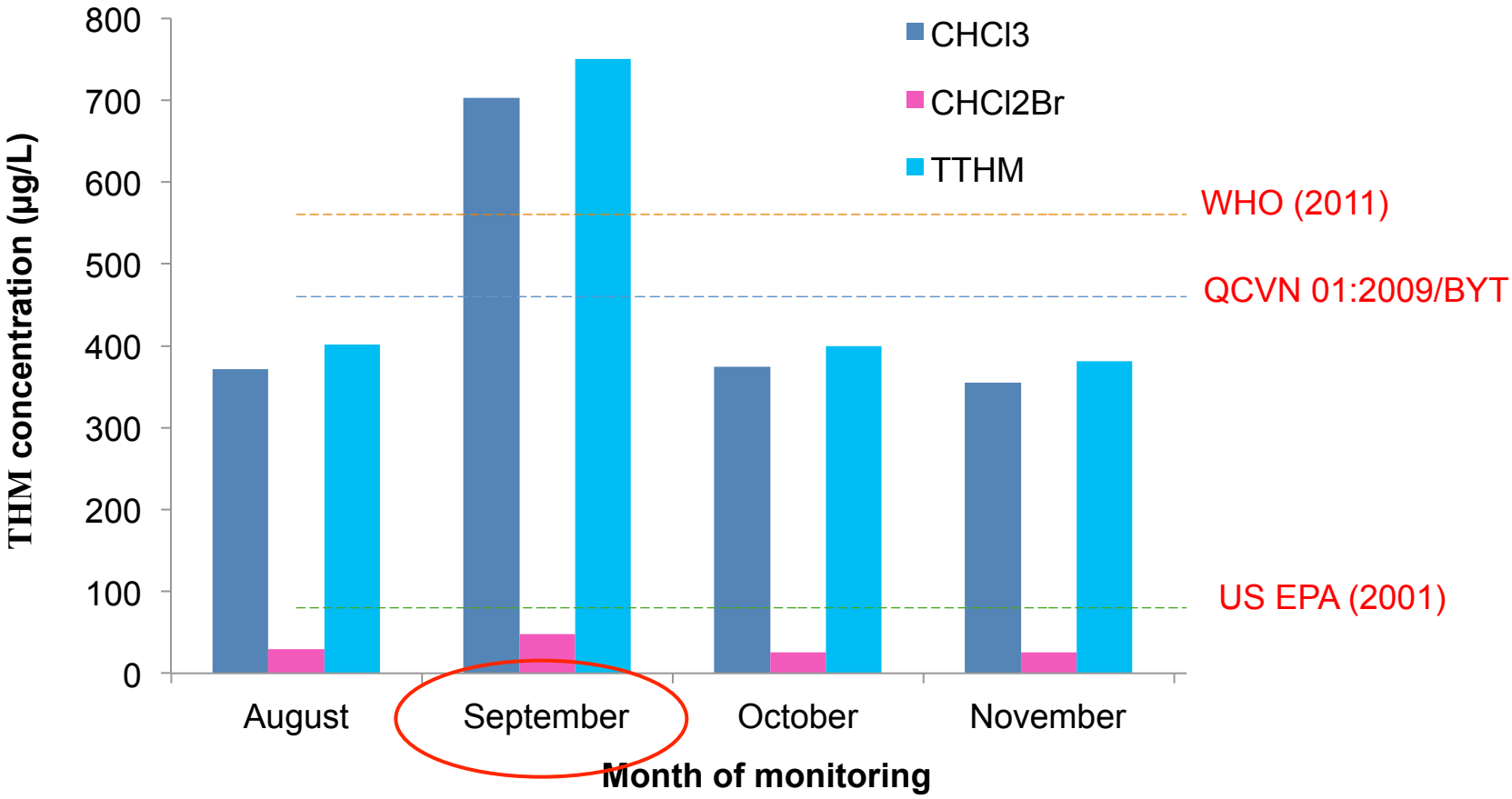
THMs of processed water at TH-WTP



- $CHCl_3$: 85-95%
  $CHCl_2Br$: 5-15%
- $CHClBr_2$ & $CHBr_3$: insignificant
- At TH1(pre-chlorination), THM:DOC ratio ~ 113 µgTHM/mgDOC

