State Ground & Surface Water Resources Data Centre

Water Resources Department

PWD, Government of Tamilnadu

Summary Report

India

Verification Survey with the Private Sector for Disseminating Japanese Technologies for Gap Resolution of Water Demand/Supply by Plastic Underground Rainwater Storage System

April, 2019

Japan International Cooperation Agency

Totetsu Mfg. Co., Ltd.

1. BACKGROUND

In India, the water supply-demand gap is expanding due to changes in socio-economic environment such as population growth and economic development, and the effects of climate change. For example, problems such as no water supply system, and, even if supply system exists, insufficiency of water quality and quantity, less supplying time are common sense in India. Therefore, securing stable water resources is an urgent and important issue.

As one of the water resource development for the gap resolution of water demand/supply, the rainwater harvesting (RWH) is much effective way because the rainwater with few impurities can be purified by a low cost and a simple treatment compared with groundwater, seawater and treated wastewater.

However, in India, almost 80% of the rain is concentrated in the monsoon season, so direct use of rainwater throughout the year effectively is generally considered to be difficult. As the result, RWH in India is much promoted in the field of groundwater recharge rather than the direct utilization of rainwater.

Table 1 shows the water balance of the whole of India. It is found out that the water demand manages to be covered by the stored surface water and groundwater somehow. In addition, the amount of evaporation loss and domestic water are found to be same in the water demand as shown in Table 1. Therefore, the necessity of underground storage is strongly required to avoid the evaporation loss.

Table 1 Water Balance of the whole of India

Annual Water Budget in India		Volume (BCM)	Ratio	As Rainfall (mm)
Total Rainfall		3694.5	1.00	1119.7
Water Resources Potential as natural run off in the rivers		1869	0.51	568.6
Utilizable Surface Water		690	0.19	209.9
Surface Storage Capacity including under construction		304	0.08	92.6
Total annual replenishable ground water potential		431	0.12	131.1
Projected Water Demand in 2010		694	0.19 (1.0)	211.1
Population 1,162.31 million	Irrigation	543	(0.78)	165.2
	Domestic	42	(0.06)	12.8
	Industries	37	(0.05)	11.3
	Evaporation losses	42	(0.06)	12.8
	Others	30	(0.04)	9.1

Water and Related Statistics 2013: Water Resources Information System Directorate, Information System Organization Water Planning & Projects Wing, Central Water Commission, India

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

(1) Purpose

In order to contribute the gap resolution of water demand/supply by utilization of rainwater, the usefulness and superiority of the universal rainwater underground storage system (UN system) is to be demonstrated and the dissemination methods of UN system and its challenges is also to be studied.

(2) Activities

1) Demonstrate that UN system for rainwater storage functions properly under the local condition and exerts usefulness.

i) Determination for the detailed specifications of UN system by pre-survey

ii) Construction planning

iii) Procurement of material, construction of UN System and leakage test

iv) Monitoring and evaluation for the operation status of the UN system

v) Preparation of maintenance manual and implementation of C/P training

vi) Establishment of UN system operation system of C/P

2) Demonstration of superiority of rainwater direct utilization through UN system

i) Planning of water supply for domestic water (including drinking water) by rainwater

ii) Installation of Water Purification Plant

iii) Supply of rainwater stored in UN Tank for the domestic water and the purified rainwater for the drinking water

iv)Verification of superiority of Rainwater Harvesting System through UN system

3) Promotion of understanding of C/P etc. regarding direct utilization of rainwater by UN system

i) Analysis on the issues concerning the spread of rainwater utilization and examination on the future directionality

ii) Provision of Guidelines (Draft) for Rainwater Harvesting Facilities using UN Tank

iii)Conduct of technical seminar

4) Creation and proposal of water supply business model by UN system

i) Examination of the possibility of collaboration with local companies

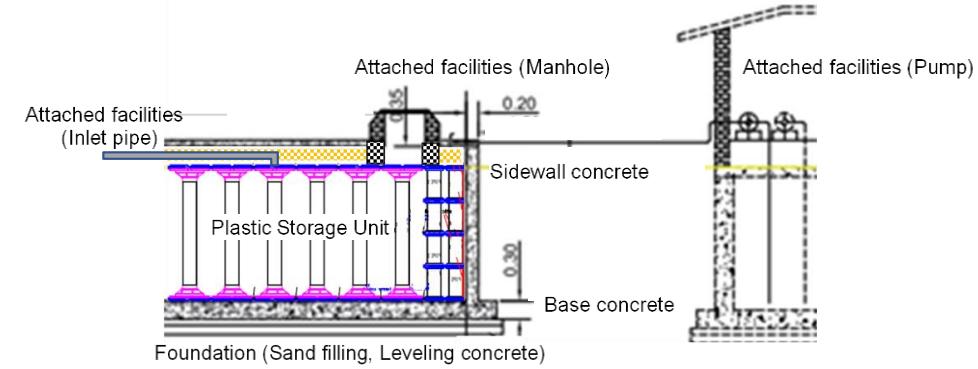
ii) Proposal of rainwater resource conversion and water supply program for government and private sector

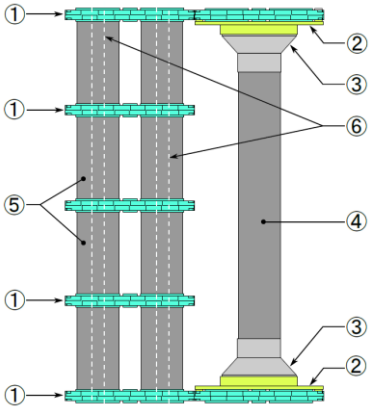
(3) Information of Product/ Technology to be Provided

Totetsu Mfg. Co Ltd developed the universal rainwater underground storage system (UN system). UN system is the company's one-of-a-kind technology with following

characteristics: 1) Large-scale and long-term rainwater storage, 2) effective utilization of underground space and 3) high possibility of cost reduction. The rainwater storage structure is made of combination of plastic parts and vinyl chloride pipes.

