From Toilets to Rivers

Experiences, New Opportunities, and Innovative Solutions

Asian Development Bank

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Acknowledgments

Following the 2nd ADB–DMC and Partners Sanitation Dialogue on May 2011, representatives from the Asian Development Bank (ADB), International Water Association (IWA) and United Nations Secretary General's Advisory Board on Water and Sanitation (UNSGAB)–Omega Alliance for wastewater revolution–agreed to develop a compendium of case studies of good practices, new approaches and working models on sanitation and wastewater management that could promote the acceptance of innovation and change, create fertile ground for reuse and applying technologies intelligently, demonstrate incentive and financing packages, and inspire investment uptake in wastewater management.

Maria Corazon M. Ebarvia was responsible for the compilation of case studies and project briefs, and prepared the introduction to each section. The project briefs were developed by Debbie Villa, Maria Corazon Ebarvia, Robert Domingo, and November Tan following the template agreed upon by ADB and IWA. IWA and its member organizations have contributed case studies/project briefs as part of its Urban Sanitation Initiative. The following helped in finalizing this publication: Anna Lissa Capili for editing, Anna Romelyn Almario for additional inputs, Ginojesu Pascua for layout and design. Publication support in terms of compliance review were ably provided by the team of Anna Sherwood, including Leonardo Magno, April Gallega, and Rodel Bautista.

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Background

There are 1.7 billion people in Asia and Pacific without access to improved sanitation—far behind the MDG target. Sanitation is central to the larger development agenda, but it remains to be one of Asia's principal socioeconomic challenges: social—because it deals with public health and human dignity; and economic—because of the tremendous losses from environmental and human impacts. Open defecation, inadequate sanitation facilities and discharge of untreated wastewater into water bodies threaten the health of local people as well as affect livelihoods, ecosystems, and water bodies, the latter of which we rely on for drinking, bathing, swimming, and fishing, among others. A paradigm shift is therefore required towards new approaches that include technological innovation, comprehensive package of financing, credit enhancement and delivery mechanisms, and performance-based and business-oriented solutions, and ensuring that investments are appropriate to the communities and industries they serve. More than ever, it is crucial to increase efforts to improve sanitation by 2015 and beyond. We need to identify doable solutions and opportunities, and agree on actions that will make sanitation happen. But neither of these two activities—identifying opportunities and committing to action—can happen without a solid knowledge base to work from.

The project briefs provide a synopsis of case studies from different countries, and demonstrate solution options from which useful lessons on sanitation management can be derived. The case studies were selected from existing publications, which can be referred to for more exhaustive discussion. Documentation was done following a template developed by the Asian Development Bank (ADB) and International Water Association (IWA). Each project brief provides an overview of the technology adopted, capital and operating and maintenance costs, financing mechanisms, institutional arrangements, and project outcomes.

While issues of sanitation are often looked at in isolation, they are directly tied to issues of water security, health, food security, environmental sustainability, energy and climate change. The case studies illustrate not only the challenges of sanitation and wastewater management, but more importantly, the proven results in:

(a) increasing access to sanitation in poor communities through on-site sanitation facilities, low-cost sewerage and decentralized wastewater treatment systems;
(b) improving service delivery through policy reforms, application of appropriate technologies, innovative financing mechanisms and contracts, and public-private partnerships;
(c) ensuring financial viability and sustainability; and
(d) reusing treated wastewater and sludge to augment water supplies for potable and non-potable uses, produce energy, and contribute to food security and greenhouse gas emission reduction.

This compilation of good practices and working models intends to show that sustainable sanitation is possible, and aims to inspire replication, institutionalization of sanitation both in policy and practice, and scaling up of investments. Given the more complex water resource and health challenges encountered in many parts of the world, it is time to engage in a rational analysis of all possible management strategies, learn from others' experiences, apply innovative approaches, and tap the potential market.

Abbreviations

A/O	– anaerobic/oxic (wastewater treatment process)
A2/O	– anaerobic/anoxic/oxic (wastewater treatment process)
ABR	– anaerobic baffled reactor
ABW	– automatic backwash
ADB	– Asian Development Bank
ADI	– Absolut Distillers, Inc.
AF	– anaerobic filters
APCF	– Asia Pacific Carbon Fund
ARWP	– Altona Recycled Water Project
AWHHE	– Armenian Women for Health and Healthy Environment
BAST	– baffled anaerobic septic tank
BASTAF	– baffled anaerobic septic tank and anaerobic filters
BDA	– Bhubaneswar Development Authority
BEST	– Institute for Integrated Social and Economic Development
BIWC	– Boracay Island Water Company
BMZ	– German Ministry for Economic Cooperation and Development
BOD	– biochemical oxygen demand
BOD_5	– five-day biochemical oxygen demand
BORDA	– Bremen Overseas Research and Development Association
BOT	– build-operate-transfer
BTDC	– Bali Tourism Development Corporation
CAPS	– Center for Advanced Philippine Studies
CAS	– conventional activate sludge
CBO	– community-based organization
CDM	– Clean Development Mechanism
CEDAC	– Cambodian Center for Study and Development in Agriculture
CENRO	– City Environment and Natural Resources Office
CER	– certified emission reduction
CHF	– Cooperative Housing Foundation
CIDS	– Cambodia Institute of Development Study
CIEDC	– Cambodia-India Entrepreneurship Development Center
CIFA	– Central Institute of Freshwater Aquaculture
CITYNET	– Regional Network of Local Authorities for the Management of Human Settlements
CMC	– Community Management Committees
COD	– chemical oxygen demand
CO_2	– carbon dioxide

CRUEIP – Central Region Urban Environmental Improvement Project
CW – constructed wetlands
CWW – City West Water
DAPH – Department of Animal Production and Health
Danida – Danish International Development Assistance
DBO – design-build-operate
DBP – Development Bank of the Philippines
DBSA – Development Bank of Southern Africa
DENR – Department of Environment and Natural Resources
DEWATS – decentralized wastewater treatment systems
DILG – Department of the Interior and Local Government
DMC – developing member country
DS – dry solid
EA – executing agency
EAST Viet Nam – Eau Agriculture et Sante en Milieu Tropical Viet Nam
ECOSAN – ecological sanitation
EMB – Environmental Management Bureau
EPA – Environment Protection Authority (in Victoria, Australia)
EPA – Environment Protection Agency (in Japan)
EPP – Ecosan Promotion Project
EWS – eThekwini Water Services
EU – European Union
FDEP – Florida Department of Environmental Protection
FIRR – financial internal rates of return
FMO – The Netherlands Development Finance Company
GDP – gross domestic product
GEF – Global Environment Facility
GERES – Groupe Energies Renouvelables Environnement et Solidarite
GHG – greenhouse gas
GIZ – Deutsche Gesellschaft für Internationale Zusammenarbeit
GTZ – Deutsche Gesellschaft für Technische Zusammenarbeit
HDPE – high-density polyethylene
HGF – horizontal gravel filter
HIVOS – Humanist Institute for Development Cooperation
HPMO – Hebei Project Management Office
HRT – hydraulic retention time

HSCS – Household Sanitation Credit Scheme
ICEF – India Canada Environment Facility
IDEA – intermittently decanted extended aeration
IEC – information, education and communication
IFAS – integrated fixed film activated sludge
IMO – International Maritime Organization
IMV – Institut des Metiers de la Ville
IPCOL – Investment Promotion Corporation of Orissa, Ltd.
IWA – International Water Association
JBIC – Japan Bank for International Cooperation
KOICA – Korea International Cooperation Agency
LGU – local government unit
LINAW – Local Initiatives for Affordable Wastewater Treatment Project
LITA – Linköpings Trafik AB
LLDA – Laguna Lake Development Authority
LRF – Federation of Swedish Farmers
MAFF – Ministry of Agriculture, Forestry and Fishery
MANTRA – Movement and Network for the Transformation of Rural Areas
MBBR – moving bed biofilm reactor
MBR – membrane bioreactors
MCGM – Municipal Corporation of Greater Mumbai
MDG – Millennium Development Goal
MF – microfiltration
MFRO – microfiltration-reverse osmosis
MHC – Ministry of Housing and Construction
MLIT – Ministry of Land, Infrastructure and Transport
MOA – Memorandum of Agreement
MOU – Memorandum of Understanding
MPW – Ministry of Public Works
MSC – Municipal Sewerage Company
MTSP – Manila Third Sewerage Project
MWCI – Manila Water Company, Inc.
MWSI – Maynilad Water Services, Inc.
MWSS – Metropolitan Waterworks and Sewerage System
MWSS-RO – Metropolitan Waterworks and Sewerage System Regulatory Office
NBK – National Bank of Kuwait

NBP – National Biodigesters Program
NCIC – Nanjing Urban Construction Investment Company
NDMD – Nanjing Drainage Management Department
NEDA – National Economic and Development Authority
NGO – nongovernment organization
NIMBY – "Not In My BackYard" syndrome
NMECD – Nanjing Municipal Engineering Construction Department
NMG – Nanjing Municipal Government
NRW – non-revenue water
O&M – operation and maintenance
PADCO – Planning and Development Collaborative International, Inc.
PBPO – Provincial Biodigester Program Office
PDA – Pilot and Demonstration Activity
PEMSEA – Partnerships in Environmental Management for the Seas of East Asia
PFK – Prudential Financial Inflation
PPP – public-private partnership
PPE – plant production envelope
PRC – People's Republic of China
PRISM – Project in Agriculture, Rural Industry Science and Medicine
PSA – Philippine Sanitation Alliance
PTA – Philippine Tourism Authority
PUB – Public Utilities Board
PWRF – Philippine Water Revolving Fund
RBC – rotating biological contactor
RO – reverse osmosis
SANAA – National Autonomous Water and Sewerage Authorities
SANIMAS – Sanitation by the Community Program
SBC – Security Bank Corporation
SBR – sequential batch reactor
Sida/SIDA – Swedish International Development Cooperation Agency
SLBE – small local business enterprise
SSP – Slum Sanitation Project
ST – settling tank
STP – sewage treatment plant / sludge treatment plant
SuSanA – Sustainable Sanitation Alliance
TA – technical assistance

TCEPC – Tianjin Capital Environmental Protection Company
TDI – Tanduay Distillers, Inc.
TIEZA – Tourism Infrastructure and Enterprise Zone Authority
TML – Tianjin Municipal Luanhe Drinking Water Source Protection Engineering
TNUIFSL – Tamil Nadu Urban Infrastructure Financial Services Ltd.
TPWWC – Tehran Province Water and Wastewater Company
TSC – Tehran Sewerage Company
TSC – Tianjin Sewerage Company
TSS – total suspended solids
TUHH – Hamburg University of Technology, Institute of Wastewater Management and Water Protection
TVAB – TekniskaVerken
UAE – United Arab Emirates
UDC – Utilities Development Company
UDD – urine diversion dehydration
UEBD – Executive Unit for Settlement in Development
UK-DFID – United Kingdom Department for International Development
UNDP – United Nations Development Programme
UNEP – United Nations Environment Programme
UNESCAP – United Nations Economic and Social Commission for Asia and the Pacific
UNICEF – United Nations Children's Fund
USAID – United States Agency for International Development
USEPA – United States Environmental Protection Agency
UV – ultraviolet
VWS – Veolia Water Services
WECF – Women in Europe for a Common Future
WEMC – Wuhan Environmental Monitoring Centre
WHO – World Health Organization
WMA – Wastewater Management Authority
WSB – Water Service Board
WSD – Water Supply and Sewerage Department
WSP – water service provider
WSTF – Water Services Trust Fund
WW&SE – Wastewater and Sanitation Enterprise
WWTP – wastewater treatment plant
XIM – Xavier Institute of Management

Weights and Measures

m^3	– cubic meter(s)
m^3/d	– cubic meter(s) per day
ha	– hectare(s)
hp	– horsepower
IG	– imperial gallon
km	– kilometer(s)
lpcd	– liters per capita per day
l/min	– liters per minute
MLD	– million liters per day
m	– meter(s)
mg/l	– milligram per liter
mm	– millimeter(s)
MGD	– million gallons per day
psi	– per square inch
km^2	– square kilometer(s)
m^2	– square meter(s)
t/day	– ton per day

Currency Units

A$	– Australian dollar
CNY	– yuan
D	– dong
€	– euro
KES	– Kenyan shilling
KWD	– Kuwaiti dinar
P	– Philippine peso
Rs	– Indian rupee
S$	– Singapore dollar
Tk	– taka
¥	– yen

Improved On-Site Sanitation: A Business Case

By the end of 2011, there were 2.5 billion people who lacked access to an improved sanitation facility. Of these, 761 million use public or shared sanitation facilities and another 693 million use facilities that do not meet minimum standards of hygiene (unimproved sanitation facilities). The remaining one billion still practise open defecation. The majority (71%) of those without sanitation live in rural areas, where 90% of all open defecation takes place. [1]

While public or shared sanitation facilities are not considered as 'improved' sanitation, these facilities nevertheless provide a means to end open defecation. Evidence supports sharing of facilities when they are shared among a small group, or in places where individual household toilet is not possible (e.g., in slum areas). Instances of shared facilities or public toilets are in schools, public markets, transportation terminals, etc. The key is to keep these shared facilities clean and safe. In addition to addressing concerns on health and dignity, some types of toilets provide opportunities for recycling, biogas production, and entrepreneurship.

In Armenia, the ecological sanitation (ecosan) project provided an affordable option to upgrade school sanitation. It serves as an example of how sanitation in schools and rural areas without any connection to sewer systems can be improved.

The community sanitation centers in Tangerang, Banten, Indonesia and the toilet blocks in Naivasha, Kenya include toilets, bathroom/shower areas, water kiosk, wastewater treatment and biogas digester. In Mumbai, India, the toilet blocks are connected to septic tanks or the sewerage system. User fees are collected in these community toilet blocks to recover the operating and maintenance (O&M) costs, as well as provide income to the operators of the facilities. The main difference between a public toilet and a community toilet block is that the latter belongs to a specific community of users, and is generally not for public use.

Sulabh has adopted a pay-and-use approach to maintain community sanitation complexes that were constructed to cater to the poor and low-income sections in many cities in India. The project proves that poor, slum communities are willing to pay for improved water and sanitation services, hence, such operations can be financially viable. Some Sulabh toilets are connected to biogas digesters, while some are connected to low-cost wastewater treatment plants, such as the duckweed-based system. The duckweed-based system also provides financial returns from pisciculture.

Both the ikotoilets and ecosan toilets involve urine diversion, and the recycling of water and nutrients contained within human wastes back into the local environment. Some farmers with ecosan toilets became entrepreneurs selling income-generating organic vegetables. In Kenya, the ikotoilets and shower sanitation centers also serve as sites for community activity. By providing complementary services, (e.g., kiosks, snack shops, shoe shines, barber shops, and newspaper stands) ikotoilets became a multi-use community space—a "toilet mall." The profits from these business activities and from advertising provide revenue streams to recover the cost of construction and maintenance of the sanitation centers.

These case studies show that such business-oriented solutions create incentives for investing in sanitation, and making them sustainable.

[1] Source: WHO and UNICEF. 2013. Progress on sanitation and drinking-water: 2013 update.

Project briefs:

- Ecosan Toilets in Rural Schools: Hayanist, Armenia
- Community Sanitation Center: Tangerang, Province of Banten, Indonesia
- Toilet Blocks with Biogas Plants: Naivasha, Kenya
- Slum Sanitation Project: Mumbai, India
- Transforming Society through Sanitation Movement: India
- Ikotoilets: Thinking Beyond a Toilet: Kenya

Ecological Sanitation (Ecosan) Toilets in Rural School

Hayanist, Armenia

Waterless urinals (AWHEE, 2006)

Ecosan UDD toilet (AWHEE, 2006)

Hayanist is located 12 km southwest of the capital Yerevan, and is situated in a basin-shaped area with swampy soil and high groundwater table. A network of open drainage channels made up of small and shallow drainage canals along each street cover the area. Majority of the households use pit latrines as sanitation system, the liquid of which often infiltrates the ground. Households with a flush toilet, on the other hand, discharge wastewater to a drainage canal without any benefit of treatment; and at times, discharged wastewater is used for irrigation purposes.

To address the common problem of inadequate school sanitation in rural areas, the Hayanist village, with approximately 2,500 inhabitants, has been chosen for an ecological sanitation (ecosan) pilot project. The pilot project applied a decentralized solution given the village's lack of capacity to shoulder the costs associated with the operation and maintenance (O&M) of a centralized sewerage system.

Technology option

- The urine diversion dehydration (UDD) technology was chosen during stakeholder consultations, where presentations of different toilet systems and a scale model of a urine diversion toilet were provided.
- A local architect, in cooperation with the Hamburg University of Technology, developed the design of the UDD toilet block. The design aims to provide sufficient number of toilets using minimal space and walls to save on expensive construction materials.
- Constructed as an extension of the existing school building, a toilet block was built with 7 male and female toilet cubicles (double-vault UDD squatting pans), 3 waterless urinals, and 6 washbasins.
    - Urine (from boys and girls) is separately collected and stored.
    - The two feces vaults of a toilet unit have urine diverting squatting pan each.
    - The urine storage tanks are located in the basement of the toilet building.
    - Double-vault UDD toilets were selected to collect and store feces for better hygiene and safety. Considering that urine collected from healthy persons is almost sterile, separation of urine and feces is maintained as most pathogens are found in the feces. It should be noted however, that the possibility of cross contamination (feces to urine) could not be completely eliminated.
- A wind-driven ventilator is provided for adequate ventilation.
- There were six washbasins installed for hand washing. Water for these washbasins are

sourced from local artesian wells. They are also stocked with towels and soap. The resulting greywater flows into the existing sewage pipes (without treatment).

- Reuse: Urine is stored for approximately 6 months before the school director used the urine as fertilizer for the barley field. This is in accordance with the World Health Organization (WHO) "Guidelines for the safe use of wastewater, excreta and greywater" (2006).

Institutional and Management Arrangements

- The Armenian Women for Health and Healthy Environment (AWHHE) is the executing agency, in close coordination with the Women in Europe for a Common Future (WECF) of Netherlands.
- Quelque-Chose Architects, a local company, developed the technical design of the UDD toilet block, in cooperation with the Hamburg University of Technology, Institute of Wastewater Management and Water Protection (TUHH).
- The Ministry of Foreign Affairs of Netherlands extended funding support.
- A trained personnel was hired to carry out (O&M) activities, i.e., inspection and cleaning of toilets on a daily basis.
- Women and Village Committees were established to mobilize the community.
- Children were involved in awareness-raising campaign through innovative artistic approaches (i.e., ecogames, exhibitions, and creation of a book).

Financing Arrangements

- The cost of the new toilet block is estimated to be around €28,740–approximately 70% was allotted for construction materials, and 30% for the design, labor, education and training.
- The Ministry of Foreign Affairs of Netherlands provided 70% of the total costs.

Project Outcome

- Cases of contamination of surface water, open drainage channels and groundwater with pathogens and nitrates were significantly reduced.
- A sustainable, affordable and safe school sanitation system was established, which was well accepted by students and teachers alike.
- No cases of helminths were recorded after project completion and operation.
- UDD toilets were installed in 3 other schools and 25 private households (partially financed by owners) in other Eastern European, Caucasus, and Central Asian countries.
- Increased awareness among politicians (both high and low administrational levels), resulting in financial support for more sustainable sanitation projects.
- The project served as an example of how sanitary conditions in rural areas without any connection to sewer or piped water supply systems can be improved.

Contact for More Information

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Community Sanitation Center

Tangerang, Province of Banten, Indonesia

Community toilet block with biogas digester (Source: RTI International)

Tangerang is a city in the Province of Banten, Indonesia. It is located about 25 km west of Jakarta. The urban slum areas in Tangerang City are mostly settlement areas without infrastructure and services, such as clean water supply and solid waste management. In order to address the need for sanitation services in many of these settlements, the Institute for Integrated Social and Economic Development (BEST) initiated Community Sanitation Centers that consist of low-cost community toilets and gas retrieval systems.

Technology option

- The community sanitation centers aim to provide basic sanitation facilities, such as bathrooms (six units), a wash area, a water point, and a wastewater treatment plant and biogas digester.
- Each sanitation center has a maintenance operator to oversee the day-to-day operations.
- BEST monitors toilet conditions, building and surrounding areas, water supply, etc., as well as conducts a Consumer Satisfaction Survey to get feedback from the consumers on the service provided. The survey includes questions on water quality and services.

Institutional and Management Arrangements

- BEST, the main actor of the project, coordinates and manages project resources.
- Donor agencies provided seed funding for the construction of the center. A Joint Cooperation Agreement was signed between BEST and international donor agencies for the construction of each sanitation center.
- The local government of Tangerang provided funding for the construction of seven centers and facilitated the implementation of the project by allowing the construction and operation of centers without permits.
- A Memorandum of Understanding (MOU) was signed between the individual communities and BEST, affirming the willingness-to-pay of the former for the facilities provided.
- The operators of the centers are families from the community. They are paid a basic salary by BEST, and take part in the profits. Each operator signs an individual contract with BEST.

Financing Arrangements

- The construction of each community sanitation center (land acquisition, construction —including a wastewater treatment plant and biodigester, and the purchase of a water pump) is fully subsidized by a grant from donors. Running costs, such as operations and routine maintenance, are generated and covered from user fees.
- BEST relies on other sources of funding because not all its staff costs for servicing the centers are covered by revenues.

Project Outcome

- There are 29 poor community settlements throughout Tangerang and Surabaya that gained access to toilet facilities and clean water and sanitation.
- Awareness on the importance of sound sanitary practices increased, while the cost of water was lowered by 60% compared to that of private water vendors.
- Community health improved.
- Land values in areas surrounding the centers have increased, and new sources of income were created for small businesses.
- There was a change in attitudes and behavior of communities, such that communities now feel encouraged to tackle other community problems like improving drainage systems and local roads.

Contact for More Information

Hamzah Harun Al Rasyid, Director, Institute for Integrated Social and Economic Development

Toilet Blocks with Biogas Plant

Naivasha, Kenya

Sanitation facility with water kiosk. Underground biogas plant in front (Source: Sustainable Sanitation Alliance)

Area of top manhole, above the biogas fixed dome (Source: SuSanA)

Naivasha is a small town located on the shores of Lake Naivasha, about 80 km north of Nairobi, the capital of Kenya. The town covers an area of 30 km^2, and has a population of approximately 70,000 people. The town relies mainly on pit latrines, with less than 5% of households and businesses connected to the sewer system. The sewer systemis linked to a poorly functioning wastewater treatment plant.

The project focused on improving the living conditions by providing hygienic and environmentally friendly sanitation solutions with reuse of the human waste. It also aims to provide a business-oriented solution that creates economic incentives for the water sector institutions to invest in sanitation.

Technology option

- The toilet block comprises of toilets, hand-wash basins, urinals, a shower, and a water kiosk. The wastewater from the facility is drained into an underground biogas plant to treat the wastewater anaerobically.
- Biogas plant:
  - The biogas has two outputs: treated effluent (continuous flow) and sludge (emptied once per year)
  - The biogas plant has a volume of 54 m^3 with two expansion chambers with underground structure at 0.5m below the ground surface.
  - Design parameters: 1,000 users per day; dimensions were based on hydraulic retention time (HRT) of 5 days.

Institutional and Management Arrangements

- The Water Service Board (WSB) planned the toilet block in partnership with the local water service provider and the municipal council of Naivasha in early 2007. The EU-SIDA-GIZ EcoSan Promotion Project (EPP), the Water Services Trust Fund (WSTF), the Rift Valley Water Service Board, the municipal council of Naivasha, and the water service provider formed a project task force that jointly developed the sanitation concept.
- The water service provider trained and licensed the operation of the facility to Banda Livestock Self Help Group, a community-based organization, to maintain the toilet block on a renewable one-year contract. The same also agreed to monitor the operation of the facilities on a weekly basis in order to identify any maintenance requirements.

Financing Arrangements

Capital investment

- The investment costs for the entire project (€25,000) was financed through a grant from the European Union (EU)—ACP EU Water Facility, Swedish International Development Corporation Agency (SIDA), Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ), formerly known as German Technical Corporation (GTZ), and WSTF (supported by the Kenyan Government).

Cost recovery

- The use of the Naivasha Public Toilet carries a fee of KES5 (€0.05) per use; shower costs KES10 (€0.1) and a 20–22 litre jerry-can of water costs KES2 (€0.02).
- These tariffs were proposed by the water service provider.
- The WSB (asset holder) and the Water Service Regulatory Board (regulator) are the ones responsible for adjusting the tariffs, if required.

Project Outcomes

- After a year of operation, the toilet blocks are delivering convenient, safe and affordable sanitation services. In 2010, the toilet block had approximately 9,000 users per month, and has drastically improved the hygienic conditions in Naivasha, and also provided an income to the operator and the water service provider.
- The project was the first sanitation project of the WSTF, which served as a learning facility for various stakeholders, and also paved the way for further improvement of the facility design and implementation. The WSTF has since then developed an improved public sanitation design with a toolkit. This is being up-scaled in Kenya.

Slum Sanitation Project

Mumbai, India

Greater Mumbai hosts a population of more than 16 million. Prior to the Slum Sanitation Project (SSP), sanitation improvement schemes for the slum dwellers were implemented by the Municipal Corporation of Greater Mumbai (MCGM) through a supply-driven approach. Subsequently, 80% of publicly constructed toilet blocks were found to be not functioning, and thus, incapable of meeting the demand. These facilities were also putting pressure on public finances since the MCGM was responsible for all maintenance costs. Taking this into consideration, it was deemed necessary to develop an appropriate strategy for improving sanitation facilities to meet the needs of slum dwellers on a more sustainable basis.

Pour-flush toilet (Source: IWA)

Toilet block (Source: IWA)

Toilet block (Source: Water and Sanitation Program)

Technology option

- The toilet blocks comprise of bathing cubicles, urinals and squatting platforms for defecation. The main difference between a public toilet and a community toilet block is that the latter belongs to a specific community of users, and is generally not for public use.
- Wastewater from the toilet blocks is discharged either into the municipal sewerage network or through septic tanks, when connection to a sewer is not feasible.

Institutional and Management Arrangements

- Participation of nongovernmental organizations (NGOs) and community-based organizations (CBOs) in all key aspects of project preparation and implementation was a cornerstone of the project design. The MCGM managed the bidding process, and contracted NGOs to undertake a range of activities according to specified standards of performance related to cleanliness and access to facilities.
- Memorandums of Understanding (MOUs) were signed between the MCGM and each of the CBOs or small local business enterprises (SLBEs) responsible for management of the toilet blocks.
- The MOU ensured that CBOs/SLBEs were held responsible for the O&M of the blocks, while the MCGM retained the right to evaluate the performance of these entities over time, and if need be, cancel the contract and offer to a different CBO/SLBE in case of unsatisfactory performance.

