Viet Nam Academy for Water Resources

Summary Report

Socialist Republic of Viet Nam

The Pilot Survey for Disseminating Small and Medium Enterprises Technologies for Introduction of Improving Water Quality in Dam Reservoir

February, 2016

Japan International Cooperation Agency

Marsima Aqua System Corp.

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1.BACKGROUND

In Viet Nam, there had not been specific studies of water quality in the field of dams.Therefore, Marsima Aqua System Corp. conducted the Project Formulation Survey in 2013 to investigate the water quality of dams in Viet Nam.

As a result of the Survey, it was found that most of the dams in Viet Nam (in Viet Nam, there are 619 dams in 2013) had been constructed, and 13 dams each year have been constructed in recent years. In addition, the status of the deterioration of water quality in these dams were a serious issue for Viet Nam, and such a serious phenomenon have been caused by the lack of implementing environmental conservation for water quality since these dams have opened. In fact, when Marsima Aqua System Corp. investigated the impact of dysoxic environment in the water of Binh Dien Dam and Huong Dien Dam in Hue Province, it was found that increasing Fe and Mn content in waters in these dams caused serious pollution in the downstream river.

Marsima Aqua System Corp. reported the result of the Project Formulation Survey to the Ministry of Agriculture and Rural Development of Viet Nam. The Ministry informed that such a problem of water quality had been found in Thac Ba Dam (Yen Bai Province), Ha Dong Dam (Quang Ninh Province), and Xa Huong Dam (Vinh Phuc Province) as well.

According to the analysis in 2013, the 390 dams out of 651 dams, which have been completed or currently planned in Viet Nam, are likely to be affected by lack of oxygen in the water.

When Marsima Aqua System Corp. discussed with a person in charge of Viet Nam Academy for Water Resources (VAWR) supervised by the Ministry of Agriculture and Rural Development, Marsima Aqua System Corp. understood that VAWR was strongly concerned water quality issues caused by dam construction, and that they were also so interested in the Products and technologies proposed by Marsima Aqua System Corp. that they expected to become the counterpart for the Survey by JICA.

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

(1)Purpose

The purpose of the Survey is to improve water quality in a reservoir and in a river flowing from the reservoir by installing aeration made by Marsima Aqua system Corp., for realizing safe water supply, and Water supply business in downstream river

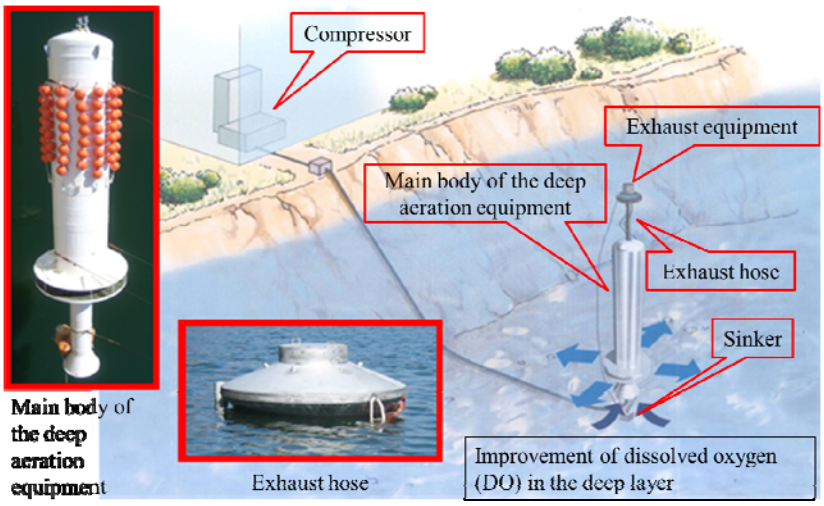
(2)Activities

The effect of the Products and Technologies with their effects have not been recognized in Viet Nam, therefore Marsima Aqua System Corp. carrid out investigations on the the current local situations in Viet Nam as the first step to

introduce the Products and Technologies. In this Survey, not only the installment of those Products, but also technological knowledge can be provided to Viet Nam through technical training in Japan, as well as sending engineers to explain operation and management of facilities and instruction of water environment conservation including assessment method and concept of environmental measures, and if possible, Japanese technologies can be transferred by public sector.

(3)Information of Product/ Technology to be Provided

The Products and Technologies have been used to improve dysoxic environment of stagnant water in the many dams in Japan. However, in Viet Nam, these Products and Technologies have not been introduced yet, therefore, it is considered that demonstration of the Products is necessary.

Name	Deep aeration equipment
Specification	Main body: Submerged double tube air lift type, standard total length of 16 m, φ 1.0 m (inner cylinder), φ 2.2 m (outer cylinder) Material: Fiber-reinforced plastic (FRP) Aeration tube: Circular diffuser, SUS304 Air supply hose: Synthetic rubber approx. 600 m Compressor: 11 kW × 1 
Dimensions	Total length: 16 m × φ 1.0 m (inner cylinder) × φ 2.2 m (outer cylinder)
Features	・ This equipment thoroughly and efficiently improves poor oxygenation in the deep layer of a dam reservoir. ・ The system is simple and the Japanese device specification can be applied to overseas sites without significant changes, resulting in

	less failures. ・ Since the main body is made of fiber-reinforced plastic (FRP) and lightweight, it can be installed easily and requires no maintenance. ・ This product is economical and has a good track record in Japan when compared to competitors' products.