UN system consists of Plastic Storage Unit (Aqua Palace), Frame Concrete (base, sidewall, slab), Foundation and Attached facilities.





① Partition plate (made of polypropylene)
② Attachment (made of polypropylene)
③ AD spacer (made of polypropylene)
④ Main SP pipe
⑤ Auxiliary SP pipe
⑥ Inner axis pipe (All pipes are made of vinyl chloride)
⑦ Joint piece (connects a plurality of Partition plates to each other)

Figure 1 Basic configuration of UN system

Table 2 Scope of Application judging from installation condition of UN system

	Installation Condition of Plastic Storage Unit	Installation Site
Scope of Application	◇ Flat Installation ◇ Thickness of Soil cover : 0.5～2 m ◇ Height of Storage Tank : Max. 4 m ◇ Length of Storage Tank : Max. 20 m ◇ Long-term durability : 50 years	◇ Schoolyard ◇ Park ◇ Parking Lot ◇ Green space
It is always necessary to examine the validity of the installation.	◆ Near the slope and the foundation of the building ◆ Ground with potential for liquefaction → liquefaction measures ◆ Soft ground less than N value 2 → ground improvement etc. ◆ Evaluation of the influence of buoyancy when the groundwater level is high	

Remarks: Not applicable for roadway and steep slope

(4) Counterpart Organization

State Ground and Surface Water Resources Data Centre, Water Resource Department, Public Works Department, Government of Tamilnadu

(5) Target Area and Beneficiaries

Target Area: Taramani, Chennai-600113, Tamilnadu, India

Beneficiaries: The employees of State Ground & Surface Water Resource Data Centre, PWD Chennai, other government offices functioning in the PWD Taramani Campus and citizens of communities near Taramani Campus.

(6) Duration

June 2017 to May 2019

i) Completion of UN Tank: January 2018, ii) Installation of Water Purification Plant: April 2018, iii) Supply of rainwater stored in UN Tank for the domestic usage: September 2018, iv) Completion of rainwater harvesting system including Water ATM and faucets in the buildings: January 2019

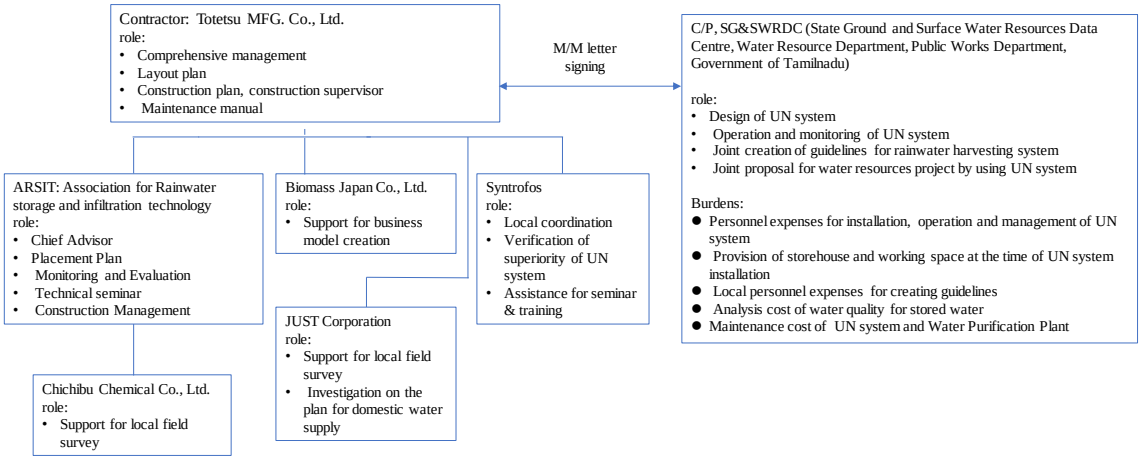
(7) Progress Schedule

Refer to Annex-1

(8) Manning Schedule

Refer to Annex-2

(9) Implementation System



3. ACHIEVEMENT OF THE SURVEY

(1) Outputs and Outcomes of the Survey

1) Construction of UN system

UN system was implemented by following the construction procedure shown in figure 2. Layout of rainwater collection network, plane and sectional drawing of UN Tank are shown in Figure 3, 4 & 5 respectively.