Financing Arrangements

Capital investment

- The total capital investment cost ($28 million) was borne by MCGM under a loan from the World Bank, which covered 60% of the costs.
- Prior to the construction of toilet blocks, the residents paid an upfront contribution between Rs100-Rs500 ($2.25–$11). This contribution was used to finance the upgrade and rehabilitation of the toilets.

Cost recovery

- The cost recovery policy was applied through monthly payment of Rs30 ($0.67) per family, whereas people without monthly passes (visitors) pay Rs1 ($0.02) per usage.

Project Outcomes

- Over 328 toilets blocks and more than 5,100 toilet seats have been constructed in the slum areas across Mumbai under SSP.
- The localised management arrangement installs a sense of ownership within communities, which translates into greater responsibility for O&M of the assets.
- Stakeholder involvement in the SSP was successful as a result of a learning-by-doing approach.
- The SSP provided a solid foundation for a new paradigm in the provision of sustainable sanitation services in Mumbai, shifting the focus away from a supply-driven and capital-intensive toilet construction approach to one that provides incentives to multiple stakeholders acting collaboratively for a more durable O&M regime to help ensure improved access and quality services.

Transforming Society through Sanitation Movement

India

Sulabh Two-Pit-Pour-Flush Toilet (Source: B. Pathak)

In India, 360 out of 1,000 million people used either dry latrines, which were manually cleaned by scavengers who carried excreta away with their hands, or just defecated in an open area. The lack of latrines caused many health problems, including the death of nearly 1.9 million children each year due to diseases, such as dysentery, hookworm or cholera. This staggering mortality rate was due to the lack of safe human waste disposal system. Low sanitation coverage in India was primarily due to insufficient motivation and awareness of the people, and lack of affordable sanitation technology.

Technology option

- The Sulabh Two-Pit-Pour-Flush Toilet technology is an indigenous, eco-friendly, technically appropriate, socio-culturally acceptable, and economically affordable technology. It consists of a pan with a steep slope of 25–28 degrees and a trap with 20-millimeter water-seal requiring only 1.5 to 2 liters of water for flushing. The Sulabh toilet does not need scavengers to clean the pits. There are two pits of varying size and capacity, depending on the number of users, these are designed for 3 years usage. Both pits are used alternately. When one pit is full, incoming excreta is diverted into the second pit. In 2 years, the sludge gets digested, and is almost dry and pathogen-free, thus, safe for handling as manure, which can then be used as a soil-conditioner.
- In some areas, biogas is produced from the human excreta to electrify homes. The Sulabh biogas technology process includes filtration of effluent through activated charcoal and the use of ultraviolet rays.
- Some of the ponds and ditches requiring wastewater treatment use duckweed technology. Duckweed aquatic plant greatly reduces biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, bacteria and other pathogens from wastewater. Small pilot projects were implemented to clean up ponds and ditches to show gains in economic returns from pisciculture.

Institutional and Management Arrangements

- Sulabh collaborated with State governments. This collaboration brought about an acceptance of Sulabh work to the people, and brought it to a meaningful scale of operations.
- State governments also conducted house-to-house contact and campaigns in the local language to uplift scavengers from their sub-human conditions using the Sulabh toilet system.

Financing Arrangements

- Financing of the Sulabh toilets are mainly from the local State governments. The local body provides for the cost of construction of the toilet complex. Sulabh does not depend on external agencies for financing as it is generated through internal resources.
- The maintenance of toilets and day-to-day expenses are taken from the user's payments. A pay-and-use system is utilized to maintain community toilets in many parts of the country, including 25 States, 4 Union Territories, and 1,075 towns and metropolitan cities, such as Delhi, Bombay, Calcutta, and Madras. However, not all public toilet complexes in the slums and less developed areas are self- sustaining. Thus, maintenance of such toilets is cross-subsidized from the income generated from busier toilet complexes in the urban and developed areas.

Project Outcomes

- To date, some major outcomes and impact of Sulabh's initiatives include: (i) 1.2 million Sulabh household toilets constructed, resulting in open defecation-free areas; (ii) 190 human excreta-based biogas plants; (iii) 640 towns made scavenging-free; (iv) 7,000 scavengers trained and resettled, thereby uplifting the social status of so-called 'untouchables'; and (v) over 10.5 million people using Sulabh facilities every day.
- Sulabh's collaboration with the State Governments helped influence policy and make sanitation part of the national mandate.

Ikotoilets: Thinking Beyond a Toilet

Kenya

In Kenya, it is expected that the population will reach 42 million by the end of 2011 with 65% of this population residing in slums. The investment by the government in public sanitation facilities in Nairobi has been almost nonexistent for the past 30 years, and as a result, sanitation facilities have been characterized by overcrowding and poor maintenance with inaccessible and unhygienic conditions.

Ikotoilets as a multi-use community center—a "toilet mall." (http://bit.ly/18Zpzac)

Ikotoilet urine-collection system, City Park, Nairobi, Kenya (http://bit.ly/1ixvF7z)

The Ikotoilet is an innovative solution to the growing environmental sanitation problem in Kenya. This is based on an enterprise model by a company named Ecotact. This initiative extends from offering sanitation services to a range of complimentary business services, such as kiosks, barber shops, etc.

Technology option

- Ikotoilet is a complete toilet facility with a separate area for men and women, integrated with a low-flush system.
- The system is constructed such that the urine is collected separately for reuse, and rainwater is collected and stored in tanks to be used as alternative water supply.

Institutional and Management Arrangements

- Ecotact is a Nairobi-based company established in 2008 to improve the urban landscape for low-income communities through a build-operate-transfer (BOT) model of public-private partnership (PPP).
- Ecotact signed a long-term contract with municipalities to use public land and, in return, the same bears all the construction costs, and operates the facilities for 5 years. However, it relinquishes ultimate ownership of the facilities to the municipalities, who can decide whether to extend their contracts with Ecotact.

Financial Arrangements

Capital investment

- The capital cost for this project was funded by Ecotact with the support of the Acumen Fund, the Global Water Challenge, and the World Bank.

Capital recovery

- The cost recovery policy applied was a user fee of KES5.00 ($0.06), complemented with advertising revenues from clients who use the Ikotoilets premises for their publicity, and from the rent derived from leasing out space to micro-entrepreneurs (who operate their businesses in the 'mall' areas).

Project Outcomes

- By the end of 2010, 29 units of Ikotoilet have been installed across 12 municipalities, inclusive of two Ikotoilets in the slums of Mathare and Kawangare, which served more than 5 million users in 2010.
- A new standard of hygiene in target communities has been achieved, reducing environmental health risks, and restoring dignity with the provision of sanitation services.
- Sustainability of Ikotoilets is enhanced through youth training programmes that provide sufficient management skills to prepare them to eventually run these facilities as entrepreneurs.

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Decentralized Wastewater Treatment Systems for Public Markets and Peri-urban Areas

The decentralized concept of wastewater management aims to provide a framework for developing "alternative" systems consisting of a variety of approaches for collection, treatment, and dispersal/reuse of wastewater. It goes beyond merely managing individual user systems. Effluent from individual dwellings, industrial or institutional facilities, clusters of homes or businesses, public markets, and entire communities may be routed to further treatment processes in smaller facilities that are closer to the sources. They provide a range of treatment options from simple, passive treatment (such as septic tanks with soil dispersal) to more complex and mechanized approaches (such as rotating biocontactor, membrane bioreactor, moving bed biofilm reactor, etc.), as well as less complicated systems like the anaerobic baffled reactor. An evaluation of site-specific conditions should be performed to determine the appropriate type of treatment system for each location.

The six project briefs highlight how decentralized wastewater treatment systems can be sustainable and appropriate options for communities and homeowners. The technologies selected to best showcase these treatment systems are: (a) rotating biological contactor for the public market in Lilo-an (Cebu, Philippines); (b) anaerobic baffled reactor for the public markets in Muntinlupa City (Philippines) and Manjuyod (Philippines), and peri-urban areas in Hanoi (Viet Nam) and Denpasar (Bali, Indonesia); and (c) ecotanks for slum areas and coastal tourism area in San Fernando City (La Union, Philippines). Decentralized wastewater systems in these sites have been demonstrated to be cost effective, economical and reliable solutions to meet public health and water quality goals as well as offer opportunity for water reuse. Awareness-raising activities and consultations with stakeholders ensured social acceptability and active participation.

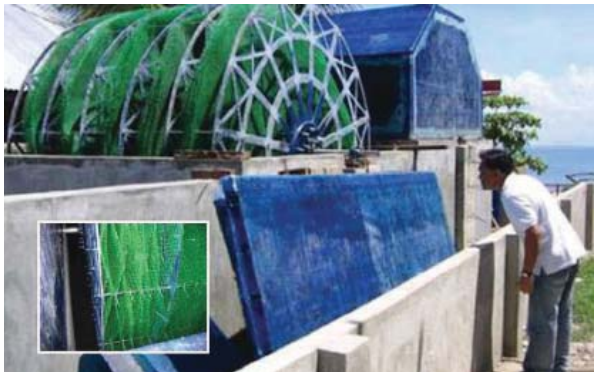
It should be noted, nonetheless, that the decentralized concept will not be the answer to all wastewater management problems. Likewise, centralized systems are not the only appropriate approach. We have to go beyond the "one size fits all" mentality. The many potential benefits of decentralized systems indicate that it is a method, which deserves much greater attention, especially in smaller communities, rural areas and the developing urban fringe, where the alternative decentralized strategy makes the best sense.

Project briefs

- Treating Wastewater to Protect Coastal Waters: Lilo-an, Cebu, Philippines
- Customizing a Decentralized Sanitation Solution for Viet Nam's Peri-urban Areas: Kieu Ky Commune, Ha Noi, Viet Nam
- Community-based Sanitation (SANIMAS): Denpasar, Bali Province, Indonesia
- Reusing the Public Market's Treated Wastewater: Muntinlupa City, Metro Manila, Philippines
- Decentralized Wastewater Treatment System for Manjuyod Public Market: Manjuyod, Negros Oriental, Philippines
- "Eco Tanks" for Seaside Communities: San Fernando City, La Union, Philippines

Treating Wastewater to Protect Coastal Waters

Lilo-an, Cebu, Philippines



Rotating biological contactor installed in the public market in Lilo-an, Cebu. (Source: ADB)

Lilo-an, a third class municipality in the province of Cebu, has a population of approximately 70,000 people. The town has been suffering from deteriorated coastal water quality with high coliform cell counts, the largest source being wastewater from the Lilo-an public market. Although the public market has a septic tank, it was deemed insufficient. Because of the poor quality of water, the town's tourism industry dropped dramatically.

The Philippine Clean Water Act (2004) suggests that local governments construct a centralized wastewater treatment system with an extensive collection system. Unfortunately, Lilo-an could not afford to do so. Thus, a decentralized wastewater treatment, which was far less expensive, was considered to be more suitable for the municipality.

Technology option

- *Wastewater treatment*. A wastewater treatment facility based on a rotating biological contactor (RBC) was constructed. Wastewater is collected via two sewerage lines. After screening, the water is directed to an underground collection tank where it will be pumped vertically to an overhead wastewater tank. From the overhead tank, the water reaches the RBC tanks via gravimetric flow. There are two RBC tanks operated by one unit of 1-hp motor at a rotating speed of one rotation per minute. The average retention time of the wastewater inside the two RBC tanks is 10 hours if the operation mode is continuous. After the RBC treatment process, the water is directed to a cloth filter tank, which then overflows to the final holding tank. From there, the water can be recycled or directed to a discharge pipe for disposal.
- *Sludge treatment*. The public market's old three-chamber septic tank was used for sludge treatment. Sludge, accumulated at the bottom of the RBC tank, is directed to the first chamber of the septic tank via separate sludge return pipes. The tank then acts as an anaerobic stabilizer for the treatment facility's surplus sludge. Once the third chamber fills up, wastewater pumps are activated to direct the liquid back to the overhead tank, and thus, to the RBC. This completes a closed loop system for sludge management.

Institutional and Management Arrangements

- The Municipal Government is owner of the plant.
- Lilo-an Community Multi-Purpose Cooperative maintains and operates the treatment plant.
- The Department of Environment and Natural Resources - Environmental Management Bureau (DENR-EMB) Region 7 monitors wastewater effluents discharged into bodies of water.

Financial Arrangements

- The project was funded by a grant from ADB.
- A cost recovery scheme, focusing on user fees, was implemented to cover the O&M costs, and ensure viability and sustainability of the project.

Project Outcomes

- A significant improvement on removal efficiency, with over 99.8% for total coliform and 97.8% for fecal coliform bacteria.
- Biochemicall oxygen demand (BOD) and chemical oxygen demand (COD) removal was also satisfactory.
- A removal of about 3.35% of ammonia was noted, as was phosphorus removal of about 18%.

Customizing a Decentralized Sanitation Solution for Viet Nam's Peri-urban Areas

Kieu Ky Commune, Ha Noi, Viet Nam

During construction of the anaerobic baffled reactor (Source: ADB)

Baffled anaerobic septic tank and anaerobic filter (Source: ADB)

Kieu Ky Commune is a peri-urban commune of the Ha Noi Capital District. Located 20 km downstream from the city center, it is directly affected by the polluted urban wastewater draining down from the city. The commune's primary economic activities are traditional crafts, such as gold leaf production, which use inefficient production processes that can further contribute to environmental air and water pollution. Wastewater from the craft industry in Kieu Ky Commune polluted the rice fields via irrigation canals. The residents consequently suffered from sanitation-related problems (e.g., contaminated drinking water, skin allergies, and foul-smelling rivers with dead fish). Though septic tanks and dry latrines exist in the commune, these facilities are not effective in treating wastewater.

ADB, together with the Ha Noi People's Committee and EAST (Eau Agriculture et Sante en Milieu Tropical) Viet Nam, managed a pilot and demonstration activity to find a sanitation solution for the people of Kieu Ky. The project had three main components: (i) identify appropriate options for domestic wastewater collection and treatment; (ii) select appropriate wastewater collection and treatment system for the craftwork shops; and (iii) implement a pilot wastewater treatment plant.

Partnership funding and technology was secured from ADB's Pilot and Demonstration Activities (PDA) fund, which aims at promoting effective water management policies and practices at the regional level, as well as from the Institut des Metiers de la Ville (IMV) and the Bremen Overseas Research and Development Association (BORDA), whose modular, decentralized, and cost-effective wastewater treatment packages that they have termed "DEWATS" (decentralized wastewater treatment systems) were used for this project.

Technology option

Septic tanks of 60 pilot households were connected to a decentralized wastewater treatment facility, which was designed to treat 40 m^3/d of wastewater, and comprised of the following components:

- Gravity-fed sewer: It consists of small-bore piping installed for each connected household to carry its septic tank effluent and greywater to the DEWATS.
- Primary settling unit: It serves as a wastewater retention point and an area for control of influent fluctuations (an equalization tank), which allows any large sludge, debris and other floatable and visible wastes to settle or be screened out.
- Anaerobic baffled reactor (ABR): An upgraded baffled anaerobic septic tank (BAST) that uses static devices to regulate the flow of fluids, forcing wastewater to flow from the inlet to the tank outlet.
- Anaerobic filters (AF): Particles and dissolved solids are trapped, organic matter is degraded, and pathogens and chemicals in the wastewater are removed by the bacterial biofilm in the filters.
- Horizontal gravel filter (HGF) and constructed wetlands: The vegetated soil filter (or reed bed) is used to further treat wastewater by copying the natural purification abilities of wetlands. The plant roots within the gravel help to oxygenate the wastewater. This oxygenation helps to degrade remaining organic pollutants and reduce the odor.

- Discharge pipe: After the HGF, the effluent is usually considered clean enough for discharge to a nearby creek or canal.

Institutional and Management Arrangements

- EAST Viet Nam is the main executing agency for the entire project; while BORDA (through provision of its DEWATS technology), the contractor (No. 5 Assembly Construction and Investment Joint Stock Company), and the District and Commune People's Committees of Kieu Ky all served as cooperating agencies.
- EAST Viet Nam: The French NGO managed project activities; provided all information needed to help BORDA design the wastewater treatment plant; and contracted a construction company for the pilot plant construction.
- Bremen Overseas Research and Development Association (BORDA): The German NGO was responsible for the layout and design of the treatment plant. BORDA worked with EAST in establishing and proposing a financing and operational mechanism for the O&M of the treatment plant. BORDA also provided O&M training for the village head and the appointed facility operator.
- Supervision Team: BORDA contracted a private supervisor for the project, as well as local supervisors to represent the community. The local supervisors ensured that the community was involved during the construction process to avoid conflicts, and give the community a sense of ownership for the treatment facility.
- Kieu Ky Commune: The commune manages the completed facility and piped network. The head of the commune is in charge of collecting a monthly fee from each household; contracting a sanitation professional company when required (sludge removal, filter cleaning, etc.); and deciding on how to further develop the sanitation infrastructure. A facility operator was appointed by the commune to handle small technical maintenance work, and ensure continuous system operation.

Financial Arrangements

- ADB PDA grant of $50,000 covered all of the research, analysis, surveying, and outreach tasks of the project. BORDA Viet Nam then supplied an additional $14,000 towards the DEWATS portion of the project, and IMV also provided $7,000. The total project cost for all parties was $71,000.
- Materials and construction costs: $31,000. (ADB = $10,000; BORDA = $14,000; IMV = $7,000)
- Monthly fee from each household: $0.30. (This cost covers the facility operator's salary and short/midterm O&M costs.)
- The People's Committee covers the costs of desludging the system every 2 to 3 years.
- The Kieu Ky Commune will need to raise money to finance cost of fixing future equipment damages.

Project Outcomes

- Through the project, it was determined that DEWATS, when combined with a baffled anaerobic septic tank and anaerobic filters (BASTAF) and constructed wetlands (CW), is one of the preferred sanitation solutions for Kieu Ky.
- Initial monitoring results showed that the facility removed up to 98% of BOD and 96% of COD, and meets the water quality standards (TCVN 5945–2005). However, proper assessments of the commune's current environmental and sanitary situation require samples taken regularly over a longer period of time.
- The project showed that raising community awareness, to encourage hygienic and environmental behavior improvement, is critical to the project's sustainability. People were willing to pay when they understood the benefits gained from collective sanitation services.
- Some limitations recognized by the project: Technical difficulties in connecting households to piped network, and the need for bigger resources to increase the number of households connected to the treatment facility.
- Practical application of this PDA is expected in the Provincial Water Supply and Sanitation Project for Thua Thien Hue Province and the Central Region Rural Water Supply and Sanitation Project.

Contact for more information

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Community-Based Sanitation (SANIMAS)

Denpasar, Bali Province, Indonesia

During construction (Source: Yuyun Ismawati)

Road with manholes for the sewer system (Source: Yuyun Ismawati)

The lack of proper septic tanks for about 80% of rooms or houses in Kusuma Bangsa, West Denpasar District, leads to a discharge of wastewater to a nearby stream. Floods cause the stream to push wastewater and rubbish back into houses. The residents, especially children below five years old, suffer from a high rate of diarrhea and other waterborne diseases due to the lack of proper sanitation and frequent flooding. In a neighborhood where monthly family income ranges from $44 to $167, the cost of constant treatment for these diseases becomes a burden. Indonesia's Sanitation by the Community Program (SANIMAS), which uses a community-based development approach, implemented a project in 2004–2005 that would provide sanitation services for 840 people in Kusuma Bangsa.

Technology option

- The community chose a simple BORDA-designed DEWATS to treat about 60 m^3 of blackwater and greywater per day.
- There were 67 household connection boxes, functioning as grease-trap units; 200 control boxes or manholes; simple sewage pipes from houses; an ABR with no electricity inputs; a drainage system next to the plant; and an electric pump to provide effluent discharge back-up during floods. These were all installed during the project.

Institutional and management arrangements

- Community-Based Organization (CBO): The CBO has legal ownership of the infrastructure, organizes meetings, identifies beneficiaries, compiles action plans, manages funds, and mobilizes people to support and participate in the project. Together with an appointed operator, who collects user fees from participating households, the CBO ensures the system works properly and takes care of minor repairs. The municipality assumed responsibility for major repairs.
- BORDA and BALIFOKUS: A German NGO (BORDA) worked through a local NGO (BALIFOKUS) to find a technical solution for the community after a needs assessment and is responsible for taking effluent samples to monitor the wastewater quality every 6 months.
- Community Action Plan Book: The CBO and BALIFOKUS compiled into one book all the plans and anticipated activities for construction fund management, sustainable cost coverage for O&M, and system and services maintenance. It was signed by all parties involved. The community used the book as a tool to submit fund disbursement requests to contributors, such as government agencies.
- Project Joint Account and Financial Report: A joint account was opened at a local bank to manage the multisourced project funding. Withdrawals required approval from all three account signatories. CBO managers and treasurers were trained by BALIFOKUS and BORDA to compile simple financial reports and receipts, which were submitted to all parties in the same financial report at the end of the construction stage.

Financing Arrangements

- Total cost of implementation, construction, and capacity building: $39,814 (multisource financing).
- User fee collected from 211 households per year: $1,406.67.
  - O&M cost per year (including solid waste collection): $827.78.
  - The CBO uses the $578.89 profit to fund other infrastructure improvements within the neighborhood.

Project Outcomes

- High level of contributions from the community resulted in solid waste collection service with new sanitation service, improved pathways, and excess funds in the community account.
- Residents enjoy better health, reduced health expenses, a cleaner neighborhood, and groundwater that is better preserved. Women no longer worry about floods and backwash during the rainy season. Children suffer less from diarrhea and are safer using the new concrete paths.
- The community's empowerment through increased awareness on health and hygiene issues gave them the confidence to lobby for initiatives to further improve the area.
- The DEWATS plant, which can treat domestic wastewater to standards set by environmental agencies, requires only simple, low maintenance approaches and procedures. User fees are reasonable for the poor and cover all O&M costs.
- Provision of off-site sanitation for 211 households, benefitting around 840 people.

Contact for more information

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Reusing the Public Market's Treated Wastewater

Muntinlupa City, Metro Manila, Philippines

Wastewater in the anaerobic baffled reactor (Source: USAID-LINAW Project)

Treated water is reused for street cleaning and flushing toilets in the market. (Source: USAID-LINAW Project)

The Muntinlupa Market, with 1,445 stall owners and 4,880 vendors serving about 4,500 customers daily, produces extremely contaminated wastewater from its eateries, toilets, and stalls. It pollutes a tributary creek of Laguna de Bay, which is a source of drinking water and freshwater fish for Metro Manila. If the market failed to abide by new regulations under the Philippine Clean Water Act 2004, it would close, and result in massive layoffs. The local government unit addressed this by constructing a low-cost, low-maintenance wastewater treatment facility for the market with technical assistance from the United States Agency for International Development (USAID).

Technology option

- The system uses grit screens, septic tanks, and an ABR to reduce the pollution level of the wastewater from more than 600 mg/l BOD to less than 30 mg/l.

- Cocopeat, a widely available by-product of the coconut processing industry, is used as an alternative filter once compacted. It is 100% organic and highly effective in removing pollutants.
- Limited space required the treatment facility to be constructed under the market's parking lot. Its main reactor was designed to withstand the heavy loads of cars and trucks. The tank lid was formed using a concrete slab with 6-inch thick steel reinforcement.

Institutional and management arrangements

- USAID: USAID provided technical assistance and expertise in designing the wastewater treatment facility under its Local Initiatives for Affordable Wastewater Treatment (LINAW) Project. It also initiated the Social Marketing Plan to raise public awareness on water and sanitation, and encourage participation from the people to support the wastewater management project.
- Planning and Development Collaborative International, Inc. (PADCO): The local government unit (LGU) signed an MOU with USAID through PADCO—an international development consulting firm under contract with the Government of the United States through USAID—detailing responsibilities on initial design, planning, construction, and monitoring of the facility.
- Local government unit: The LGU for Muntinlupa City worked with its City Engineer's Office, Muntinlupa Public Market Cooperative, and City Planning and Development Office to construct the facility with guidance from PADCO and USAID. The LGU coordinated and led all local project activities according to the Local Government Code, and the signed MOU with PADCO. Local project activities included collection of data, consultation with local stakeholders, and establishment of teams needed to implement project activities. Since the LGU owns the treatment facility, benefits and income generated from the project are directly used for the O&M of the facility.
- Muntinlupa City Public Market Cooperative: The cooperative, which is managed by the LGU, manages the collection of the "user's fee" for the use of the wastewater treatment facility. It also helped the city raise awareness about the facility's contributions to the public market and its consumers.

Financing Arrangements

- Facility construction cost: P6.7 million, funded by Muntinlupa City.
- Social Marketing Plan estimated cost: P118,512.50 (70% funded by USAID and 30% by Muntinlupa City).
- Cost recovery for construction cost:
  - O&M per year: P324,000.
  - User fee collected from market stall owners per year: P2,601,000 (at P5.00/day per stall owner).
  - Cost recovery for construction: Within 3–4 years.

Project Outcomes

- Water pollution level decreased from 600 mg/l to less than 30 mg/l.
- Treated water is used for flushing toilets, street cleaning, and watering plants, which saved the city about P25,000 per month in operation costs of the market.
- Compliance to the Philippine Clean Water Act of 2004 prevented closure of the market and guaranteed livelihood for stall owners and vendors. Community is more educated on proper waste disposal, wastewater management, and water and sanitation.

Contact for more information

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- Jet D. Pabilonia, City Environment Protection and Natural Resource Office, Muntinlupa City (Email: jetdp3369@yahoo.com)

Decentralized Wastewater Treatment System for Manjuyod Public Market

Manjuyod, Negros Oriental, Philippines

View of the anaerobic treatment modules: settling tank (ST), anaerobic baffled reactor (ABR), and anaerobic filter (AF). (Source: BORDA)

Manjuyod is a municipality in the province of Negros Oriental. One of the problems that it faced was the blackwater generated by the public market that contributed to the degradation of its water bodies. Waterborne diseases, such as diarrhea, typhoid fever and acute gastro-enteritis, are among the leading causes of morbidity in the municipality.

A new public market was to be constructed. It was necessary to integrate an environmentally sound system, which provides hygienic and sanitary facilities alongside the construction. Thus, the new market was the site of the wastewater treatment system, so that raw wastewater would be treated and disposed of in a manner that minimized potential harm to public health and detrimental impacts on the environment. Sources of untreated water were the new public market, the fruit and vegetable market, restaurants, nearby residents, and the Municipal Health Office.