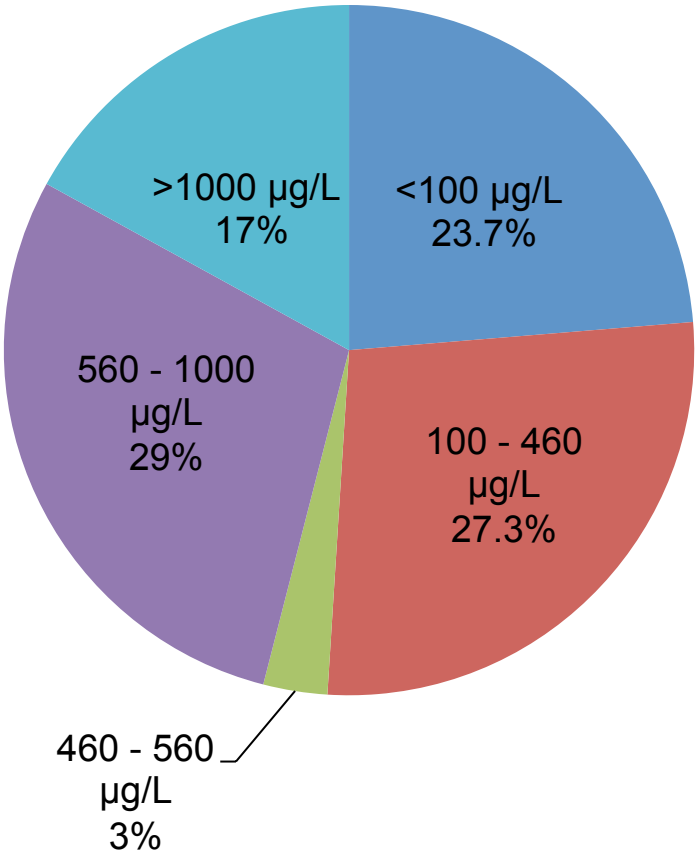
- THMs was highest in September ➔ DOC, turbidity & color of raw water were highest in this month
- THMs increased after chlorine addition

Quality of tap water in TH-WTP distribution network



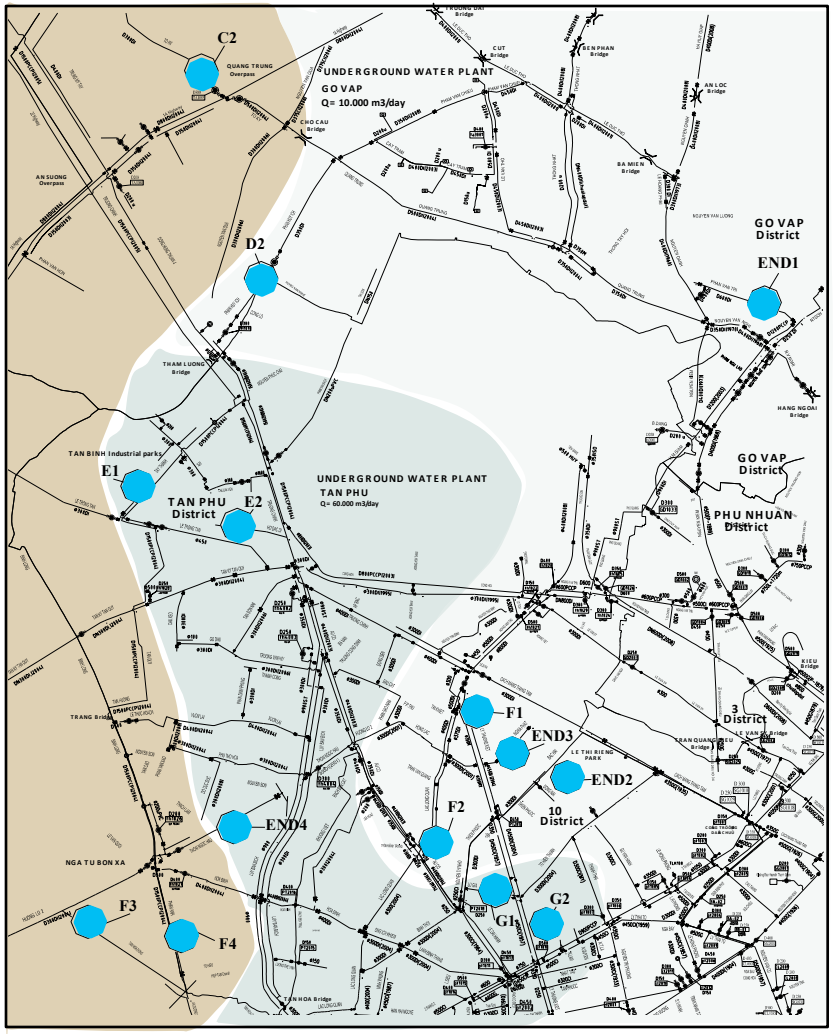
- THMs in the distribution network vary significant by months and sampling sites. THMs value was also highest in September
- The concentration of $CHClBr_2$ and $CHBr_3$ in all samples were very low or under detection thresholds