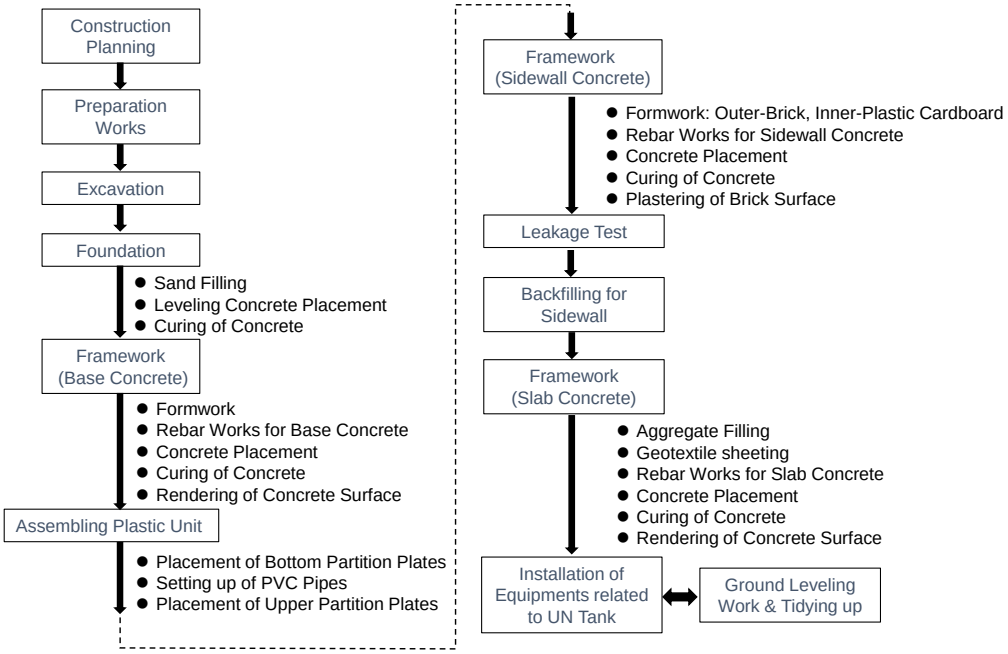


Figure 2 Construction Procedure of UN system

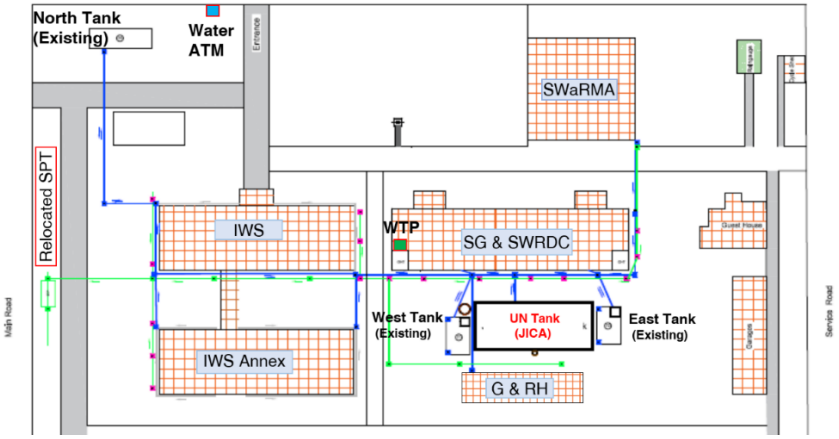


Figure 3 Layout of rainwater collection network

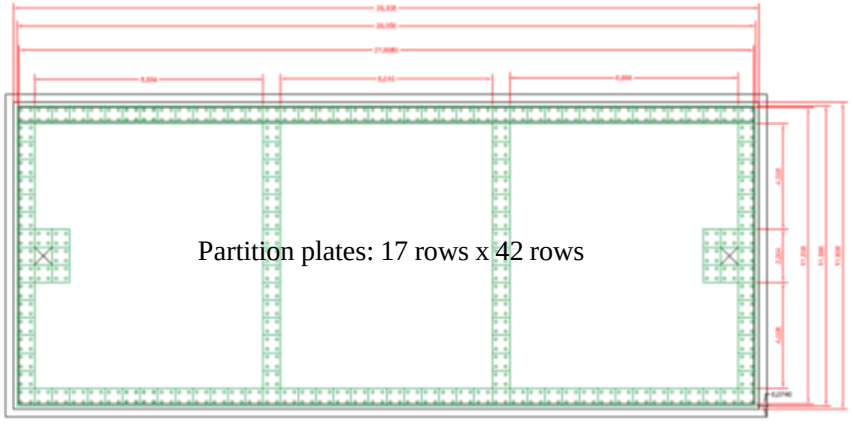


Figure 4 Plane drawing of UN Tank

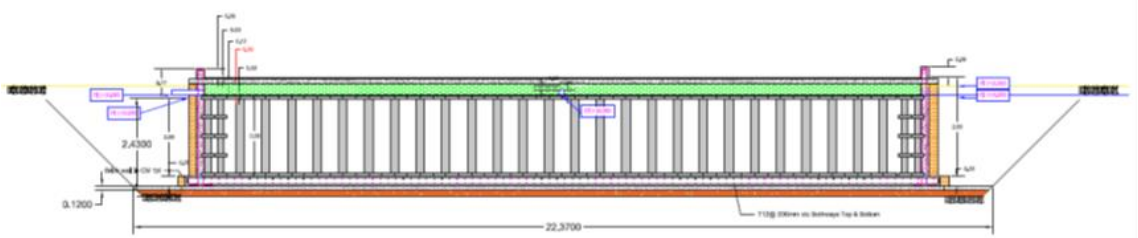


Figure 5 Sectional drawing of UN Tank

Table 3 shows the results of calculation of the possible storage capacity of UN Tank and its void ratio obtained from the material volume used for the UN Tank and the external dimensions of the plastic part. The possible storage capacity was estimated to be more than 620 m ^{3} and the void ratio was estimated to be 95%.

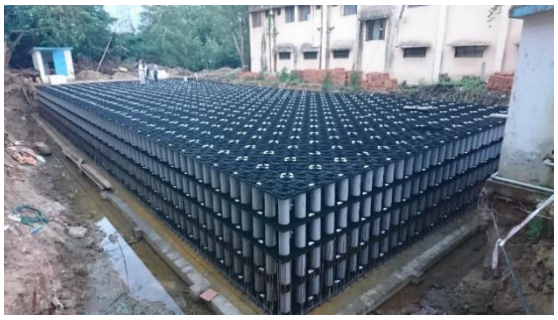
The picture of the status of the construction work is shown in Figure 6. The construction work was carried out by the local subcontractor under the supervision of JICA survey team. It was confirmed that the local worker was capable to assemble Aqua Palace of 620m^3 within three days.