Technology Option

- The DEWATS in Manjuyod has the capacity to treat 40 m^3 of wastewater per day. The system consists of five components: (i) a settling tank; (ii) an 8-chamber anaerobic baffled reactor; (iii) a 1-chamber anaerobic filter; (iv) a planted gravel filter; and (v) an indicator pond to monitor effluent quality as well as for aesthetic purposes.
- Raw wastewater is first collected. It is then brought to the settling tank for the separation of solid material and scum. The wastewater then passes through an anaerobic baffled reactor to reduce the BOD and COD content. Oxygen is then introduced to the wastewater in the next step via a planted gravel filter with plants and their roots. To complete the aerobic process, a polishing pond was installed. The pond is used to monitor wastewater quality after treatment, specifically for BOD_5 and total suspended solids (TSS). Treated wastewater will then be discharged to the sea.

Institutional and Management Arrangements

The LGU is the project proponent. The planning and executing institution is the Negros Oriental Provincial Engineer's Office. Monitoring of the treated wastewater, specifically BOD_5 and TSS, will be undertaken by the Municipal Environment and Natural Resources Office.

Financing Arrangements

The cost of the construction of the DEWATS was P1.2 million, and was paid for using funds generated from the internal resources of the local government of Manjuyod and augmented by the Provincial Government. O&M cost is minimal because no mechanical part was installed. If a pump is installed, electricity cost will be factored in.

Project Outcomes

- There has been an improvement in the water quality after treatment, complying with Class C water quality standards of the national government.
- The DEWATS facility provides communities with a means to reduce pollution load, thereby protecting public health and preserving the natural environment and ecosystems.
- Effluent quality was reduced to less than 30 mg/l.

"Eco Tanks": Decentralized Wastewater Treatment for Seaside Communities

San Fernando City, La Union, Philippines

Eco Tanks (Source: Citynet)

San Fernando City is located in La Union province. By 2000, the city had a population of 102,082 with an annual average growth of 2.3%. The population increase corresponded with an increase in water pollution, especially in many slum communities that are largely unserviced by proper sewerage systems.

There were three sites chosen for the project. The first two, Barangays Catbangen and Poro, are residential slum areas located on each side of the Catbangen creek. The third site, Barangay San Francisco, is located along the coast, and is popular with the locals and tourists. The sites experienced poor sanitation, including: (i) toilets that did not have properly constructed septic tanks, and mostly, not desludged; and (ii) open pit toilets. Thus, the quality of groundwater, river water and seawater was compromised.

Technology Option

- Eco Tank is a small-scale sewage treatment system, which uses anaerobic bacteria to biochemically treat wastewater from residential areas.
- The tank(s) consists of just two chambers: an anaerobic settling area or holding tank, and a chamber filled with small, porous, plastic balls that will harbor anaerobic bacteria, and act as an anaerobic filter.
- The tank is lightweight, low cost, nonmechanized, easy to install, and made of fiberglass.

Institutional and Management Arrangements

- The City Government sent representatives of the City Environment and Natural Resources Office, health workers, and City Engineering Office during the assessment and construction phases.
- CITYNET conceptualized and piloted the Eco Tanks in the three communities.
- Philippine Sanitation Alliance (PSA) helped fund a third tank for the city.
- Barangay Councils and staff of Catbangen, Poro and San Francisco helped during the assessment study and the construction phase.

Financing Arrangements

- The main funding agency was the City Government, with CITYNET and the PSA (via USAID and Rotary) providing additional funding substantially.
- The city's funds paid for (i) rapid technical assessment, (ii) two Eco Tanks and pumps needed at Barangays Catbangen and Poro sites, (iii) shipping costs for the tanks from Manila to San Fernando, La Union, and (iv) installation of the tanks and all associated infrastructure. CITYNET's funds paid for the shipping of the tanks from Bangkok to Manila, as well as all information, education and communication (IEC) activity costs. PSA (using Rotary International and USAID funds) assisted in the funding for the San Francisco site.
- The total project cost for all parties was about $78,000. Much of this was due to international shipping cost, installation costs for diverting the drainage canals, and, in the case of San Francisco, creating a new drainage system. The Eco Tanks themselves, as sold by Premier Products, only cost as much as $5,000 for the largest model.

Project Outcomes

- The Eco Tank system was installed in three sites, treating wastewater from drainage canals.
- A similar project was also undertaken in Negombo, Sri Lanka through CITYNET.

Contact for more information

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Constructed Wetlands with Reuse Applications

The use of natural processes to remove pollutants in constructed wetlands has been extensively investigated and effectively applied in Western countries for decades. Constructed wetlands are man-made, engineered systems that utilize natural treatment processes to reduce the pollution levels in wastewater. The combination of soil, plants and microorganisms efficiently removes organic pollutants, nutrients and toxic contaminants in wastewater using a variety of physical, biological and chemical processes.

Compared to conventional treatment systems, constructed wetlands have lower energy and chemical requirements. Lesser energy requirement means less greenhouse gases. In fact, the plants sequester carbon dioxide into their biomass. The low capital and O&M costs of these systems, together with good removal efficiency, and simplicity in operation, make them an attractive wastewater treatment option for developing countries.

The two cases from the Philippines and United Arab Emirates show that in areas where land is available, but capital may be limited, the constructed wetlands offer a cost-effective and ecologically sustainable option. In addition to having access to an improved and sustainable sanitation system, the people in the two communities were able to augment their water supply for irrigation.

In Bayawan City, the local government introduced vegetable and cut flower production using organic farming methods as one of the projects that aim to diversify livelihood in the coastal village where the constructed wetland is located. Due to available nutrients in the wetland effluent, the end users are very satisfied using it for irrigation purposes. Part of the treated wastewater is also stored for fire fighting purposes.

Similarly, the inhabitants of Dubai had benefited from being able to safely reuse treated effluent for irrigation.

Project briefs

- Constructed Wetland for a Peri-urban Housing Area: Bayawan City, Negros Oriental, Philippines
- Wastewater Reuse After Reed Bed Treatment: Dubai, United Arab Emirates

Constructed Wetland for a Peri-urban Housing Area

Bayawan City, Negros Oriental, Philippines

Families that lived in informal settlements along the coast had no access to safe water supply and sanitation facilities, resulting in a high incidence of morbidity and mortality from waterborne diseases.

The families were resettled and provided with improved housing (676 terraced houses), sanitation (pour-flush toilets), and connection to safe, piped water supply. The social housing project—Fishermen's Gawad Kalinga Village—is located in Barangay Villareal, a peri-urban area of Bayawan City. The housing project also includes a health center, day care center, multipurpose hall, and community center.

The local government prepared for an expected population growth of 2.9%, and corresponding increase in pollution by developing a wastewater treatment system. Bayawan City, with support from the Department of the Interior and Local Government (DILG)-GTZ Water and Sanitation Program, developed and implemented the country's first constructed wetland wastewater treatment facility within the 7.4-hectare (ha) housing project.

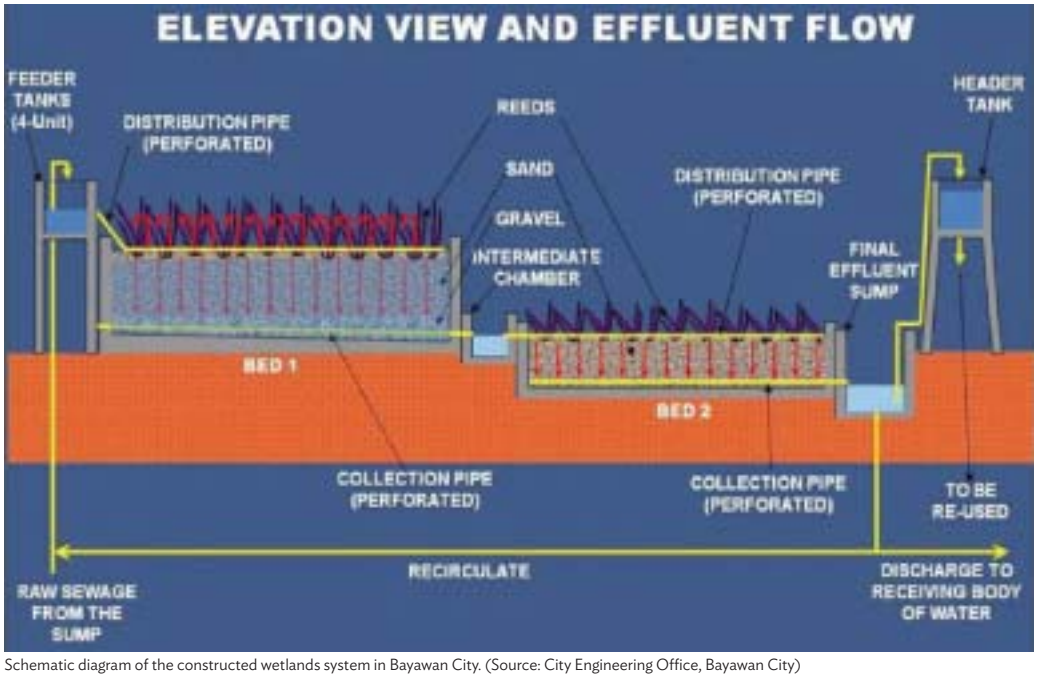
The constructed wetland covers around 3,000 m^2. The project would be used as a pilot and demonstration project for other communities and cities.

Technology Option

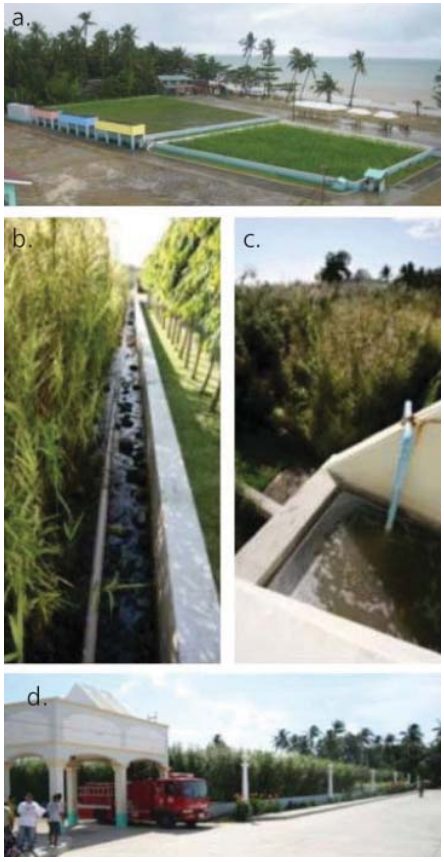
- The hybrid constructed wetland system combines two reed bed systems, namely, vertical and horizontal flow wetlands, to act as biological filters. The plants used in the filter are locally available reeds called 'tambok' *(Phragmites karka)*. Designed for a flow rate of 50 liters per day for the 3,400 people and a BOD concentration of 300 mg/l, the constructed wetland works together with the three-chamber septic tanks and small-bore sewers that were already under construction as part of the housing project.
- The wastewater distribution system is composed of four concrete header tanks, and a system of perforated high density polyethylene (HDPE) pipes. The system is operated manually, i.e., switching on and off the pump and emptying the header tanks into the distribution system. The water flows by gravity through the distribution system. This design helps save on electricity cost. The header tanks are covered to reduce odor.
- The treated wastewater is then collected and pumped into a storage tank, and reused in construction works, irrigation, fire fighting and home gardening.
- Improvements made after the project: A pipe system with tap stands was installed to distribute the treated wastewater to the vegetable and flower fields. The sludge from the septic tanks will be composted in the drying beds in the city's sanitary landfill facility, and then made into biofertilizer. Methane will be recovered as well through filtering and processing by a biogas digester. The wastewater treatment system is, therefore, integrated with the sanitary landfill project of the city.

Institutional and Management Arrangements

- A Memorandum of Agreement (MOA) was signed in April 2005 between the City Government of Bayawan and the German Technical Cooperation Agency (GTZ) for the provision of technical assistance.
- Planning and site assessment: A German consultant from Oekotec GmbH and two Filipino consultants worked together, and consulted with the city government and stakeholders to introduce the constructed wetlands technology, as well as assess potential sites.
- Construction: Bayawan City Government, using a loan from the World Bank, financed the construction of the treatment system. The City Engineering Office, under the supervision of the local consultants, carried out construction.



Schematic diagram of the constructed wetlands system in Bayawan City. (Source: City Engineering Office, Bayawan City)



a. constructed wetland system (Mark Mulingbayan); b. collection pipe (Steve Griffiths); c. feeder tank (Steve Griffiths); d. elevated storage tank for reuse (Bayawan City)

- Public awareness and capacity development: During the construction, execution, implementation, and operation stages, the City Government of Bayawan, through its Engineering office, undertook IEC campaigns, and took full ownership for setting up a village association to prepare future inhabitants of the relocation area. The staff of the City Engineering Office and City Environmental and Natural Resources Office, as well as members of the village association also attended training workshops for the operation, maintenance, and management of the wastewater treatment facility. The residents and farmers were also trained on proper reuse of treated wastewater, using WHO Guidelines (e.g., wearing gloves, watering the soil and not the leaves, to stop irrigating with treated wastewater 4 weeks before harvest, etc.).
- Sustainability: Upon completion of the GTZ sanitation program in the Philippines, the Bayawan City Council assumed responsibility for the operation of the constructed wetland, particularly the allocation of a budget to cover the O&M cost.
- Monitoring: The local water service provider regularly analyzes the influent and effluent of the constructed wetland. Analysis includes total dissolved solids, pH, BOD, ammonia, nitrate, phosphate and coliform.

Financing Arrangements

- Total construction cost is about €160,000. Bayawan City financed the bulk of this cost with a loan from the World Bank.
- The technical assistance provided by the DILG-GTZ Water and Sanitation Program covered the costs of the international consultant, workshops, community participation, and social preparation sessions.
- O&M per year: €3,500 (€200 for electricity and €3,300 for labor), paid for in full by the city administration.
- Households pay only for their water and electricity consumption, not for wastewater treatment. Also, residents and gardeners use the treated wastewater at no cost.

Project Outcomes

- The constructed wetland has reduced water pollution. Laboratory analysis shows that the physical and chemical parameters of the treated wastewater have significantly improved (e.g., 97% BOD removal efficiency; increase in dissolved oxygen, 54% reduction of TSS, 71% reduction of total coliform). If land is available, the constructed wetland is a cost-effective solution for domestic wastewater treatment.
- The level of social acceptability for the wastewater treatment system by the residents of the housing project is high. The constructed wetland has contributed to the reduced incidence rate of diarrhea and intestinal worms in children in the area.
- The system produces treated wastewater that can be reused.
- Treated wastewater was used in: (a) concrete production, thereby reducing construction costs; (b) organic cut flower and vegetable farming; and (c) fighting fires. Money is saved through the use of the treated wastewater, in lieu of public water supply. The treated wastewater also saves on

fertilizer since it is rich in nutrients. The effluent has almost ideal concentrations of nitrate and phosphate to be used for fertilizer and irrigation.
- The organic farms provide alternative or supplemental livelihood opportunities for the residents who mostly derived their income from fishing.
- The constructed wetland serves as a demonstration site for local engineers and decision-makers from other local government units. An increase in visitors at the housing project to view the facility was observed.
- With the knowledge and experience gained, Bayawan City built an additional wetland system combined with an ABR for the District Hospital. (The institutional arrangements with the Department of Health still need to be secured for the connection of the hospital to the treatment system.)
- The constructed wetland project complements other programs being implemented by Bayawan City, such as the Healthy City, Food Security, Integrated Solid Waste Management, the 'Character First', and the Organic Farming programs.

Wastewater Reuse after Reed Bed Treatment

Dubai, United Arab Emirates

Dubai has a sub-tropical, arid climate (temperatures range from 10°C to 48°C) with infrequent and irregular rainfall totalling less than 130 mm per year. With rapid industrialization and population growth, public infrastructure is unable to keep up with the increasing volume of sewage.

At present, there are two ways to transport wastewater: (i) via long sewer networks to the main sewage treatment plant, or (ii) if the site is not connected to sewers, stored in tanks and then transported by tanker to a central sewage treatment plant at a later time or pretreated in septic tanks before being released to the ground for infiltration.

While the second approach presents problems, (e.g., soil and groundwater contamination) installation of huge sewer lines as an option is quite expensive and would entail technical expertise. Thus, innovative technical solutions are required to address such situation given that the high water demand in this hot, dry region is in conflict with its extremely limited availability.

Technology Option

- The reed bed technology, which combines both aerobic and anaerobic decomposition processes in a sand layer up to a meter thick, is used in Dubai for treatment of car wash wastewater, greywater, blackwater, and septic sludge.
- Reed beds are an example of a constructed wetland treatment process (vertical or horizontal subsurface flow, soil filter planted with *Phragmites communis* or *Phragmites australis* or other marsh plants). A major change in the oxygen's system can be achieved through intermittent loading of the reed beds.
- Long-term use and transport of pretreated water into the soil is guaranteed. This is due to the continuous growth and decay of the roots and rhizomes of the aquatic macrophytes, and the resulting soil macropores that prevents clogging by filter substrates, such as sand and gravel.

Reed Bed (Source: IWA)

Sedimentation Tank (Source: IWA)

- Project 1: Domestic wastewater at the Waagner Biro Gulf head office is collected by separate gravity sewer lines for greywater and blackwater.
  - Greywater: After settling in a two-chamber tank, wastewater is pumped into two parallel vertical flow sand filter reed beds, each with an area of 250 m^2.
  - Blackwater: This is passed through a three-chamber septic tank for pretreatment prior to treatment in a mechanical self-backwashing filter. Final disposal is via subsurface drip irrigation.
  - The settled solids from the pretreatment units of greywater and blackwater are pumped every 3 months from the settlement tanks into 200 m^2 sludge dewatering reed bed for mineralization.
- Project 2: Car washing wastewater from Waagner Biro Gulf workshop is collected through gravity sewer to the pretreatment: (i) three-chamber oil separator without chemicals; (ii) 20 m^2-horizontal flow sand filter reed bed; and (iii) final treatment in the reed bed for greywater treatment.
- Project 3: Domestic wastewater of SAMA Dubai: (i) three-chamber septic tank and 100 m^2-vertical flow sand filter reed bed treatment for toilet blackwater; (ii) two-chamber settlement tank and 40 m^2-separate vertical flow sand filter reed bed treatment for greywater; (iii) 20 m^2-sludge dewatering reed bed (reed-planted sand filter bed) for mineralization of septic tank sludge. Treated water is reused for landscape irrigation.
- Project 4: Conversion of conventional septic tank with soak away at Dubai Municipality Jaddaf: The septic tank is used as pretreatment system. The pretreated water is pumped to a vertical flow sand filter reed bed for biological and tertiary treatment. The treated effluent is then used for irrigation.

Institutional and Management Arrangements

- Waagner Biro Gulf is the executing agency for the project. Waagner Biro Gulf is a construction company specializing in steel, bridge, and marine constructions with a special branch for environmental technologies involving innovative solutions in the field of closed loop wastewater treatment for various clients in different settings.
- Mizan Consult FZE designs and supervises construction, training and operation. Mizan Consult FZE is a UAE-based independent wastewater consultant specializing in reed bed technology, and working as sub-consultant or directly for the client. The construction and operation and maintenance (O&M) is carried out by different local contractors supervised and trained by the specialised consultant.

Financing Arrangements

- Clients are generally responsible for the investment. Build-Operate-Own-Transfer (BOOT) projects are also under operation in the UAE. Financing is then carried out by contractors.
- The actual construction investment for reed bed systems in this region is equal to conventional systems (activated sludge plants) for up to 15,000 persons (for larger installations, the conventional systems may have lower cost than reed bed systems).
- On average, 90% of the investment costs are civil works, e.g., earth movement and installation of filter material, and distribution and drainage of pipe works.
- Operational costs of reed bed systems are estimated to be about 10%–30% of activated sludge plants.

Project Outcomes

- There is significant improvement in public health due to reduced sewage overflow of septic and holding tanks.
- It prevents traffic jams caused by vacuum tankers.
- It reduces freshwater consumption with reuse of treated wastewater as service water.
- In terms of operational efficiency in treating wastewater, average pollutant concentrations from reed beds indicate the following:
  - Biochemical oxygen demand (BOD): 10 mg/l (average influent parameter: 200–400 mg/l)
  - Chemical oxygen demand (COD): 25 mg/l (average influent parameter: 400–600 mg/l)
  - Total suspended solids (TSS): < 5 mg/l
  - pH: 7.5
  - Ammonium as Nitrogen (NH_4-N): 1
- The vertical flow reed planted sand filter performed perfectly under hot climate

conditions. It was able to achieve results that comply with all Middle East irrigation standards in the treatment of all kinds of sewage (grey, raw, black, tanker, and oil), proven by more than 20 systems currently in operation in the Middle East.

- Direct treatment of raw sewage in a double stage reed bed has the lowest O&M requirements, and is therefore the most appropriate reed bed technology for remote treatment of sewage in the Middle East.
- The investment costs for reed beds are equal or even higher compared to conventional package plants. However, the O&M costs are much lower. After 5–7 years, the reed bed system becomes financially viable than the conventional package plants.
- The reed bed system (i) consumes only little energy (maximum 0.3 kWh/m^3), (ii) produces a biomass which is a valuable by-product, and (iii) serves as biotope.
- Depending on the type of reed bed system used, no sludge disposal is required for 15 years as sludge gets directly mineralized in the system.
- The reed bed technology provides a wastewater treatment solution that is long lasting, low-maintenance, easy-to-operate with high performance, and sustainable.
- The reed bed technology, however, is not a low cost solution for short term projects.

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Low-Cost Sewerage Systems

The low-cost simplified sewer system, also known as condominial sewer (in Brazil) or small-bore sewer system, collects all household wastewater (both blackwater and greywater) in small-diameter pipes laid at fairly flat gradients. Simplified sewers are laid in the front yard, backyard, or under the pavement (sidewalk), rather than in the center of the road as with conventional sewerage. It is suitable for existing unplanned low-income areas, as well as new housing estates with a regular layout. Cost-saving features of any simplified sewerage system include smaller diameter of pipes, smaller and shallower trenches, simplified manholes, and connection to decentralized, small-scale wastewater treatment. Consequently, the main collectors and sewage pumping stations are eliminated in the process. It is important to take note that with simplified sewerage, it is crucial to have in place expert design, construction supervision, and management arrangements to remove blockages in interceptor and junction chambers, which are more frequent than with conventional sewers. Construction can be carried out by trained and properly supervised contractors or community members.

Simplified sewer systems have been used in slum and peri-urban areas in Brazil, Pakistan, Peru, South Africa, Sri Lanka, etc. In Tegucigalpa, Honduras, around 20 communities with 24,000 inhabitants in the marginal areas have benefitted from this low-cost sewerage system.

Small-bore Sewerage System

Tegucigalpa, Honduras

In 1995, statistics showed that about 150 peri-urban communities (279,000 persons) in Tegucigalpa lacked access to proper sanitation. The inconveniences of traditional latrines were unbearable for the community, thus, they requested support from the Executive Unit for Settlement in Development (UEBD) for the construction of a sewerage system. Based on community demand for better sanitary facilities, the National Autonomous Water and Sewage Authorities (SANAA), with support from UNICEF, included a sanitation component to the Tegucigalpa water programme (generally referred to as 'Tegucigalpa model').

Technology Option

- The technology option used was small-bore sewerage system (solid-free sewerage), which has been implemented successfully in the United States, Brazil and Australia.
- The small-bore sewerage system refers to the transport of domestic sewage, which is settled on-site in a septic tank. Only settled sewage is discharged into the sewage pipes to the main collector.

Institutional and Management Arrangements

- The SANAA, with the support of UNICEF, created the UEBD for execution of the sanitation programme.
- The construction, administration, maintenance and operation of the sewerage systems were planned through Junta de Agua (Community Water Board), which is owned by the community. The Community Water Board takes independent decisions on the technology and management options, tariffs, and speed of repayment.

Construction of small-bore sewer system (Source: UNV/Natasha Mistry).

- The community provided the manual labour (each household had to excavate 15 m of trench and some local construction materials including PVC accessories).
- UNICEF, in partnership with the Cooperative Housing Foundation (CHF), provided families with near-market rate credit for the construction of household sanitary services, such as toilet, shower, etc.
- The UEBD has the commitment and responsibility to implement courses on O&M of the sewerage system and also a hygiene programme for all beneficiaries.

Financing Arrangements

Capital Investment

- Construction of toilets was carried out through the Honduran Fund for Social Investment.
- The capital investment was financed by the community, UNICEF, and the Government. The communities and the investors made sure all initial costs were covered.

Cost recovery

- The cost recovery policy was applied through monthly payments by the communities to a rotating fund, which enabled UEBD to expand the programme's coverage.

Project Outcomes

- There were four sewerage systems constructed two years after implementation of the programme, and 3,500 people benefited. Subsequently, an additional 19 sewerage systems were constructed between 1998 and 1999, which benefitted an additional 25,000 people.
- However, for some poorer households, the cost of connecting their house to the sewerage system was too high, and consequently, these households remain unconnected to the sewerage system.
- Note: The sewerage system could no longer meet the demands of the city 10 years after construction due to population increase, ageing infrastructure, and damage caused by an earthquake in 2009. Now, SANAA is seeking a loan to meet the cost ($500 million minimum) for total replacement of the sewer system in Tegucigalpa.

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Applying Innovative and Multidimensional Approaches

Existing and emerging challenges, stricter regulations, new requirements, stakeholder needs, climate change issues, and market opportunities—all these require novel ideas and approaches, and doing something different rather than just doing the same thing better. There is a need to move away from the traditional approach of doing business to ensure functioning sanitation systems—from collection to conveyance to treatment and reuse. Adopting and implementing innovative approaches would entail strategic application of science and technologies as well as reforms in policies and institutional arrangements, introduction of new financing mechanisms, and most importantly, behavior change.

The six case studies feature innovations in technologies, design, financing, contract management, and ways in dealing with the needs of poor communities. Such innovations are necessary in today's world to meet the challenge of having universal sanitation coverage and scaling up much-needed wastewater treatment.

Innovative technologies are being used by one of the water concessionaires in the different decentralized wastewater treatment facilities in Metro Manila to address energy and land availability issues.

Wastewater reuse should be seen as a means of mitigating pressures in areas where water is scarce. Singapore is solving its water security problem through proper wastewater management, and applying innovative technologies to ensure the quality of water for potable use.

Performance-based contracting has been applied by City West Water in Melbourne, Australia for its water recycling facility. This approach focuses on incentivised contracts with specific and measurable performance metrics agreed on by the contracting parties, and directly relating contract payment to performance against indicators. This stands in contrast to the traditional waterfall approach, where payment is related to completion of project milestones and deliverables.