Quality of tap water in TH-WTP distribution network

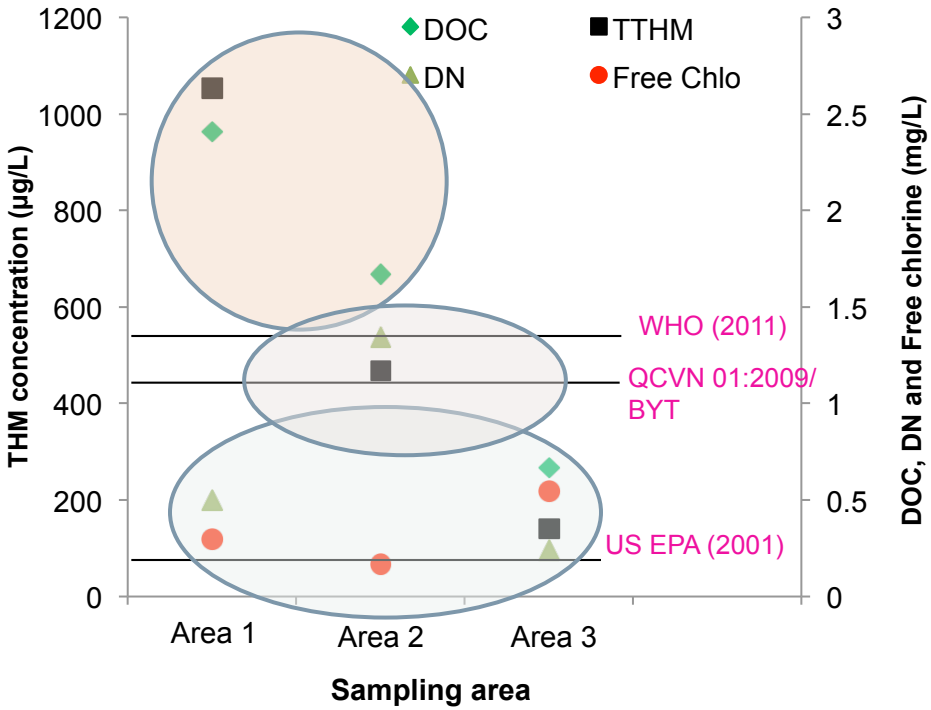


- n = 59 samples
- 23.7% met EU drinking water quality standards
- 51% met QCVN 01:2009/BYT (54% by WHO standards);
- About 17% had THMs values higher than 1000 µg/L.