Table 3 Estimation of possible storage capacity and void ratio of UN Tank

Estimation of possible storage capacity and void ratio of UN Tank	Quantity	Unit	Unit Volume	Total Volume
			m^3/Piece, m^3/m	m^3
Partition plate	1870	Pieces	0.00522	9.76
Attachment	1140	Pieces	0.00279	3.18
AD Spacer	1140	Pieces	0.00186	2.12
Joint piece	5000	Pieces	0.00005	0.25
Main SP pipe: Φ216, 1.76m length	564	Pieces	0.00523	5.19
Main SP pipe: Φ216, 1.26m length	18	Pieces	0.00523	0.12
Auxiliary SP pipe: Φ165, 0.485m length	2316	Pieces	0.00371	4.17
Inner axis pipe: Φ90, 2.08m length	104	Pieces	0.00055	0.12
			①Total	24.91
②Concrete volume invaded inside(including plastic cardboard): 0.42m x 0.07m x 0.67m x 118 sides x 4 steps				9.30
③External volume of the plastic part: 17 rows (17.356m) x 42 rows (28.056m) x 2.08m				662.7
④Possible Storage Capacity ＝③ - ① - ②				628.8
⑤Void ratio ＝④÷③×100 %				95

Excavation

Base concrete & Rebar Work for Sidewall



Assembling Aqua Palace

Sidewall Construction

Sidewall & Slab Concrete

Backfilling & Ground Leveling Work

Figure 6 Status of Construction work

2) Installation of rainwater harvesting system (direct utilization)

The water purification plant and water supply network installed at the PWD Taramani Campus are outlined in Figure 7. The treatment capacity of the plant was designed to supply 3 liters of drinking water a day to a total of 1230 people, 230 people, which is 90% of the total number of employees in the campus, and 1000 people in the local community as shown below.

1230 x 3 L/capita/day=3,690 L/day＜Treatment Capacity 500L/h x 8h/day=4,000L/day

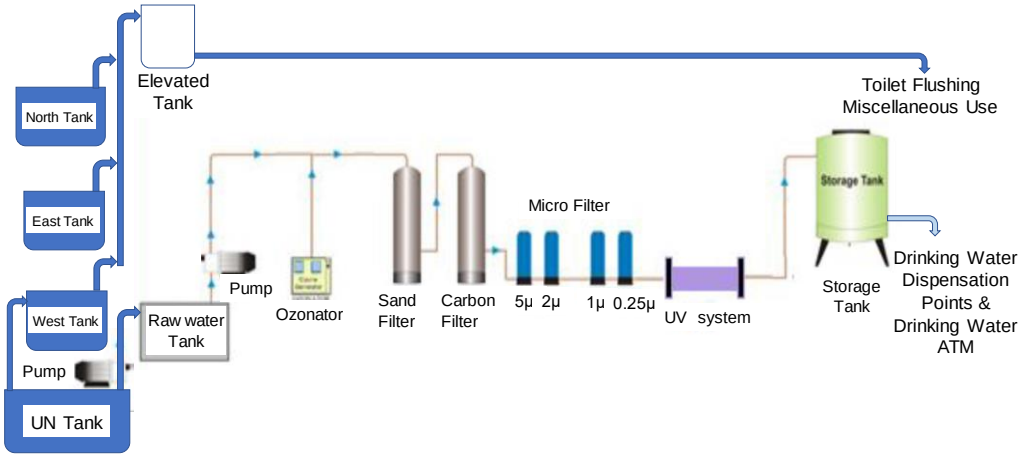


Figure 7 Underground storage tank, Water purification plant and Rainwater & Drinking water supply network installed at PWD Taramani Campus

The rainwater from the rooftop is stored in the UN Tank of capacity of 620 m^3 made of plastic composite concrete. The purified water is supplied to the drinking water dispensation points in the buildings and Water ATM (refer to Figure 3). In addition, the stored rainwater in UN Tank is also supplied to the west tank for the domestic usage such as toilet flushing whenever the west tank tends to be empty.

Although TDS of rain itself and the rainwater from rooftop was measured to be around 50 and 150 mg/L respectively TDS raises again to around 300 mg/L due to the contact with concrete while it is stored in the tank. Then. the water from UN Tank is mixed with ozone from Ozonator. Ozone can kill the pathogens and degrade organic matters, these pathogens are filtered at sand and carbon filter, where the sediments and impurities are separated.

Water is further filtered using Micron filter. This filter is wound by a spun type which promotes further filtration by removing 5 to 2 microns impurities.

The water is then allowed to flow through bacterial removal filter. This filter removes bacteria and hence removes impurities from 1.0 micron to 0.25 micron.

The filtered water is accumulated in a storage tank after the UV treatment, where UV rays can kill the bacteria present. The purified water is then used as a drinking water.

The results of water quality analysis on the rainwater stored in UN Tank, the water in each building faucet, and the water from Water ATM are shown in Table 4 to 6.

It is confirmed that the rainwater stored in UN Tank has an excellent quality for the domestic usage and the purified water has a suitable quality for the drinking water.

Table 4 Result of water quality analysis on the rainwater stored in UN Tank

Collection date	16/10/2018		07/11/2018	Standard Acceptable Limit
Parameter	C176	C177	Bore water	
EC	610	590	518	—, µS/cm@25℃
pH	7.4	7.6	7.43	6.5 -8.5
Calcium (Ca)	24	18	22	75 mg/L
Magnesium (mg)	24	26	12	30 mg/L
Sulphate (SO4)	44	60	44	200 mg/L
Chloride (Cl)	96	85	76	250 mg/L
Nitrate (NO3)	14	17	—	50 mg/L
Fluoride (F)	0.26	0.24	—	1 mg/L
TDS	344	334	311	500 mg/L
Total Hardness	160	160	104	300 mg/L
Total Alkalinity	120	105	102	200 mg/L
Color	—	—	<1.0	5
Odor	—	—	Agreeable	Agreeable
Turbidity	—	—	<1.0	1 NTU
Total iron as Fe	—	—	BDL(DL:0.05)	0.3 mg/L