The Alandur sewerage project in India became a bankable project through a coordinated effort involving the municipalities of Alandur and Chennai, the State of Tamil Nadu, state asset management and credit facilities, donors, and stakeholders working together to implement a comprehensive package of innovative financial and credit enhancement mechanisms. Arrangements were made to also ensure affordability and access to sanitation by poor communities.

Innovative technologies combined with the public-private partnership (PPP) approach resulted in saving water, energy and costs in the case of the city of Fillmore in California, USA. The plant features state-of-the-art technology that meets the stringent federal and state requirements, maximizes energy efficiency helping to keep costs down, and allows reuse of water for irrigating school grounds, parks and other green areas.

Adopting an integrated approach to clean up the Qinhuai river, the city of Nanjing, People's Republic of China embarked on projects that focused on sewerage, wastewater and sludge treatment, stormwater drainage, river improvement and water replenishment projects. Funding for these projects are through loans from an international financing institution, such as ADB and commercial bank. Access to capital markets through issuance of 10-year water bonds was also pursued by the municipal government with private sector participation.

Project briefs

- Innovative Technologies for Cost-effective Wastewater Management: West Zone, Metro Manila, Philippines

- Making the Unthinkable Drinkable: Singapore
- Performance-based Contract for Wastewater Treatment and Recycling Facility: Melbourne, Australia
- Innovative Financing Arrangements for Inclusive and Financially Viable Sanitation and Wastewater Management: Alandur, Tamil Nadu, India
- Saving Water and Costs through Innovative Technology and Contract: City of Fillmore, California, United States of America
- Investing in Integrated Infrastructure Solution for Qinhuai River Environmental Improvement: Nanjing, Jiangsu Province, People's Republic of China

Innovative Technologies for Cost-Effective Wastewater Management

West Zone, Metro Manila, Philippines

Maynilad Water Services, Inc. (MWSI) is one of the two concessionaires that provides the western portion of Metro Manila as well as parts of the provinces of Cavite and Bulacan with water supply and wastewater services.

In Metro Manila, the major factors being raised against putting up centralized sewerage systems include: high initial investments cost, relatively flat terrain (affecting gravity sewer option), high energy cost, social cost from digging up the roads, high water table, low lying land, and susceptibility to natural disasters and climate change impacts. Therefore, the decentralized system is the best alternative.

However, in choosing decentralized wastewater treatment systems, energy cost—a major component of the O&M cost—becomes a primary consideration for technology selection. Based on the experience of the private concessionaires, approximately half of the O&M cost is for energy consumption of decentralized systems. After five years, the cost of O&M can exceed the capital cost of the treatment plant. Thus, energy cost is the main constraint for technology selection.

The new decentralized systems utilizing biological treatment technologies are relatively more cost effective, can be retrofitted into aging systems, and have small footprint. Nutrient reduction solutions are also needed due to harmful algal blooms, eutrophication and hypoxic problems in Manila Bay. These biological treatment technologies include membrane bioreactors (MBR), moving bed biofilm reactor (MBBR), integrated fixed-film reactor, and biological aerated filters.

Technology Option

- Five sewerage systems (Central Manila Sewerage System, Dagat-dagatan Sewerage System, sewerage system with communal septic tanks, Makati Isolated System, and Ayala Alabang System), with more than 490 km of sewer lines and total treatment capacity of 469,000 m^3/d, serving approximately 120,000 households.
- Technologies used in the five sewerage systems include:
  a) Physico/Chemical Screening/Grit Removal/ Aeration: treatment process used in the Central Manila Sewerage System and communal septic tanks.
  b) Lagoon (waste stablization ponds): man-made ponds used to treat organic wastes through the symbiotic actions of algae and microorganisms (by natural and mechanical aeration). The facility consists of a collection system, interceptor, screen chamber, wet well, pumping station, aeration ponds, facultative ponds, and polishing ponds. It is the treatment process used in the Dagat-dagatan Sewage Treatment Plant (STP) (200,000 m^3/d capacity). Maynilad also operates a 450-m^3/d Septage Treatment Plant inside the Dagat- dagatan STP compound.
  c) Activated Sludge - Extended Aeration: type of activated sludge process with no primary settling and long aerobic detention time to generate less excess sludge overall. It is the treatment process used in the Ayala Alabang System (capacity of 10,000 m^3/d).
- Technologies used in the decentralized STPs:
  a) Conventional Activated Sludge (CAS) is the most common suspended growth process used for municipal wastewater treatment. It consists essentially of an aerated biological

reactor followed by a secondary clarifier. It is the treatment process used in Bahay Toro STP (13,400 m³/d). Features:

- Good process flexibility
- Reliable operation
- Proven track record in all plant sizes
- Low odor emission
- Energy production
- Ability to withstand nominal changes in water characteristics

b) Sequencing Batch Reactor (SBR) is a fill-and-draw activated sludge system designed to operate under non-steady state conditions. It is the treatment process used in Congressional STP (567 m³/d), Grant STP (4,800 m³/d), Legal STP (4,800 m³/d), Bagbag STP (10,400 m³/d) and Tatalon STP (8,100 m³/d). Features:

- Smaller footprint because of absence of primary, secondary clarifiers and digester
- Biological nutrient removal (nitrogen and phosphorus)
- High degree of coliform removal
- Less chlorine dosing required for post disinfection
- Ability to withstand hydraulic and organic shock loads

c) Moving Bed Biofilm Reactor (MBBR) uses a variant integrated fixed film activated sludge (IFAS) process, and it is essentially a hybrid between a suspended growth (activated sludge process) and a fixed film system. It is the treatment process used in San Antonio STP (3,310 m³/d), Paco STP (410 m³/d), Del Monte STP (3,510 m³/d), and Paltok STP (4,900 m³/d). Features:

- Flexible design that allows for increased capacity
- Stable under large load variations
- Smaller footprint
- Single pass treatment
- Extremely compact and simple biological treatment system

d) STM Aerotor uses IFAS technology as part of a process that provides biological nutrient removal for municipal and industrial wastewater treatment. It is the treatment process used in Baesa STP (390 m³/d), Tandang Sora STP (1,200 m³/d), and Samson STP (3,510 m³/d). Features:

- Low energy requirement (lowest energy cost compared with CAS, MBBR and SBR)
- Small footprint

Activated sludge with extended aeration (Ayala Alabang STP) (Source: M. Ebarvia)

Sequential batch reactor (Congressional STP) (Source: M. Ebarvia)

STM Aerotor (Tandang Sora STP) (Source: M. Ebarvia)

Moving bed biofilm reactor in Johkasou tanks (Paco STP) (Source: M. Ebarvia)

- Improved sludge settling and quality
- Low capital cost
- Advanced biological nutrient removal
- Stable process
- No odors
- Handles various load fluctuations

Institutional and Management Arrangements

As one of the two concessionaires, MWSI is tasked to provide water supply, sewerage and sanitation services in the West Zone area (western part of Metro Manila, and parts of the provinces of Cavite and Bulacan). The Metropolitan Waterworks and Sewerage System Regulatory Office (MWSS-RO) evaluates the proper implementation of the Concession Agreement, monitors water quality and supply in all service areas, and handles the water tariffs being charged by the concessionaires to all their customers. On the other hand, the Department of Environment and Natural Resources (DENR) and the Laguna Lake Development Authority (LLDA) provide and enforce wastewater standards for treatment operation and facilities.

Financing Arrangements

As of December 2012, all customer types (residential, commercial and industrial) in Metro Manila pay a 20% environmental charge from the basic water charge. For MWSI, a sewerage charge is levied (as high as 20% of the basic water charge) on commercial and industrial customers who are currently connected to sewer lines.

Project Outcomes

By selecting technology based on performance indicators, Maynilad is able to achieve cost-effective solution for wastewater management with lower capital costs, and lower operating and maintenance costs.

Contact for more information

Francisco Arellano, Vice President, Maynilad Water Services, Inc.

Making the Unthinkable Drinkable

Singapore

Microfiltration (Source: PUB Singapore)

Reverse Osmosis (Source: PUB Singapore)

Singapore is a small island city state covering an area of 710 km^2. Freshwater has always been a challenge, considered inadequate and uncertain. Singapore relied on rainwater collection through its network of drains, canals, rivers and stormwater collection, and imported water from Malaysia that will end in 2061. To reduce Singapore's dependence on imported water, the government took steps to increase the size of the local water catchment area, and build up supply from non-conventional sources, e.g., reclaimed and desalinated water.

Technology Option

Three stages of the system:

- Microfiltration (MF): Treated used water is passed through membranes to filter out suspended solids, colloidal particles, disease-causing bacteria, some viruses and protozoan cysts. Only dissolved salts and organic molecules can pass through the membrane.
- Reverse Osmosis (RO): This process uses a semi-permeable membrane with very small pores allowing very small molecules, such as water molecules, to pass through. At this stage, the water is free from viruses and bacteria,

and contains negligible amount of salts and organic matters.
- Ultraviolet (UV) Disinfection: Considered a safety back-up to the RO stage, the UV disinfection ensures that all organisms are inactivated, and the purity of the product water is guaranteed. With the addition of some alkaline chemicals, NEWater is ready to be used for a wide range of applications.

Institutional and Management Arrangements

- The Ministry of the Environment and Water Resources tasked both the Public Utilities Board (PUB) and the National Environment Agency to come up with a solution to Singapore's water problem.
- The goal of the joint venture was to determine the suitability of using NEWater to supplement water supply. PUB made sure there was an efficient, adequate and sustainable supply of water while the National Environment Agency made sure the technology would not harm the quality of the environment.
- An expert panel consisting of local and foreign experts oversaw the study. The panel, after 2 years, concluded that the technology would ensure an efficient, adequate and sustainable water supply, and did not harm human health and the environment.

Financing Arrangements

- Water tariffs in Singapore were set at a level allowing for cost recovery, including capital costs. PUB issued a bond to raise $400 million to finance part of its investment program. Also, water tariffs were set based on the volume used. These included:
  (i) A water conservation tax to reinforce the water conservation message. Proceeds would go directly to the government. The tax was set at 30%, but a 45% tax level is applied to domestic consumption above 40 m^3 per month and connection;
  (ii) A water fee which is the fee for the volume of water used; and
  (iii) A sanitary appliance fee, which is a fixed, used water fee, based on the number of sanitary appliances owned.

Project Outcomes

- Today, there are four NEWater plants supplying 30% of needed water. The biggest market has been in the industrial sector freeing up reserves of potable water.
- NEWater technology brings about a closed water loop system for more efficient resource use.
- NEWater passed more than 65,000 scientific tests and surpasses World Health Organization (WHO) requirements.

Performance-based Contract for a Wastewater Treatment and Recycling Facility

Melbourne, Australia

Altona wastewater treatment plant (Source: M. Giesemann)

City West Water (CWW) owns and operates a wastewater treatment plant in the suburb of Altona in Melbourne that treats mostly domestic wastewater from a catchment, with a population equivalent to 50,000. In 2007, to obtain a new operating license to upgrade its plant and gain community acceptance for the new plant, CWW agreed to maximize the recycling of the brackish-like treated effluent from the original treatment facility, instead of discharging the treated effluent to Port Phillip Bay.
A private operator was engaged to design, build and operate (DBO) a microfiltration-reverse osmosis (MFRO) desalination plant for 5 years. There were some difficulties in preparing the contract, i.e., how to handle those periods when there was insufficient feedwater available. Thus, performance-based indicators and other new concepts were introduced in the contract to solve such issues.

Technology Option

- The Altona Wastewater Treatment Plant uses an activated sludge, nutrient removal treatment

process known as Intermittently Decanted Extended Aeration (IDEA) to treat the sewage to a standard required by Victoria's Environment Protection Authority (EPA) for discharge via a submerged marine outfall to Port Phillip Bay. The biosolids are taken off-site and fully reused.
- To further treat the effluent, remove the salt and other contaminants, and permit recycling, CWW constructed the MFRO desalination plant, using a membrane process consisting of strainers, MF membranes, and a two-stage RO process.
- In addition to the MFRO plant, the Altona Recycled Water Project (ARWP) also consists of feedwater and process water storage tanks, three pumping stations, and three delivery pipelines.

Institutional and Management Arrangements

- The institutional arrangement involves CWW as the provider of recycled water services to its irrigation and industrial customers within the city, and the MFRO Plant Operator.
- The type of contract for the ARWP was a traditional design and construct contract with an added O&M contract for a period of 5 years, and with an option for a further 5 years. The O&M contract included a performance payment component.
- The performance-based component sets conditions based on: (i) a sensible assignment of responsibilities and risks; and (ii) a performance-based payment system that rewards the maximization of catchment yields, and the consistency and quality in the recycled water produced.
- Moreover, to ensure that the assignment of accountabilities matched only the factors over which each party could exercise control, three new operational concepts were introduced: (a) Plant Production Envelope (PPE) – the maximum amount of recycled water the MFRO Plant could produce in any given month without external limitations); (b) Plant Productivity (ratio of the actual volume of recycled water produced to the PPE in a given time period); and (c) Plant Performance Factor (calculated based on key performance indicators, weights, targets and actual performance achieved).

Financing Arrangements

- The total estimated cost of the ARWP is over A$50 million ($52.6 million).
- Under the terms of the contract, payments to the MFRO Plant Operator were based on the Key Performance Indicators developed and weighted.

Project Outcomes

- The MFRO plant supplies 5.9 million liters per day (MLD) to industry (for boilers and cooling towers) and 3.1 MLD to irrigate two local golf courses and nearby local government recreational areas.
- The operational performance-based contract: (i) permitted risks to be appropriately allocated; (ii) provided an incentive to the contractor for the delivery of good performance; and (iii) ensured better compliance of CWW to health and environmental regulations.

Contact for more information

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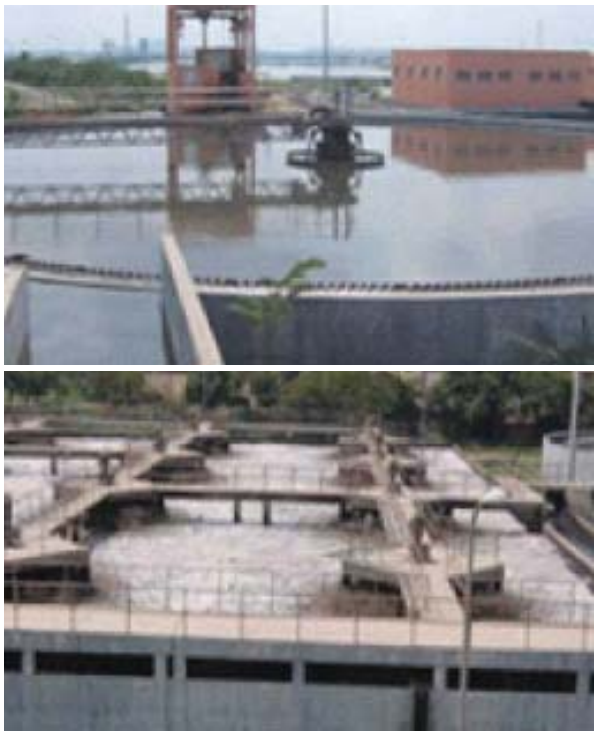
Innovative Financing Arrangements for Inclusive and Financially Viable Sanitation

Alandur, Tamil Nadu, India

Alandur is a town located in the eastern coast of Southern India in Tamil Nadu adjacent to the City of Chennai with a population of 165,000 (approximately 25% of which live in slums). The Alandur Sewerage Project is a good example of PPP in the urban sanitation sector. As the first project in the municipal sanitation sector to take the PPP route in India, this case study demonstrates a model that represents an effective institutional and financial approach to implement a sewerage and treatment system with cost recovery.



Wastewater treatment plant (Source: IWA)

Technology Option

Conventional sewerage system

- Main sewer of 19 km and branch sewer lines of 101 km and pumping stations.

Treatment system

- Sewage treatment plant with a total capacity of 24 MLD (two units of 12 MLD each).

Low cost sanitation system

- Community toilet blocks connected to sewerage system/septic tank.

Institutional and Management Arrangements

- Tamil Nadu Urban Infrastructure Financial Services Ltd. (TNUIFSL) was nominated by the municipality of Alandur as the agency to coordinate, supervise and structure the finances for the Alandur project. It was also responsible for the conduct of detailed studies on the feasibility of the project.
- Initially, it was decided that the municipality would operate and maintain the sewerage system, but due to lack of resources, it was decided to transfer management responsibility, via a competitive bidding process, to a private contractor. Clear contract conditions and cost control guidelines were followed.
- Public awareness campaigns and stakeholder consultations at all stages of the project were carried out to resolve issues in a transparent manner.

Financing Arrangements

- TNUIFSL ensured financial discipline by setting up an accounting system, and with the municipality creating a special account for all project transactions.

Capital investment

- One-off deposits in the form of connection charges were collected from users in different category ranges (domestic, commercial, industrial), and a loan facility was arranged through a nationalized bank.
- In order to offset any deficit in the sewerage account, the Government of Tamil Nadu provided gap funding to bridge any shortfall in domestic connection payments.
- The financial arrangement for community toilets and its connection to a sewerage system was made by the municipality of Alandur.

Cost recovery

- The municipality charges the residents (consumers) a monthly fee derived through an iterative process with TNUIFSL.
- Wastewater tariffs were structured based on affordability and willingness-to-pay survey.

Project Outcomes

- From a public health perspective, the key positive impacts are the improved standard of living and public health for all households with connections to the sewerage system.
- Of the 23,000 households, 8,350 were connected in 2005. Nearly 500 slum households were provided with sewerage connections, and 14 toilet blocks have been constructed for the benefit of the poorer sectors.

Lessons Learnt

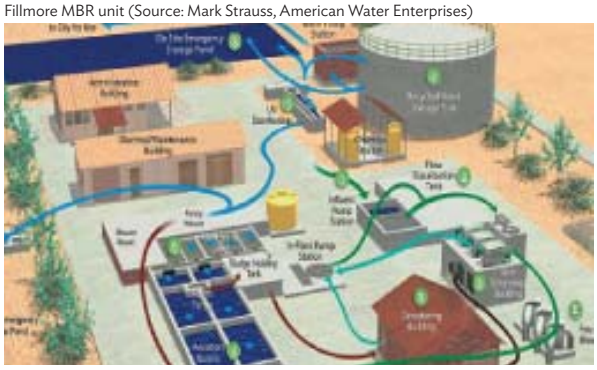
- The inclusive approach in which different sectors of the population are taken into consideration based on income levels, proved to be effective when aiming to increase service users. Those unable to afford connections to the sewerage network benefit from improved communal toilets. Measures, such as allowing for domestic

customers to pay the connection charge in installments, ensured that the public's concerns were addressed.
- The municipality's concerted efforts in spreading awareness about the project have resulted in a good response from communities. People's participation has been on-going, and this has been encouraged through collective efforts as well as transparent procedures.

Saving Water and Costs through Innovative Design and Contract

City of Fillmore, California, United States of America

Fillmore MBR unit (Source: Mark Strauss, American Water Enterprises)



Layout of MBR unit (Source: Mark Strauss, American Water Enterprises)

In response to the stricter regulations imposed by the Los Angeles Regional Water Quality Control Board to improve the quality of treated wastewater discharges to the Santa Clara River, as well as to meet the demands of a growing population, the City of Fillmore decided to upgrade its existing wastewater treatment plant using an innovative approach.

The plant was replaced by a state-of-the-art water recycling facility, which would end the practice of river discharges, and enable development of full-scale water reuse system to benefit many areas of the town. The result is a facility, which meets the requirements of federal and state regulations as a zero-discharge facility, and a water-recycling program that irrigates school grounds, parks and other green areas.

Technology Option

- The plant features state-of-the-art technology that maximizes energy efficiency, helping to keep costs down.
- A flow-equalization system minimizes water flow during the day when cost and energy use is highest.
- Wastewater is cycled back into the plant where it is treated during off-peak hours when power demand and cost is lower.
- MBR and UV disinfection system are expected to yield cleaner recycled water suitable for irrigation.
- The UV disinfection system features an automated mechanical wiper-cleaning system that removes debris without removing the UV lamps or halting operation.
- Operating at full capacity, the Fillmore plant is designed to treat 2.4 MGD (9,000 m^3/d). The current configuration is intended to operate at 1.8 MGD (4,500 m^3/d).
- The plant's peak pumping capacity is 4,146 gallons of effluent per minute (15,700 l/min). The facilities also include a recycled water tank that has a storage capacity of 1 million gallons (3,785 m^3).

Institutional and Management Arrangements

- The city engaged the services of American Water Company in a PPP under a DBO model to build a facility capable of producing high-quality disinfected water to meet the stringent standards required for surface and sub-surface irrigation of public and private facilities.
- American Water Company (American Water) is the operator of the plant. The company handled coordination activities with W.M. Lyles Construction Company and the design-engineering firm of Kennedy/Jenks Consultants.
- American Water will maintain and operate the wastewater treatment system over the next 20 years.

Financing Arrangements

- The total project cost is around $42.5 million, of which $26 million were allotted for the MBR treatment plant and its accessories, and $4 million for the water reuse system. The remaining balance is expended on offsite engineering, construction, and securing of permits.
- Potential savings in the contingency funds are shared among the city, American Water, the contractor, and the design-engineering firm.

Project Outcomes

- Compliance with state and federal regulatory requirements;
- Generation of substantial cost savings;
- The PPP approach and DBO model helped the city achieve savings of about $4 million.
- Working through a single contract with the city at a guaranteed cost allowed city officials to effectively manage expenditures, and significantly contributed to the project being completed ahead of schedule, and within budget; and
- Reduction in the demand for surface and groundwater through the use of reclaimed water for irrigation purposes.

Contact for more information

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Investing in Integrated Infrastructure Solution for Qinhuai River Environmental Improvement

Nanjing, Jiangsu Province, People's Republic of China

Nanjing, the capital of Jiangsu Province, is a rapidly developing city with a population of 6.4 million, of which 4.5 million is urban. Nanjing City comprises 11 districts and 2 counties that straddle the Yangtze River. It is located in the lower reaches of the Yangtze River, about 270 km to the northwest of Shanghai.

Wetland park (Source: ADB)

River rehabilitation (Source: ADB)

Traditional urban wastewater management practice in the People's Republic of China (PRC) was based on the use of septic tanks. Rapidly increasing urbanization makes such an approach inadequate. Over the past decade, a fundamental shift has been to an integrated approach to urban water management, and use of centralized municipal wastewater treatment.

Although much improvement has been made, the current status of wastewater management still provides numerous opportunities to reduce water pollution, protect water resources, and improve the living conditions and public health of urban and suburban residents. Key problems and opportunities in Nanjing include (i) worsening surface water quality; (ii) inadequate wastewater treatment capacity; (iii) lack of a sludge treatment facility and disposal site; (iv) inadequate stormwater discharge capacity resulting in frequent urban flooding; (v) high river siltation contributing to formation of organic substances that pollute rivers; and (vi) the need for ongoing financial and institutional reforms to make urban services sustainable.

Technology Option

The Project has five major components:

- Inner Qinhuai River Sewerage and Water Replenishment: involves the construction of river sewer interceptors, river intake pumping stations and pipelines, culverts, and installation of a water diversion system.
- City East Wastewater Treatment Plant (WWTP) and Sewerage System: involves the installation of additional sewer pipelines and expansion of the existing wastewater treatment plant, river improvement works and the construction of an ecological wetland park.
- North He Xi District Sewerage, River Improvement, and Water Replenishment: involves the installation of sewer pipelines and expansion of sewer pumping station, river improvement works, and construction of controlling water gates.
- Stormwater Drainage System: involves the construction of drain outlets and pipelines.
- Sludge Treatment and Disposal: involves the construction of: (i) a sludge treatment facility (80 tonnes/day of dry solid); (ii) municipal sludge disposal facility (840 m^3/d); and (iii) a leachate collection and treatment system.

Additional components involve institutional development as well as the proposed active participation of women in park development.

Institutional and Management Arrangements

- Nanjing Municipal Government (NMG) is the executing agency for the project.
- Nanjing Urban Construction Investment Company (NCIC), which is one of the largest city infrastructure state-owned enterprises in the PRC, is in charge of construction and operation of the City East WWTP and its sewerage components.
- Nanjing Drainage Management Department (NDMD) is the implementing agency for the three components: (i) Inner Qinhuai River sewerage and water replenishment; (ii) North He Xi District sewerage, river improvement, and water replenishment; and (iii) sludge treatment and disposal.
- Nanjing Municipal Engineering Construction Department (NMECD) is a non-revenue-generating legal entity and a government department within Nanjing Municipal Public Utilities Bureau. It is the implementing agency responsible for the construction of drainage engineering works, and O&M of drainage facilities, and will handle the stormwater component of the project.

Financing Arrangements

- Total project cost is estimated to be at $236.7 million, broken down as follows: $100 million (ADB loan); $54.9 million (commercial bank loan); and $81.8 million (NMG counterpart).
- NMG is keen on pursuing private sector participation for the project by gaining access to capital markets to finance water and wastewater infrastructure through bond issuance.
- NCIC proposes to issue 10-year bonds value at CNY2 billion, subject to the same implementing capacity building measures.

Project Outcomes

- The impact of the project is to improve the urban environment, public health, and quality of life of urban residents and businesses in Nanjing City. The outcome of the project is improved management of surface water resources in Nanjing.
- Specifically, by 2010, the project will benefit about 2.7 million urban residents in Nanjing whose living conditions and public health standards will improve as a result of (i) reduced pollution in Nanjing's surface water following the improvement of wastewater collection and treatment rate, better sludge management, and renewal of degraded urban wetland; (ii) protection from flooding, and elimination of hazards associated with inadequate stormwater drainage; and (iii) reduction of incidence of waterborne infectious diseases to below the 2005/2006 level of 43 cases per 1,000 people.
- By 2010, the project will improve the management of surface water resources in Nanjing by (i) achieving the goal of 85% wastewater treatment rate in Nanjing; (ii) reducing the annual pollution load in the Qinhuai River by 5,000 tonnes BOD, 9,000 tonnes COD, 6,800 tonnes of TSS, 950 tonnes

ammonia nitrogen, and 110 tonnes total phosphorus; (iii) significantly reducing flooding in urban areas; (iv) increasing the efficiency and management capacity of the implementing agencies; and (v) improving cost recovery through a better tariff structure, with gradual increases to achieve cost recovery.

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Wastewater as a Strategic Part of Economic Development

Better access to clean water and sanitation services is a progressive strategy for economic growth, and results in immediate and long-term economic, social, and environmental benefits that make a difference to the lives of many people. The project brief articulates the close link between water and the economy. Good management of wastewater and water resources brings more efficiency and higher productivity across economic sectors as well as contributes to the health of the people and the ecosystem. It creates huge opportunity for attracting investments and tourists, generating employment, improving public health, reducing poverty, and managing the environment and water resources more sustainably. The economic returns from tourism, real estate, businesses and reuse applications more than offset the investment cost for the clean-up and wastewater management system.