Quality of tap water in TH-WTP distribution network



Map of the study area



Area 1 where tap water is provided mainly from the TH-WTP

Area 2 where tap water is provided partly from TH –WTP and other WTPs

Area 3 where tap water is provided mainly from Thu Duc WTPs/GW and insignificantly from TH-WTP

Modeling of THMs formation within distribution network

Based on earlier researches of THM within distribution network

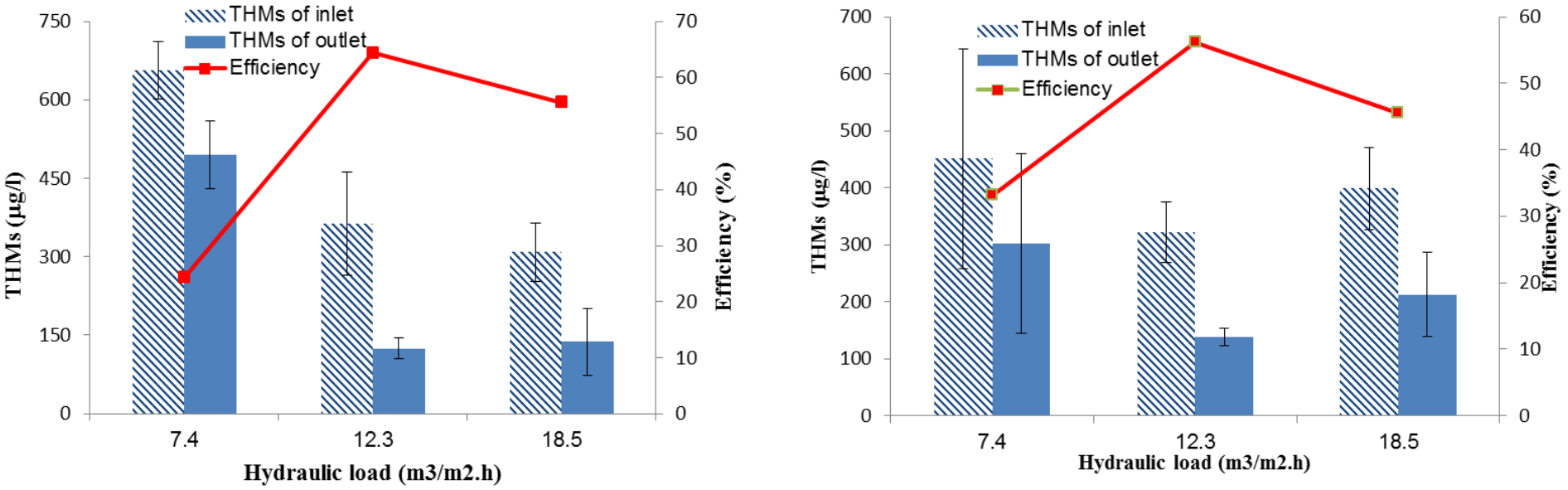
Authors	Model	Parameters
Garcia-Villanova *et al.*, (1997)	**THM = *f*(DOC, UV, Cl, Br^-, pH, T, t)**	DOC: dissolved organic carbon (mg/L) UV: ultraviolet ray absorption capacity Br^-: bromide conc. (mg/L) Cl: chlorine dose (mg/L) T: water temperature (^oC) t: contact time (h)
Toroz and Uyak, (2005)	**$THM = 11.967(TOC)^{0.398}\ (T)^{0.158}(Cl)^{0.702}$**	TOC: total organic carbon (mg/L)

Model for estimating THMs concentration (*by Stata statistical software*)

$$THM = 788.86\ (DOC)^{0.771}\ (DN)^{0.12}\ (Cl\text{----}\_combined)^{0.33}$$

n= 51 samples $R^2 = 0.66$ $p < 0.0001$

Air stripping column(AS)