(4)Counterpart Organization

Viet Nam Academy for Water Resources (VAWR)

(5)Target Area and Beneficiaries

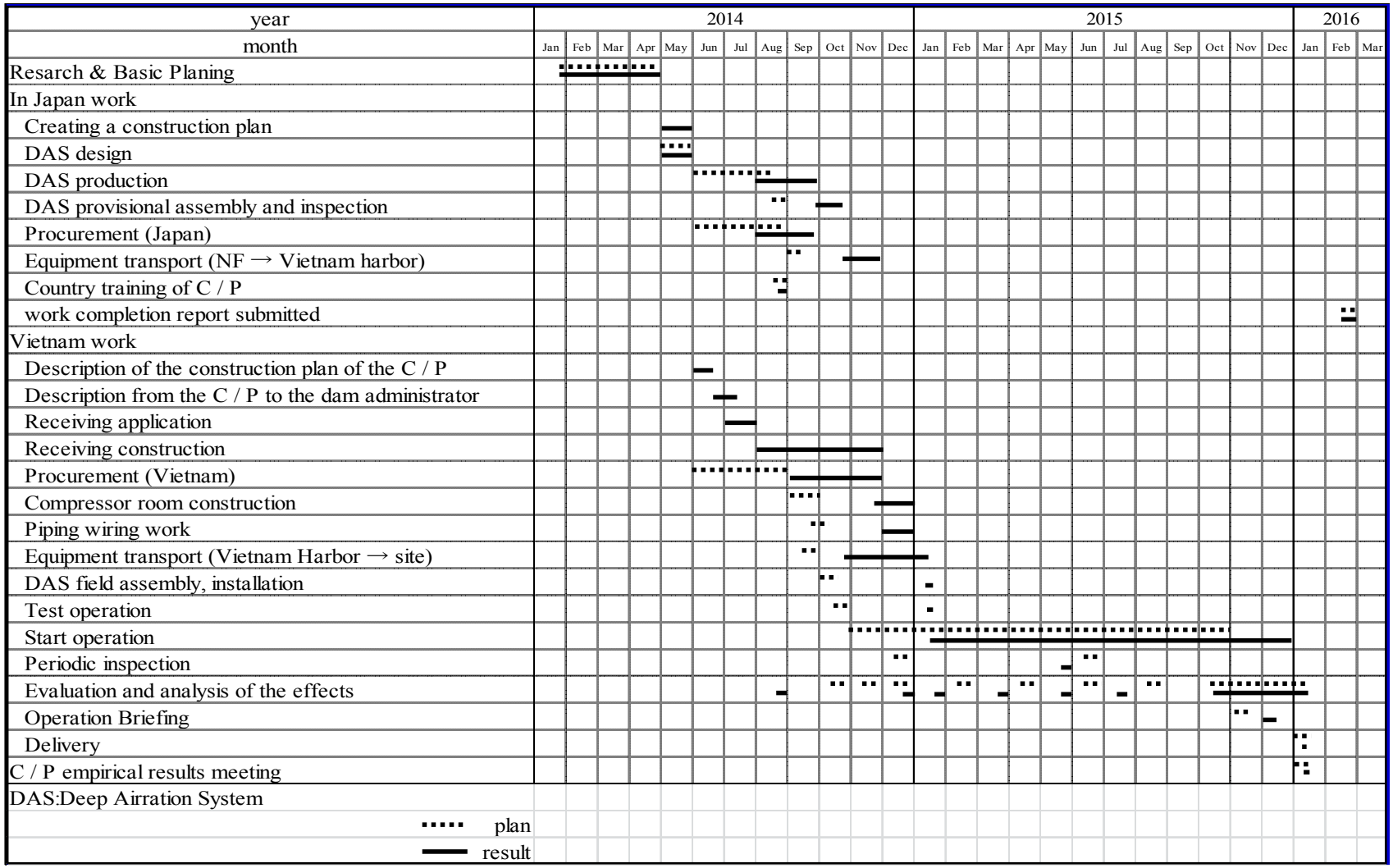
Target Area : Trongdam Hoa Binh Province, Socialist Republic of Viet Nam

