Hanoi Water Limited Company

Summary Report

Socialist Republic of Vietnam

Verification Survey with the Private Sector for Disseminating Japanese Technologies for “CHEMILES” Technology - Groundwater treatment system without chemical to improve water quality

June, 2017

Japan International Cooperation Agency

NAGAOKA International Corporation

1. BACKGROUND

Water demand in Hanoi metropolitan areas is now sharply increasing due to the high rate of urbanization and industrialization. At present, almost 70% of water consumption in the metropolitan Hanoi is derived from the groundwater source. And the city has to rely on the existing water treatment plants to satisfy its thirsty-water demand. However, deterioration in groundwater quality, especially high content rate of iron, ammonia nitrogen and manganese in groundwater, is an emerging problem for waterworks companies in Hanoi to supply safe and sufficient water to the people. Though the government of Vietnam is planning to use surface water from Red River and the Duong River to suffice increasing water demand in the near future, these projects are still on the table as project contractor and funding for them haven't been decided yet.

Hanoi Water Limited Company is the government organization responsible for domestic water supply services in metropolitan Hanoi. Currently, Hanoi Water Limited Company comprises nearly 80% of Hanoi's total water supply capacity and is using groundwater through 12 major water treatment plants (capacity more than 20,000 m^3/day) and several small water supply stations. As these plants were almost built more than 20 years ago, Hanoi Water Limited Company now has to tackle the problems of deterioration of facilities, changes of groundwater quality, lack of treatment capacity and chemical injection management.

Through Vietnam Water and Sewerage Association, since 2013 NAGAOKA has introduced to Hanoi Water Limited Company CHEMILES technology that can simultaneously treat iron, manganese and ammonia nitrogen in groundwater by method to saturate dissolved oxygen without chemical injection. Consequently, NAGAOKA and Hanoi Water Limited Company had cooperated to implement a Pilot Study of CHEMILES at Tuong Mai water treatment plant from July 2014 to March 2015. The results of the Pilot Study have proved the high treatment efficiency of CHEMILES to remove high content rate of iron, ammonia nitrogen and manganese in Tuong Mai's groundwater source. Throughout the Pilot Study, both companies discussed the possibility of installing CHEMILES at full scale.

In April 2015, NAGAOKA submitted a project proposal to JICA for application of CHEMILES to improve water quality of Tuong Mai water treatment plant under the program "Verification Survey with the Private Sector for Disseminating Japanese technologies "and the proposal was then adopted by JICA in June 2015.

The MM for implementing the Survey was concluded in February 2016. The Survey has been implemented from March 2016 to June 2017.

2. OUTLINE OF THE PILOT SURVEY FOR DISSEMINATING SME'S TECHNOLOGIES

(1) Purpose

This survey aims to verify advantages and effectiveness of CHEMILES technology to contribute for improving water quality at Tuong Mai Water Treatment Plant and study the feasibility for apply this technology at Hanoi Water Limited Company's water treatment plant.

Also this survey aims to promote the result of newly implemented Hanoi Water Limited Company's water treatment plant with CHEMILES to other area. Especially, it will study the problems of the groundwater and studies the feasibility of applying CHEMILES technology to Ho Chi Minh City and its surrounding area.

Expected Outcomes

1) Effectiveness and advantages of CHEMILES technology for improving treatment water quality of Tuong Mai water treatment plant is confirmed.
2) Technologies of operation, monitoring, and maintenance of CHEMILES is transferred to Hanoi Water Limited Company and operation system for sustainable use of CHEMILES is established.
3) Dissemination plan in Hanoi and Hanoi Water Limited Company's introduction plan of CHEMILES is formulated.
4) Problems of the groundwater in Ho Chi Minh City and its surrounding area and demand for CHEMILES are clarified and dissemination plan to other area in Vietnam after this project is formulated.

(2) Activities

1) Install CHEMILES groundwater treatment system at Tuong Mai water treatment plant to improve water quality:

①In order to install a new groundwater treatment system that is suitable with current Tuong Mai water treatment plant, conducted initial site survey and meetings with Hanoi Water Limited Company to collect and analyze site data for system design.

②Designed and fabricated a CHEMILES groundwater treatment system that is suitable for Tuong Mai water treatment plant and installed at Tuong Mai water treatment plant.

③Monitored the quality of water treated by CHEMILES (Iron, Manganese and Ammonia Nitrogen) to prove that its quality satisfies Vietnamese and Japanese water quality regulation.

④Monitored blended water of CHEMILES treated water and current Tuong Mai's

treated water to confirm that the overall water quality of Tuong Mai water treatment plant is improved.

⑤Based on the monitoring results, adjusted system operation parameter.

⑥Monitored chemicals (e.g coagulant) and backwash frequency of Tuong Mai water treatment plant after the installation of CHEMILES.

⑦Based on the monitoring results, estimated running costs at Tuong Mai in the case of using CHEMILES.

⑧Summarized results of this survey to confirm the applicability and advantage of CHEMILES.

2) Establish an operation and management system for CHEMILES

① Conducted activities in Japan and visited current CHEMILES-adopted water treatment plant for Hanoi Water Limited Company's staff to understand site management process.

②Trained Hanoi Water Limited Company and Tuong Mai water treatment plant engineers on operating CHEMILES system, monitoring operational data, trouble shooting, maintenance method and procedures.

③Monitored the CHEMILES installed at Tuong Mai by using remote monitoring system and give technical advice if necessary.

④Developed an operation and maintenance manual for CHEMILES groundwater treatment systemlocal engineers can follow to sustainably operate the system.

⑤During the survey and based on collected results, conducted technical seminars with Hanoi Water Limited Company to evaluate and promote application of CHEMILES.