BDL; Below Detection Level, DL: Detection Limit

Table 5 Result of water quality analysis on the water from each building faucet

Collection date	21/01/2019, 29/01/2019, 04/02/2019						
Parameters / Chemical Examination:	Unit	IWS	IWS Annex	SG&SWRDC	SWaRMA	Evaluation	Acceptable Limit(Max)
Appearance	—	Clear	Clear	Clear	clear	—	—
pH@25℃	—	7.12-7.71	7.03-7.60	7.11-7.42	7.05-7.73	OK	6.5-8.5
		7.53	7.38	7.29	7.45	7.41	
Color	Hazen	0.9-1	0.8-1	1.0-1.0	0.9-1	OK	5
		0.97	0.93	1.00	0.97	0.97	
Odor	—	Agreeable	Agreeable	Agreeable	Agreeable	OK	Agreeable
Turbidity	NTU	0.3-0.4	0.4-0.9	0.6-0.9	0.7-1.1	OK	1
		0.4	0.7	0.7	0.8	0.65	
Electrical Conductivity @25℃	µS/cm	309-415	393-412	356-376	324-353	—	—
		346.3	403.3	365.3	340.0	363.8	
Total Suspended Solids	mg/L	Nil	Nil	Nil	Nil	—	—
Total Dissolved Solids	mg/L	199-321	227-309	188-245	177-211	OK	500
		241.0	259.0	212.3	193.3	226.4	
Total Hardness as CaCO3	mg/L	107-119	107-174	99-155	91-145	OK	200
		112.7	145.7	122.0	110.3	122.7	
Microbiological Examination:	Unit	**IWS**	**IWS Annex**	**SG&SWRDC**	**SWaRMA**	Evaluation	Shall not be detectable in any 100ml of Sample
Coliform	MPN	Absent	Absent	Absent	Absent	OK	
E.Coli	MPN	Absent	Absent	Absent	Absent	OK	

Table 6 Result of water quality analysis on the water from Water ATM

Collection date	29/01/2019			
Parameters	Unit	Water ATM	Evaluation	Acceptable Limit (Max)
Chemical Examination:				
Appearance	—	clear	—	—
p H@25℃	—	7.95	OK	6.5-8.5
Color	Hazen	1	OK	5
Odor	—	Agreeable	OK	Agreeable
Turbidity	NTU	1.1	NG	1 Permissible Limit: 5
Electrical Conductivity@25℃	µS/cm	295	—	—
Total Suspended Solids	mg/L	Nil	—	—
Total Dissolved Solids	mg/L	164	OK	500
Total Hardness as CaCO3	mg/L	90	OK	200
Microbiological Examination:				
Coliform	MPN	Absent	OK	Shall not be detectable in any 100ml of Sample
E.Coli	MPN	Absent	OK	

Figure 8 Water Purification Plant installed on the rooftop of SG&SWRDC building

Figure 9 Drinking Water Dispensation Points & Drinking Water ATM

3) Monitoring and evaluation on the operation performance of the UN system

Figure 10 shows the change of water level monitored in UN Tank with the daily rainfall during 19th Feb. to 31st Dec. 2019. It was observed that water collection network was properly functioned because the water level raised with rainfall. In addition, Figure 11 shows the rising height of water level accompanying each rainfall event obtained from this monitoring result. Theoretically, the following equation holds between the both.

Rising height of water level = daily rainfall x water collection ratio (f) from rooftop x [Catchment area of rooftop] /[water surface area in UN Tank]

The main catchment area for UN Tank is considered as 1,109 m^2, which corresponds to the sum of the rooftop areas of SG&SWRDC and Garage & Rest House. In addition, water surface area in UN Tank can be obtained as 302.3 m^2 by dividing 628.8 m^3 of storage capacity by 2.08 m of the UN tank height shown in Table 3.

Therefore, the coefficient of the correlation equation in Figure 9 is expressed by the following equation; $f \times [1109 / 302.3] = 3.0461$

Then, water collection ratio (f) from rooftop is calculated as 0.83. This value is found to be almost same as the design value (0.8) initially considered.

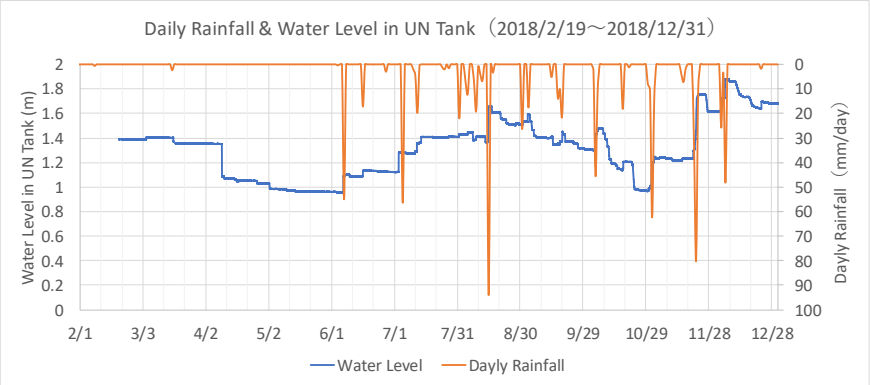


Figure 10 Change of water level in UN Tank with the daily rainfall

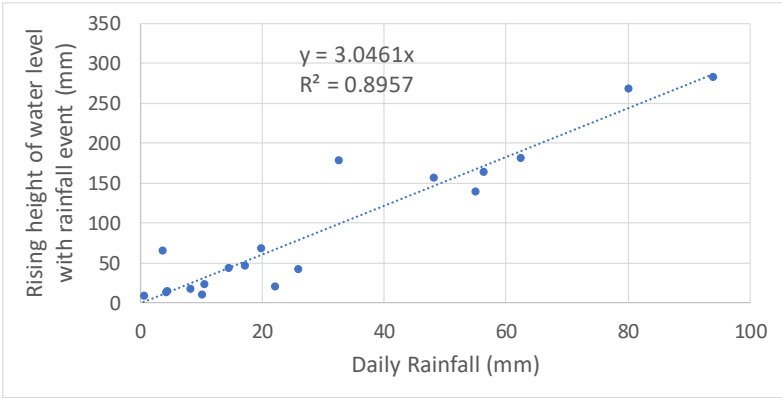
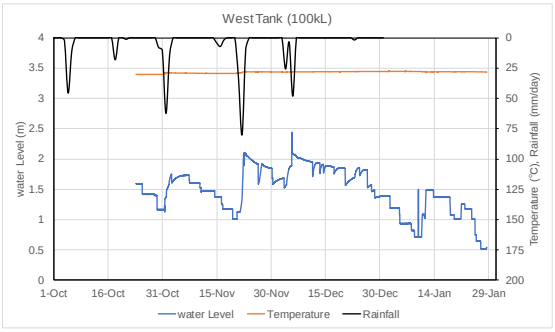
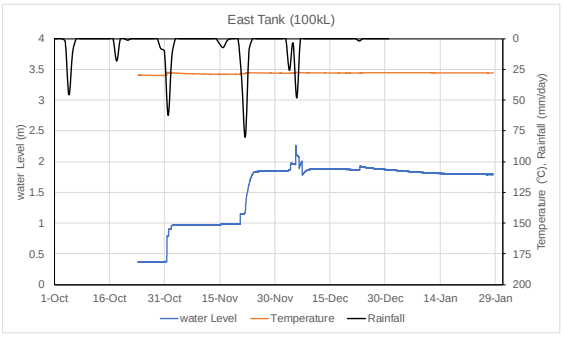