Beneficiaries: Businesses of water supply

(6)Duration

From January 2014 to March 2016

(7)Progress Schedule

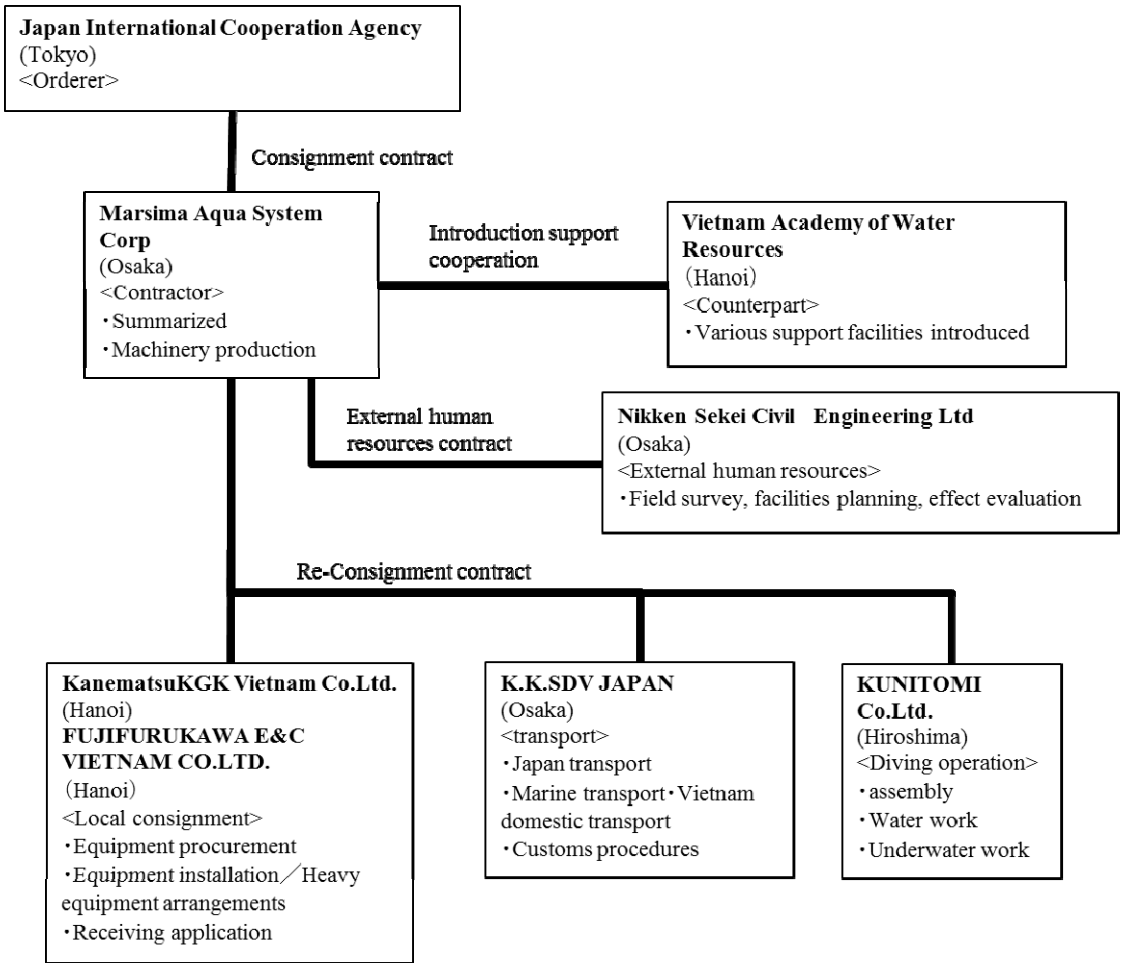


(8)Manning Schedule

Work	Name	Cooporation	plan/ result	year	2014												2015												2016			total	
				nant	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Japan	Field
Supervisor	Takaya Yanobu	MAS	plan			1 4 1		1	1	1	1	1	1	1 4 1		1										1	1	1 4	1 4 1		1	0.85	0.53
			result			1 5 1		1	1	1	1	2	1	1	1	1 4			1	1						1	1	1 5	1 5 1			0.95	0.63
Equipment design, installation and operation	Masataka Yamagishi	MAS	plan			3 4 1		1	1	1	1	3	1 4	1 4 1		1 3	1	1	1	1	1	1 3	1	1	1	2	2	2 4	1 4 1		1	1.65	0.87
			result			3 5 1		1 3	1	1	1	5	1	1	3	1 4	1 9	1	1	1	1 4	1	1	1	2 4	2	2 5	1 5 1			1.8	1.30
External negotiators	Hidetoshi Asoda	MAS	plan			1 4 1						3													1	1	1	1 4 1		1	0.55	0.27
			result			1 4 1						4.5						1							1	1	1		1	1	0.625	0.13
Installation and operation	Ryosuke Yonemitsu	MAS	plan									1	1 4	1 4																	0.15	0.27
			result									1	1	1			9														0.15	0.30
Chief Advisor	Akihiko Nonaka	NSC	plan			1 4 1		2 4 2						0.5 4 0.5		0.5 3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5 4	0.5 4			0.7	0.77
			result			1 4		0.5 6 0.5	1	1	2			0.5	0.5	1 4	0.5	0.5	0.5	0.5	0.5 5	0.5	0.5	0.5	0.5 4	1	0.5 5	0.5 1			0.75	0.97
Field surveys and field survey	Shinya Fukuju	NSC	plan			1 4 1 4		2	2					1 4 0.5	3	0.5	0.5	0.5	0.5	0.5	3	1	0.5	0.5	0.5	3	0.5	0.5	0.5	4	4			0.7	0.97
			result			1 5 1 5		1	1	0.5	1 2	2		1	0.5	1 5	0.5	2	0.5	0.5	4	0.5	1	5	0.5	0.5	4	0.5	0.5	1	0.5		2		0.85	1.13
Local and domestic operations coordinator	Hiroyuki Kumo	NSC	plan			0.5 4																							0.5 4			0.05	0.27
			result			0.5 5						3																0.5 0		5			0.20	0.33
Field survey and effect evaluation	Kenta Fujio	NSC	plan				1 4 1		1						1 3								3					1	1				0.3	0.33
			result				1	0.5	0.5																			1					0.15	0.00
Field survey and effect evaluation	Le Duc Tri	NSC	plan					2 4 2										1 3			1	1				1	1 3 1	1 4 1					0.6	0.47
			result				5	1 6 1		1.5	1 2	2			1			1			1 5	1				1	1 4 1	1 5		1			0.725	0.93
Orders companies		Man・Month (plan)				0.25 0.40 0.15		0.10	0.10	0.10	0.10	0.40	0.15 0.27	0.15 0.40	0.10	0.10 0.10	0.05	0.00 0.05	0.05	0.05	0.05	0.05 0.00	0.05	0.10	0.05	0.05	0.05	0.20	0.20	0.20 0.27	0.15 0.40	0.15	0.00 0.15	0.00	3.20	1.93
		Man・Month (results)				0.25 0.47 0.15		0.10	0.10 0.10	0.10	0.10	0.63	0.15	0.15	0.20	0.10	0.27	0.05	0.60	0.05	0.15	0.10	0.05	0.13	0.05	0.05	0.05	0.05	0.20	0.13	0.20	0.20	0.33	0.10	0.33	0.15	0.00	0.05	0.00	3.53	2.37
External human resources		Man・Month (plan)				0.13 0.40 0.15	0.27	0.35	0.27	0.35				0.08	0.27	0.10	0.20	0.05	0.10	0.05	0.00	0.10	0.10	0.05	0.05	0.10	0.13	0.00	0.10	0.10	0.05	0.00	0.05	0.10	0.10	0.10	0.10	0.15	0.13	0.40	0.10	0.40	0.00	0.00	0.00	0.00	2.35	2.80
		Man・Month (results)				0.13 0.47 0.10	0.33	0.15	0.40	0.15	0.15	0.15	0.13	0.45	0.08	0.10	0.10	0.30	0.05	0.07	0.10	0.05	0.13	0.05	0.13	0.50	0.10	0.05	0.13	0.05	0.10	0.10	0.27	0.20	0.13	0.33	0.03	0.30	0.00	0.00	0.00	0.00	2.68	3.37
The total of each month		Man・Month (plan)				0.38 0.80 0.30	0.27	0.45	0.27	0.45	0.10	0.10	0.15 0.27	0.23	0.67	0.20	0.20	0.15	0.20	0.10	0.00	0.15	0.10	0.10	0.10	0.10	0.18	0.00	0.15	0.20	0.10	0.00	0.10	0.10	0.15	0.30	0.10	0.35	0.33	0.67	0.25	0.80	0.15	0.00	0.15	0.00	5.55	4.73
		Man・Month (results)				0.38 0.93 0.25	0.33	0.25	0.50	0.25	0.25	1.08	0.15	0.23	0.30	0.20	0.57	0.10	0.67	0.15	0.20	0.13	0.15	0.18	0.63	0.15	0.10	0.13	0.10	0.15	0.30	0.40	0.40	0.33	0.67	0.13	0.63	0.15	0.00	0.05	0.00	6.20	5.73