3) Propose a plan for developing CHEMILES's market in Vietnam

①During the Survey, collected information of Hanoi's future water demand, water treatment plant management, new water treatment plant construction, as well as groundwater usage prediction.

②Collected information and analyzed the data relating to country risk, financial risk, business risk, and risks on business expansion.

③Based on the above data and results of analysis, clarified the problems in developing market of CHEMILES in Hanoi.

④Promoted discussion with Hanoi Water Limited Company, Hanoi People's Committee and JICA for further potential application of CHEMILES.

⑤Based on the above data and results of analysis, formulated a business plan for developing market of CHEMILES in Hanoi.

⑥Together with the business plan proposal, promoted business with local partner companies and potential customers.

4) Clarify the problems of groundwater and demand for CHEMILES in other area of Vietnam

①Collected information of distribution and quality of groundwater in other area, especially in Ho Chi Minh City, clarified the problems and needs for groundwater usage in each area.

②Introduced CHEMILES and this project at Vietwater 2016, the largest water exhibition in Vietnam in November. At this event, researched the situation of water purifying technologies and its problems, and competitors' trends in Vietnam.

③During the Survey, collected information of Vietnam's future water demand, water treatment plant management, new water treatment plant construction plan, as well as groundwater usage prediction. Formulated a business plan for developing market of CHEMILES after this project in Vietnam.

(3) Information of Product/ Technology to be Provided

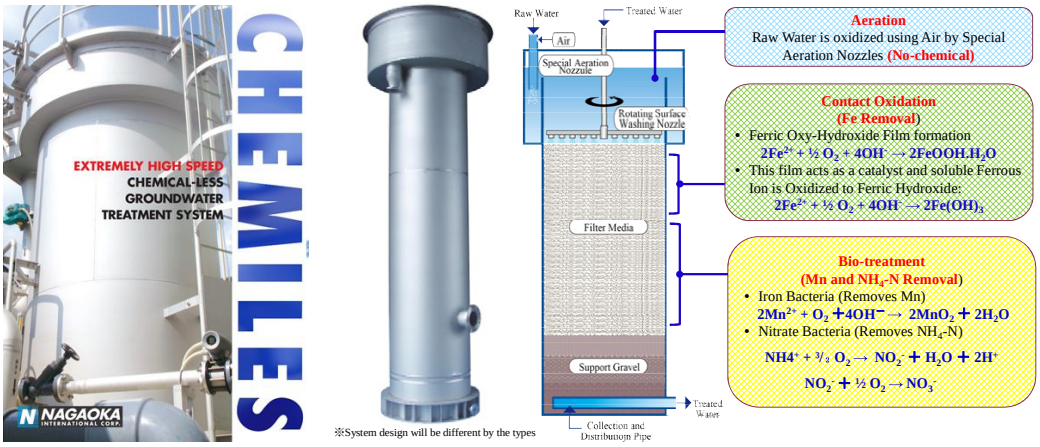
1) Technology name:

CHEMILES–Extremely high speed chemical-less groundwater treatment system

2) Introduction of technology:

The CHEMILES system is a self-contained, chemical-less system designed for treatment of groundwater, especially for Iron, Manganese, and Ammonia Nitrogen removal. The system is a column design, intended for outdoor placement. The treatment column contains a sand filter medium, with a support gravel layer at the base. CHEMILES uses no chemicals like Chlorine for oxidation, so not bothered by chemical management as well as Chlorination by-products and is friendly to health and environment.

Raw water is introduced into the top of the column through special oxidation nozzles. The oxidation nozzle increases the dissolved oxygen (DO) level of the raw water, causing soluble ferrous iron to oxidize to insoluble ferric iron. The sand filter media



becomes coated with ferric oxy-hydroxide, which acts as a catalyst to oxidize and retain a remaining portion of the iron. The bacteria on the filter medium oxidize any remaining ferrous iron to ferric iron, and they also oxidize ammonia to nitrate, and soluble manganese to insoluble manganese dioxide. The ferric iron and manganese dioxide are retained by the filter medium. Arsenic is removed by oxidation and co-precipitation with ferric during iron removal process.

There are two types of backwashes for the CHEMILES system – "P" Backwash and "W" Backwash. The P Backwash is Partial Backwash, and W Backwash is Whole-system Backwash. The P Backwash just backwashes the upper filtration zone, where most of iron precipitate is retained. The P Backwash utilizes NAGAOKA's rotating surface washing nozzles to assist in the backwash process. This approach minimizes disturbances of the biological-active lower treatment zone. The W Backwash is a general, intensive backwash. W Backwash is mainly aimed at entirely filter media washing and performed at a frequency that avoids damage to the bacteria accumulated in filter layer. After several times of P Backwash, there will be one time of W Backwash. Numbers of P Backwash is depended on raw water quality.

NAGAOKA's development of washing method allows to optimum treatment by contact oxidation and biological, an extremely high speed treatment with maximum linear velocity of 400 m/day (6.82gpm/ft2) is reached. In addition, energy and water consumption associated with filter backwashing are reduced.