Catalyzing Environmental Investments and Economic Development

Xiamen, Fujian Province, People's Republic of China

Xiamen is a coastal city located in the south of Fujian. The city covers 1,565 km^2 of land, and 390 km^2 of sea areas. In 1980, Xiamen was designated as a special economic zone, specifically as an international port, and a scenic tourist city.

The poor exchange of water in Yuan Dang Lagoon with the outside sea area, combined with untreated sewage and garbage being dumped into the lagoon, resulted in the deterioration in the lake's water quality. Additionally, several red tide outbreaks occurred during the 1980s.

In 1989, the cleanup of Yuan Dang Lagoon was initiated by the Municipal Government of Xiamen, prompted in part by the adverse reactions of foreign and local investors towards the lake's unsightly condition, and the threats it posed to the community's well-being. The initial cleanup program involved the installation of two wastewater treatment plants, dredging of bottom sludge, construction of tidal channels, wastewater interception and collection system, retention walls, lake shoreline protection and greening work, and the development of Egret Island.

Technology Option

- There were 7 sewage treatment plants, 376 km of piping system, and 31 sewage pumping stations constructed in Xiamen.
- Technologies used: (i) traditional activated sludge for sewage, gravitational sedimentation; (ii) anaerobic/oxic (A/O) process for the removal of phosphorous; (iii) anaerobic/anoxic/oxic (A^2/O) process; (iv) O'Bell oxidation ditch; (v) improved activated sludge; (vi) deoxidation ditch; (vii) activated sludge with biochemical treatment; and (viii) anaerobic treatment for sludge.

Financing Arrangements

- Total investment for the construction of the above was greater than CNY1 billion.
- Financing sources for the investment in environmental protection and management include: (i) public financial budget; (ii) an environmental protection special fund taken from the pollution discharge fee; (iii) the "three simultaneous investments" of any construction project; and (iv) loans from the World Bank and the Asian Development Bank.
- *Cost recovery:*
  - Wastewater treatment fees;
  - Selling organic fertilizer produced from treated sludge (as of 2007, two sludge treatment plants produced 0.25 million

tonnes of organic fertilizer—for tea plants, fruit trees, and for export.); and

- Selling reclaimed water. For example, as of 2007, the Shiweitou Sewage Treatment Plant supplies 24,000 t/day of midwater for watering plants in more than 500 hectares of green belts in the city, thereby generating an income of CNY2 million annually.

Xiang'an Sewage Treatment Plant (Source: Zhou Quilin)

Project Outcomes

- With the successful clean up of the Yuan Dang Lagoon, there was an increase in urban sewage treatment investments from CNY68 million in 1996 to CNY179 million in 2005. Also, there was an increase in sewerage investments from CNY146.41 million in 1996 to CNY236 million in 2005.
- Environmental benefits: There have been distinctive overall improvements in the water quality, with significant reductions in BOD, COD and heavy metals, such as mercury, lead, and cadmium.
- In 2007, the coverage of treatment has reached 80% on Xiamen Island. The discharged treated sewage was in compliance with the first category of Xiamen Standards for Water Pollution Discharge Control. (COD: 20mg/l, and BOD_5: 6mg/l after treatment)
- Economic benefits: (i) increased real estate values; (ii) enhanced tourism; and (iii) attracted businesses. More investments came in as many investors chose Yuan Dang Lagoon as the site of their business for aesthetic reasons. The Yuan Dang Lagoon area has emerged as a center for international and domestic investment, tourism, and residential development in Xiamen. (The average annual growth rate of gross domestic product of Xiamen reached 23.3% from 1981 to 2004.)
- The cleanup project has helped to evolve the techniques for commercial use of biogas, sludge, and treated wastewater from the wastewater treatment plants.
- Social benefits: Yuan Dang Lagoon has become a community venue for cultural, recreational, tourism and leisure activities. City dwellers no longer worry about living near the lake's banks. Instead, they frequent the area for recreational purposes. In addition, the successful cleanup of Yuan Dang Lagoon has stimulated the awareness of the general public and various government departments on the importance of a healthy environment in enhancing urban economic development.

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Rethinking Financing Options

Financing of innovative wastewater management systems does not seem to be the real constraint. The problem seems to be in terms of capacity to access financing and set in place the appropriate enabling conditions. There are already a number of financing sources and modalities. The project briefs demonstrate that shaping new ways to secure financing for households, markets and the public sector, and drive change is possible and doable. Innovative financing mechanisms also provide incentives for cities to invest in wastewater and septage management systems, and for households to invest in onsite sanitation systems.

Cost sharing between national and local governments in the case of Kitakyushu, Japan and Guangzhou, People's Republic of China (PRC), and between the local government and the water utility in the case of Dumaguete City, Philippines, show how massive investments for wastewater management can be financed through strategic collaboration. The key is to optimize public funds, consider targeted subsidy schemes, and structure affordable user fees for cost recovery.

In Japan, the national government subsidies will finance up to 55% of capital cost for wastewater treatment plants, and 50% for sewer lines. For the unsubsidized portion, funding is done through local bonds issued by the local government, beneficiary contribution, and general account of the local government. Sewer user charges are collected from households for O&M.

The wastewater management systems in Guangzhou, PRC were financed through bank loans, the Municipal Construction Fund, national and local government appropriated funds, and foreign grants.

In Dumaguete City, the city government and the local water district (utility) jointly funded the construction costs of the septage treatment plant and desludging equipment as well as the O&M costs. Full cost recovery is attained through the collection of user fees from households and establishments.

A noteworthy innovation is socialized community fundraising, which has been implemented with great success by Gram Vikas, a nongovernment organization that works with the poor to improve sanitation in the rural villages in Orissa, India. Gram Vikas ('village development') has helped households in these villages acquire good quality toilets and bathrooms as well as 24-hour water supply, with cofinancing from the village corpus fund. All households in the village contribute a certain amount, in cash or in kind, to the corpus fund, depending on their capacity to pay. Most of these villages are tribal and *dalit*—the poorest of the poor—which makes their success all the more incredible.

Microfinance also provides a solution to the household sanitation cash trap, and allows poor households to gain access to improved sanitation facilities at affordable and flexible payment terms. In Cambodia, microfinancing and national subsidy provided farmers with the means to acquire biogas digesters to treat human and animal wastes, and then process them into safe fertilizer as well as create biogas for use in cooking and lighting. This has resulted in reduced time for fuelwood gathering by women. The project in central Viet Nam shows how a sanitation credit scheme and revolving fund enabled households to construct latrines and septic tanks. Also noteworthy is the strong participation of the Women's Union of Viet Nam, making the improvements more socially relevant.

The socialized corpus fund in Orissa, India, and the microfinancing schemes in central Viet Nam and Cambodia are some of the examples of community-based financing that allowed poor households to gain access to improved sanitation.

Project Briefs

- Optimizing National and Local Government Financial Resources for Wastewater Management and River Clean Up: Kitakyushu City, Fukuoka Prefecture, Japan
- Local Government-financed Citywide Septage Management System: Dumaguete City, Negros Oriental, Philippines
- Leveraging Capital for Pollution Reduction through Various Financing Mechanisms: Guangzhou, Guandong Province, People's Republic of China
- Bringing Water Supply and Sanitation Services to Tribal Villages: Orissa, India
- Household Sanitation Credit Scheme: Viet Nam
- Microfinancing for Biogas Digesters: Cambodia

Optimizing National and Local Government Financial Resources for Wastewater Management and River Clean Up

Kitakyushu City, Fukuoka Prefecture, Japan

Before (1960s) (Source: City of Kitakyushu)

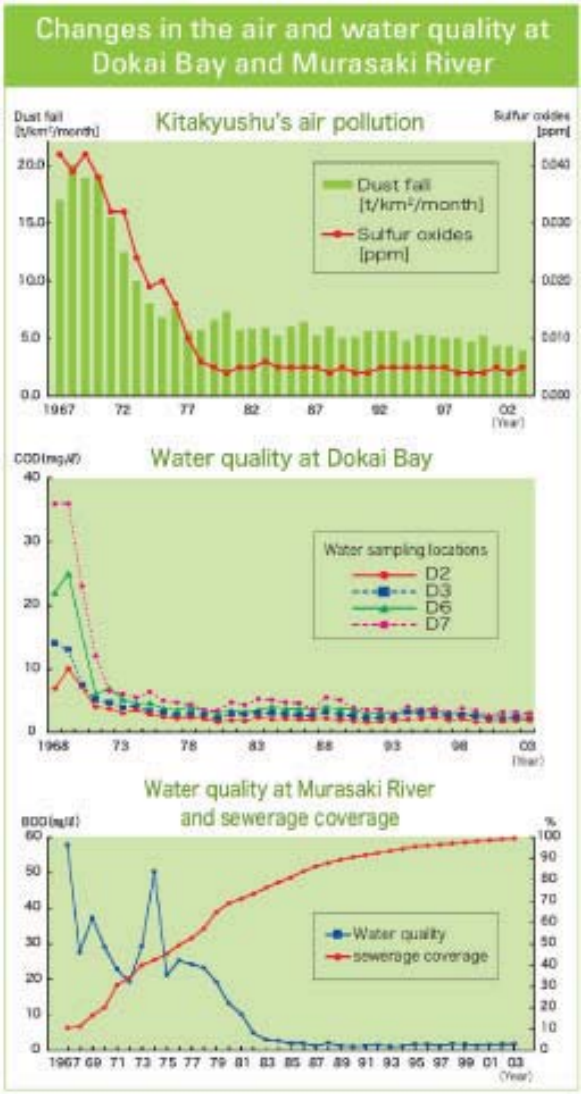
Present (Source: City of Kitakyushu)

The city of Kitakyushu is an industrial city in Western Japan, with a population of 1 million. The city has a long coastalline of 210 km and abundant nature with 40% of the city area covered by forest. The GDP of this city is approximately ¥3 trillion, and many heavy industry groups, such as iron foundries, are located in the coastal area. In the 1960s, the pollution at Douai Bay, which is located in the middle of an industrial area, became so serious that its marine life became completely extinct. The area was called the "Sea of Death". The water quality of the Murasaki River—which flows through the center of Kitakyushu—was extremely polluted in 1967 with a BOD value of 58 mg/l (around 1 mg/l currently) due to the city's rapid industrialization and urbanization, and the lack of wastewater treatment facilities. As a result, residents disliked approaching the riverside.

Technology Option

- Around 99.8% of the population is connected to the public sewerage system.
- The onsite treatment systems (Johkasou) cover approximately 600 households from small communities in rural areas (where sewerage construction is difficult).
- For a rapid and relatively cheap manifestation of sewerage benefits, i.e., water quality improvement and flood damage reduction, the combined sewer system was introduced in the 1960s in almost all of the central city area.
- At the final stage of sewerage implementation, the combined sewer system, which covers an area of 3,422 ha, represents 20% of the whole wastewater-treated area, while the separate sewer system has been installed in the remaining 80%.
- Since 2003, the city of Kitakyushu is fully tackling the improvement of the combined sewer system, while continuing the changeover to the separate sewer system, and the construction of stormwater reservoirs for pollution control during heavy precipitation events.
- Small-scale sewerage systems have been planned in suburban areas with low population density. The wastewater unit load and the minimum diameter of sewer pipes were determined based on data from water supply conditions to reduce construction costs.

- The city has five wastewater treatment plants. These plants use the conventional activated sludge process, and have a total capacity of 621,000 m^3/d.



Source: Japan Sanitation Consortium. 2013. Wastewater Treatment and River Clean Up: Case of Kitakyushu

Institutional and Management Arrangements

- Kitakyushu's Water and Sewer Bureau manages sewage works. Although the Water Bureau and Sewer Bureau merged in April 2012, their general accounts remained separated.
- The financial regulations of the Local Public Enterprise Act have been applied since 1985, and a corporate accounting method has been adopted.
- The operations at the central control center of the wastewater treatment plants have been outsourced to the private sector since the 1970s.
- Various citizen organizations conducted environmental research, river cleanup campaigns, and collections of the cans and bottles thrown along roadsides.
- In 1968, the city of Kitakyushu created the 'Countermeasures Association of Murasaki River' as a special organization to tackle water pollution issues. This was followed by a resettlement plan for the barracks of low-income earners located along Murasaki River, and included consultations with the occupiers for relocation in building plots and apartments provided by the city.
- The private sector took part from the beginning in the creation of 'The Restoration Project of Murasaki River', which started in 1987.

Financing Arrangements

- In Japan, the implementation of sewage works is placed under the responsibility of
- local governments.
- Experts and knowledgeable persons from central and local governments were gathered in the so-called Sewerage Finance Research Committee. The goal of this committee is to determine the fundamental principle for the financing of sewage works according to socioeconomic conditions (decision of subsidy rules with transparency).
- The central government provides subsidies at fixed rates, which depend on the type of facilities.
- The funding of unsubsidized facilities is done through local bonds, and the general account of the local government. Residents also partly pay for the capital cost through beneficiary contribution.
- The current subsidy rate is 55% for eligible wastewater treatment plants, and 50% for sewer lines.
- The total capital investment cost for sewerage facilities in Kitakyushu exceeded ¥600 billion over the past 40 years. According to the fundamental principle of sewerage finance established by the Sewerage Finance Research Committee, this cost was shared between municipality bonds (65% of total cost), subsidies from the central government (26%), beneficiary contribution (3%), and the general account of the city (6%).

- At the time of bond repayment by local governments, the law authorizes about 50% redemption with the tax revenue allocated to local governments for this purpose.
- Generally, sewer user charges are calculated by the addition of basic charge, and the charge depending on the supplied water amount. In the case of Kitakyushu, for a family that uses 20 m^3/month (40 m^3/2 months), the sewer user charge is ¥4,292 (for 2 months), which is equivalent to ¥107/m^3 ($1.34/$m^3$). This is cheaper than in many cities of Europe. (Conversion factor: ¥80/$1)

Project Outcomes

- As with many cities of Japan in the 1960s, the bay and rivers of Kitakyushu were extremely polluted; a situation comparable to the conditions currently found in cities of developing countries. Pollution has been overcome because of the investment made by private factories in wastewater treatment facilities for industrial effluent, as well as the significant public investment made for the development of sewerage systems.
- The understanding, efforts and collaboration of Kitakyushu City, the residents, and the private sector enabled sewerage progress.
- Kitakyushu was the first city in Japan that improved its water environment.
- The improvement of water environment in cities of the country not only supported Japan's economic development, but also allowed all sorts of environmental engineering development by both the public and private sectors. The developed technologies supplied outside Japan enabled environmental improvement in other countries as well. This well paid back the large investment required for sewerage.
- Positive outcomes of sewerage works in Kitakyushu:
  (i) The development of a legal and financial support system from the central government was a powerful incentive for sewerage implementation.
  (ii) The determination of a business scheme well suited to the characteristics of the city enabled effective project cost reductions.
  (iii) The adoption of the combined sewer system in areas with urgent needs.
  (iv) The establishment of a monitoring system to assess water quality in the major discharge points receiving industrial wastewater from factories.
  (v) The strong will of the city authorities represented by the mayor, and supported by the residents, was a powerful driving force for sewerage projects.

Local Government-financed Citywide Septage Management System

Dumaguete City, Negros Oriental, Philippines

Vacuum trucks for septage collection (Source: Josie Antonio)

Treatment Ponds (Source: Josie Antonio)

Dumaguete City is the administrative capital of the province of Negros Oriental, and a regional center of commerce and trade in Western Visayas in the Philippines. It is known as a university town for its institutions of higher learning. Studies showed poor water quality of its coastal areas, and the high risk of contaminating the city's groundwater. In 2006, in an effort to protect groundwater, this being the only source of water supply, the city government of Dumaguete, with the technical assistance from the USAID, adopted a septage management program

in a joint venture with the Dumaguete City Water District, the local water utility company. The septage management program mandates appropriate design, construction and maintenance of septic tanks, regular desludging, treatment of septage, and "user fees" to recover capital and operating costs of the system. The city also constructed a decentralized wastewater treatment system for the city's public market in 2007 to further minimize degradation of the city's coastal waters. Local and city ordinances have been passed to support the septage and wastewater management program.

Technology Option

Public Market Wastewater Treatment Plant:

- Anaerobic Baffle Reactor System, a nonmechanized treatment process with a treatment capacity of 80 m^3/d.
- The system is composed of a settling tank, anaerobic baffle reactor, anaerobic filter, planted gravel filter, and chlorinator.

Septage Treatment Plant:

- The treatment system uses stabilization ponds composed of anaerobic, facultative and maturation ponds. A planted gravel filter and wetland are used for polishing operations.

Institutional and Management Arrangements

- The city government of Dumaguete is the project owner, with the City Planning and Development Office as supervising agency.
- The Dumaguete City Water District desludges septic tanks of residences, business establishments and institutions and transports the septage to the septage treatment plant.
- The City Government operates the septage treatment plant.
- The Dumaguete City Water District collects the septage "user fee" as an add-on to the monthly water bills.
- The City Environment and Natural Resources Office regularly monitors the septage treatment plant efficiency.

Financing Arrangements

- The city government and the local water district jointly and equally funded the initial construction costs of the septage treatment plant and desludging equipment.
- The city government and the water district equally share operating costs.
- Capital and operating costs are recovered through the septage "user fee" of P2.00 ($0.05) per m^3 of water consumed.

Project Outcomes

- Ended the indiscriminate disposal of septage by private desludgers.
- Community awareness of the local government's environmental protection initiatives.
- City's desludging fees through "user fee" are lower than those of commercial desludgers.
- Full capital cost recovery in 6 years.
- Farmers use dried sludge as soil conditioners.
- Generated savings of about P4.1 million in 2012.
- Number of septic tanks desludged is around 9,000, with an estimated septage volume of about 44,000 m^3.

Contact for more information

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Pollution Reduction and Wastewater Management

Guangzhou, Guandong, Province, People's Republic of China

Guangzhou is the capital of Guangdong Province, along the Pearl River delta. The river has made the city the political, economic, cultural, scientific, and technological center of the province. With the increase in economic development and population, domestic sewage also increased, affecting the river water quality negatively. The construction of the Municipal Sewage Treatment Plant in 1997 spurred an increase in environmental infrastructure investments with the introduction of foreign and local capital via BOT arrangements and bank loans.

Technology Option

- Sewerage systems, pumping stations, and wastewater and sludge treatment facilities:
  (i) Xilang: 5 stations, 69 km of pipelines, activated sludge process of

dephosphorization and denitrogenation, and a sludge treatment process;

(ii) Liede: 4 stations, 144 km of pipelines, and activated sludge process; the third phase adopted the improved anaerobic/anoxic/oxic (A^2/O) activated sludge process

(iii) Datansha: 5 stations, 10.3 km of pipelines, and both an A^2/O activated sludge and inverted A^2/O activated sludge process for removal of phosphorus and nitrogen;

(iv) Lijiao: 7 stations, 115 km of pipelines, and an anaerobic/oxic (A/O) activated sludge process;

(v) Dashadi: 2 stations, 120 km of pipelines, and an A^2/O activated sludge process;

(vi) Zhuliao: 2 stations, 51.6 km of pipelines and an A^2/O activated sludge process;

(vii) Jiufo: 61 km of pipelines and an oxidation ditch process; and

(viii) Longgui: 2 stations, 123 km of pipelines and an A^2/O activated sludge process.

- The Jinsheng Sludge Treatment Plant in the Panyu District, considered the largest sludge treatment plant in the world, includes the use of an additive that deactivates heavy metals, anaerobic sludge treatment, vacuum dehydration, compaction, and sintering.

Liede sewage treatment plant (Source: Lin Duan)

Xilang sewage treatment plant (Source: Lin Duan)

Institutional and Management Arrangements

- The central government provides the laws and policies on pollution prevention and project financing.
- The Guangzhou City Wastewater Treatment Limited Company was set up in 2004.
- The local government chooses the company to operate in a BOT arrangement.

Financing Arrangements

- BOT contracts were arranged for Xilang and the Jinsheng treatment systems.
- In Xilang, treatment charges were collected from the residents and corporations that are connected to the system. The amount was enough for credit repayment, maintain sewage treatment plant operation, and gain meager profits.
- For Jinsheng, the government paid for the sludge treatment cost during the operation period.
- Most of the sewage treatment systems were partially financed through bank loans, the Municipal Construction Fund, national and local appropriated funds, grants-in-aid, and foreign donations.
- The Guangzhou water company, representing the government, would collect sewage treatment fees from the residents and corporations that are connected to the treatment facilities. Shortfall in collected fees for the repayment of the loans would be partly provided by the government through sewage treatment subsidies.

Project Outcomes

- In Xilang, the foreign company involved considered other project investments because of the reasonable return on investment.
- There is an improvement in water quality and environmental conditions. In Liede, the treated sewage met the state's second class emissions standards. In both Datansha and Lijiao, treated sewage met the state's first class emissions standards.
- In the Jinsheng Sludge Treatment Plant, its compaction and sintering processes resulted in the production of red bricks, which were of world class quality.

Bringing Water Supply and Sanitation Services to the Tribal Villages

Orissa, India

A Gram Vikas village: houses with water supply, bathrooms and toilets
(Source: Joe Madiath

Many remote tribal villages in Orissa lack basic sanitation facilities. The only available water source is tainted with human waste, and disease is prevalent among its members. Access to clean water is restricted to powerful members of the community.

Gram Vikas implemented the MANTRA (Movement and Network for the Transformation of Rural Areas) program, an integrated habitat development program. The program's key areas are water and sanitation for the poorest and most marginalized communities.

Technology Option

- All households are provided with bathing facilities, a toilet, and clean running water supply. An overhead water tank using the gravity flow design is used with zero energy inputs.

Institutional Arrangements

- Gram Vikas provides skills building, training, and education.
- The Village General Body is the platform for community discussions.
- The Village Executive Committee is elected from the body. When registered and legally recognized, it is known as a Village Society.
- The Village Society undertakes financial transactions, leverage development resources, and enters into formal agreements.

Financing Arrangements

- Communities are required to cover part of the cost of the bathroom, toilet and water supply, and contribute towards building the structures. Also, the communities collaboratively establish their water supply systems. The cost of O&M of the system are borne by the community. To put this into effect, a village corpus fund is created with contributions from all families. Poorer families that cannot afford to pay the whole amount contribute in other ways, such as collecting raw materials. More affluent families pay more to help maintain the average.
- The corpus fund is then invested in a local bank, and the interest generated covers the cost of extending water and sanitation facilities to new households. Also, the interest covers increasing the capacity of the water tank, or other major infrastructural capital expenses that may come up.
- External sources include government programs and international and domestic donors. If there is a gap between funds generated, the gap is met using Gram Vikas' resources.

Project Outcomes

- There are 404 registered Village Societies created.
- Around 700 villages raised a combined corpus fund of over Rs50.7 million.
- Approximately 44,697 families have access to toilets; 21,947 families have access to 24 hours protected water supply.
- An 80% reduction in incidences of water-borne diseases and morbidity rates has been observed.

Household Sanitation Credit Scheme

Viet Nam

The Central Region Urban Environmental Improvement Project in Viet Nam (CRUEIP)—loan approved in December 2003; project completed in April 2011—aimed to improve living conditions in a series of six mid-size coastal towns in the

central provinces of Viet Nam. To achieve these objectives, the project supported the construction of stormwater drainage and flood control works, as well as infrastructure facilities for the management of solid waste and wastewater. In addition, the project aimed to strengthen awareness on the benefits of environmental sanitation amongst urban communities, and also with local government agencies. Linked with this were provisions that encouraged poor families to invest in improved personal sanitation facilities, most notably through a household sanitation credit scheme.

Construction of toilet and septic tank (Source: Do Nhat Hoang)

Technology Option

- Household latrines, toilets and septic tanks.

Institutional Arrangements

- The entire community awareness programme and the credit scheme was managed by the Community Management Committees (CMC), one for each project town, with the membership largely drawn from the local chapter of the Viet Nam Women's Union.
- Consistency with project approach and guidelines was ensured through representation within each CMC of an official from the provincial Project Management Unit.
- The CMCs informed households about the opportunity to take on short-term loans for the construction of a toilet, a septic tank or latrine, through a Household Sanitation Credit Scheme (HSCS). Poor and near-poor households (based on the assessment of the Women's Union) will have access to the credit scheme.

Financing Arrangements

- The project provided the start-up capital for this revolving fund; but the members of the CMC determined the conditions for loan and repayment as well as defined the criteria for eligibility.
- The CMCs administered the credit scheme as a revolving fund, and provided health awareness and technical information to borrowers.
- The community awareness and pro-poor sanitation component only represented about 1% in pure financial terms of the CRUEIP project effort.
- Credit terms: Loan amount is D4 million or around $250 (80% of the estimated costs of the proposed septic tank/superstructure/connection to the sewerage system for the household). The remaining 20% is in-kind contribution by the household (i.e., labor). The interest rate is 0.5% per month. Payment is within 24 months on a monthly basis.

Project Outcomes

- By the end of the project in 2011, approximately 2,230 houses in the CRUEIP towns had constructed new latrines and septic tanks as compared with a target number of 1,220. Three-quarters of credit recipients were women. The revolving fund operation is now expected to continue the program after completion of CRUEIP.
- The concept of creating or stimulating the demand for investing in sanitary facilities at the household level, boosted by a tailor-made community-managed credit scheme, can be replicated at a larger scale in many other urban settings throughout Viet Nam.

Contact for more information

Hubert Jenny, Hoang Nhat Do, and Jan Jelle van Gijn (Viet Nam Resident Mission, Asian Development Bank).

Microfinancing for Biogas Digesters

Cambodia

A nearly completed biodigester, showing the mixing tank (rear), biodigester (middle), and outlet (front). (Source: National Biodigester Program, 2011)

Standard model of the Farmer's Friend Biodigester (Source: National Biodigester Program)

Majority of Cambodians who live in the rural areas are into agriculture. They have no access to electricity, use collected firewood for cooking, and rely on either expensive commercial fertilizers or risky raw animal manure to fertilize their fields. Faced with these challenges, the biogas digester presents a cost effective solution to address their concerns.

The biogas digester is a simple, yet powerful sanitation technology option that is capable of: (i) processing human and animal feces into safe and free fertilizer; (ii) reducing cases of groundwater contamination by processing feces instead of having it discharged untreated; (iii) creating biogas for use in cooking and household lighting; (iv) empowering women and families by reducing their time spent on gathering fuelwood and cooking; (v) reducing indoor air pollution brought about by burning fuelwood; and (vi) eliminating carbon dioxide (CO_2) emissions during fermentation of openly-discharged sewage, thereby helping to reduce the threat of climate change and potentially create carbon offset credits for sale to industrialized countries.