MAS Marsima Aqua System Corp.
NSC Nikken Sekkei Civil Engineering Ltd.
Work in Japan
Field Work

(9)Implementation System



3.ACHIEVEMENT OF THE SURVEY

(1)Outputs and Outcomes of the Survey

Evaluation of the effects of introducing the aeration equipment

The Trong dam was selected as the test target site of the Survey, where issues due to poor oxygenation were confirmed by a detailed investigation. According to the investigation, more significant stratification was observed at a water depth of approximately 10–12 m. Because the entire dam reservoir does not circulate by itself, the oxygen at the bottom layer is gradually consumed by microorganisms. As a result, poor oxygenation develops near the bottom of the reservoir in the summer months.

In this Survey, the aeration equipment was introduced to the reservoir, and during a demonstration period of one year, water quality measurements were carried out every month to analyze trends in water quality. The following results were obtained.

- **Water quality improvement in the dam reservoir due to the deep aeration equipment**.

  Generally, it is said that an environment is not habitable for fish when the DO (dissolved oxygen) content drops lower than 2 mg/L. It can be assumed that there were no fish in the bottom layer of the Trong dam reservoir before installation of the deep aeration equipment. Although fish farming commenced at the Trong dam after the start of the demonstration, the reservoir was highly unsuitable for fish farming initially, considering the water quality of the Trong dam. However, the farming site had expanded every time Marsima Aqua System Corp. visited the site for operation and maintenance purposes. Therefore, it is thought that the water quality improved as a result of the introduction of deep aeration equipment and the environment subsequently became suitable for fish farming.

  Additionally, since there was no significant change in water depth, which maintained a constant level of approximately 22 m, it is inferred that the conditions were suitable for installation of the deep aeration equipment. Temporal changes in water temperature, DO, Fe, and Mn are shown in Figure 1. Measurements were taken at points near the dam body, the deepest point, and approximately 250 m and 1,100 m upstream of the dam body. Notably, introduction of the aeration equipment significantly affected DO, Fe, and Mn, details of which are described below.

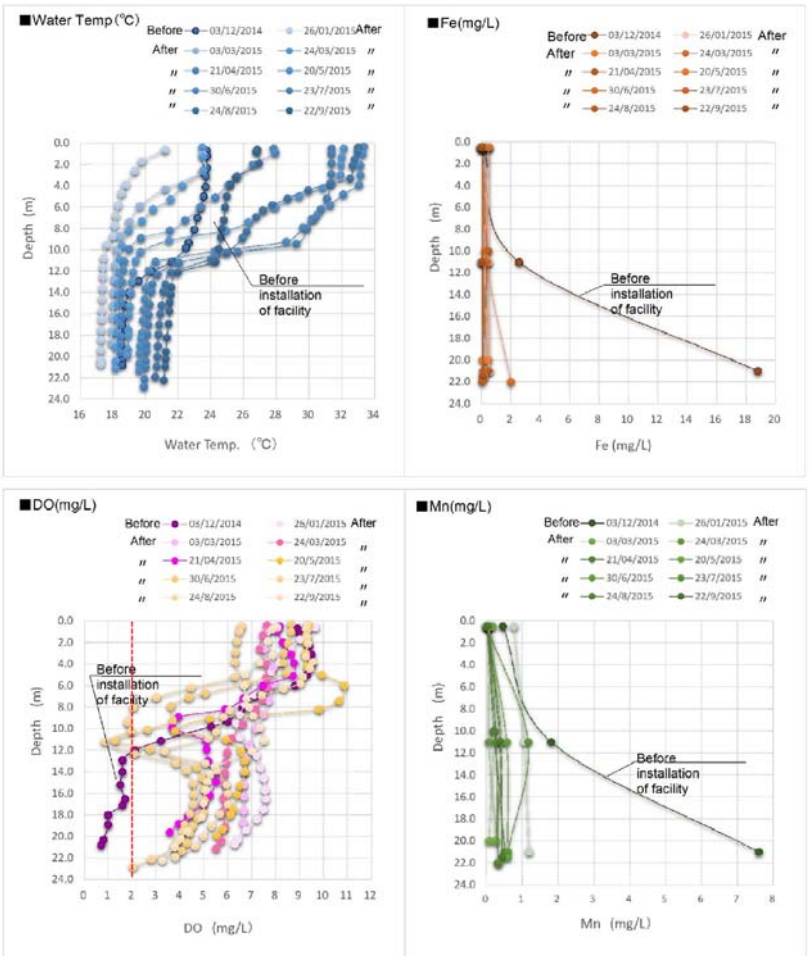


Figure 1. Temporal changes in water temperature, DO, Fe, and Mn in the Trong dam

【DO】

◆ Results

Timing	DO Concentration	Poor oxygenation
Before introduction (Dec. 3, 2014) Winter season	2.0 mg/L or lower (at a depth of 12 m or greater)	Obvious poor oxygenation up to 800 m upstream of the dam body
After introduction (Jan. 13, 2015) 13 days after operation	6.0 mg/L or higher (in all layers)	The area of poorly oxygenated water was eliminated instantly.