(4) Counterpart Organization

Hanoi Water Limited Company (HAWACOM)

(5) Target Area and Beneficiaries

Tuong Mai Water Treatment Plant, Hanoi

(6) Duration

From March 2016 to June 2017

(7) Progress Schedule

Annex 2-2 Process Plan Chart

Item of Survey		2016										2017						
		3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7
①Selection of the project																		
−Contract/Preparation of Kick off	Plan																	
	Done																	
−Detail Project Scheme	Plan																	
	Done																	
−Kick off Meeting	Plan																	
	Done																	
②Chemiles Installation (Achievement No. 1)																		
−Site survey, Design meeting, Meeting with local construction company	Plan																	
	Done																	
−Deign, Fabrication, Transportation	Plan																	
	Done																	
−Intallation, Trial operation	Plan																	
	Done																	
−Water Analisis（Subcontracting）	Plan																	
	Done																	
−Water analysis/Data collecting	Plan																	
	Done																	
③Instruct Operation and Maintenance method（Acheivement No. 2）																		
−Preparation of Knwoledge co-creation program	Plan																	
	Done																	
− Knwoledge co-creation program	Plan																	
	Done																	
−Instruct operation method and daily inspection（Including Remote monitoring）	Plan																	
	Done																	
−Instruct maintenance method	Plan																	
	Done																	
−Preparation of Technical Exchange meeting	Plan																	
	Done																	
−Technical Exchange meeting	Plan																	
	Done																	
−Briefing Session for CP	Plan																	
	Done																	
④Business plan for developing market in Hanoi（Achevement No. 3）																		
−Forecast for chemiles demand	Plan																	
	Done																	
−Consideration of chemiles installation plan with CP	Plan																	
	Done																	
−Development of business expanssion plan and business policy	Plan																	
	Done																	
⑤Business plan for developing market in other area（Achevement No. 4）																		
−Forecast for chemiles demand	Plan																	
	Done																	
−Presentaion and research at Viet Water 2016	Plan																	
	Done																	
−Development of business expanssion plan and business policy	Plan																	
	Done																	
⑤Implementation of Middle and Final Progress Report																		
−Preparation of Progress Report	Plan																	
	Done																	
−Middle and Final Report	Plan																	
	Done																	

(8) Manning Schedule

No	Name	Role	所属		Term of contract 2016 2	3	4	5	6	7	8	9	10	11	12	2017 1	2	3	4	5	6	7	Working Days (Plan)	Working Days (Done)	Man Month Total	Man Month Total
Work in Vietnam	Katsuhiko YAMADA (Change to OIWA in March 2017)	Project Manager	NAGAOKA Inc.	Plan		(5.0days)													(5.0days)				10		0.33	
				Done		3/21~3/25 (5.0days)																		5		0.17
	Tadao OIWA	Technical Adviser	NAGAOKA Inc.	Plan		(4.0days)				(4.0days)			(5.0days)						(5.0days)				18		0.60	
				Done		3/22~3/26 (5.0days)			6/27~6/30 (4.0days)									(4.0days)	(3.0days)					16		0.53
	Kazuhisa ODA	Assistant Project Maneger	NAGAOKA Inc.	Plan										(5.0days)				(5.0days)					10		0.33	
				Done																				0		0.00
	Nguyen Thanh Trung	Local Coordinator, Interpreter	NAGAOKA Inc.	Plan		(5.0days)		(4.0days)	(30.0days)	(6.0days)		(4.0days)	(5.0days)	(12.0days)				(5.0days)	(12.0days)				83		2.77	
				Done		3/21~3/26 (6.0days)		5/16~5/21 (9.0days)	5/29~6/8, 6/27~7/2 (17.0days)	(3.0days)	7/31~8/7 (7.0days)	9/12~9/17 (6.0days)		11/7~11/19 (13.0days)	12/12~12/16 (5.0days)			(12.0days)	(12.0days)				90		3.00
	Katsutoshi OHASHI	Coordinator	NAGAOKA Inc.	Plan		(4.0days)				(4.0days)			(5.0days)	(5.0days)				(5.0days)	(5.0days)				28		0.93	
				Done		3/22~3/25 (4.0days)								11/8~11/17 (8.0days)	12/12~12/16 (5.0days)			(4.0days)	(4.0days)					25		0.83
	Kento NAKAMOTO	Design, Installation, Test Run and Training	NAGAOKA Inc.	Plan					(30.0days)					(5.0days)					(5.0days)				40		1.33	
				Done				5/16~5/21 (9.0days)	5/29~7/2 (30.0days)	(3.0days)	7/31~8/5 (5.0days)	9/14~9/17 (4.0days)		11/13~11/19 (7.0days)					(11.0days)				69		2.30
	Tadashi MORINAGA	Design, Production control	NAGAOKA Inc.	Plan		(4.0days)		(4.0days)															8		0.27	
				Done		3/22~3/26 (5.0days)					8/2~8/4 (3.0days)								(5.0days)				13		0.43
	Takashi SHIBUYA	Installation, Maintenance	NAGAOKA Inc.	Plan				(4.0days)	(30.0days)					(5.0days)					(5.0days)				44		1.47	
				Done				5/16~5/21 (6.0days)	6/8~6/16, 6/27~6/30 (13.0days)					11/13~11/19 (7.0days)									26		0.87
	Hayato SHIGENOBU	Analysis of Verification	NAGAOKA Inc.	Plan						(5.0days)		(4.0days)											9		0.30	
				Done																				0		0.00
	Hidetoshi NAKANO	Chief Adviser	Oriental Consultants CO.,LTD	Plan		(4.0days)				(4.0days)			(5.0days)					(5.0days)	(5.0days)				23		0.77	
				Done		3/22-3/25 (4.0days)					8/2~8/5 (4.0days)			11/8~11/12 (5.0days)				(6.0days)	(5.0days)				24		0.80
	Rie KAWABATA	Coordinator	Oriental Consultants CO.,LTD	Plan						(4.0days)			(5.0days)	(4.0days)				(5.0days)	(5.0days)				23		0.77	
				Done							8/2~8/5 (4.0days)			11/14~11/17 (4.0days)	12/12~12/16 (5.0days)			(5.0days)	(5.0days)				23		0.77
	Dang Nguyen Tuan	Local Coordinator, Interpreter	NAGAOKA Inc.	Plan																			0		0.00	
				Done					6/5~7/2 (26.0days)	(3.0days)	7/31~8/5 (4.0days)			11/12~11/19 (8.0days)									41		1.37

