Development of Eco-Efficient Water Infrastructure for Socio-Economic Development in Asia and the Pacific Region

Executive Summary for the Project on Integrated Stormwater Recycling System for Green Growth in the Philippines

June 2011
Executive Summary of a Project
on
Integrated Stormwater Management System
in Cebu, the Philippines

15 June 2011

Environment and Development Division
United Nations Economic and Social Commission
For Asia and the Pacific
1. Background

United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), Department of Science and Technology\(^1\) Regional Office No. 7 (DOST 7) of the Philippines have cooperated to conduct a pilot project on “integrated stormwater management system” in the headquarter of the DOST 7 for the year 2009-2010, as the demonstration of the eco-efficient approaches in the Philippines.

Water resources management in urban areas is now one of key challenges for sustainable development. Many developing countries have experiences serious water issues categorized as drought, flooding and polluted water. What makes the problem even worse is urban development. Green spaces in urban areas are destroyed and replaced with impervious surfaces, resulting in urban problems such as heat island, urban flooding and increasing pollution of wastewater due to non-point source pollution.

Specifically, stormwater management caused by poor managed-urbanization, heavy rainfall and climate change has appeared as one of key water challenges to address seriously adverse socio-economic and environmental impact in the region. The unmanaged stormwater causes extensive economic damages, human causality and negative environmental impacts through serious flooding, the contamination of water sources by overflowing untreated pollutants/sewage, the increased soil erosion in the river basin, which results in overall degradation of watershed and ecosystem in developing counties with little resources and capability. In addition, climate change deteriorate the challenges. Climate change distorts natural water cycle and heat cycle, which are already affected by urban development. This implies that the impact of climate change is more serious in urban areas. Therefore, the sustainable management of stormwater is one of key challenges of countries to achieve sustainable economic growth, social health and environmental conservation (sustainability).

\[<\text{Urban Development and Climate Change}>\]

\(^1\) DOST is the Ministry of Science and Technologies in the Philippines.
One of effective suggestions to manage the stormwater in urban area is to strengthen the integrated planning of rainwater harvesting, stormwater management, wastewater treatment with active application of innovative knowledge, technologies and advanced design of land use. In this connection, integrated rainwater, stormwater and wastewater management system is suggested as one of eco-efficient approaches, to achieve the sustainable growth (green growth) by promoting the positive recycling of rainwater, stormwater and wastewater in the eco-system. The integrated approaches of the system contains the active collection and use of rainwater and stormwater, active treatment and recycling of stormwater and wastewater, the application of modern technologies on IT-based decentralized monitoring and controlling system, membrane technologies, and the advanced design and planning of eco-efficient land use.

In detail, the approaches provide multiple benefits namely (1) economic savings from the control of stormwater damage, reduced reconstruction of water supply facilities, unnecessary investment in overlapping infrastructures between storm water prevention facilities and rainwater facilities, reduction of water demands, reduction of pumping energy, and health services; (2) protection and conservation of watershed and its ecosystem from flooding, the improvement of water quality, reduced soil erosions and the conservation of the water sources; and (3) the provision of the strong motivations to officials of government/agencies in incorporating eco efficient approaches into existing framework of water resources such as policy planning, watershed management practices and watershed related law and regulations in order to ensure the water sustainability. As a result the approaches contribute to achieving the sustainable growth by addressing stormwater-related flooding and management in the long run.

<Key Concept of the System>
2. Outline of the Project

- Venue: DOST 7 Office Building,
  The S&T Complex, Sudlon, Lahug, Cebu City, 6000 Philippines
- Project cost: US$45,000 from ESCAP
  ✓ Construction cost of the tanks by DOST 7
  ✓ MF system donated by EREDE co. Ltd.
- Project duration: 2009-2010 (12 months)
- Information Source: http://www.ro7.dost.gov.ph/
  Regional Director: Mr. Rene Burt N. Llanto (enertrub@yahoo.com)
  Tel: (63-32) 254-8269 or 418-9032

<Bird-eye View for a Project Site: DOST 7>
3. Objectives of the Project

- To strengthen the capacities of local government officials for the planning and management on the integrated rainwater and stormwater recycling system through the implementation of the pilot demonstration project.
- To establish the model for integrated rainwater and stormwater recycling system in the selected building to demonstrate the eco-efficient approaches for water infrastructure.