Figure 11 Rising height of water level accompanying each rainfall event

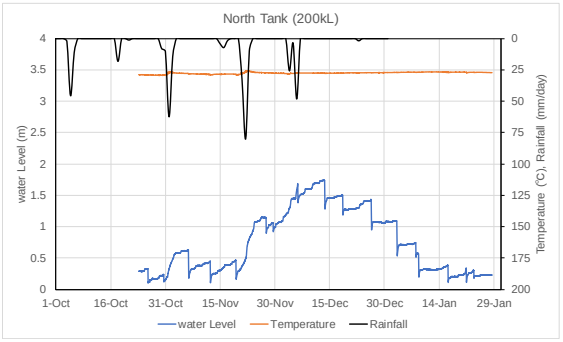
Figure 12 shows the water level behavior in four tanks during same period. It was observed that all tank is well functioned for rainwater harvesting.



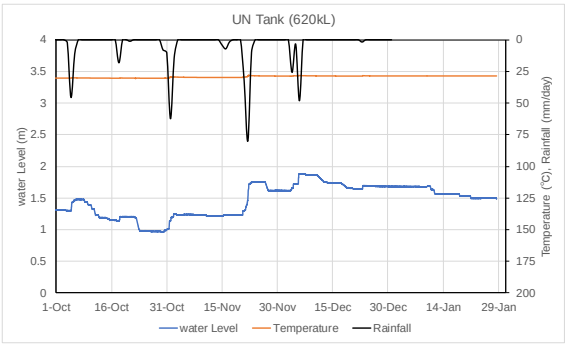
West tank



East tank



North tank



UN Tank

Figure 12 Comparison of water level behavior in each tank

Figure 13 shows the comparison between the water temperature in the UN Tank and the outside temperature. It was confirmed that the water temperature change in the tank was small compared to the air temperature. From this point, it was suggested that the influence on the water quality deterioration due to the high fluctuation of temperature is less at the underground storage tank

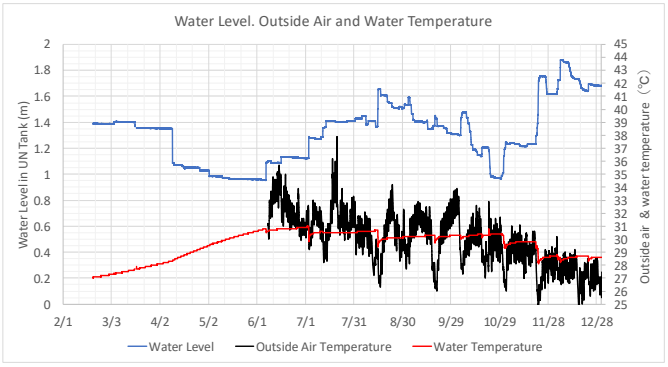


Figure 13 Comparison between the water temperature in the UN Tank and the outside temperature

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

1) Conduct of Technical Seminar

In order to commemorate the completion of the UN tank, a workshop was held on the UN tank as the first technical seminar on 17th April, 2018. On the other hand, for the occasion of the completion of the rainwater harvesting system, the second technical seminar was held at Radisson Blu Hotel on 26th March, 2019.

Figure 14 Conduct of Technical Seminar (Left: 1st, Right: 2nd)

2) Proper Operation and Maintenance

It was decided to maintain each part based on the maintenance procedure sheet of the rainwater harvesting system shown in Figure 15. In addition, the operation and maintenance manual on Water Purification Plant and Water ATM was prepared.