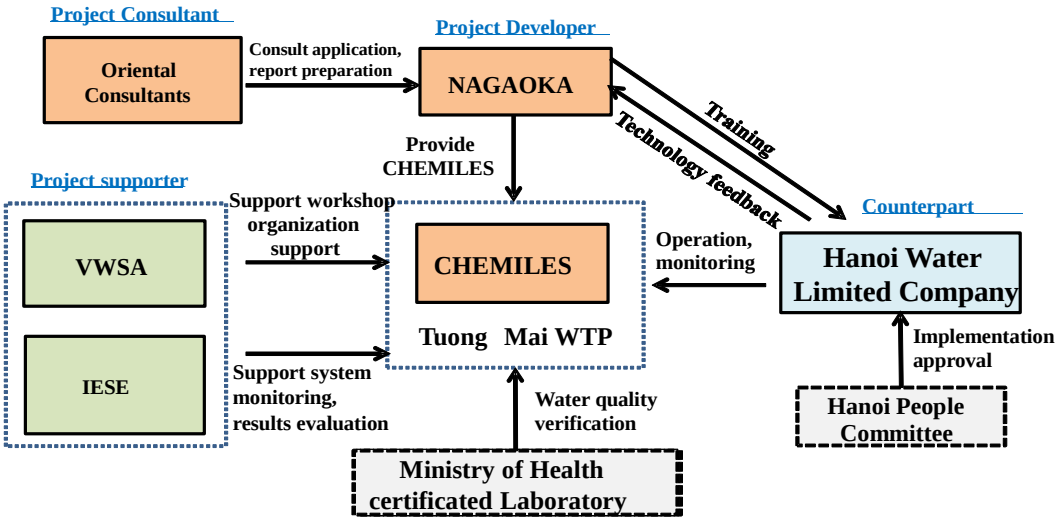
Work in Vietnam	Plan	250.00		8.33	
	Done		285.00		9.50
Consultants work in Vietnam	Plan	46.00		1.53	
	Done		47.00		1.57

Domestic Work	Katsuhiko YAMADA	Project Manager	NAGAOKA Inc.	Plan		(3.5days)		(0.5days)				(4.5days)			(0.5days)			(0.5days)	(3.0days)				12.5		0.63	
				Done		(3.5days)	(1.0days)	(0.5days)					(4.0days)	(0.5days)											9.5		0.48
	Tadao OIWA	Technical Adviser	NAGAOKA Inc.	Plan		(3.5days)		(0.5days)		(3.0days)		(3.5days)			(0.5days)			(0.5days)	(3.0days)				14.5		0.73	
				Done		(3.5days)	(1.0days)	(0.5days)		(1.0days)			(4.0days)	(0.5days)	(0.5days)			(0.5days)	(3.0days)					14.5		0.73
	Kazuhisa ODA	Assistant Project Maneger	NAGAOKA Inc.	Plan		(3.5days)		(0.5days)		(3.0days)		(4.5days)		(3.0days)	(0.5days)		(3.0days)	(0.5days)					18.5		0.93	
				Done		(3.5days)	(1.0days)	(0.5days)					(4.0days)	(3.0days)	(0.5days)		(3.0days)	(0.5days)						16		0.80
	Nguyen Thanh Trung	Local Coordinator, Interpreter	NAGAOKA Inc.	Plan		(5.5days)		(10.5days)		(5.0days)	(5.0days)	(9.5days)		(5.0days)	(0.5days)		(5.0days)	(0.5days)	(5.0days)				51.5		2.58	
				Done		(3.5days)	(3.0days)	(10.5days)		(5.0days)	(3.0days)		(4.0days)	(5.0days)	(0.5days)	(3.0days)	(2.0days)	(0.5days)	(5.0days)					45		2.25
	Katsutoshi OHASHI	Coordinator	NAGAOKA Inc.	Plan		(5.5days)		(0.5days)		(5.0days)	(5.0days)	(9.5days)		(5.0days)	(0.5days)		(5.0days)	(0.5days)	(5.0days)	(6.0days)	(4.0days)		51.5		2.58	
				Done		(5.5days)	(3.0days)	(0.5days)		(5.0days)	(3.0days)		(4.0days)	(5.0days)	(0.5days)	(3.0days)	(2.0days)	(0.5days)	(5.0days)	(6.0days)	(4.0days)			47		2.35
	Kento NAKAMOTO	Design, Installation, Test Run and Training	NAGAOKA Inc.	Plan		(0.5days)		(5.5days)				(0.5days)		(5.0days)	(0.5days)			(0.5days)	(5.0days)				17.5		0.88	
				Done		(0.5days)	(11.0days)	(5.5days)		(3.0days)	(3.0days)			(5.0days)	(0.5days)			(0.5days)	(5.0days)					34		1.70
	Tadashi MORINAGA	Design, Production control	NAGAOKA Inc.	Plan		(5.5days)		(5.5days)				(0.5days)			(0.5days)			(5.0days)					17		0.85	
				Done		(5.5days)	(9.0days)	(5.5days)		(3.0days)				(0.5days)	(0.5days)			(5.0days)	(5.0days)					34		1.70
	Takashi SHIBUYA	Installation, Maintenance	NAGAOKA Inc.	Plan		(0.5days)		(10.5days)		(5.0days)		(0.5days)			(0.5days)			(0.5days)	(5.0days)				22.5		1.13	
				Done		(0.5days)	(1.0days)	(10.5days)		(1.0days)				(0.5days)	(0.5days)			(0.5days)						14.5		0.73
	Hayato SHIGENOBU	Analysis of Verification	NAGAOKA Inc.	Plan		(0.5days)		(0.5days)		(5.0days)	(5.0days)	(0.5days)			(0.5days)			(0.5days)					12.5		0.63	
				Done		(0.5days)	(1.0days)	(0.5days)						(0.5days)	(0.5days)			(0.5days)						3.5		0.18
	Hidetoshi NAKANO	Chief Adviser	Oriental Consultants CO.,LTD	Plan		(4.5days)		(0.5days)		(4.0days)	(4.0days)	(4.5days)			(0.5days)		(8.0days)	(0.5days)	(5.0days)	(5.5days)	(5.0days)		41		2.05	
				Done		(4.5days)		(0.5days)		(5.0days)	(5.0days)		(2.0days)	(0.5days)	(0.5days)	(8.0days)		(0.5days)	(4.0days)	(5.5days)	(5.0days)			41		2.05
	Rie KAWABATA	Coordinator	Oriental Consultants CO.,LTD	Plan		(4.5days)		(0.5days)		(4.0days)	(4.0days)	(4.5days)			(0.5days)		(8.0days)	(0.5days)	(4.0days)	(5.5days)	(5.0days)		41		2.05	
				Done		(4.5days)		(0.5days)		(5.0days)	(5.0days)		(2.0days)	(0.5days)	(0.5days)	(8.0days)		(0.5days)	(4.0days)	(5.5days)	(5.0days)			41		2.05
	Dang Nguyen Tuan	Local Coordinator, Interpreter	NAGAOKA Inc.	Plan																			0		0.00	
				Done						(5.0days)	(2.0days)			(0.5days)	(0.5days)									8		0.40