![Combined system diagram]

4. Key Components of the System

A. Application of Computer Simulation Modeling

- Identified optimal tank sizes and the framework of the system by using a computer software of simulation modeling called “Rain City”
- Analyzed the rainfall data in Cebu for last 3 years to identify the rainfall and stormwater patterns
- Applied innovative design to enhance the eco-efficiency through optimal design of the water cycle in the building, specifically focusing on reducing the distance among relevant components of the system.

<Decision-making Support Tool: Raincity Software>
B. High Quality of Rainwater Recycling Component

- Used green filters to collect high-quality of rainwater from the roof top

- Removal on SS, Oils, Heavy metals, TN, TP
- Effective for first flushing of rainwater below 5mm per hour
- Non-powered device

- The filter of Green filter is developed jointly by the Korea Institute of Construction Technology and the US Forest Laboratory (now registered under the Korean patent)
- An electronic butterfly valve is installed to control the flow of rainwater and the level of rainwater tank
<Rainwater Flow and Filtering System in the Green Filter>

- Microfilter system (MF system) is installed for treatment of rainwater to use in the building
- Collected and treated rainwater is used for toilet and gardening

<MF System in DOST 7>

- Type: Hollow fiber
- Material: PVDF (Polyvinylidene Fluoride)
- Out size: 0.65/1.0mm
- Membrane space: 42 m²/module
- Pore size: 0.2 μm

- Decided the rainwater tank size, 60 cubic meter, after analysis of the volume of rainfall in Cebu province, the size of the DOST building space, and the expected daily consumption of water in the building
<Construction of Rainwater and Stormwater Tanks in DOST 7>

* 60 cubic meter for each tank

C. Stormwater Management Component

- Stormwater management component is set up for flooding control, infiltration into the groundwater and additional water supply to cleaning and gardening.
- 60 cubic meter tank for stormwater is installed to collect and reuse the stormwater.
- A green filter is installed to get the better quality of stormwater.
- An electronic butterfly valve is installed to control the flow of stormwater and the water level of stormwater tank.
- Microfilter system is installed for treatment of stormwater.
- The stormwater is used for crop, gardening and infiltration into groundwater.

<Reuse of stormwater and wastewater in the gardening of DOST 7>

Plants and crops watered through the ISWM system.
D. Wastewater Treatment Component

- Micro Bio Reactor (MBR membrane) is installed to treat the wastewater, which is the combination model of micro bacteria method and membrane technology.
- Treated wastewater can be reused or released to the river for eco-system.
- The treated water through MBR in DOST 7 is re-circulated to the cistern on the top of roof for reuse in the toilet and gardening

<Flow of MBR System>

<Photo of Membrane in MBR>  <Installation of Membrane in Wastewater Tank>

<Cross section of Membrane>
E. Decentralized Integrated System for Monitoring

- The system aims to demonstrate the integrated monitoring and controlling for dozens of multi-water facilities in remote different locations by using IT technologies and software of integrated management.
- The component shows the possibility of decentralized development and management of water infrastructure and facilities in real time and in multi-facilities.
- As real time monitoring, the prompt action, for example emergency disasters, can be taken.

Screen Chart of a Remote Management System, DOST 7

<Charts of Measurement by Remote Management System>
F. Innovative Design Component

- Integrated architectural design of key components in DOST 7, Cebu, Philippines: rainwater, stormwater and wastewater management system

![Integrated rainwater and wastewater management system](image)

G. Capacity Building Programme Component

- The training materials (guidelines) were developed in collaboration with DOST 7 officers and ESCAP.
- Advocacy and training workshops were held for maintenance & operation and for development of the replication plan to other regions.
- Site visits were arranged for stakeholders in the region to enhance the awareness and replication of the system into region.

<Advocacy and Training Workshops for the ISWM in Cebu>
5. **Sustainability of the Project**

A. Long term objective of this project is to upscale the concepts of integrated rainwater, stormwater and wastewater management system in the urban planning and design.

B. It is an integrated approach to demonstrate one of eco-efficient designs of water infrastructure for green growth.
   - Besides local knowledge, design and practices, apply modern technologies such as green filter, MBR membrane, MF system, Raincity software, and remote monitoring system, etc.
   - Provide opportunities to identify the appropriate new technologies suitable for local conditions in the region 7 of the Philippines for further application and upscaling.