Technology Option

- Serving as the primary settling tank, the biogas reactor is an anaerobic, sealed chamber, which facilitates the relatively fast passage of liquid effluent through the chamber, and digestion of much of the settled sludge by anaerobic bacteria.
- The biogas reactors built for this project, also known as the "Farmer's Friend Biodigester", are of the 'fixed dome' type. Each reactor has (i) an inlet mixing chamber, where animal manure can be mixed with water to allow its flow into the unit; (ii) a main chamber, where the anaerobic fermentation and biogas production takes place; and (iii) a raised outlet area (and maintenance manhole), where liquid effluent and sludge is gradually discharged through pressure exerted on the liquid by the accumulating biogas.
- The generated gas, which is dependent on the size of the biogas reactor, can be used for small scale applications (e.g., operating a gas stove or light), or for large scale applications (e.g., powering the scalding vats of a slaughterhouse).

Institutional Arrangements

- The main executing agencies are: (i) Ministry of Agriculture, Forestry and Fishery (MAFF), as the program owner and host; (ii) SNV-Netherlands Development Organization, as the main technical assistance and planning agency; and (iii) Department of Animal Production and Health (DAPH) of Cambodia, as the coordinating agency for the project.
- The Ministry of Foreign Affairs of Netherlands is the main funding agency, through their Asia Biogas Program. The German International Cooperation (GIZ) provided additional funding for program establishment and maintenance, IEC campaign activities, and a flat rate subsidy on the cost of the biodigesters for the farmers.
- The Netherlands Development Finance Company (FMO) provides loans to two local cooperating microfinance institutions—PRASAC and AMRET. In turn, both institutions provide loans to farmers for the purchase of their biodigester facilities.
- Cooperating agencies include:
  - Humanist Institute for Development Cooperation (HIVOS), which is purchasing the carbon offsets generated by the project;

- PRASAC Microfinance Institution and AMRET Microfinance Institution;
- ACELDA Bank, which channels funds from the program to individual farmers for a postconstruction, flat rate subsidy of $150 off the cost of all biodigesters purchased through the program;
- Cambodian Center for Study and Development in Agriculture (CEDAC), acting as the Provincial Biodigester Program Office (PBPO) in Kampot, Prey Veng, Kandal, and Kampong Thom provinces;
- Preah Kossomak Polytechnic Institute, which provides training for technicians and masons on biodigester construction;
- Development Technology Workshop Cambodia, which develops appropriate biodigester accessories for the program (e.g. stoves, drains, lights);
- Cambodia-India Entrepreneurship Development Center (CIEDC), which assists in the capacity development for entrepreneurs who wish to start a new biodigester company as part of the program;
- Groupe Energies Renouvelables Environnement et Solidarite (GERES), consultant for rural energy-related studies;
- Cambodia Institute of Development Study (CIDS), consultant for socioeconomic studies;
- iLi Consulting Engineers Mekong, consultant for technical engineering issues;
- Local governments of the provinces of Siem Reap, Battambang, Pursat, Kampong Thom, Kampong Cham, Kampong Chhnang, Kampong Speu, Svay Rieng, Prey Veng, Kandal, Takeo, Kampot, Kep, and Sihanoukville. All these provinces helped to establish their PBPO, except for Kampot, Prey Veng, Kandal, and Kampong Thom provinces. Their local governments liaised directly with the biodigester sales companies, the microfinance institutions, and with interested farmers.

Financing Arrangements

- To cover the cost of biodigesters in the National Biodigesters Program (NBP), a flat-rate subsidy of $150 is provided using GIZ funding (Table1). The balance is paid for by farmers through loans from the microfinancing institutions (PRASAC and AMRET). The farmers can borrow up to a maximum of $1,000, with an interest rate of only 1.2% per month, for a duration of 4–24 months. Table 1 shows the total cost, subsidy, and cost for the farmer-borrower (loanable amount).
- Table 2 shows the payback period of a 4 m^3-biodigester at a cost of $400, per prior fuel source.

Table 1. Cost and Subsidy

Biodigester size (m^3)	Total cost	subsidy from NBP	Farmer cost
4	400	150	250
6	500	150	350
8	550	150	400
10	650	150	500
15	900	150	750

Source: National Biodigester Programme. 2011.

Table 2. Cost Savings and Payable Period

Type of Fuel Sources	Quantity Saved	Cost per unit	Total cost save per day	Total cost save per year	Payback period without subsidy	Payback period with subsidy ($150)
Firewood	6 kg	$ 0.07	$ 0.42	$ 153	2.6 years	1.6 years
Charcoal	2kg	$ 0.20	$ 0.42	$ 153	2.6 years	1.6 years
Kerosene	0.7 liter	$ 0.65	$ 0.46	$ 166	2.4 years	1.5 years
LPG	0.5 kg	$ 1.00	$ 0.50	$ 183	2.2 years	1.3 years

Source: National Biodigester Programme. 2011.

Project outcomes

- Improved overall sanitation in Cambodia;
- Improved lives of the farming families by utilizing an existing resource (manure of their animals) that provides them with free biogas for cooking and lighting;
- Improved agricultural productivity of the farmers through their 'closing the loop' use of the output bio-slurry;
- Improved governing and marketing institutions by using the multipartnership program to bring together and utilize the talents of the different government agencies, private sector groups, and nongovernment organizations operating in the country; and
- Sale of about 12,000 biodigester units that have benefitted an estimated 60,000 Cambodians.

Contact for more information

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Public-Private Partnerships: Driving Innovations

In general, the public sector provides the water, sanitation and waste management services. However, experience demonstrates that government alone cannot meet the growing demand for such services. In many countries, central and local governments are hard pressed to develop and finance the construction and operation of these much-needed facilities and services as a consequence of lack of capacity and knowledge as well as other socioeconomic issues that compete for limited financial resources.

Whereas traditional development assistance plays a vital role in enabling some governments to meet the challenge, it provides only a fraction of the needed investment. This indicates that an alternative approach is required to develop, finance and implement such traditionally public domain projects—one that involves collaboration with the private sector.

A PPP arrangement allows the public sector to consider otherwise unaffordable projects. PPP can provide the delivery mechanism to fill the infrastructure gap between what the government and communities can afford, what the citizens expect, and what environmental management and sustainable growth require. Through PPP, the public sector can leverage the private sectors' technical and managerial expertise and financial support. However, the enabling conditions—clear policy and regulatory framework, contract management, cost recovery mechanism, consistent enforcement of laws—have to be in place to attract private sector participation and ensure sustainable partnership.

The three cases in Kuwait, South Africa and the Philippines highlight the adoption of PPP as a delivery mechanism for putting in place innovative design and technologies for more effective wastewater treatment and reuse application. The wastewater recycling project in Durban, South Africa, which is operating on a BOT basis, found profitable use for its treated effluent. It supplies water to industries as well as potable water to the city. Likewise, the wastewater management project in Sulaibiya, Kuwait uses the BOT modality, and provides an alternative to the more expensive desalination plants in addressing the country's problem with scarcity of water resources. In the Philippines, the water concessionaire for the East Zone of Metro Manila as well as Rizal Province applies innovative design of the facilities to meet land constraints, and gain acceptability in the communities.

Project Briefs

- Addressing Water Scarcity through PPP and Innovative Wastewater Management: Sulaibiya, Kuwait
- Pioneering Wastewater Treatment and Reuse: Durban, eThekweni Municipality, South Africa
- Adopting Innovative Design for Wastewater Management Systems: East Zone, Metro Manila, and Rizal Province, Philippines

Addressing Water Scarcity Through PPP and Innovative Wastewater Management

Sulaibiya, Kuwait

The Sulaibiya Wastewater Treatment and Reclamation Plant is a groundbreaking project, not only in the Middle East where it is the first infrastructure facility of its size to be executed as BOT, but also the largest of its kind using the RO/UF technique in domestic wastewater treatment and reclamation. The BOT arrangement is part of the Kuwaiti Government's plan to encourage effective participation by the private sector in the development of the national economy through the execution of infrastructure projects.

The plant has a total ultrafiltration (UF) membrane area of 304,640 m² arranged in 68 skids. (Source: IWA)

Technology Option

Pretreatment system

- The Ardiya plant acts as a pretreatment phase, with four parallel lines of 6 mm step screen with aerated grit chamber to remove particles, sand, and grit to a particle size of 0.2 mm.
- There are two circular buffer tanks (20,000 m³) to balance the wastewater influent variation agitators.
- All the structures are covered with a scrubber system to prevent odour nuisance.
- The pumping station consists of eight pumps, two of which are standby units to transfer wastewater through three pressure pipelines from Ardiya to the Sulaibiya treatment plant.

Treatment system

- The Sulaibiya Wastewater Treatment Plant is comprised of three elements: biological nutrient removal, RO/UF membranes, and sludge treatment. The capacity is 375,000 m³/d, with the option to be extended to 600,000 m³/d. The treatment process starts with nine aeration tanks. Air is supplied through the blower building which contains five blower units.
- The secondary clarifiers (consisting of nine circular secondary clarifiers) and the effluent are discharged to a collection basin where the reclamation processes are started.
- The suspended solids are pumped into the gravity belt thickening building, and then the wastewater is discharged to eight aerobic digesters.
- The sludge produced is transported to the sludge drying beds, and stored in a special area for 6 months to make use of it as fertilizer.
- The secondary treated wastewater is pumped from the collection basin to the ultrafiltration unit, which has five trains containing 8700 filter units for complete removal of suspended solids.
- Then the filtrate flows into a 6000-m³ basin before being pumped to the RO facility.

Institutional and Management Arrangements

- The contract was administered by the Kuwait Ministry of Public Works (MPW) and awarded to Utilities Development Company (UDC) – jointly owned by the Kharafi Group (75%) and Ionics Italba – an Italian company (25%).
- The German company Philipp Holzmann and the Italian company Italba, a subsidiary of Ionics Inc. (USA), were involved in the design and construction of the project.
- Kharafi National KSC (closed), formerly called the National Company for Mechanical and Electrical Works, was responsible for the O&M of the treatment facility with the participation of United Utilities Company of the United Kingdom.

Financing Arrangements

Capital investment

- The National Bank of Kuwait (NBK), Gulf Bank, and The Bank of Kuwait & the Middle East arranged for the capital expenditure, with NBK acting as the facility agent. ABN Amro acted as the financial advisers to UDC, while Prudential Financial Inflation (PKF) acted as financial model auditor for the loan arrangers. The total project cost was KWD130 million ($140 million).

Estimated cost of water produced in Kuwait

- The Al-Kharafi company sells UF-treated wastewater at $1.73/1,000 IG (=$0.38/m³), and RO treated wastewater at $2.95/1,000 IG (=$0.65/m³) to the MPW. These prices are lower than the cost of freshwater (e.g., from desalination), which is $17.51/1,000 IG ($3.86/m³).

Price of water charged to consumers

- MPW water charges are $0.35/1,000 IG ($0.07/m³) for UF-treated wastewater, and $0.70/1,000 IG ($0.15/m³) for RO-treated wastewater. The treated wastewater is utilized for agricultural and industrial uses. The price of freshwater is $2.77/1,000 IG (0.61/m³).

Project Outcomes

- Sulaibiya wastewater treatment plant is the first in a series of similar projects in the region through which problems related to the scarcity of water resources are expected to be solved. Similar projects will also be beneficial, as they will reduce the need to build more expensive seawater desalination plants.
- The project had reduced environmental pollution, as partially treated wastewater is no longer discharged into the Arabian Gulf.
- The State will generate savings of around KWD3.2 billion ($11 billion) over the lifetime of the concession ($265 million annually), even with subsidies to the consumers, due to lower cost of wastewater treatment compared to the cost of desalination.
- The project will provide the State of Kuwait with a fully functional wastewater reclamation plant free of charge when the concession period expires (when the project is transferred to the State of Kuwait).
- Effluent quality surpasses that of government, WHO and US Environmental Protection Agency (USEPA) standards.

Contact for more information

International Water Association

Pioneering Wastewater Recycling

Durban, eThekweni Municipality, South Africa

Durban is part of the eThekweni Municipality, located on the east coast of South Africa. The combination of limited water resources in the city along with sewage capacity constraints, led to the investigation of different wastewater recycling processes since the region produces approximately 450 million litres of wastewater per day.

The overall objective of this project was to treat about 48 million litres of domestic and industrial wastewater (approximately 10% of the city's wastewater) to a measure near to potable standards, and sell the same to industrial customers for use in their processes.

Wastewater treatment plant in Durban (Source: IWA)

The project was South Africa's first private wastewater recycling project, operating on a 20-year BOT basis, and designed to provide effluent of a particular standard for industries.

Technology Option

- Existing activated sludge process: Upgraded from 50ml/day to 77 ml/day. A conventional design was used to remove 95% of the incoming COD, and 98% of incoming ammonia loads.
- Tertiary plant treatment process for removal of iron through lamella settlers.
- Dual media filtration to remove the iron precipitate, and ozonation for breaking down the remaining non-biodegradable organic compound.

Institutional and Management Arrangements

- The project was based on a PPP arrangement, following a formal tender process. Durban Water Recycling (Pty) Ltd. was eventually awarded a 20-year concession contract for the production of high quality reclaimed water.
- Technology and processes are managed by Veolia Water Services (VWS), which makes sure that the installations are highly specialised and tailored specifically to meet the water quality requirements of Durban Water Recycling's primary clients.

- Preliminary and primary wastewater treatment processes were performed by eThekwini Water Services (EWS), while the effluent from the primary settlement tank, which is fed into the activated sludge plant, is operated by VWS. At the end of the contracted 20-year period, the facilities will be handed over to the municipality.

Financing Arrangements

Capital investment

- The Development Bank of Southern Africa (DBSA), Rand Merchant Bank, Societe General and Natixis Bank (two French banks) financed the capital investment, which ensured all initial capital expenditure was covered.
- The cost of further upgrading, including new technology investments and its attendant risks, was covered by VWS under their BOT concession.

Cost recovery

- The cost recovery policy was applied through monthly payments by the users.
- Mondi Paper, through its commitment of using recycled water in its entire paper production, gave the project an assurance of having a secured client for its end product. The project also covers various industries, thus, increasing the profitability of the initiative.

Project Outcomes

- At operational capacity, the reclamation plant meets approximately 7% of the city's current potable water demand, and at the same time, reduces the city's treated wastewater output by 10%, thus, minimizing the wastewater load discharged into the marine environment.
- A profitable use was found for a product which would in the past be discharged into the environment, contributing to its pollution. This new perspective is advantageous not only to the community, who enjoys a more stable supply of drinking water, but also to the reclaimed water clients, who are able to satisfy their production requirements with the treated wastewater for a lower price.

Contact for information

International Water Association

Innovative Design of Facilities to Address Land Constraints

East Zone, Metro Manila and Rizal Province, Philippines

In 1997, Manila Water Company, Inc. (MWCI or Manila Water), a private company, was awarded the concession contract by the Metropolitan Waterworks and Sewerage System (MWSS) for the east zone area of Metro Manila and nearby Rizal province. Currently, MWCI provides water and wastewater services to over 6 million people from 23 cities and municipalities of eastern Metro Manila and Rizal Province.

Olandes STP (Marikina City): process tanks built underground and support facility on stilts (Source: Steve Griffiths)

Pineda STP (Pasig City): aeration tanks under a basketball court (Source: Steve Griffiths)

Poblacion STP (Makati City): elevated and on top of a Flood Control Pond (Source: MWCI)

At the start of the concession, there were very little available sewerage services in the area, estimated to be at only 3% coverage. In 2004, only about 10% of the population of the East Zone was connected to a public sewerage system, and less than 1% of the generated sewage received secondary treatment. Because of the rapid growing population of the metropolis, the volume of untreated wastewater increased accordingly. This led to the deterioration of Metro Manila's major water bodies, which were found to be polluted with organic wastes.

Steep targets for both septage and sewerage management are in place. Manila Water's wastewater management program comprises of: (i) septage management, including desludging of septic tanks; (ii) separate sewer networks; and (iii) combined sewer-drainage systems.

Some of the challenges faced in the implementation of a wastewater treatment system included: (i) the high costs of conventional sewerage systems; (ii) existing urban infrastructure with its narrow roads; (iii) the lack of available land; and (iv) increasing population and rapid urbanization. In a densely populated city, where real estate is premium, it is difficult to acquire a land that will be conducive for a wastewater treatment plant. There was also the added difficulty of the "Not In My BackYard (NIMBY)" syndrome.

Given all these, Manila Water had to explore innovative ways on how to implement wastewater projects. Manila Water has successfully implemented many projects without having to purchase land. This is done through masterplanning for early land acquisition, effective stakeholder engagement, and innovative use of the land. Essentially, Manila Water incorporates a community feature in its facilities to ensure public acceptability for the project as well as inculcate 'ownership'. Common features incorporated are basketball courts, parks, and parking lots. At the same time, Manila Water designs its facilities in a way that will blend in with its surroundings. Many of the treatment tanks are covered, and all facilities are landscaped and maintained on a daily basis.

Technology Option

- Conveyance of wastewater is usually through combined sewer-drainage network, or in some selected places, through separate sewer lines.
- Desludging of septic tanks per household is done every 5–7 years through vacuum tanker trucks of various sizes. The septage collected is brought to MWCI's septage treatment plants.
- Manila Water employs activated sludge treatment, mostly conventional and a few which will employ sequencing batch reactors (upon the completion of the Taguig North, and Marikina North Sewage Treatment Plants).
- In 2001, a Batch Treatment Process was constructed to equalize, aerate, and clarify wastewater in a timed sequence in one reactor basin.
- Sludge from septage and wastewater treatment is dewatered before final disposal to lahar-affected areas in Central Luzon.
- Treated wastewater is used for gardening purposes or in water toilets within the facilities.
- Mesophilic Anaerobic Digester became operational in 2008.

Institutional and Management Arrangements

- The Concession Agreement is a 25-year contract, which was recently extended, pushing the effective end date of concession to 2037.
- Several regulatory bodies interact and monitor the performance of Manila Water regarding its conduct of business. The MWSS-RO evaluates the proper implementation of the Concession Agreement, monitors water quality and supply in all service areas, and handles the water tariffs being charged by the concessionaires to all their customers. The DENR and the LLDA, on the other hand, provide and enforce wastewater standards for treatment operation and facilities.
- Manila Water has also formed strong partnerships with different sectors of the community, including the local government units and communities to fast-track the implementation of the combined sewer-drainage system, and the operation of the sewage treatment plants (STPs).

- In terms of innovation in managing stakeholders, Manila Water is aggressively and continuously pursuing efforts to educate communities regarding wastewater through educational trips (e.g., Lakbayan), and information and education campaigns.

Financing Arrangements

- A Rate Rebasing exercise is performed every 5 years to (i) look at performance of the concessionaire in the previous period; and (ii) review proposed business plans. This exercise also determines whether there is merit in increasing or decreasing the effective tariff imposed on consumers.
- As of December 2012, all customer types (residential, commercial, and industrial) in Metro Manila pay a 20% environmental charge from the basic water charge. The sewerage charge is pegged at 30% of the basic water charge for East Zone customers.[2]
- The combined sewer-drainage system strategy is a component of the Manila Third Sewerage Project (MTSP), which was aided by a $64 million loan from the World Bank.
- All of Manila Water's expenditures are recovered through the imposition of a water tariff, consistent with the allowed rate on return base.

Project Outcomes

- From the MTSP Loan, three STPs are constructed using the combined sewer-drainage system approach. The approach allowed rapid and efficient provision of coverage while directly addressing issues on land availability and congested roads. In addition, it minimizes pipe laying cost by integrating with existing drainage infrastructure. Manila Water has saved approximately a billion pesos ($25 million) in land acquisition costs through this scheme. Close to 5 ha of land have been acquired through agreements with various government agencies.
- The concentration of pollutants discharged from the STPs into the major rivers is within the allowable levels specified by national and regional standards.
- The climate-proofed Olandes STP received global recognition for its state-of-the-art design from the International Water Association's 2010 Asia Pacific Regional Project Innovation Award with an Honor Award for Small Projects, making it a world class wastewater treatment facility. The Olandes STP grounds also serve as a recreational park for nearby residents.
- Communities have become more open to the idea of having wastewater and septage treatment facilities nearby, and enjoy using the community features.

Contact for more information

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[2] Source: MWCI billing statements

Protecting Water Resources and Coasts

An estimated 90% of all wastewater in developing countries is discharged directly into rivers, lakes or the oceans without treatment.* Contaminated water from poor sanitation, and inadequate wastewater management contribute to poverty through costs to health care, lost labor productivity, and impacts on fisheries, tourism, and other socioeconomic activities. Without better infrastructure, services and management, millions of people will continue to get sick or die each year, and there will be further losses in biodiversity and ecosystem resilience, thereby affecting livelihoods and restricting development and efforts towards a more sustainable future.

The three case studies show how these challenges can be turned around. Finding appropriate solutions will require innovation to reduce the volume of wastewater produced, treat and even reuse the waste, and do it in an affordable, sustainable way.

The wastewater management system being implemented in five cities (Baoding, Chengde, Tangshan, Xuanhua, and Zhangjiakou) in Hebei Province, People's Republic of China (PRC) contributed to the protection of drinking water sources not only in these cities, but also in downstream Beijing and Tianjin. The project also resulted in lower incidence of waterborne diseases and pollution reduction in Baiyangdian Lake, Bohai Bay, and Hai River Basin. Treated wastewater is used in industries, parks, and thermal plants while the sludge is processed into fertilizer.

In Tianjin, the Wastewater Treatment and Water Resources Protection Project strengthened capacity for water supply and wastewater operations through management based on corporate approach and commercial principles, including cost recovery from users, and an improved water and wastewater tariff structure.

The wastewater management projects in Hebei and Tianjin are especially noteworthy for improving public health and living conditions as well as controlling pollution in Bohai Sea, an important gateway to the PRC.

In Florida, USA, the wastewater management system in Orange County enhances the environmental conditions in the River Econlockhatchee catchment. With 100% of the treated wastewater reused, mostly as cooling water for a power plant, the demand on limited groundwater reserves in the Florida aquifer is reduced.

Project Briefs

- Pollution Reduction and Wastewater Management: Hebei Province, People's Republic of China
- Wastewater Treatment and Water Resources Protection: Tianjin, People's Republic of China
- Protecting Groundwater and Ensuring Energy Security: Orange County, Orlando, Florida, United States of America

Pollution Reduction through Wastewater Management

Hebei Province, People's Republic of China

Hebei Province covers an area of 188,000 km^2. With a population of 70.34 million in 2009, Hebei lies in the heavily polluted Hai River Basin, which drains into the Bohai Sea through nine tributaries. The Hebei Province Wastewater Management Project was implemented in five cities—Baoding, Chengde, Tangshan, Xuanhua, and Zhangjiakou—all priority areas under the Hai River Basin Pollution Prevention and Control Plan.

Sewerage construction (Source: ADB)

Wastewater treatment plant in Hebei (Source: ADB)

Project Components

- Wastewater management infrastructure and facilities were constructed in:
  - (i) Baoding: 104 km of sewers, two submersible-pump lift stations, and a wastewater treatment plant (WWTP) expansion with a capacity of 240,000 m^3/d;
  - (ii) Chengde: 32 km of sewers and a WWTP with a capacity of 80,000 m^3/d;
  - (iii) Tangshan: 10 km of sewers and a WWTP with a capacity of 80,000 m^3/d;
  - (iv) Xuanhua: 24.5 km of sewers and a WWTP with a capacity of 120,000 m^3/d; and
  - (v) Zhangjiakou: 27.8 km of sewers, 1.5 km of open channels, and a WWTP with a capacity of 100,000 m^3/d.

Technology Option

- Treatment processes include secondary biological treatment with nitrification and organic phosphorus reduction. Based on the varying conditions and requirements, the oxidation ditch process was selected for Chengde, Xuanhua and Zhangjiakou; and the A/O process for Baoding and Tangshan.

Institutional and Management Arrangements

- The Hebei Provincial Government was the executing agency responsible for the overall supervision of the project through its Hebei Project Management Office (HPMO) as implementation and coordinating office.
- Local project implementation agencies were the Municipal Sewerage Companies (MSCs) in the project cities. Each MSC sets up a project implementation unit to coordinate with the HPMO, implements project activities on time, and takes responsibility for day-to-day implementation.

Financing Arrangements

- Total project cost was $173.61 million, of which the central and municipal governments provided around $92 million with ADB loans amounting to $82 million.
- By mid 2009, 46 civil works and equipment packages ($74 million) were awarded through international competitive bidding, national competitive bidding, and international shopping.
- Revenues were based on the actual and proposed tariffs, and estimates of water volume, minus the service fees paid to the water supply company.
- The financial viability of the individual components and the project as a whole was confirmed. The financial internal rates of return (FIRR) for the five components ranged from 3.5% to 11.1%, with three of the components higher than estimated at appraisal. The overall FIRR for the project was 6.4%, higher than the estimate of 5.7% at appraisal, and higher than the weighted average cost of capital of 3%.

Project Outcomes

- WWTPs were constructed, or expanded, to include pre-treatment and primary treatment facilities as well as secondary and sludge treatment facilities in the five cities.
- In all the WWTPs, effluent will be conveyed by an outfall to a river, from which the water will be available for irrigation and other uses downstream.
- Various schemes and facilities were put in place to utilize reclaimed water. The water

recycling facilities mainly supply industries, landscaping, and thermal plants. The total capacity for water recycling is 150,000 m^3/d, which is nearly 30% of the entire wastewater treatment under the project.

- For the Baoding WWTP, a portion of the sludge will be processed into fertilizer pellets. Chengde and Tangshan have also developed and implemented a pilot program for sludge utilization for composting and fertilizer production.
- The project improved the living environment as well as public health standards in the five cities. The newly installed sewer systems and WWTPs collected and treated about 540,000 m^3/d of wastewater. This has contributed to the protection of drinking water sources of project cities and the downstream cities of Beijing and Tianjin. It has also reduced and controlled pollution in Baiyangdian Lake, Bohai Bay, and the Hai River Basin. In addition, the improved environment has provided opportunities for local environmental, economic and social development, and has even promoted sustainable tourism.
- Incidence of waterborne diseases was significantly reduced with zero cases of schistosomiasis, giardia, and cholera in 2008–2009.