Work in Vietnam	Plan	218.00		10.90	
	Done		226.00		11.30
Consultants work in Vietnam	Plan	82.00		4.10	
	Done		82.00		4.10

Total	**Plan**	468.00		19.23	
	Done		511.00		20.80
Consultants Total	**Plan**	128.00		5.63	
	Done		129.00		5.67

(9) Implementation System



Japan side

-NAGAOKA International Corporation: Proposal developer, project manager

-Oriental Consultants Co. Ltd: Project consultant

Vietnam side

- Hanoi Water Limited Company: Project Counterpart
- Hanoi People's Committee: Counterpart's Administration Organizer.
- Vietnam Water and Sewerage Association (VWSA): Project supporter
- Hanoi University of Civil Engineering, Institute of Environmental Science and Engineering (IESE): Project supporter

3. ACHIEVEMENT OF THE SURVEY

(1) Outputs and Outcomes of the Survey

1) Confirm the effectiveness and advantages of CHEMILES technology for improving treatment water quality of Tuong Mai water treatment plant.

This project was performed to install CHEMILES at Tuong Mai Water Treatment Plant and purify some of treated water to a level that satisfies Japan's water quality regulation, thereby contributing to the provision of safe tap water by Hanoi Water Limited Company.

3 CHEMILES treatment systems were installed at the plant on June 2016, and a completion ceremony was held in the presence of concerned parties on June 29, 2016.

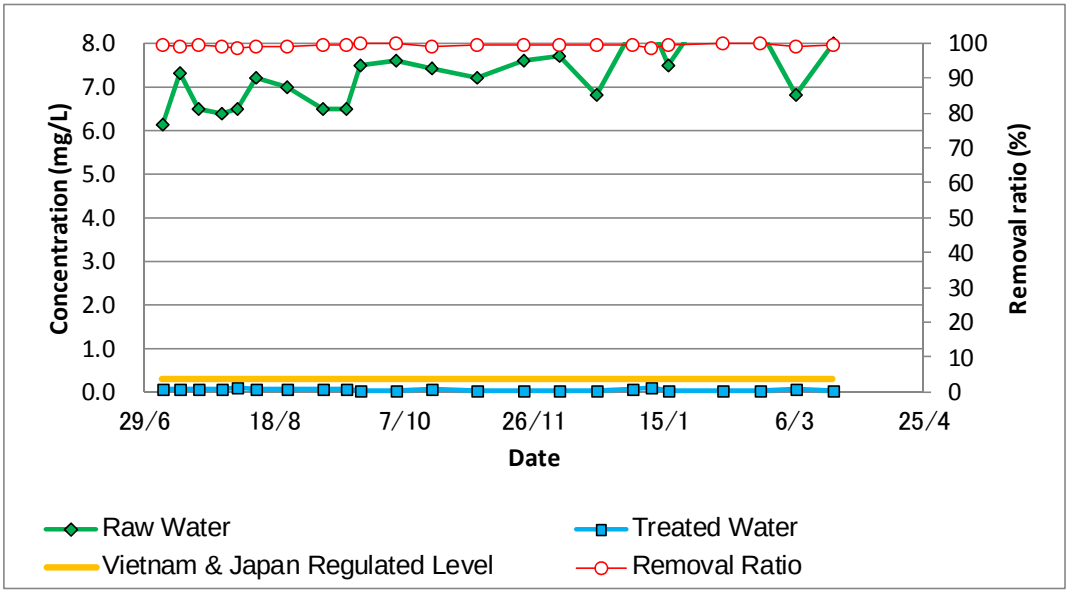
After the installation, the CHEMILES treatment systems were automatically and successfully operated to remove Iron, Manganese and Ammonia Nitrogen without using chemicals. After June 2016, function maintenance was conducted twice by Nagaoka, and once by the staff of Tuong Mai water treatment plant.