◆ Consideration

・Poor oxygenation in the bottom layer was improved by the deep aeration equipment.

・The effect of the deep aeration equipment greatly depends on the water temperature of the stratified layers. In the summer season, the water temperature of the deep layer exceeds

20 °C. As a result, the oxygen consumption rate in the dam reservoir becomes high and the effect of the deep aeration equipment does not effectively extend upstream.

・Concerning the basic design of the deep aeration equipment, the oxygen consumption rate in Viet Nam must be considered.

【Fe/Mn】

◆ Results

・Before introduction (Dec. 2014): high concentrations of Fe and Mn were confirmed in a wide area extending to the sluice opening.

・After introduction (Jan. 2015): after operation of the deep aeration equipment, areas with previously high concentrations of Fe and Mn showed improvement in both Fe and Mn concentrations to 1 mg/L or lower.

◆ Consideration

・By improving poor oxygenation in the bottom layer through operation of the deep aeration equipment, it is clear that the elution of Fe and Mn can be suppressed.

・If deep aeration equipment is not used, the dysoxic water might extend upstream of the intake opening and, as a result, water with high concentrations of Fe and Mn might be released further downstream. When a water purification plant exists downstream, the release of Fe and Mn-rich water will greatly impact on treatment processes at the plant.

➢ **Influence of the deep aeration equipment on water quality of the downstream river**

Daily variability in Fe, Mn, BOD, and COD at a point 500 m downstream of the Trong dam was recorded before and after operation of the deep aeration equipment, and the results are shown in Figure 2. Regarding Mn, BOD, and COD, significant changes were observed. It is suggested that poor oxygenation in the bottom layer was improved after operation of the deep aeration equipment and the amount of Fe released to the river was reduced. As for BOD and COD, it is thought that organic substances eluted from the bottom layer were degraded due to the activation of aerobic microbes in the dam reservoir as a result of newly aerobic conditions. Although the results obtained are promising, the data acquisition period is short. Therefore, it is important to continue the monitoring to see how long these trends continue.

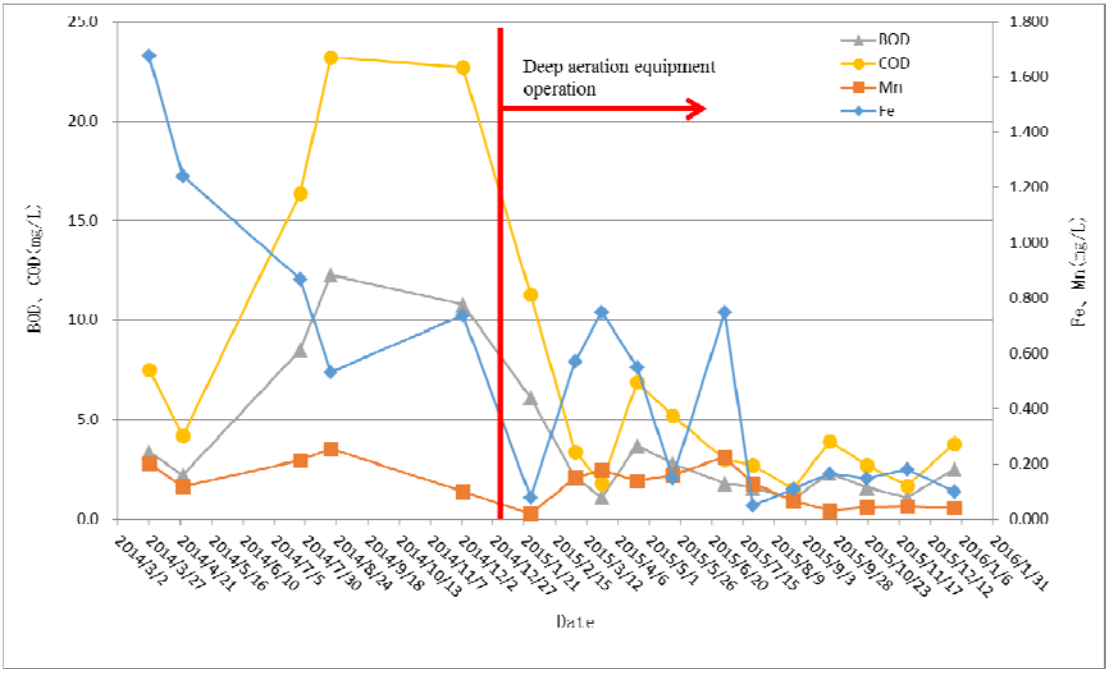


Figure 2. Results of the water quality survey from the river downstream of the Trong dam

In this Survey, it was verified that the poor oxygenation phenomenon of the Trong dam reservoir in Viet Nam can be improved by introduction of deep aeration equipment. Meanwhile, solutions are needed to overcome the problem of how to efficiently supply oxygen when water temperatures in the deep layer are constantly high, particularly in the summer season. For example, oxygen dissolution efficiency may be increased by further reducing the current size of the air discharge opening in the aeration equipment. In the future, when introducing the deep aeration equipment to other dam reservoirs, the water quality survey results of the Trong dam can be effectively used in the consideration of site-specific factors, such as the appropriate oxygen supply based on survey results of the water temperature, DO, etc.

- **Economic effect of introducing the deep aeration equipment**

Assuming that the water supply of a water purification plant for approximately 10,000 people is 3,000 m^3/day (clean water use per person: 0.3 m^3/day[1]), the initial running costs with and without introduction of the deep aeration equipment in the Trong dam are considered below.

When the deep aeration equipment is introduced, the Fe concentration at the intake

[1] This value is obtained by dividing the water supply capacity of the city of Hai Phong and the city of Da Nang, Ha Nam Province, from the report "FY 2009 Water Service International Contribution Promotion Survey" issued by the Health, Labour and Welfare Ministry, by the population supplied with the water.

opening of the water purification plant is 0.3 mg/L and the Mn concentration is 0.1 mg/L. However, when the equipment is not introduced, the Fe concentration at the intake opening of the water purification plant is 6 mg/L and the Mn concentration is 3 mg/L (It should be noted that the discharge opening of the Trong dam is approximately 14 m and the Fe and Mn values are from December 2014, or before the operation of the deep aeration equipment, and the average values after the operation).