Wastewater Treatment and Water Resources Protection

Tianjin, People's Republic of China

The Tianjin Wastewater Treatment and Water Resources Protection Project was approved by ADB in December 2000. It aimed to improve: (i) the urban environment by reducing environmental contamination through improved wastewater management; and (ii) the quality of raw water supply in Tianjin. Secondary objectives included: (i) strengthening the capacity of the raw water supply and wastewater operations to be more efficient and managed on commercial principles: (ii) introducing comprehensive watershed management approaches: and (iii) improving cost recovery from users through an improved tariff structure.

Technology Option

- Component A included: (i) construction of the Beicang wastewater treatment plant with a capacity of 100,000 m^3/d with secondary treatment and sludge-dewatering facilities, and capacity of treated water for reuse; (ii) laying 14.80 km of sewer pipes; and (iii) constructing a pump station with a 86,400 m^3/d capacity. The biological treatment process selected was the A/O process with high phosphorus removal efficiency.
- Component B included: (i) improving open channel works from the Jiuwangzhuang Gate to the Dazhangzhuang Pump Station, including structure maintenance and landscape works; (ii) constructing a closed culvert, with a total length of 34.14 km, encompassing a regulating gate, closed box culvert, outlet sluice gate, regulating tank, and maintenance gate to avoid pollution from the Zhou River; (iii) Yuqiao Reservoir works involving soil and water conservation, village waste treatment, hospital solid and wastewater treatment works; and (iv) establishing a management information system, mostly for hydrological quality monitoring, and pump station gate remote control.

Aeration Ponds (Source: ADB)

Sludge-Dewatering Centrifuges (Source: ADB)

Institutional and Management Arrangements

- The Tianjin municipal government was the executing agency (EA).
- The project had two components: (i) component A, focusing on wastewater treatment, under the implementation of the Tianjin Sewerage Company (TSC), and subsequently transferred to the Tianjin Capital Environmental Protection Company (TCEPC), a semi-private company; and (ii) component B, focusing on water resources protection, under the implementation of Tianjin Municipal Luanhe Drinking Water Source Protection Engineering (TML).

Financing Arrangements

- *Capital financing:* The total project cost after completion was $337.3 million, with local financing of $208.9 million, through the government's equity, and a loan from the China Development Bank.
- *Cost recovery:*
  - Component A: Introduced wastewater tariffs on 1 December 2003 of CNY0.60 per m^3 for domestic consumers, and CNY1.00 per m^3 for nondomestic consumers. Gradually but affordably increased wastewater tariffs to CNY0.80 per m^3 for domestic consumers, and CNY1.20 per m^3 for nondomestic consumers.
  - Component B: Introduced different tariffs for different water consumers on 1 September 2002. Gradually but affordably increased water tariff from CNY1.40 per m^3 in 1999 to currently CNY3.90 per m^3 for domestic consumers. Implemented a significant increase in water tariff from CNY1.40 per m^3 in 1999 to currently CNY21.90 per m^3 for special consumers.

Project Outcomes

- Cases of cholera decreased by 40%, and hepatitis by 64% (2001–2007).
- Percentage of urban wastewater collected: 50%–60% by end of 2008; 100% by 2010.
- Raw water remained in good quality, and in accordance with national standards (Class III).
- Public satisfaction with urban environment increased.

Protecting Groundwater and Ensuring Energy Security

Orange County, Orlando, Florida, United States of America

The Orange County Eastern Water Reclamation Facility is located in one of the most rapidly growing areas in the United States. In 1984, this advanced water reclamation system was designed and constructed to enhance the environmental setting of the River Econlockhatchee catchment in east Central Florida, to reduce demand on potable groundwater, provide reclaimed water for non-potable uses, and provide sufficient wastewater treatment capacity for the city.

Orange County wastewater treatment plant (Source: IWA)

Technology Option

- The full scale treatment plant capacity is 72 MLD.
- Pretreatment unit with screening unit and a 'pista' grit removal system.
- A five-stage 'Bardenpho' nutrient removal system comprised of in-line fermentation tank, 1st anoxic tank, an aeration basin, 2nd anoxic tank, re-aeration, and secondary clarification.
- Final stage polishing with an automatic backwash (ABW) filter, and chlorination to disinfect the treated wastewater.
- Dechlorination occurs in the dechlorination zone of the wetlands, prior to reclaimed water entering wetlands vegetation zone.

- Air from the headworks is treated for odor control in three biofilters.

Institutional and Management Arrangements

- The Board of Orange County (consisting of the Executive Officer, the Mayor, and 6 elected district commissioners) is responsible for reviewing all Orange County utility department activities, and setting policies for their growth.
- The Water Reclamation Utility (under the Orange County Utilities Department) oversees the O&M of the treatment plant.

Financing Arrangements

Cost recovery

- The capital investment was financed by the Orange County Utilities Department, with the support of the Board of Orange County.
- The wastewater customers pay a monthly fee to cover O&M costs and also capital expenditures for treatment plant expansion.

Project Outcomes

- The water reclamation facility uses reclaimed water in a combination of natural and constructed wetlands, which was among the first treatment facility to be permitted by the Florida Department of Environmental Protection (FDEP) to be exempted from existing wetlands rules and regulations.
- The treated effluent (water reclaimed) is currently 100% reused, thus reducing the demand on limited groundwater reserves in the Florida aquifer.
- The treatment facility produced reclaimed water, 90% of which is used as cooling water for the Orlando Utilities Commission's Stanton Energy Center, a 900-megawatt power plant located adjacent to the facility.
- In recent times, user revenues have declined due to the economic (market) downturn. As such, the Orange County Utilities Department is faced with changing regulations and uncertain funding, which has made it more complicated to operate and maintain the facility. It is therefore considered to be essential for the Orange County Utilities to have better bond issuance to supplement the current budget plan.

Contact for more information

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International Water Association (IWA)

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Creating Synergies for Energy and Nutrient Recovery

In an era of stringent regulations and sustainable thinking, wastes are now seen as resources. The traditional goal of wastewater treatment has been to protect the water environment from organic and nutrient pollution. While this goal is even more important today, it is also being recognized that the pollutants are resources—in the wrong place. Therefore, the focus is moving towards recovering valuable energy and nutrient resources. Biogas production is an effective measure to replace fossil fuels with renewable fuels, and chemical fertilizer with biofertilizer.

Methane capture in wastewater treatment facilities not only contributes to climate change mitigation efforts, but also to generation of renewable energy source for use by the wastewater treatment facilities and nearby communities. Wastewater treatment projects capture methane-rich biogas that would have otherwise been released in the atmosphere. Many poor households with toilets connected to biogas digesters have improved not only the sanitation conditions, but they now have alternative source of energy for cooking and lighting as well . In some cities in Europe (e.g., Linköping in Sweden, Oslo in Norway, Lille in France, etc.), public buses and trains are fuelled by biogas from municipal and agricultural wastewater treatment. In addition, carbon credits can be earned, providing additional financial incentives for wastewater and sludge management. Both the wastewater treatment facilities in Suva City, Fiji and at the Absolut Distillers Inc. plant in Batangas, Philippines availed of the clean development mechanism.

Sludge from septic tanks and wastewater treatment can also be converted into soil conditioners and fertilizer. Recovering nutrients can offer several benefits, such as (a) revenue from a saleable organic fertilizer product, (b) savings from using chemical fertilizer, (c) improving operations by reducing nutrient loads in return streams, and (d) preventing the formation of struvite, which clogs system pipes. Considering that the phosphate deposits worldwide are becoming depleted, recovery of phosphorus from wastewater as struvite, and recycling these nutrients into agriculture as fertilizer appear promising.

Project Briefs

- Sewage Treatment Plant with Greenhouse Gas Emission Reduction Project: Suva City, Viti Levu Island, Republic of Fiji
- An Innovative Recycling Hub of Regional Biomass by a Public Wastewater Treatment Plant: Suzu City, Ishikawa Prefecture, Japan
- Industrial Wastewater Treatment with Energy and Nutrient Recovery and Carbon Credits: Batangas, Philippines
- 100 % Biogas for Urban Transport: Linköping, Sweden

Sewage Treatment Plant with Greenhouse Gas Emission Reduction Project

Kinoya, Suva City, Viti Levu Island, Republic of Fiji

Fiji, covering a total land area of 18,376 km^2, consists of more than 300 islands, mostly of mountainous terrain and volcanic origin. Eighty-five percent of the total area is composed on its two largest islands—Viti Levu and Vanua Levu.

sequential batch reactors (Source: ADB)


anaerobic sludge digester (Source: ADB)


sludge drying beds (Source: ADB)

With most of the developmental interventions in the area confined to coastal areas, this has put growing pressure on coastal resources. Increasing population, urbanization, and industrial and economic development are identified as the main drivers for such a situation. Coastal development has resulted in the degradation of natural habitat (due to inappropriate agricultural activities, mining, etc.), pollution due to improper waste disposal, increased withdrawals from freshwater sources, and depletion of coastal fisheries.

Technology Option

Through the introduction of a methane recovery and combustion system to the existing and proposed anaerobic sludge treatment units (anaerobic digesters), the project aims to recover generated methane resulting from the anaerobic decomposition of organic matter.

Institutional and Management Arrangements

- The project was conceived by the Water Supply and Sewerage Department (WSD) under the Ministry of Works, Transport and Public Utilities, Government of Fiji Islands.
- Operation of the facility is now under the responsibility of the Water Authority of Fiji, since its establishment in 2010.

Financing Arrangements

- Project was developed with support from ADB, Technical Support Facility, and Carbon Market Programme.
- On December 2003, ADB approved a loan for the "Suva-Nausori Water Supply and Sewerage Project" (L2055-FIJ) of which the sewage treatment project is made a subcomponent of said project.
- Asia Pacific Carbon Fund (APCF) is cofinancing carbon savings though upfront payment against the purchase of certified emission reduction (CERs) to be generated by the project up to 2012.
- Total Clean Development Mechanism (CDM) expenditure: $330,000
- Income from CDM: $1million–$2million

Project Outcomes

- Being the first of its kind in the Pacific, the project is expected to serve as a model for the development of other similar undertaking, focusing on renewable and environmentally sound interventions.
- The project is expected to contribute to the worldwide effort in controlling the release of GHG emission.
- The living and working conditions of local communities are expected to be improved with the elimination of obnoxious odors and air pollution at the Kinoya Sewage Treatment Plant and its surroundings.
- The reduction of a significant quantity of methane will translate to additional revenues for the national government with the sale of CERs. The generated revenues could then be utilized to implement urgently needed developmental activities in the country.
- Annual CERs are estimated to be around 22,469 CERs. Total expected CERs for the APCF are 44,938.

Contact for more information

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An Innovative Recycling Hub of Regional Biomass by a Public Wastewater Treatment Plant

Suzu City, Ishikawa Prefecture, Japan

Suzu City in Ishikawa Prefecture is located at the tip of the Noto Peninsula, off the coast of the Sea of Japan. Because of the new global warming mitigation measures, the city was faced with having to improve sanitation and solid waste management. Sewage works need to be expanded from the central community to those communities at the fringes where it was difficult to extend pipe networks. In addition, conventional sanitation methods needed to be changed and remodeled such that only one facility would be used to treat all the waste in the region. This new system was introduced at an existing public wastewater treatment plant that would undergo remodeling. The main objectives of the project were to: (i) lessen the amount of greenhouse gases generated; (ii) introduce and remodel a facility that accepts different forms of raw waste from all parts of the city; and (iii) recover energy and convert excess methane sludge into green fertilizer.

Aerial view of the Suzu City wastewater treatment facility. (Source: Saburo Matsui)

Vertical steel methane fermentation tank. (Source: Saburo Matsui)

Technology Option

- The following structures and equipment illustrate the new methane fermentation facility:
  - o Machine Building: to receive and pretreat biomass. The pretreatment system can effectively remove substances not suitable for fermentation, such as plastics. Equipment includes (i) garbage crushing and separation machines with an improved crushing and sorting system that enables a higher collection rate of kitchen, raw fish and other seafood processing waste; (ii) a solubilization tank that contributes to more efficient methane fermentation; and (iii) a thickening machine;
  - o Fermentation Building: for methane fermentation, which includes mixing and methane fermentation tanks;
  - o Gas Holder Facility: to temporarily store biogas generated, including a gas holder, dried desulfurization equipment, and a boiler, etc.;
  - o Heating Building: to heat the Fermentation Building by using biogas, which includes a sludge dewatering machine and an indirect steam heating dried machine;
  - o Drying Building: to dry dewatered sludge;
  - o Sludge Treatment Building: for anaerobic digestion and dewatering digested sludge; and
  - o Deodorizing equipment, which includes a biological deodorizing apparatus and an activated adsorption tower.

Institutional and Management Arrangements

- The local government of Suzu City is the owner of the project, with Matsui Consulting Firm Co., Ltd. providing advice and guidance.
- The Japan Institute of Wastewater Engineering Technology prepared the biomass recycling system, the carbon dioxide reduction effect, and clarified legal procedures.
- Kawasaki Plant Systems was responsible for the design of the project, the fast implementation of contract for the works, and adoption of a steel-made digestion tank and a film-made gas holder.

Financing Arrangements

- This is the first biomass utilization project jointly promoted by Japan's Ministry of Land, Infrastructure and Transport (MLIT), and the Ministry of the Environment. The project was financed through subsidy from the Ministry of the Environment.

Project Outcomes

- The facility allowed Suzu City to achieve both cost merits and the challenge to meet global warming measures when compared to individually treating and disposing of sludge.
- The biogas generated was useful to reduce the energy requirements of the facility.
- The drying condition showed that the dried sludge meets Environment Protection Agency (EPA) standards and is safe.
- When a comparison of costs was conducted, ¥43 million per year of savings was realized by the use of the new facility, and treating waste collectively. In particular, the sludge disposal cost becomes zero by introducing the dry fertilizer to agricultural areas.
- Approximately 4,500 tonnes of carbon dioxide could be reduced within 19 years.
- The innovative recycling hub of the facility provides a model to many other municipalities in Japan, which have similar difficulties in sanitation and municipal solid waste management.

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International Water Association (IWA)

Industrial Wastewater Treatment with Energy and Nutrient Recovery and Carbon Credits

Batangas, Philippines

Thermophilic anaerobic digester and lagoons (Source: G. Tee)

Reed bed (Source: M. Ebarvia)

Absolut Distillers (formerly, Absolut Chemicals) Inc. (ADI) is a subsidiary of Tanduay Distillers, Inc. (TDI). It is a distillery business located in Lian town in Batangas, Philippines. ADI distillery produced high-strength wastewater, which polluted waterways, specifically the Bagbag and Pamlico Rivers. In 1998, the Pollution Adjudication Board of the DENR issued a cease-and-desist order due to its contribution to the pollution of the said rivers. A state-of-the-art wastewater treatment plant was not economically viable at that time because it required a large investment. ADI needed to find an alternative solution in the management of its wastewater.

Technology Option

- Lagoons were enlarged and retrofitted with extremely strong HDPE geomembrane liners in 1998.
- The following year, with the assistance of the University of the Philippines in Los Baños, the Liquid Fertilization Program was initiated.

- The Pilot Reed Bed System was constructed in 2000 for further polishing of the treated wastewater.
- In 2001, the Sequential Batch Reactor (SBR) System was constructed to equalize, aerate, and clarify wastewater in a timed sequence in one reactor basin.
- A Thermophilic Anaerobic Digester became operational in 2008. The process used a Hybrid Anaerobic Digester System and a Covered In-ground Anaerobic Reactor lagoon to capture methane. The methane is then used as a fuel for the boilers, and flared using an Enclosed Type Biogas Flare System.

Institutional and Management Arrangements

- This was considered a large investment project, thus a Clean Development Mechanism (CDM) Memorandum of Agreement was signed in November 2007 among TDI, ADI, and Japan's Mitsubishi Corporation.
- Under the CDM agreement, there are certified emission reduction (CER) credits to be generated by the digester system. Mitsubishi can purchase any and all the credits up to 480,000 units. Thus, ADI should take all necessary measures to make the project result in (i) greenhouse gas reductions; and (ii) the creation of CER credits.
- Mitsubishi Corporation provided funding for the construction of the digester system, its basic design, and operational parameters.
- SGV & Co. is an auditing firm that will audit ADI's financial report, a copy of which will be delivered to Mitsubishi Corporation.
- The DENR is the national authority that provides rules and regulations for effluent standards.

Financing Arrangements

- The CDM agreement allowed Mitsubishi to fund the construction of a biogas digester in exchange and/or transfer of CER credits from the project to Mitsubishi.
- The payment by Mitsubishi for the construction of the digester is to be made in advance, detailed in an agreed upon schedule.

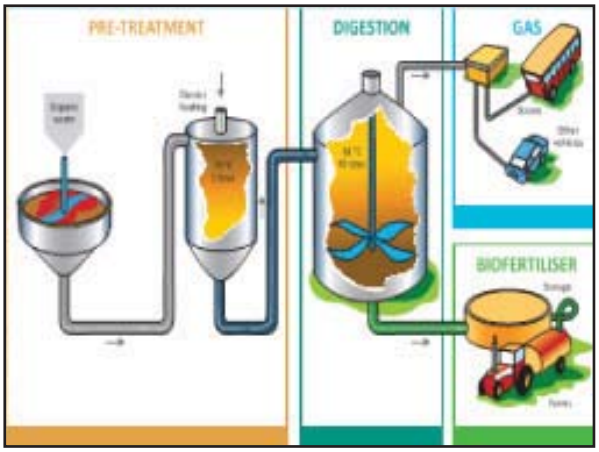
Project Outcomes

- ADI was granted by the Food and Pesticide Authority the license as manufacturer and distributor of liquid fertilizer.
- The cease-and-desist order was lifted in 2004.
- The use of distillery effluents benefitted 150 sugarcane farmers and four sugarcane plantations (a total area of 1,339 ha).
- The liquid fertilizer is given away to the farmers for free. The application of the distillery slops in sugarcane fields has resulted in a 60% increase in yield.
- Fossil fuel use and consequent emissions were displaced due to ADI's capture of carbon dioxide and methane generated from the alcohol distillation slop water treatment. This was then used as fuel for the boilers. Sixteen tonnes of bunker oil was displaced per day, while carbon dioxide emissions were reduced to 96,000 tonnes per year.
- ADI's initiatives received numerous accolades including: (i) annual citations from the DENR and the Office of the President; (ii) the Global CSR Award in 2011; and (iii) the gold award in the 2011 International Green Apple Environment Award in London.

100% Biogas for Urban Transport

Linköping, Sweden

Linköping is a city located in the middle of an agricultural district on the east coast of Sweden, with 140,000 inhabitants. Because of its location, the prerequisites for building biogas plants are therefore apparent. The manure from cattle and pigs in the



Source: Bioenergy from waste: Biogas Production Model (http://bit.ly/POeoLf)

area could be codigested with abattoir waste and organic waste from other food industries in the area. In the early 1990s, the city of Linköping was in the process of converting the bus fleet to use alternative fuel in order to reduce the local pollution from diesel buses. The most interesting alternative was to shift to natural gas. However, the decision to expand the natural gas grid from the south and up to the central parts of Sweden was delayed. The City of Linköping, therefore, decided to use locally-produced biogas as fuel for the urban bus fleet.

Technology Option

- The plant has an annual treatment capacity of 100,000 tonnes, and produces 4.7 million m^3 of upgraded biogas (97% methane), which is used by 64 buses and a number of heavy and light duty vehicles.
- The Linköping plant handles 2,000 tonnes/year of animal manure and 36,000 tonnes/year of other waste materials, mainly waste from different food industries (waste fat, vegetable waste, slaughter-house waste, etc.). The plant was originally designed to handle 100,000 tonnes/year, including 25,000 tonnes/year of manure. In 2005, the total throughput was 45,000 tonnes.
- Abattoir waste (blood, rumen content, and process water) is pumped through a 1.7 km-long pipeline from the source to the biogas plant in an underground pipeline. The same trench is used by the low pressure pipeline for upgraded biogas to the refuelling station for buses. The rest of the abattoir waste is minced before it is transported on road to the biogas plant.
- The waste is mixed with manure at the biogas plant, and then pasteurized for an hour at 70°C before being fed to the digesters.
- The biogas plant has two conventional stirred tank digesters, each with a capacity of 3,700 m^3, and with a residence time of 30 days. The process is operated at mesophilic conditions. The digestate is removed continuously from the digester, and stored at the plant for a few days before it is transported back to the farmers, and used as biofertilizer. The annual production of government-approved high grade biofertilizer is around 52,000 tonnes.

Linköping biogas plant (Source: Svensk Biogas)

Slow filling system for city buses (Source: Svensk Biogas)

Institutional and Management Arrangements

- In 1991, TekniskaVerken (TVAB), the municipal service provider, set up a pilot project of five buses powered by methane collected from the wastewater treatment plant.
- Close collaboration between TVAB and Linköping University helped to speed up the development of biogas knowledge and production.
- The source of feedstock was then expanded to include waste from the local slaughterhouse owned by Scan-Farmek. The Federation of Swedish Farmers (LRF) also came on board to supply feedstock in the form of crop residues and manure.
- To solidify their cooperation, the three stakeholders started an associated company with shared ownership called Linköping Biogas AB (now Svensk Biogas) in 1995.

Financing Arrangements

- The company received government funding to build a €140,000 methane production facility, which was completed in 1996.
- Additional funding and expertise came from the municipality of Linköping, the county, the regional bus authority, Linköpings Trafik AB

(LITA), and TVAB to cover the risks (financial and technical) associated with the application of new technology in the city.

Project outcomes

The project resulted in:

- Reduction of CO_2 emissions from urban transport by 9,000 tonnes per year as well as the local emissions of dust, sulphur, and nitrogen oxides.
- Decrease in dependence on fossil fuels, with the biogas generated effectively replacing 5.5 million liters of petrol and diesel annually.
- Provision of an environmentally sound process for the treatment of organic waste in the region, with reduction in the volume of waste sent for incineration by 3,422 tonnes annually.

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Wastewater and Septage Treatment and Reuse for Agriculture

With the increasing scarcity of freshwater resources, but ever growing demand for more efficient food production for the expanding populations, much wider recognition is being given to wastewater as an important resource. In arid and semi-arid climates, and in areas without irrigation systems, wastewater may constitute an indispensable source of water and nutrients for agriculture. In rural and peri-urban areas of most developing countries, the use of sewage and wastewater for irrigation is a common practice because its high nutrient content reduces or even eliminates the need for expensive chemical fertilizers. Wastewater treatment and reuse also protects groundwater from both contamination and depletion.

Concern for human health and the environment are the most important constraints in the reuse of wastewater. Risks can be minimized by applying suitable irrigation techniques, and wastewater and sludge treatment technologies, selecting crops that are less likely to transmit pathogens to consumers, and using protective measures to reduce exposure.

The projects in Viet Nam and Iran illustrate the opportunities for wastewater management and reuse in safely meeting the growing demand for water resources for agricultural use without degrading the environment.

The biosolids from septage and wastewater treatment in Metro Manila, Philippines are composted and applied in sugar plantations affected by lahar (volcanic mudflows) as organic soil conditioners.

Project Briefs

- Wastewater Treatment for Irrigation: Buon Ma Thuot City, Dak Lak Province, Viet Nam
- Tehran Sewerage Project: Iran
- Septage and Biosolids Management: Metro Manila and Rizal Province, Philippines

Wastewater Treatment for Irrigation

Buon Ma Thuot City, Dak Lak Province, Viet Nam

The capital of Dak Lak province, Buon Ma Thuot City is the administrative, economic, social and cultural center, and regional hub of the Central Highlands of Viet Nam. It plays a key role in national security and defence, and is a center of trade and human resource training for the central highlands and central coast areas. The city's population is expected to grow steadily over the next 10 years. It was envisioned to become a modern Class 1 City by 2015.

Technology Option

- The wastewater management system was developed for the collection of domestic wastewater and treatment. It included the following components: (i) a central sewage pumping station; (ii) stabilization ponds; and (iii) separate sewerage and drainage systems with 5,500 house connections. No energy and chemicals were required for the stabilization ponds. The technology is simple and understandable. It minimized mechanical and

electrical content, maximized available human resources, and used local products.

- The Wastewater Reclamation System was constructed in order for the treated wastewater to be reused for agriculture. The system included the following: (i) enhanced treatment, which made use of four additional maturation ponds and a pumping station; (ii) conveyance through high and low reservoirs; and (iii) final delivery of the reclaimed water to the farmers and fields through a gravity distribution pipeline.

Wastewater treatment ponds (Source: Viet Anh Nguyen)

Sewerage system (Source: Viet Anh Nguyen)

Institutional and Management Arrangements

A Wastewater and Sanitation Enterprise (WW&SE) was established to manage and operate the treatment and reclamation facility. This institution made great efforts in creating favorable revenue conditions from which the new enterprise would be realized. The WW&SE was formed under the operating "umbrella" of the Urban Management Environmental Sanitation Company, the recipient organization of the DANIDA grant funds.

Financing Arrangements

- The total project value, inclusive of the 20% contribution from the Government of Viet Nam is D126.2 million ($21.7 million).
- A drainage surcharge, equal to a 10% surcharge on current water rates, was integrated into the water tariff, which is collected by the Buon Ma Thuot Water Supply Company. In addition, a wastewater fee of 20% of the water bill was included for those households connected to the separate sewerage system.

Project Outcomes

- A total of 5,500 house connections were completed by the end of 2007. Under the fully expanded capacity of the sewerage network and WWTP, around 17,000 house connections will be served.
- The Separate Sewerage System minimized odors, excluded rainwater flow resulting in smaller pipe sizes, reduced pumping costs, and minimized sewage quantity for economical WWTP dimensioning.
- Diseases related to polluted environment (such as diarrhea) have decreased.
- People's knowledge regarding the relationship between a polluted environment and health has been improved. Locals are now agreeing to voluntarily connect to the drainage system.
- Around 4,000 m^3/d of reclaimed wastewater is provided to subsistence farmers. This is equal to serving 100 ha of agricultural land with or without rain. Thus, the farmers, including the ethnic minorities, now have a reliable year-round source of irrigation water.
- Wastewater residual nutrients have reduced the need for supplemental fertilizer.
- 115 ha of coffee plantation are being irrigated with treated wastewater.

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Tehran Sewerage System

Tehran, Iran

Wastewater treatment plant in Tehran (Source: IWA)

The Tehran Sewerage System is an innovative project to improve the environmental conditions in the Greater Tehran area, through the installation of wastewater collection and sewage treatment facilities to improve the general public health and further enhance irrigation systems in the surrounding areas. The project also targeted the low-income groups living in the southern part of Tehran, which represented about 65% of the total population.

Technology Option

- The project promotes an integrated approach to water management, in which the construction of a sewerage network reduced contamination of groundwater, and treated wastewater is reused in agriculture.