In order to verify the effectiveness of the CHEMILES technology, the water treated by CHEMILES was periodically monitored. A few days after the installation, iron was removed to the level that meets water quality target, and Ammonia Nitrogen was removed to the same level a week after the installation. Although it took time to grow microorganisms, Manganese was removed to the level that meets the water quality target of 0.05mg/L, Japan's water quality regulation, about 2.5 months after the installation. Furthermore, monitoring of Arsenic was started in September 2016. In the result, it was confirmed that the substance was removed to the level satisfying Japan's water quality regulation.

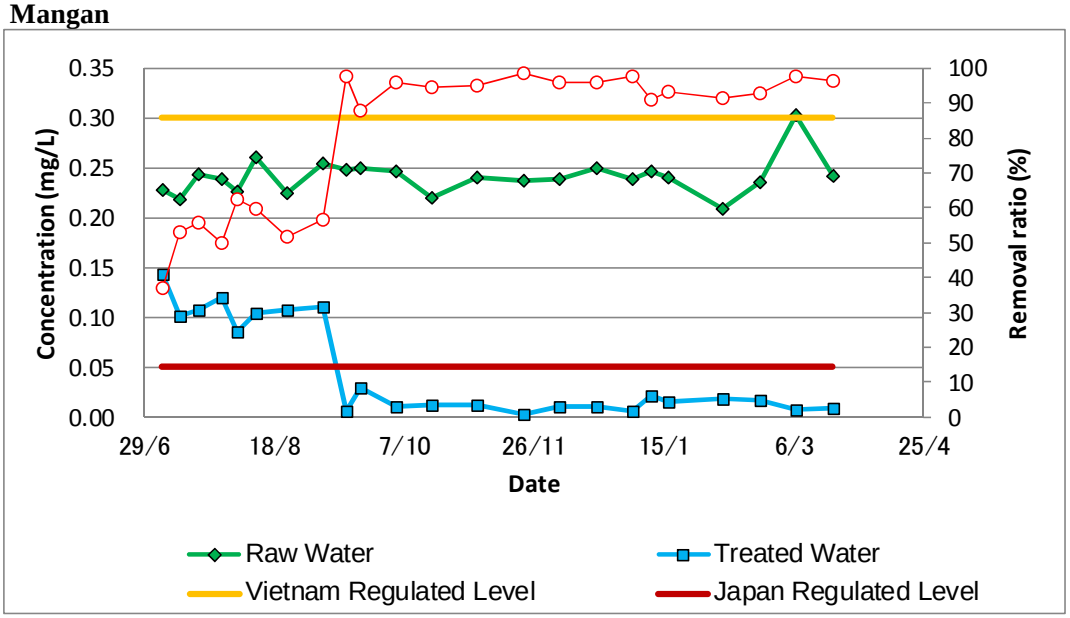
Figure 1 Results of water quality monitoring

(Iron, Manganese, Ammonia Nitrogen, and Arsenic)