C. Respect local ownership and local practices
   - Procured most of equipment from the local market except for green filter, MF system and MBR.
   - Reflected the local stakeholders’ opinions into architectural design.
   - Strengthen local stakeholders and officers’ knowledge and technologies.

D. Good example of Public-Private Partnership
   - It is a joint cooperation of diverse teams; namely ESCAP, DOST 7, KICT, Cebu city administration, local water agencies, and private sectors.
   - ESCAP provides the general direction and advisory services for policy formulation with project fund.
   - DOST 7 provides own funds for the construction of tanks and technical views on development of architectural design in collaboration with the KICT.
   - KICT provides the overall architectural design for integrated stormwater management system.
   - Cebu city administration was committed to play a role to replicate the system to other region together with the DOST 7.
   - Local water agencies such as Metropolitan Cebu Water District, Hydronet Consultants, Inc, Pollution Control of the Philippines, University of San Carlos participated and committed to work together.
   - Private sector (EREDE co. Ltd) joined in the project with contribution of own funds and free supply of equipment with the objectives to demonstrating its technologies to local stakeholders and to exploring business opportunities.
E. Strategy to publicize to media
   • This pilot project was broadcasted and interviewed by a few of local TV programmes and newspapers

F. Sustainable and Replicability
   • DOST 7 secured annual budget for operation by saving water supply cost
   • ESCAP, DOST 7, and Cebu government agreed to replicate the system in the Cebu province with the continued cooperation on “Integrated rainwater, stormwater and wastewater management system for green school development” to disseminate the model to other regions

Annex
1. Analysis of Quality for Rainwater and Wastewater
2. Progress and Achievements of ISWM
3. Integrated Stormwater Management Chart

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Analysis of Quality for Rainwater and Wastewater
Annex 2

Progress and Achievements of ISWM (Drafted by DOST 7)

1. Background on the ISWM Project:

The ISWM project is a cooperation of the Water Security Section of United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP), the Korea International Cooperation Agency (KOICA), the Korea Institute of Construction Technology (KICT), EREDE Co., Ltd. and the Department of Science and Technology Region 7 (DOST7).

This undertaking is a pilot activity for the Philippines to develop and install in a public building a system capable of managing rainwater, storm water and waste water treatment. The project aims to promote awareness and advocacy on eco-efficient water infrastructure development in the Philippines.

The location of the project is in the new building of the DOST 7 at the Lahug S&T Complex, Lahug, Cebu City, Philippines. The system collects rainwater and storm water as well as treat wash and “grey” water.

2. Details of major components of the ISWM facility:

2.1 Primary Rainwater Treatment Facility (Green Filter)

This is designed to eliminate various types of point source pollutants, yellow dust and coarse material brought from roof and pavement surface. It selectively cleans primary rainfall under 5mm through contact with hydrophobic wood and functional (EPP) materials.

2.2 Micro-Membrane Filtration System (MF System)

This system is designed to eliminate dissolved pollutants and pathogenic bacteria by penetrating rainwater into a 0.2 microns diameter hollow fiber membrane and eventually meet the criteria of reuse water and secure good quality of rainwater.

2.3 Integrated Rainwater Remote Administration System:

This consists of the Digital Direct Control Panel (DDC) installed at the machine room, the computer software and the sensors. Monitoring is on-line and can be accessed remotely through the internet. Conditions of the 2-way electric butterfly valve (on and off) can be monitored on the main screen. This is connected to the ultrasonic wave water transmitter inside the storage tank.

2.4 Rainwater Drainage against emergencies (2 way electric butterfly valve)

When water levels reach maximum level, the system receives signals from the ultrasonic wave transmitter which causes the butterfly valve to shutdown and send excess water to
outside drainage pipes.

2.5 Reuse Water Treatment System

This is an advanced treatment method which collectively removes organic compound, Nitrogen and Phosphorus from the waste generated from the building.

3. Operation and Maintenance:

The system is designed to operate at a fully automated mode but it can also be manually controlled. The situation of the entire system can be monitored and controlled on the web through the Integrated Rainwater Remote Administration System. Butterfly valve operates automatically by receiving signal from the ultrasonic wave water transmitter. It can be manually operated by using the valve handle in the fore part of the unit in case the power supply fails. Pumps operate in accordance with the level sensors installed inside the tank. High and low level alarms are provided in the controls.