Table 1. Comparison of water purification project costs with and without introduction of the deep aeration equipment

Item			With deep aeration equipment: 2 filtering ponds (3,000 m3/d)				Without deep aeration equipment: 6 filtering ponds (3,000 m3/d)			
Initial cost			Qty.	Unit	Unit price	Amount of money	Qty.	Unit	Unit price	Amount of money
Water purification plant facility		Receiving well	1	Pond	¥1,920,000	¥1,920,000	1	Pond	¥1,920,000	¥1,920,000
		Filter pond	2	Pond	¥8,160,000	¥16,320,000	6	Pond	¥8,160,000	¥48,960,000
		Water distribution pond	1	Pond	¥5,120,000	¥5,120,000	1	Pond	¥5,120,000	¥5,120,000
		Aggregating agent injection equipment	1	Set	¥1,200,000	¥1,200,000	3	Set	¥1,200,000	¥3,600,000
		Hypochlorous acid injection equipment	1	Set	¥800,000	¥800,000	2	Set	¥800,000	¥1,600,000
		Water pump	2	Unit	¥750,000	¥1,500,000	2	Unit	¥750,000	¥1,500,000
		Electric equipment	1	Set	¥4,000,000	¥4,000,000	1	Set	¥8,000,000	¥8,000,000
		Facility construction cost	1	Set	¥6,000,000	¥6,000,000	1	Set	¥12,000,000	¥12,000,000
		Dewatering equipment					1	Set	¥25,000,000	¥25,000,000
Water source facilities		Deep aeration equipment	1	Unit	¥38,000,000	¥38,000,000				
		Scuttled hose	600	m	¥2,800	¥1,680,000				
		Compressor	1	Unit	¥1,500,000	¥1,500,000				
		Control panel etc.	1	Set	¥2,000,000	¥2,000,000				
		Installation work cost	1	Set	¥8,000,000	¥8,000,000				
Facility total						¥88,040,000				¥107,700,000
Depreciation			15	Year		¥5,869,333.33	15	Year		¥7,180,000
Running cost										
Electric power	Capacity	Aggregating agent injection equipment	1.0	kW			3.0	kW		
		Hypochlorous acid injection equipment	1.0	kW			2.0	kW		
		Water pump	7.5	kW			7.5	kW		
		Dewatering equipment					7.5	kW		
		Compressor	11	kW						
	Operating time	Aggregating agent injection equipment	12.0	hr			12.0	hr		
		Hypochlorous acid injection equipment	12.0	hr			12.0	hr		
		Water pump	12.0	hr			12.0	hr		
		Dewatering equipment					1	hr		
		Compressor	18	hr						
	Power price	Aggregating agent injection equipment	12	KW・hr	¥9.2	¥110	36	KW・hr	¥9.2	¥331
		Hypochlorous acid injection equipment	12	KW・hr	¥9.2	¥110	24	KW・hr	¥9.2	¥221
		Water pump	90	KW・hr	¥9.2	¥828	90	KW・hr	¥9.2	¥828
		Dewatering equipment					7.5	KW・hr	¥9.2	¥69
		Compressor	198	KW・hr	¥9.2	¥1,822				
	Electric power total		1	d		¥2,870	1	d		¥1,449
Chemical	Injection amount	12% hypochlorous acid	1.4	ml/min			8.7	ml/min		
			2.1	L/d	¥100	208	12.5	L/d	¥100	¥1,250
		PAC	0.1	mg/L			5.0	mg/L		
			0.3	kg/d	¥100	¥30	15	kg/d	¥100	¥1,500
	Chemical total		1	d		¥238	1	d		¥2,750
Sludge disposal	Amount of sludge occurred (0% water content)						40.8	kg-DS/d		
	Sludge disposal cost (85% water content)						272	L/d	¥20	¥5,440
Operation and Maintenance total cost	Per day					¥3,109				¥9,639
	Per month					¥93,262				¥289,170
	Per year					¥1,134,688				¥3,518,235
Total cost		Amount per year (Yen)				¥7,004,021				¥10,698,235
		Amount per year (USD)				USD58,986				USD90,098
		Amount per year (VND)				VND1,297,040,926				VND1,981,154,630
Water charge per 1 m^3	Yen					¥6.40				¥9.77
	USD					USD0.054				USD0.082
	VND					VND1,185				VND1,809

∗ February, 2016 JICA rate USD1=VND21,989

The conditions for the trial calculation, in the case where a water purification plant is introduced downstream of the Trong dam, are as follows:

- The plant is an aggregating agent addition type precipitation and filtering system, which is generally adopted in Viet Nam.
- The filter pond, receiving well and water distribution pond, are made of concrete.
- The prices of the machinery and equipment are equal to those of our company.
- The depreciation period of the equipment is 15 years.
- The electricity cost for the trial calculation is 0.076 USD/kw-h (according to a report by the Japan External Trade Organization (JETRO), Mar 13, 2015).
- The chemical cost for the trial calculation is the unit price obtained from the hearing investigation.
- Both the land rent and labor cost for maintenance and operation are omitted.