Treatment system

The project consists of:

- Interceptors and laterals to convey wastewater in the northern, southern, and partly in the central areas of Tehran.
- Western Trunk Main (pipeline of about 24 km) and Eastern Trunk Main constructed as a tunnel 20 km long (4 km of which was constructed as a culvert).
- Secondary treatment (capacity of 450,000 m^3/d) with chlorination (disinfection unit).
- Provisions made available for possible extension to tertiary treatment system.

Institutional and Management Arrangements

- In 1991, the Government of Iran (GOI) approved an Act on the establishment of Water and Sewerage Companies to set up the institutional and governance framework for the reform in the water and sanitation sector. This resulted in the creation of six water and wastewater companies in provincial capitals. For the Tehran Province, this entailed the establishment of the Tehran Province Water and Wastewater Company (TPWWC).
- In order to promote accountability and autonomy of its line management, the TPWWC commenced a program in 1996 for spinning off line units into subsidiary companies to operate independently. Thus, the Tehran Sewerage Company (TSC) was established with delegated responsibility to operate and maintain the wastewater collection and treatment system.

Financing Arrangements

Capital investment

The capital investment was financed through the International Bank for Reconstruction and Development - World Bank ($145.0 million), with local financing of $196.45 million through the TPWWC.

Cost recovery

- Sewage collection tariff, based on the volume of water consumption.
- User connection fees.

Project Outcomes

- By December 2008, TSC had a total of 211,000 connections. This means over 2 million people had benefitted from the provision of wastewater collection and treatment facilities, as well as reduced health risks due to the improved sanitary and environmental conditions.
- The farmers of the Varamin Plain also benefitted by having increased agricultural outputs through the use of treated effluents for irrigation, and of treated sludge for soil conditioning.

Septage and Biosolids Management

Metro Manila and Rizal Province, Philippines

Vacuum trucks for desludging septic tanks. (Source: S. Griffiths)

South Septage Treatment Plant (Source: S. Griffiths)

Biosolids spread out and sprayed with inoculants. (Source: MWCI)

Manila Water Company, Inc. (MWCI) is one of the two concessionaires of MWSS. MWCI provides the eastern portion of Metro Manila as well as the province of Rizal with water supply and wastewater services. The area includes over 6 million people, of which 1.6 million belong to the low-income communities. Around 85% of the population use septic tanks. Many of the septic tanks were deemed improperly designed, constructed and maintained. Up to 58% of the organic load of Metro Manila's receiving bodies of water came from these septic tanks. This has contributed to the poor water quality of Laguna de Bay, Pasig River, and Manila Bay.

In response, MWCI's wastewater management program comprises of: (i) septage management, including desludging of septic tanks; (ii) separate sewer networks; and (iii) combined sewer-drainage systems.

Technology Option

- Desludging of septic tanks per household is done every five to seven years in the East Zone area via 78 vacuum tanker trucks of various sizes. The size of the trucks used is dependent on the ease of access to individual septic tanks.
- The collected sludge from the septic tanks is brought to the MWCI's septage treatment plants, which have a combined capacity considered to be the largest in the world. The North Septage Treatment Plant, located in San Mateo, Rizal, has a capacity of 586 m^3/d while the South Septage Treatment Plant, located in Taguig City, has a capacity of 814 m^3/d. The two plants have a combined treatment capacity of 1,400 m^3/d.
- The treatment processes include: (i) primary treatment, which involves screening and grit and scum removal; and (ii) secondary treatment, which uses the activated sludge process. This is followed by the coagulant-assisted mechanical dewatering in screw presses for the sludge, including adding polymers, and mechanical compaction for stabilization and subsequent reduction of volume. The filtrate (liquid component) is treated further in a conventional sewage treatment facility. The dewatered sludge or biosolids are then brought to lahar-affected areas in Central Luzon for composting and inoculation in preparation for being used as organic soil conditioners in the corn and sugarcane plantations.

Institutional and Management Arrangements

- As a concessionaire of the MWSS for the period of 1997 to 2037, MWCI is tasked to deliver and expand water and wastewater services to the eastern part of Metro Manila and Rizal Province. MWCI has direct management control of their septage and biosolids management program.
- The MWSS Regulatory Office (MWSS-RO) evaluates the proper implementation of the

Concession Agreement, monitors water quality and supply in all service areas, and regulates the water tariffs being charged by the concessionaires to all their customers. The DENR and the LLDA provide and enforce wastewater standards for treatment operation and facilities.

Financing Arrangements

- In 2005, MWCI collected fees for septage collection services amounting to P803, and P5,000 per truckload for residential and commercial areas, respectively. Scheduled septic tank maintenance is provided to residents at no additional charge by MWCI. Charges for residential customers are applicable only for services requested by the customer outside of the regular schedule.
- As of December 2012, all customer types (residential, commercial, and industrial) in Metro Manila pay a 20% environmental charge from the basic water charge. The sewerage charge is pegged at 30% of the basic water charge for East Zone customers.[3]

Project Outcomes

- Number of septic tanks desludged: 217,765 benefitting around 850,000 households (as of February 2011).
- The treated septage consistently meets the Class C standards specified by DENR.
- Since the start of its operations, the project brought about the following: (i) reduction in the frequency of overflowing septic tanks; (ii) reduction of health risks from contact with septage in drainage systems; and (iii) elimination of indiscriminate dumping of raw septage by private contractors.
- The biosolids are further processed by service providers to yield higher value soil conditioners, and these are given or sold to corn, sugarcane and mango producers in lahar-affected areas in Tarlac and Pampanga. Between 2006 and 2008, approximately 49,000 m^3 of biosolids were applied. The volume of biosolids that MWCI delivered to these nutrient-poor areas has tremendously helped in improving the soil fertility of these once barren areas.
- Through the biosolids management program, MWCI assisted in the rehabilitation of farmlands affected by the eruption of Mount Pinatubo, provided both an economical and environmentally-sustainable method of biosolids disposal and reuse, and delivered employment and agricultural benefits to a severely disaster-stricken area.

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[3] Source: MWCI billing statements.

Wastewater Treatment and Aquaculture

Duckweed aquaculture has been regarded as a potential technology to combine both wastewater treatment and feed production in developing and industrialised countries. In the United States, use of duckweed-covered lagoons for tertiary treatment is classified by the USEPA as an innovative and alternative technology. Aquatic macrophytes, such as duckweeds, grow readily in ponds fed with human waste, and their use in wastewater treatment has been studied with regard to BOD and nutrient removal, including nutritional value for raising animals. The rapidly growing duckweeds are capable of accumulating nutrients and minerals from wastewater, which are removed from the system as the plants are harvested from the pond surface. Duckweed ponds also have the potential to create a financial incentive for controlling faeces and wastewater, and improve sanitation in both rural and urban areas. Duckweeds are cultivated in these ponds, mainly for feed for Chinese carps and India's major carps, but also for chickens, ducks, and edible snails. Because of their comparatively high productivity, and high content of valuable protein, they provide an excellent feed supplement. When duckweed biomass is used for animal production, the generation of income, and nutritional improvement appear as possible side-benefits from the wastewater treatment process. In Mirzapur, Bangladesh, the full potential of duckweed aquaculture lies in its combined use in sanitation, food production, and income generation as illustrated in the following project brief.

Project Brief

Integrated Duckweed-based Wastewater Treatment and Pisciculture: Mirzapur, Bangladesh

Integrated Duckweed-based Wastewater Treatment and Pisciculture

Mirzapur, Bangladesh

Duckweed ponds (Source: Masum A. Patwary)

Situated in the central Bangladeshi district of Tangail, Mirzapur is a town with an estimated resident population of around 20,000. The town gained popularity for its Kumudini Welfare Trust Hospital, which was considered the largest hospital in the country during the time of its construction.

The hospital complex has an estimated wastewater volume equivalent to a population of about 2,000 to 3,000. The generated volume is sourced from the hospital, school, and staff quarters.

In recognition of the inadequacy of the existing, aid-funded 4-cell facultative wastewater treatment

system to treat the wastewater treatment requirements of the hospital complex, the Mirzapur Shobuj Shona (Green Gold) project was conceived. The initiatitive was spearheaded by the Project in Agriculture, Rural Industry Science and Medicine (PRISM)-Bangladesh, a local nongovernmental organization (NGO).

Technology Option

- The Mirzapur Shobuj Shona project made use of the existing 4-cell facultative lagoon complex by converting three lagoons into fish ponds, with the fourth one serving as a primary receiving and settling tank.
- A 0.6 ha plug flow duckweed wastewater treatment system was also established, and is attached to the lagoon complex.
- Collected wastewater is received in the 0.25 ha primary receiving pond to remove suspended solids.
- Wastewater effluent from the receiving pond is then pumped to the adjacent duckweed-covered serpentine plug-flow lagoon for treatment.

Institutional and Management Arrangements

- The project is managed by the following entities: (i) the Kumudini Welfare Trust, a non-profit family trust managed by an outside board of directors, with one of its representative member being a nominee by the Government of Bangladesh; (ii) PRISM-Bangladesh, a nonprofit Bangladeshi NGO in charge of developing and maintaining the wastewater system; and (iii) the public.
- Obligations among parties involved are specified in contracts.

Financing Arrangements

- Based on financial records spanning 8 years, the average total income generated from the sale of duckweed-fed fish and livestock is estimated to be around Tk399,630 ($1= Tk80) annually.
- The system makes a net profit (average of about Tk83,777 before taxes), which is enough to cover capital investment and recurrent costs.
- System is self-sustaining. Charging of user fees and/or subsidies from the government are not needed to sustain the operation of the system.

Project Outcomes

The Mirzapur Shobuj Shona project has demonstrated the following:

- With the use of duckweed, treatment of conventional wastewater to advanced tertiary levels can be done (effluent parameters: BOD: 8.2 mg/l; TSS: 7.8 mg/l).
- The system showcased efficient resource recovery—(i) reuse of treated effluent for irrigation; (ii) production of high quality duckweed feed supplement for fish and livestock; (iii) generation of biogas for energy needs; and (iv) use of composted sludge as fertilizer.
- The system has become a model for financial robustness, earning profits to achieve cost-recovery, without the need for user fees or subsidies.

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Wastewater Treatment for Sustainable Tourism and Recreation

The tourism sector subsists by offering cleanliness and a comfortable environment. Sanitation facilities are essential in tourism areas. A very obvious reason for wastewater treatment for tourist sites, whose income depends on tourists coming, and coming again, is that nobody wants to swim in dirty water.

In the Nusa Dua hotel complex in Bali, Indonesia, the wastewater treatment system not only provides reclaimed water for the gardens and golf course, it is also a mini-ecosystem by itself, attracting recreational fishers, bird watchers and tourists.

Boracay is a prime tourist destination in the Philippines, with its fine white sand beach. News on coliform levels in the coastal waters resulted in a decline in tourist arrival. In response, the government entered into a joint venture agreement with a private company to ensure water supply and sanitation for sustainable tourism in Boracay.

Also using the PPP approach, the joint venture agreement between a local government entity in Bhubaneswar City, Orissa, India and a private company that operates amusement parks turned an unsanitary wetland into a recreational park with wastewater treatment system. A lake in the park was developed for boating facilities, and a filtration plant, duckweed pond, sedimentation pond, and fishpond were set up for treatment of the water. The low-cost wastewater treatment system improved the environmental conditions in the city and downstream areas, while the park generated employment, and attracted over a million visitors from within and outside the city.

Project Briefs

- Eco-lagoon: Nusa Dua, Bali Province, Indonesia
- Water and Sanitation for Sustainable Tourism: Boracay, Aklan Province, Philippines
- Wastewater Treatment and Recreation Park: Bhubaneswar City, Orissa, India

Eco-Lagoon

Nusa Dua, Bali Province, Indonesia

Nusa Dua was established in the 1970s in Bali, Indonesia to provide world-class facilities within the island. It is an enclave of four- and five-star hotels, with an 18-hole golf course and a retail village. In its concept development, Nusa Dua prioritized ecofriendly approaches towards the natural physical surroundings, and preservation of the sociocultural setting. Environmental concerns are also prioritized as demonstrated by the wastewater treatment system.

Technology Option

- Collection and conveyance: There are pumping stations for conveying the wastewater collected from the hotels in the Nusa Dua hotel complex to the treatment ponds.
- Treatment system:
  - Area: 30 ha.
  - Capacity: 10,000 m^3/d
  - Average loading: 5,700 m^3/d
  - Three lagoons: primary treatment, secondary treatment
    - stabilization pond
    - aeration
    - sedimentation
    - filtration

- There is also biotechnology and tertiary treatment so wastewater can be reused for irrigation in nearby villages, and watering the golf course in the hotel complex.

Wastewater treatment ponds: "Eco-Lagoon" (Source: M. Ebarvia)

Institutional and Management Arrangements

- The wastewater treatment facility is centrally managed by the Bali Tourism Development Corporation (BTDC). The wastewater from 12 big hotels in Nusa Dua and two hotels outside Nusa Dua is collected and conveyed to the wastewater treatment system located in Bualu village outside Nusa Dua. Wastewater from these hotels undergoes primary and secondary treatment. There is a final wastewater station known as the "Eco-Lagoon" that has become a recreational site, educational center, and tourist attraction.
- All construction and development within the complex was carried out according to the standards and guidelines outlined in the Design Criteria, Covenant Construction and Restriction Area Code. These regulations are intended to preserve the natural surroundings within the complex.

Financing Arrangements

- The capital investment was financed by the Nusa Dua Hotel complex and BTDC.
- The cost recovery policy was applied through monthly payments by the hotels to BTDC.
- User fees are collected from visitors upon entering the Eco-Lagoon.

Project Outcomes

- Treated wastewater is reused for watering the public gardens in the Nusa Dua complex, and grounds of individual hotels.
- The presence of mangrove trees, and the algae produced in the Eco-Lagoon encourages fish to breed, and tiny frogs to flourish, which then attract various species of birds to feed at the lagoon. Because of the high diversity and number of birds, the Eco-Lagoon has become a bird-watching site. In addition to the endemic species, migratory birds like the egrets have attracted bird watchers to the complex. Recreational fishing amenities also attract visitors to the Eco-Lagoon park. Training activities on bird counting are also conducted in the park. Like a miniature ecosystem, the Eco-Lagoon has turned into a tourist attraction, and site for study tour.

Contact for more information

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Water and Sanitation for Sustainable Tourism

Boracay, Aklan Province, Philippines

Boracay Island is the Philippines' premiere beach destination, boasting of kilometers of powdery, fine, white sand. Approximately a million tourists flock to this destination to enjoy the sun and the beach. Before the entry of the Boracay Island Water Company (BIWC), the existing wastewater treatment plant was no longer able to competently perform, given the huge volume and changing characteristics of wastewater generated. This was a critical issue, which can affect its prime economic activity. Untreated wastewater seeps into the beaches, presenting aesthetical and sanitation

concerns. At the same time, Boracay was facing water supply inadequacy issues. In April 2009, the East Zone concessionaire of Metro Manila, Philippines—Manila Water Company, Inc. (MWCI)—entered into an agreement with the government with the goal to ensure sustainability of Boracay, creating the Boracay Island Water Company.

Boracay white sand beach (Source: Bernardo Mañosca)

Boracay Island Water Company (Source: Bernardo Mañosca)

Technology Option

- Treatment system: Complete mix activated sludge

Institutional and Management Arrangements

- MWCI entered into a joint venture agreement with then Philippine Tourism Authority (PTA, now Tourism Infrastructure and Enterprise Zone Authority or TIEZA) to form Boracay Island Water Company, which will operate, manage, rehabilitate, expand, and finance water supply and sewerage services in the island for 25 years.
- Operating under a concession agreement, Boracay Island Water will undergo a periodic review.
- This joint venture was considered a landmark milestone as it was the first to be formed under the new National Economic and Development Authority (NEDA) guidelines.

Financing Arrangements

- On 29 July 2011, Boracay Island Water entered into an Omnibus agreement with Development Bank of the Philippines (DBP) and Security Bank Corporation (SBC). The lenders have agreed to provide loans in the aggregate principal amount of up to P500 million. The table below shows the schedule of commitment of the lenders under Tranche 1.

Financing the Water Supply and Wastewater Treatment in Boracay

Sub-Tranche	Lender	Fund Source	Commitment Amount
Sub-Tranche 1A	Development Bank of the Philippines	Philippine Water Revolving Fund (PWRF)	P250,000,000.00
Sub-Tranche 1B	Security Bank Corporation	PWRF	P125,000,000.00
Sub-Tranche 1C	Security Bank Corporation	Internally Generated Funds	P125,000,000.00

Source: Boracay Island Water Company

- On 14 November 2012, the company entered into a second Omnibus agreement extending the loans for another P500 million with the same commitment amounts shown in the table.


International Kite Boarding Event in Boracay (Source: Bernardo Mañosca)

Project Outcomes

- Water loss is down from 37% to 15%, water pressure increased from 15 pounds per square inch (psi) to an average of 34 psi, and 98% of the island is enjoying 24-hour water supply.
- Wastewater treatment capacity increased from 2.6 MLD to 6.5 MLD.
- Joint venture of MWCI-PTA has posted positive gains since 2011.
- The project is 4 years ahead of target in environmental compliance with the completion of Sewage Treatment Plant (STP) upgrade.
- The International Kite Boarding Event, cancelled in 2005 due to issues in wastewater pollution affecting the beach, was recommenced in 2010 after STP upgrade was completed.

Contact for more information

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Wastewater Treatment and Recreation Park

Bhubaneswar City, Orissa, India

Bhubaneswar City is the administrative capital of Orissa, India, with a natural river system running through it. It has experienced a spiraling population growth rate from 16,512 in 1951 to a current estimate of almost 1 million. This growth has resulted in excessive wastewater generation, estimated at 180 MLD. The city has no centralized sewage treatment, thus, untreated and semi-treated sewage flow into the city's water bodies that creates unsanitary conditions. A strip of wetland, NICCO Park, was earmarked for development. It covered 57 acres (27.07 ha), and was primarily used as a dumpsite for the city. Also, the site was encroached upon by slum dwellers.

As part of the Bhubaneswar Master Plan, a lake in the park was developed for boating facilities and a filtration plant was set up for treatment of the water. To further clean the water, a wastewater treatment facility using biotic methods was also set up. The project aims to expand affordable recreation facilities in Bhubaneswar, and to improve the city's sanitation system in a cost-effective way.

Technology Option

- Phase 1: Basic water treatment which included filtration and aeration.
- Phase 2: Natural treatment process using duckweed and pisciculture. Sedimentation pond and a fishpond were constructed.
- The system will treat 4 MLD of wastewater.


(Source: UNESCAP)

Institutional and Management Arrangements

- Public-Private Partnership (PPP): In 1996, Bhubaneswar Development Authority (BDA), a local government entity, and NICCO Parks and Resorts Ltd, a private company, formed the BDA-NICCO Park as a joint venture company. An MOU specified the roles and responsibilities of each partner. The Board of Directors consisted of seven members—three members each from BDA/Government of Orissa and NICCO, and one from the Investment Promotion Corporation of Orissa Ltd. (IPCOL).
- NICCO Parks, a private recreation company that sets up and manages amusement parks, operates and manages the facility, as well as markets and promotes the amusement park.
- BDA, a state government agency responsible for all city-level planning, liaised with all external agencies to obtain necessary approvals.
- Government of Orissa provided the land for the project.
- IPCOL provided the loan to partly finance the park.
- Xavier Institute of Management (XIM), in collaboration with its technical partner, the Central Institute of Freshwater Aquaculture (CIFA), designed and established the biotic wastewater treatment system.
- India Canada Environment Facility (ICEF), a bilateral funding agency, which supports water and energy initiatives, provided financial support for the wastewater treatment system.

Financing Arrangements

- The amount budgeted for the park was Rs44 million. Of this amount, the two partners invested Rs12 million as equity; Rs27.5 million was taken as a term loan from the financial institution, IPCOL; Rs2.1 million from the Orissa State Finance Corporation; and Rs1.6 million from internal revenue. The agreement includes a paid up capital of Rs12 million, of which 49% is subscribed by BDA, and the remaining 51% by NICCO.
- The amount budgeted for the wastewater treatment was Rs5.5 million. Financial support was given by ICEF for one year of operation. It was then handed over to BDA-NICCO Park.
- Resources for the park were largely sufficient, but those for the wastewater treatment were not.
- Flexibility in financing arrangements, especially in loan repayments, given the vulnerable natural environment of the park, was key in the development of the facility.
- Risk is shared equally between the BDA and NICCO. Guarantees and undertakings required by banks and financial institutions are provided by both BDA and NICCO.
- Profits are apportioned as per share in equity.
- All assets are insured for natural calamity or other losses.
- The BDA is answerable to the Government of Orissa and its citizens on any aspect relating to the facility, such as water quality, issues of access, expansion, etc.

Project Outcomes

- Conversion of an unsanitary wetland into a green area with recreation facilities. The recreation facility attracted an estimated 1.2 million paying visitors both from within and outside the city.
- The park and wastewater treatment activities resulted in the generation of employment in the area, including low income workers, and skills creation through training by NICCO. Local staff were trained in the O&M of equipment in the park and commercial operations.
- A sanitary environment for the city residents was created. The wastewater treatment facility has improved the quality of water downstream from the project site where many poor communities continue to use the river as a source of water for many daily tasks.
- The simple and low-cost treatment technology used in the project makes it easy for local people to manage and maintain. This can be replicated in other cities.
- On the wastewater treatment aspect, by working with a joint venture ran primarily as a private company, bureaucratic hindrances and delays often associated with government procedures were removed.
- At present, PPP has been accepted as an effective and viable mechanism for service

delivery reflected through the national level guidelines on private sector participation in urban development, specifically in the area of water and sanitation. In the Department of Industry, Government of Orissa, a policy framework has recently been developed for PPP in infrastructure.

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Environmental Sanitation and Good Governance

Good governance is not just about government. It is also about how citizens, leaders, public institutions, the media, the private sector, and civil society relate to each other in order to make change happen. An important part of the equation is the way government goes about the business of governing. Good governance requires three things: (a) state capability – the extent to which leaders and governments are able to get things done; (b) responsiveness – whether public policies and institutions respond to the needs of citizens, and uphold their rights; and (c) accountability – the ability of citizens, civil society, and the private sector to scrutinize public institutions and governments, and hold them to account.[4]

So how does all this relate to sanitation?

States that are capable, responsive and accountable are more likely able to provide the basic services, such as education, health, water, and sanitation. And they are more likely to attract investment, generate long term economic growth, and reduce poverty. Unless governance improves, poor people will continue to suffer from a lack of security, public services, such as water and sanitation, and economic opportunities.

In Mauritius, to reduce pollution of rivers due to rapid residential and industrial development, the Wastewater Management Authority (WMA) was set up in accordance with the Wastewater Management Authority Act. The WMA in Mauritius is a good model of an effective organization capable of implementing a national sewerage program, providing wastewater treatment services to consumers, achieving cost recovery through monthly tariffs, successfully negotiating agreements with industrial plants on pretreatment systems, and enforcing compliance with the discharge standards and regulations.

The project in Port Louis, Mauritius makes the case that investing in wastewater management and services is a necessary condition for enabling sustained economic growth, and that good governance is an essential sufficient condition.

Environmental Sanitation Project

Port Louis, Mauritius

At the time when the project was prepared in the mid-1990s, Mauritius had already become a middle-income country with a GDP per capita of about $3,550 per year. During this period, rapid growth in both residential and industrial development in Port Louis resulted in noticeable pollution of rivers and land that prompted the government to undertake a program to connect household and industrial polluters to the sewerage system.

Technology Option

Wastewater collection treatment

- A rising main conveys wastewater from Fort Victoria (capacity of 23,000 m^3/d) and Pointe aux Sables pumping stations (capacity of 25,000 m^3/d) to the treatment plant.

Treatment system

- Over 150 pretreatment plants (either individual or jointly installed) treat industrial effluents before discharge to the public sewer.
- Sewage treatment: Primary treatment with disinfection, treating over 40,000 m^3/d of wastewater.

[4] UK Department for International Development (DFID) . 2006.

- The plant was also designed to stabilize and dewater sludge.
- Sea outfall: The outfall reaches about 695 m offshore, with six diffusers set at an average depth of 30 m to ensure that the effluent mixes with seawater.

Institutional and Management Arrangements

- The Wastewater Management Authority (WMA) was set up in accordance with the Wastewater Management Authority Act in 2001 to operate, maintain, and manage all public sewerage systems, and treatment facilities.
- The WMA in Mauritius is an example of an effective organization capable of implementing a national sewerage program, providing wastewater services to consumers successfully negotiating agreements with industrial plants on pre-treatment systems, and enforcing compliance with the discharge standards and regulations.
- The Ministry of Environment is responsible for supervising an environmental audit, consisting of a team set up at the level of the Government to monitor the impact of the wastewater projects being implemented under the national sewerage program.

Financing Arrangements

Capital investment

- The World Bank financed the sewerage system ($12.4 million), capacity building for the wastewater authority, and program implementation.
- The Japanese Bank for International Cooperation (JBIC) financed, with a soft loan ($33.6 million), two new pumping stations, the Montagne Jacquot wastewater treatment plant, and the sea outfall. The government of Mauritius also provided funds for some aspects of each component.

Cost recovery

- Cost recovery was achieved through monthly wastewater tariffs.

Construction of sewerage system.(Source: IWA)

Project Outcomes

- The number of household connections to sewage treatment facilities has increased on a yearly basis, and this has significantly improved the sanitary conditions and public health in Port Louis. By 2006, 30% of Mauritians were connected to the network (10% increase).
- The institutional performance of the wastewater sector improved, with revenues generated through tariffs covering all O&M costs as well as the interest payments for loans.
- Environmental degradation has been reversed. Treated wastewater rose from 20.2 million m^3 in 1999 to 30.5 million m^3 in 2005.

Lessons Learnt

- Regularly reviewing the organizational effectiveness of implementing agencies, and quickly addressing weaknesses can help ensure that agencies perform as effectively as possible.
- Introducing joint billing for water and wastewater makes cost recovery more efficient, and also reduces costs for administration of the scheme.

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From Toilets to Rivers
Experiences, New Opportunities, and Innovative Solutions

This publication showcases a compilation of project briefs culled from case studies of good practices, new approaches, and working models on sanitation and wastewater management from different countries. The project briefs demonstrate solution options from which useful lessons can be derived. Not only do they illustrate how sanitation and wastewater management challenges can be addressed, the project briefs also aim to inspire replication and show opportunities for actions and investments. Given the more complex water resource and health challenges in many parts of the world, it is time to engage in a rational analysis of all possible management strategies, learn from others' experiences, apply innovative approaches, and tap potential markets.

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