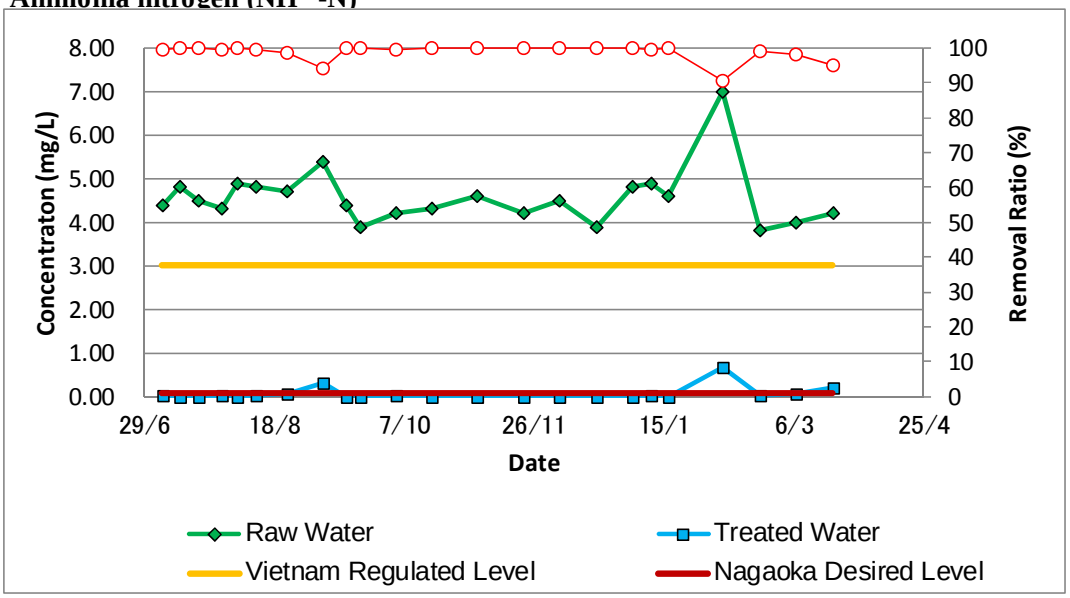
Total Iron



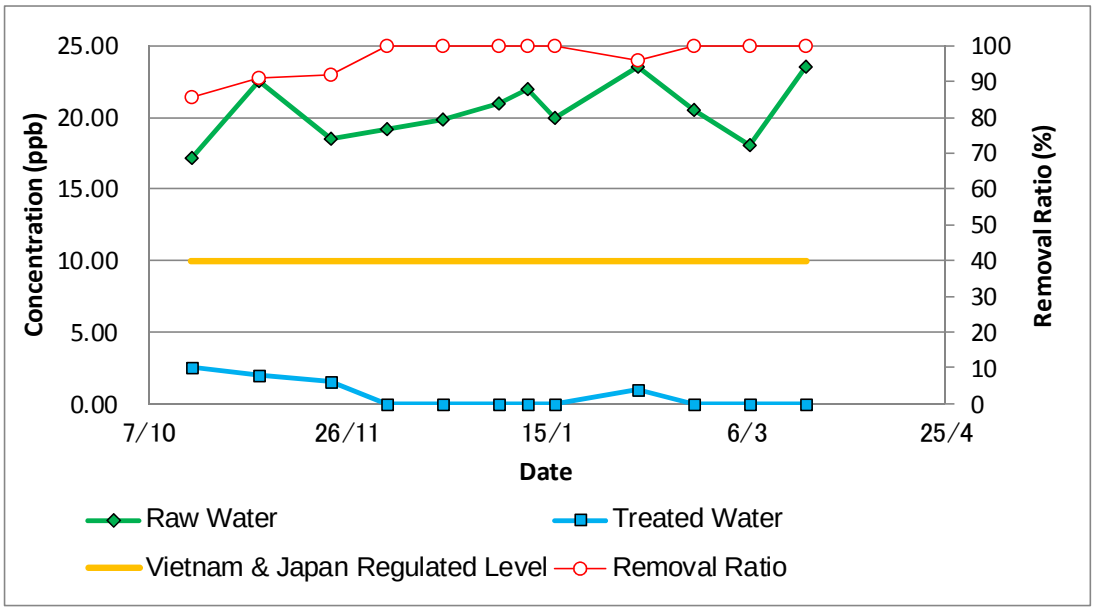
Mangan



Ammonia nitrogen (NH^{4+}-N)



Arsenic



[Source: Prepared by JICA Study Team]

Installed CHEMILES treatment systems are expected to reduce chemical or labor costs, backwash drainage volume, and maintenance outage periods. The initial cost of CHEMILES is seemingly expensive, but it was confirmed that the principal could be got back in a several years due to the reduction of the running cost and lower repair cost of CHEMILES.

As a result of this demonstration test, the usefulness and superiority of CHEMILES were confirmed, as shown below.

- In addition to Iron, Manganese and Ammonia Nitrogen, CHEMILESS can also treat Arsenic to the almost same level satisfying Japan's water quality regulation.
- Due to disuse of chemicals and automatic operation, CHEMILE requires fewer facility managers.
- CHEMILES has a higher electricity cost than the existing facility, but reduces chemical and labor costs.
- The area required to install the CHEMILES facility is small, and redundant space can be use for another purpose.
- CHEMILESS can significantly reduce the running cost, so the initial cost can be recovered in the short to medium term.
- The maintenance works of CHEMILES is very simple and does not require special vehicles or to replace filter media. Only 5,000,000 VND (equal to 25,000 JPY) is required for maintenance works (including labor cost, consumable…).

2) Transfer of the technologies of operation, monitoring, and maintenance of CHEMILES and operation system for sustainable use of CHEMILES

CHEMILESS will be transferred to HAWACOM when this project is completed. For that reason, we carried out the instruction of the maintenance to the plant staff of Tuong Mai water treatment plant so that the maintenance of CHEMILES can be done by themselves. The handbook of CHEMILESS was already translated into Vietnamese and submitted to HAWACOM.

On-the-job training of the CHEMILESS maintenance was implemented to the plant staff of Tuong Mai water treatment plant aiming for function maintenance in April.

Photo 1 Maintenance OJT

Photo 2 Nozzles washing

In addition, manager of Counterpart's technical department, water quality monitoring department, and Tuong Mai water treatment plant manager was invited to visit current operating CHEMILES system in Japan waterworks in October 2016. Through this visit, they were trained and introduced actual construction, operation and management of water treatment plant where CHEMILES was applied.

3) Dissemination plan in Hanoi and Hanoi Water Limited Company's introduction plan of CHEMILES is formulated.

According to Hanoi City's water supply master plan (to 2030 year), Tuong Mai water treatment plant capacity will be reduced to 6,500 m3/day. In addition, at the meeting with Hanoi City People Committee in March 21, 2017, Hanoi City announced that the City is aiming to increase water supply quality so that treated water can be directly drinkable. Therefore, in order to meet with master plan as well as demand of Hanoi City, NAGAOKA proposed an additional 4,000 m3/day CHEMILES system as following (refer to Figure 2)

[redacted]

(2) Self-reliant and Continual Activities to be Conducted by Counterpart Organization

The staff of Tuong Mai water treatment plant will now maintain the CHEMILESS treatment system. Based on the result of maintenance during the demonstration test period, it is recommended that function maintenance should be performed every 3 to 3.5 months.

The CHEMILESS systems is supposed to treat about 10 percentage of the total treatment volume of Tuong Mai water treatment plant, and the quality of final treated water after being mixed with water treated at the existing facilities was increased comparing to its quality before adopting CHEMILES. The Vietnamese government will now tighten its water quality regulation to meet with WHO standard (Ammonia Nitrogen 3.0 mg/L $\rightarrow$ 1.5 mg/L, etc.). Accordingly, efforts to satisfy the water quality regulation, such as addition of CHEMILESS treatment system, with the renewal of the facility, are required.

4. FUTURE PROSPECTS

(1) Impact and Effect on the Concerned Development Issues through Business Development of the Product/Technology in the Surveyed Country

In order to contribute to the solution of the issues around increasing water demand and water quality, the project focusing on the introduction of extremely high speed

chemical-less ground water treatment system "CHEMILESS" was carried out. The following table summarizes issues, solutions, and effects.