According to the trial calculation, the comparison of the annual operation and maintenance costs is as shown in Figure 3

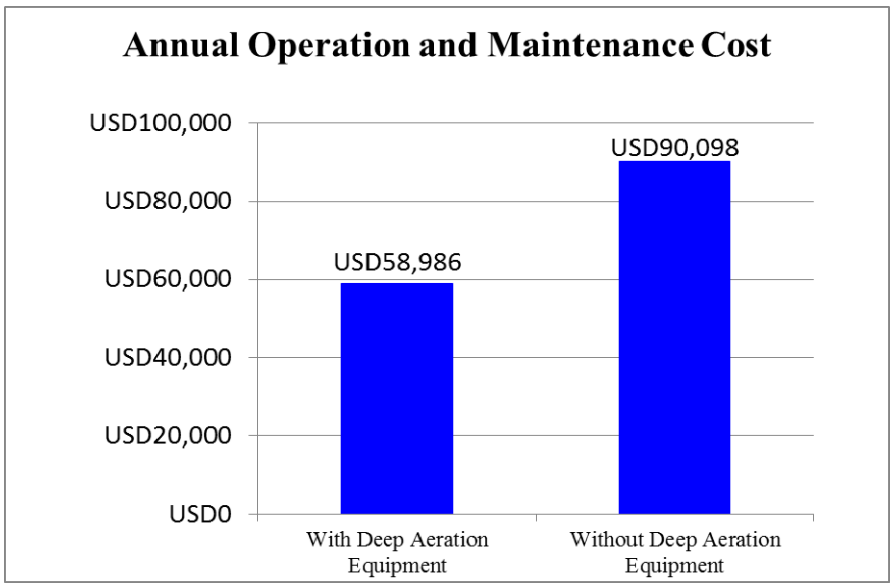


Figure 3. Cost comparison of water purification plants
with and without introduction of the deep aeration equipment

As shown in Figure 3, the cost of water purification, including the annual operation and maintenance costs and the depreciation of construction costs, is 58,986 USD when the deep aeration equipment is introduced and 90,098 USD when the equipment is not introduced. The difference is 31,111 USD, approximately 1.52 times greater. Therefore, it is expected that the savings will easily exceed the cost of the water supply project. In

this case, the result of the trial calculation is that for the Trong dam, a comparatively small dam, however, it is expected that the water service price will be higher for a larger dam.

Then, it is considerd the cost recovery for the case when a water purification plant is constructed and the deep aeration equipment introduced using ODA Loans assistance. Note that the underlying values are as follows:

- Construction debt loan: 1,750,211 USD (according to the facility cost in Table 1)
- Interest rate: 2 %
- Operation and maintenance costs (chemical and electricity): 9,557 USD/year (according to total operation and maintenance costs)
- Operation and maintenance costs (labor): 12,296 USD/year (trial calculation of 8.42 USE/person × 4 persons)
- Water supply: 3,000 m^3/day
- Water supply rate: 0.143 USD/m^3

The breakdown of the debt loan is based on the trial calculation described above. The number of pieces of deep aeration equipment is one.

Chemical costs and electricity costs are also based on the trial calculation described above

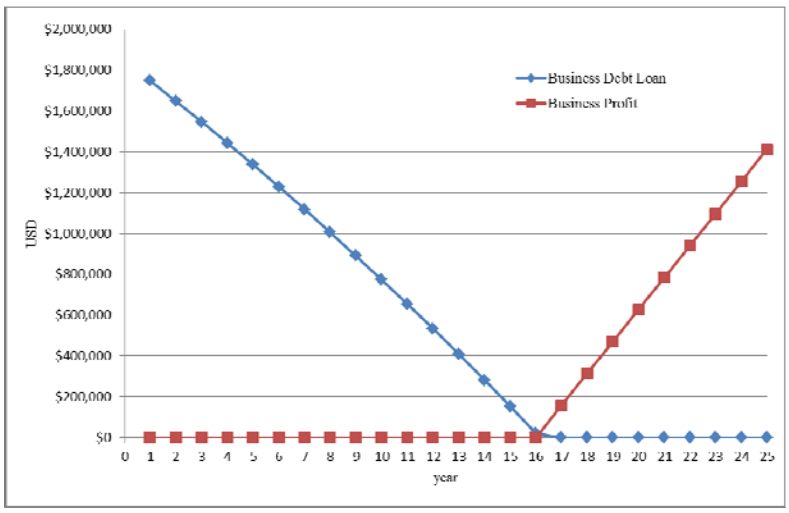


Figure 4. Transition of business profit for a water purification plant

Chemical costs, electricity costs, and labor costs are subtracted from the water charge and the remaining amount is applied to the repayment of the loan borrowed for the construction. Note that the interest rate is assumed to be 2%. Additionally, the operation and maintenance of the water purification plant shall be performed by four people. A daily allowance of 8.42 USD/day/person shall be paid, which is average for Viet Namese workers. The result of the trial calculation is shown in Figure 4. The horizontal axis of Figure 4 represents years and the vertical axis represents the total accumulated money. The calculation method assumes that labor costs, chemical costs, and

electricity costs required for maintenance and operation are subtracted from the water charge collected by the water company, and the remaining money is applied to the repayment of the loan from the time of construction. Therefore, by covering the costs required for maintenance and operation with the water charge and by applying the remaining money to the repayment of the loan, ODA Loans can be repaid in approximately 16 years and a profit will occur thereafter.

In this way, even for a water purification plant where the deep aeration equipment is introduced using loan assistance, the loan can be repaid solely by collection of the water charge and the business can be operated continuously. Note that the number of years for repayment will be reduced further by reducing the price of the deep aeration equipment.

Secondly, we consider the cost advantage of introducing deep aeration equipment. The trial calculation is the same as described above and the result of the trial calculation is shown below and in Figure 5. When introducing the deep aeration equipment to a water purification plant with a water purification amount of 1,000 m³ or lower, as shown in Figure 5, it is disadvantageous because the unit cost per 1 m³ becomes comparatively high. However, for a water purification plant with a water purification amount of 1,000 m³ or higher, it is expected that introduction of the deep aeration equipment will be advantageous in terms of cost.