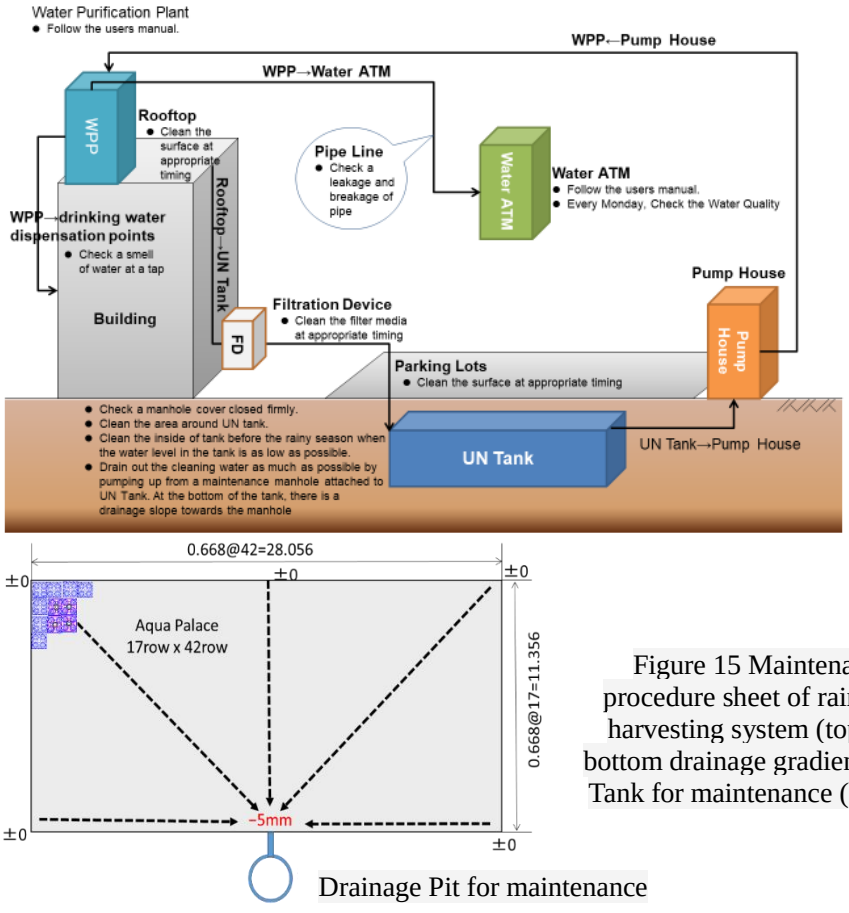


Figure 15 Maintenance procedure sheet of rainwater harvesting system (top) and bottom drainage gradient of UN Tank for maintenance (bottom)

4. FUTURE PROSPECTS

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

A rainwater harvesting system (direct utilization) consisting of an UN system, Water Purification Plant, a rainwater collection and water supply network, and Water ATM for drinking water was installed at PWD Taramani Campus. Judging from the monitoring results, the system collected rainfall and stored rainwater as designed. Based on the analysis of water quality of stored rainwater in UN Tank, C/P (SG&SWRDC) has never purchased a tank lorry water (27 m^3 / week) for the domestic usage after September 2018. Water ATM meets the drinking water quality standard and is ready to start operation at any time. Attention is being paid to Water ATM since it was the first ATM selling the purified rainwater in Tamilnadu.

The effectiveness of UN system using Aqua Palace is beginning to be recognized through the exhibitions and two technical seminars. Although there have been many inquiries from private companies, government offices, etc., the main issue in business development is that the construction cost of the UN system is higher than existing concrete tanks.

However, in Tamilnadu, where water is very scarce, the benefits of a UN system that can quickly build large-scale underground tank before the rainy season are extremely significant. It is thought that the possibility of spread will be expanded by pursuing quantitatively the merit of the way to obtain drinking water by rainwater direct utilization without purchasing bottled water.

(2) Lessons Learned and Recommendation through the Survey

In the case of overseas business development for Japanese technology, it should be proceeded after accurately examining the needs in the partner country. In addition, we should prove the effectiveness of the project and proceed to the diffusion stage based on the quantitative data demonstrated. At the stage of this survey pilot project, so to speak, most of the funds come from Japan, then it will become the first business of the proposing company with persons, companies and organizations of the partner country at the next diffusion stage. The quantitative analysis data obtained during the survey pilot project period is important, but at the same time, it is also very important to be able to confirm that the facility continues to operate even after the end of the pilot project. It is important to build a maintenance and management system so that C/P side can properly continue to operate the facilities after the project ends. This is because the end of this survey pilot project will be the beginning of the true business for the proposed company.

In addition, in the case of SMEs, we should focus on promoting concrete business

development with local companies as much as possible during the period of pilot project since we cannot afford to invest the funds

Regarding to the operation of the system including the treatment process, a certain period is required for training and trial operation for its acquisition. we hope to create a new system that will also support follow-up by JICA after the survey pilot project is over.

ATTACHMENT: OUTLINE OF THE SURVEY

India

Verification Survey with the Private Sector for Disseminating Japanese technologies for Gap Resolution of Water Demand/Supply by Plastic Underground Rainwater Storage System
Totetsu Mfg. Co., ltd., Tokyo, Japan

Concerned Development Issues in India

- The gap between water demand and supply has been expanding due to population growth, economic development and climate change.
- Although the use of rainwater can be effective water resource development, it is not effectively utilized mainly because of its time distribution of precipitation affected by the monsoon.

Implemented Activities in the Survey

- Verify the effects of Totetsu's unique plastic underground rainwater storage system in Chennai city.
- Assess superiority of Totetsu's technology as a solution to the water demand/supply gap by a pilot project.
- Conduct capacity training on effective utilization of rainwater.
- Propose the disseminating plan of Totetsu's technology to the public and the private in India.

Proposed Products/Technologies

Universal Underground Storage System

- **Utilization of underground space for large scale storage with long-term stability of water quantity and quality**
- **Plastic unit "Aqua Palace" is more durable and easier for maintenance with higher cost reduction potential because of its configurative flexibility.**

Survey Overview

Name of Counterpart : Ground & Surface Water Resources Data Centre, Public Works Department, Government of Tamil Nadu, India
Survey duration: June 2017 ~ May 2019
Survey Area: Chennai City