Periodic inspections of the Primary Rain Water Treatment System (Green Filter) are necessary to reduce the non-point source pollutants generated from the roof and pavement during rainfall. Water drainage passages are checked to prevent it from clogging.

Motors and electrical controls need to have a regular inspection to prevent electrical failure. Regular cleaning of the rainwater storage tank is recommended to prevent water fouling.

4. Performance of the ISWM System:

4.1 Energy Performance

Two (2) filtration systems were installed in the facility the Micro- Filtration System and the Membrane Biological Reactor system. Table below shows the specific energy consumption based on the installed capacity of the system.

<table>
<thead>
<tr>
<th>System components</th>
<th>Capacity $m^3/day$</th>
<th>Energy Consumption $Kw-hr/day$</th>
<th>Specific Energy Consumption $Kw-hr/m^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) Micro Filtration System for Rain Water and Storm Water Treatment</td>
<td>10</td>
<td>19</td>
<td>1.9</td>
</tr>
<tr>
<td>2.) Membrane Biological Reactor System for Waste Water Treatment</td>
<td>5</td>
<td>11</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Electrical utilities such as pumps and blowers are major equipment that consumed more energy since they are driven by electric motors. Computerized data acquisition and control
system also contributed a small factor of energy to run the system on a 24 hour operation.

4.2 Water Quality

Water quality was monitored regularly to check the performance of the system. Parameters such as pH, Total Dissolved Solids (TDS), Conductivity and Biochemical Oxygen Demand (BOD) were the basis of water quality. Obtained data are shown on the table below.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Date of Sampling</th>
<th>pH values</th>
<th>Total Dissolved Solids (TDS) ppm</th>
<th>Conductivity $\text{MicroS/cm}$</th>
<th>Biochemical Oxygen Demand BOD, mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Treated Rain/Storm Water</td>
<td>04-15-2011</td>
<td>9.8</td>
<td>90</td>
<td>160</td>
<td>2</td>
</tr>
<tr>
<td>2. Treated Waste Water</td>
<td>04-15-2011</td>
<td>8.0</td>
<td>540</td>
<td>1010</td>
<td>14</td>
</tr>
</tbody>
</table>

A slight increase of pH values on treated rain water that exceeded the criteria of 6.0 to 9.0 for residential purposes. Whereas the treated waste water pH value is acceptable for reuse. The Biochemical Oxygen Demand (BOD) level of the treated waste water comply with the Department of Environment and Natural Resources (DENR) effluent standard requirement of 30 mg/l but the targeted level of 5 mg/l as normal quality for reuse were difficult to achieved. Further improvement of the waste water treatment is necessary to meet the targeted level of criteria for BOD in the system.

5. Advantages of the ISWM system:

Using membrane technology the system has the following advantages and key benefit.

- High efficiency/low maintenance
- Membrane modules are backflushable
- Easy to clean
- Compact design – small footprint than conventional
- Long lifetime
- Less manpower needed

6. Savings and Benefits of ISWM:

Having an ISWM facility the following long term benefits are:

- The consumption of water coming from the Metro Cebu Water District (MCWD) as it is supplied to the DOST 7 was 160 cu. m in August of 2010. When the ISWM facility of the DOST 7 was installed, dependence on MWCD water reduced to 40 cu. m as of May 2011 or a reduction of 75%.
- The facility controls flooding at the DOST 7 compound.
- Treatment of the wash and “grey” water allows the DOST 7 to comply with the requirements of the clean water law.
- The project serves as an inspiration to water policy makers in Cebu.
- The ISWM project provides a “proof of concept” those intending to emulate such facility.
- The facility also is a potent visual tool for the education of students on rainwater, stormwater and waste water management.

7. Financial Aspect:

The investment cost of the ISWM system is roughly P 2.0 M. However, investment cost would depend on the required capacity for the building based on the demand of the facility.

_Average monthly usage: 70 Cu.M./Month_

*Note:* This is based on DOST 7’s MCWD Water Consumption/Local Water Utilities
Annex 3

Integrated Stormwater Management Chart