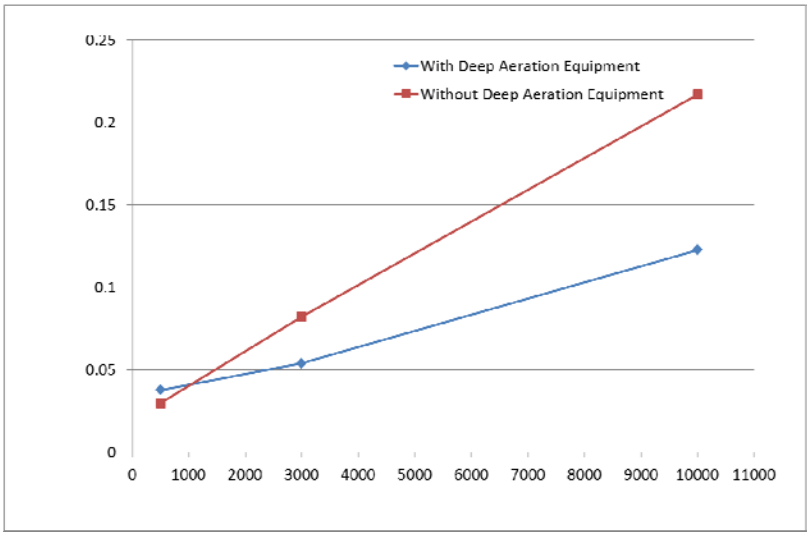


Figure 5. Cost per m^3 of introducing deep aeration equipment against water purification amount

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

It is considered that the experiment at the Trong dam was completed successfully, and the effectiveness of the Product and Technology was verified by the Survey. The same understanding was obtained from C/P also.

Additionally, it was proposed that, in order to disseminate the deep aeration equipment throughout Viet Nam in the future, it would be necessary to first install and operate the

Product in areas intending to introduce it and then prove its effectiveness.

Thus the C/P suggested that the possibility of a concrete business development will be increased if the dam administrators of Ha Tinh Province understand the effect of the deep aeration equipment. This can be achieved by relocating the equipment at the Trong dam to a reservoir in the province that exhibits very poor oxygenation.

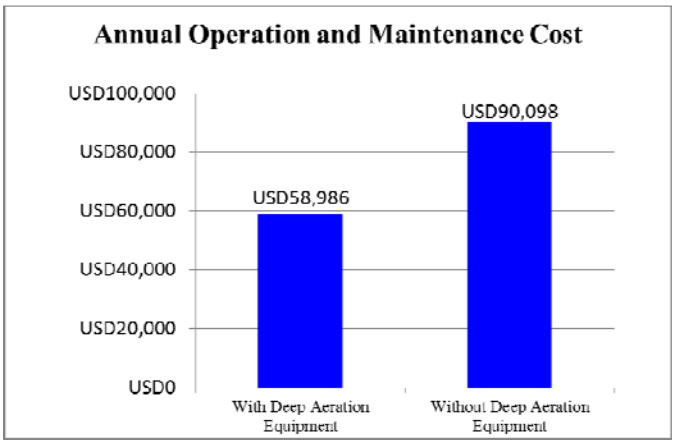
Thus, Marsima Aqua System Corp. visited Ha Tinh Province on December 4, 2015 to hold talks with the governor and the deputy governor of the province. It is confirmed approval of the relocation of deep aeration equipment and that the costs related to the relocation shall be paid by the province.

From now on, the demonstration will be completed after successfully relocating the equipment to Ha Tinh Province and then dissemination of the equipment within the province will be endeavored. Technical advices for this shall be given by VAWR, Nikken Sekkei Civil, and Marsima Aqua System Corp.

4.FUTURE PROSPECTS

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

Through the Survey at the Trong dam, it was demonstrated that DO could be maintained at 2 mg/L or higher throughout the year in a poorly oxygenated reservoir with original DO values of 0 mg/L. As a result, it was confirmed that the concentration of Fe and Mn could be reduced. Based on this, it is showed that, when a water purification plant is installed downstream of the Trong dam reservoir, the cost of the water purification plant can be reduced by 40% by operating the deep aeration equipment, the effectiveness of which was evident to the C/P. These results are not limited to the Trong dam reservoir and can be obtained at dam reservoirs all over Viet Nam where the bottom layer of the water supply source shows poor oxygenation. In other words, introduction of the deep aeration equipment is expected to contribute to the supply of safe and stable purified water in Viet Nam.



Cost comparison of water purification plants with and without introduction of the deep aeration equipment

Additionally, when surveying the various water purification plants, it was found that the performance of plants using a dam reservoir with poor oxygenation was hampered by high concentrations of Fe and Mn and the plants could only distribute amounts of water below that of the planned water supply. It is confirmed, therefore, that the situation was more serious than expected. The deep aeration equipment can therefore be a powerful solution to this problem.

Furthermore, it was confirmed that there are many very shallow dam reservoirs in Viet Nam, with a depth of only approximately 10 m. For these shallow dam reservoirs, it is thought that water quality can be improved using equipment other than the deep aeration equipment. In these reservoirs, water quality disorders occur mainly due to the existence of blue-green algae. For water purification plants using this type of reservoir as a water source, they are expected to require significantly increased injections of aggregating agent. Therefore, similar to the water source with poor oxygenation, it is possible to reduce the amount of aggregating agent used at the water purification plant and stabilize both the water purification operation and the water supply by introducing water quality conservation equipment to these shallow dam reservoirs

Water Purification Plant in Viet Nam
(Khe Doc Water Purification Plant)

(2)Lessons Learned and Recommendation through the Survey

◆ Fundamental groundwork related to introduction of the equipment

In the Project Formulation Survey conducted by Marsima Aqua System Corp. in 2013, on dam specification in Viet Nam, some problems existed that were not identified by the desk research, such as road access and the installation location of the compressor, and were only found when checking the actual situation at the site in this Survey. Therefore, it is important to complete necessary groundwork before conducting a project.

◆ Improvement of the water environment in Viet Nam

It was confirmed that, from a technical point of view, the Products can also perform well in Viet Nam and improvement of the water source quality leads to reduction of costs and a stable water supply. In the future, it is recommendable that the government of Viet Nam will consider revising the existing laws and regulations in order to promote the introduction of water quality improvement equipment.

ATTACHMENT: OUTLINE OF THE SURVEY