Table 4.1 Solutions for issues in Vietnam and effects of the solutions

Issues	Solutions	Effects
1. Imminent water demand	[1] Introduction and spread of CHEMILES • Reduction of backwash waste* volume (*drainage occurring when a filter is cleaned during maintenance) • Reduction of installation area by fast treatment	The capacity of water supply is increased with the following effects. • The rate of backwash drainage is reduced from 7% to 4%. ・At specified footprint, due to high filtration speed, larger treatment capacity system is possible. •
2. Issues concerning water quality	[1] Introduction and spread of CHEMILES • Increase of water purification capacity	The capacity of water purification is increased with the following effects. • The values for Iron, Manganese and Ammonia are reduced to NAGAOKA's target values (Japan standards). • CHEMILES treatment is done at some of existing facilities, which roughly satisfies Vietnamese water quality regulation values. • Arsenic that may cause health damage is removed.
3. Issues concerning operation and maintenance (O&M)	[2] Technology transfer for operation and maintenance (O&M) • System that facilitates maintenance • Proper facility operation [3] Activities for acceptance of Japan's practices • Make the Counterpart recognize the effectiveness of CHEMILES. • Make the Counterpart get more understanding of Japan's water supply management.	Operation and maintenance are improved with the following effects. • CHEMILES enables automatic operation, and accordingly reduces operation and maintenance costs. • CHEMILES is introduced as a renewal of the facility, thereby enabling the reduction of a water treatment plant site. • Due to disuse of chemicals, chemicals management is not required.
⇒ [4] Contribution to the basic policy for supporting Vietnam and Japan-Vietnam joint statement		

(2) Lessons Learned and Recommendation through the Survey

Even though the new large scale water treatment plants which are being developed in Hanoi area are going to use surface water as water resource, in order to secure safe and stable water supply, groundwater resource should be continuously utilized in an effective manner, since surface water resources in Hanoi contain high level of turbidity and are effected by up-stream river running through other countries. In order to

efficiently utilize groundwater resource, an effective groundwater treatment technology is required.

As mentioned above, other water treatment plants in Hanoi do not currently satisfy the water quality regulation. Emphasizing more water quality than water quantity, Hanoi People's Committee aims to accomplish the quality of water that can be drunk from a tap in two years. The Vietnamese government is scheduled to tighten its water quality regulation (Ammonia Nitrogen 3.0 mg/L $\rightarrow$ 1.5 mg/L, etc.). Accordingly, more efforts to improve water quality are required.

Arsenic was detected in ground water at Tuong Mai water treatment plant. Even past reports indicated that ground water around Hanoi contained arsenic. So, it is considered that ground water at other water treatment plants in the city probably contains the toxic substance. Due to that chronic intake of the substance may cause health damage, immediate countermeasures, such as introduction of CHEMILESS and other system that can remove arsenic, are needed.

ATTACHMENT: OUTLINE OF THE SURVEY

SOCIALIST REPUBLIC OF VIETNAM

Verification Survey with the Private Sector for Disseminating Japanese Technologies for "CHEMILES" Technology –Groundwater treatment system without chemical to improve water quality-

NAGAOKA International Corp., Osaka, Japan

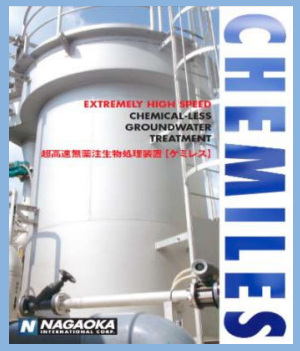
Concerned Development Issues in Vietnam

- Hanoi and surrounding cities are currently using groundwater as a main water supply source. However, groundwater contains high level of iron, manganese, ammonia nitrogen, therefore suitable groundwater treatment technology is necessary.
- In Hanoi, government decided to increase the usage of surface water, however new surface water treatment projects are being delayed. Therefore, it is necessary to use groundwater more effectively.

Implemented Activities in Survey

- Installation of CHEMILES at Tuong Mai water treatment plant, Hanoi Water Limited Company and collecting data to verify the performance and efficiency of CHEMILES.
- Inviting HAWACO staff to Japan to observe and understand CHEMILES operation and maintenance methods.
- Conducting technical meetings and workshops to PR CHEMILES technology.

Proposed Products/Technologies



Extremely High Speed Chemical-less Groundwater Treatment System " CHEMILES "

- Remove high concentration of iron, manganese, and ammonium nitrogen
- Environmental friendly system without using chemicals due to contact oxidation and biological treatment.
- No damage on biological treatment sand layer by WP washing and stabilizes the treatment system.

Survey Overview

Name of Counterpart:
Hanoi Water Limited Company
Survey Duration:
March, 2016~ July, 2017
Survey Area:
Tuong Mai Water Treatment Plant

Impact on the Concerned Development Issues in Vietnam

- Improvement of the water quality in Tuong Mai water treatment plant.
- Utilize the existing water resource and treatment plants, and also increase the treatment ability at the same time.
- By instructing the management method, it is possible to stabilize operation and maintenance in Vietnam water project.

Outputs and Outcomes of Survey

Current situation

- CHEMILES pilot testing in Tuong Mai: Waterworks and the performance confirmation have approved.

After the project

- Install CHEMILES to other treatment plants in Hanoi to improve the water quality.
- Expand market to Ho Chi Minh area and other rural areas in Vietnam.
- Based on the project in Vietnam, we will spread our business to Laos, Cambodia, and other nearby countries.