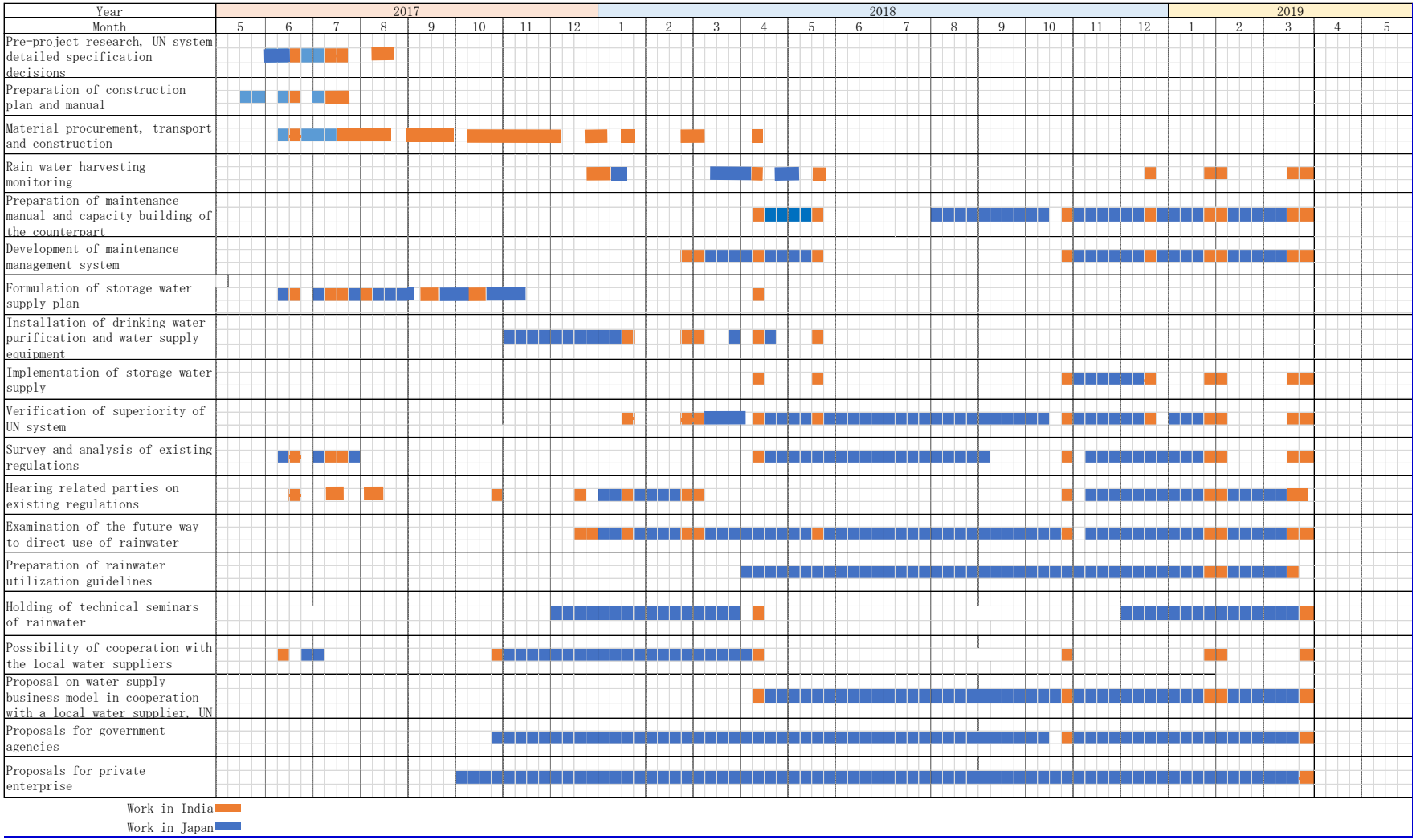
Impact on the Concerned Development Issues in India

- With the introduction of Japanese rainwater utilization technologies (both soft and hard) including proposed one, direct utilization of rainwater will be effectively promoted, helping the sustainable water resource development.

Outputs and Outcomes of the Survey

- Although there are numerous rainwater utilization technologies in Japan including proposed one, their dissemination in India, which is suffering from the water demand/supply gap and can be the prospective market, is still limited.
- By promoting the effectiveness and superiority of rainwater utilization and Totetsu's technology to both public and private institutions in this survey, their dissemination in India is expected to progress.

Annex-1 Progress Schedule



Annex-2 Manning Schedule

Person name	In charge of work	Affiliation	2017							2018												2019					Total
			6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	
Takai Seiichiro	Project Manager	Totetsu Mfg.Co.Ltd	2	8	4				2	2	2	2	2	2	2	1	2	2	2	1	2	1	1	1			41
				7	6	18	18	6						7					3					6			71
Hisanaga Tetsuro	Construction plan, construction plan instruction, field survey, construction supervision	Totetsu Mfg.Co.Ltd	10	3						2	2	2	2	2	2	1	2	2	1	2	2	2	1	2			40
			7	7	13	29	26	30	5	8	10	8	11	7					8		7	5	3	10			194
Ando Yusaku	Material transportation, contract preparation (deputy), construction supervision (deputy)	Totetsu Mfg.Co.Ltd	13	1	4				5	5	5	5	5	5	5	2	1	2	3	2	4	1	1	1			70
			7		15	12	15																				49
Takamatsu Naoki	Construction supervision (secondly)	Totetsu Mfg.Co.Ltd			1	1																					2
					13																						13
Ito Etsuro	Planning and conducting field survey, counterpart interview	Totetsu Mfg.Co.Ltd	10	3	7																						20
			7		9																						16

Person name	In charge of work	Affliation	2017							2018												2019					total
			6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	
Imbe Masahiro	Chief Advisor	ARSIT		6	6				2						4												18
				6	5	9							5														25
Okui Hiroyuki	Layout plan, monitoring and evaluation, construction supervision, preparation of tender documents and guidelines	ARSIT	3	3	2	2	3		2	5	5	9		2	6	3	2	2	3	1	3	1	1				58
			7	7	16	17	8	8	7	1	7		11						5			5	3	1			103
Ozaki Masatsugu	Field survey, construction supervision & monitoring support	Chichibu Chemical Co.Ltd		2																							2
				6															6								12
Ravinder Singh Negi	Local coordination, counterpart hearing,	Syntrofos																									
				7	8																						15
S.K. Srivastava	Verification of drinking water purification system superiority using UN system	Syntrofos																									
						3	6	4	6																		19
Lalit Agrwal	Verification of drinking water purification system superiority using UN system	Syntrofos	2	2	2	3	3		1	1																	14
Sanjay Satyadarshi	Local coordination, counterpart hearing,, Assistant of seminar	Syntrofos			1	3			1				2	4		1			2								14
			7	7	27	25	18	6		2	5		10														107
Mizumoto	Field survey support	JUST Corpolation	4	2	2	2			2	2	2				2	2			2		3						23
					6						6																12

Work in Japan
Work in India