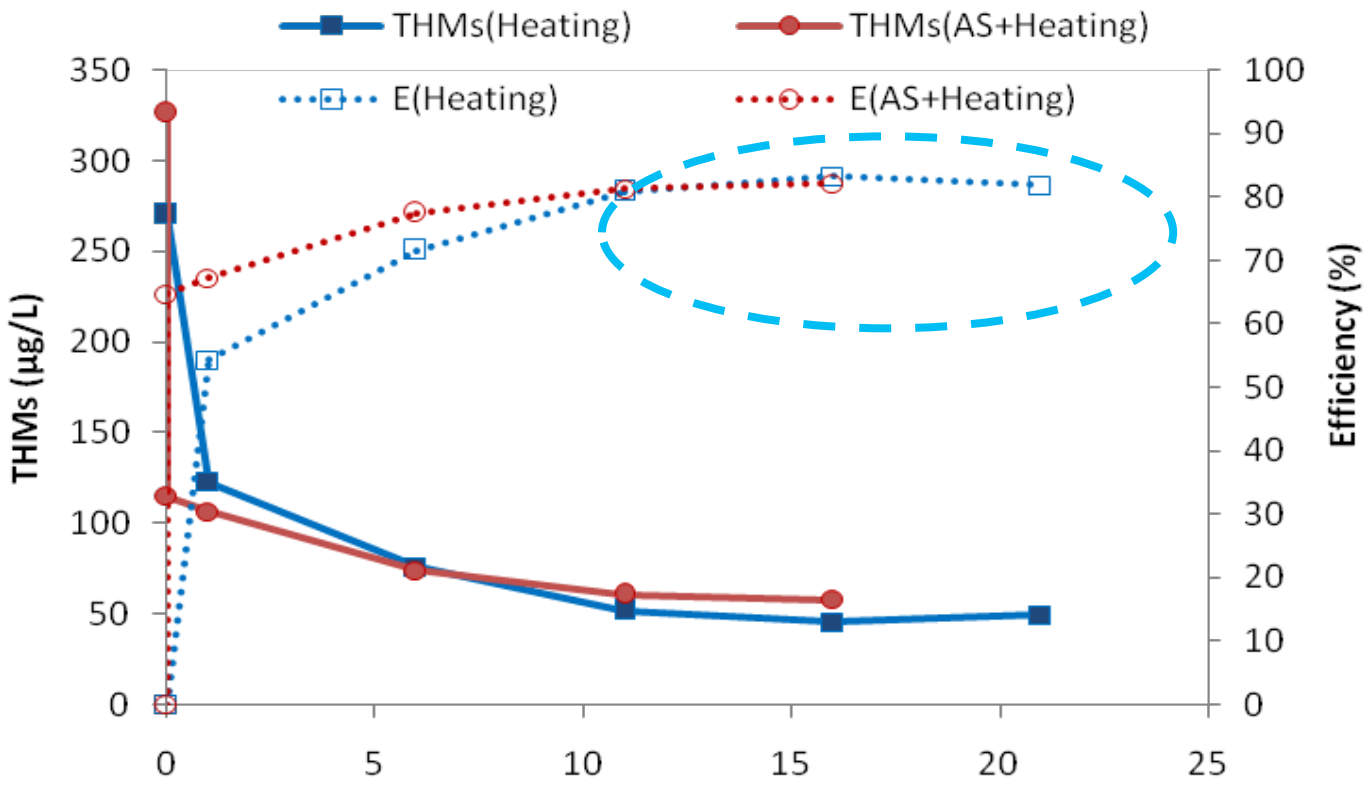
THMs removal efficiency in AS column (a) with media and (b) without packed media

- Best performance was achieved at the hydraulic loading of 12.3 $m^3/m^2.h$.
- AS column without media, the highest efficiency was 64.4% at hydraulic load of 12.3 $m^3/m^2/h$, whereas the THM removal was 56.2% for the AS with media.

➔ THMs removal efficiency of the AS column with packing media was little bit lower. This may be due to worse effects of packing media on ventilation.

- Packing media at low air-to-water ratio in such experiment did not improve THMs removal.

Boiling



- THMs reduced steeply as soon as water started boiling and then THMs value of tap water and effluent of AS reached stable value of 52 µg/L and 61 µg/L after 10 minutes of boiling, respectively.
- The highest THM removal for both tested water was 82-83% after 15 minutes of boiling

Conclusions

- The mean THMs concentration of produced water at the TH-WTP was ranged from 390 to 940 µg/L that sometimes higher than THMs threshold of the DW quality standards.
- High THMs conc. in piped water was found at sites under water supply of TH-WTP. 49% of samples had THMs conc. > the THMs limit of (QCVN 01:2009/BYT).
- A low cost ASC had a high THMs (64%) and free chorine removal efficiencies at hydraulic load of 12.3 m3/m2/h.
- Water boiling reduce significantly THMs. The highest THM removal was 83% after 15 minutes of boiling.

Acknowledgement

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Thank you for your attention