Wastewater: From Waste to Resource

The Case of San Luis Potosí, Mexico

Integrated Wastewater Management Plan and Water Reuse

Context

Water is scarce in the state of San Luis Potosí, Mexico. With more than 2.7 million inhabitants in the metropolitan area (as of 2015) and intensive industrial and economic development, the region gets less than 400 mm of rainfall a year. The state government has been a pioneer in understanding wastewater as a resource to utilize rather than a waste only to dispose. Since the 1990s, the city's development has been tied to water conservation efforts and wastewater reuse. Given the area's fast growth, the aquifer was being depleted, with extractions doubling its natural recharge.

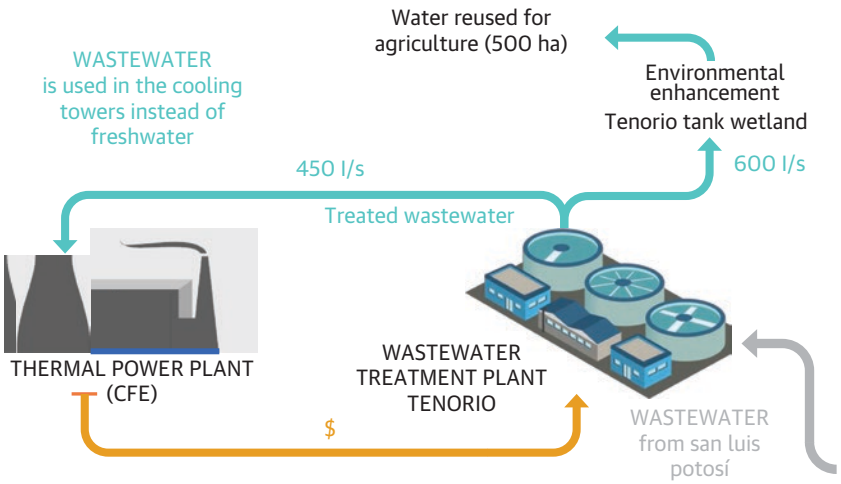
To protect the aquifer and to promote the use of wastewater for nonpotable uses such as for agriculture and industry, the state government implemented an Integrated Plan for Sanitation and Water Reuse. Since then, seven wastewater treatment plants have been built in the region, treating most of the wastewater from the metropolitan area and reusing 100 percent of the wastewater treated. The innovative water reuse contracts and agreements with different industrial stakeholders have ensured the economic sustainability of the program. The Plan for Sanitation and Water Reuse has had economic, environmental, and social benefits for the area and the community. This case study focuses on the largest wastewater treatment plant in the area: the Tenorio-Villa de Reyes wastewater treatment plant (WWTP).

PHOTO 1. Tenorio Wastewater Treatment Plant

Source: ComisiÓn Estatal del Agua 2006.

CHALLENGE
Population growth and rapid economic development → overextraction of the aquifer
OBJECTIVE
• Better exploitation and management of groundwater sources
• Diversify water sources through incorporating alternative sources (treated wastewater)
• Use of treated wastewater for non-potable uses (wastewater reuse)
• Improve water efficiency in agriculture
• Rainwater management and control
• Artificial recharge of the aquifer
• Health improvement of citizens

FIGURE 1. Project Tenorio, San Luis Potosí



Source: Treatment plant image is by Tracey Saxby, Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/imagelibrary/).
Note: CFE = Comisión Federal de Electricidad (Federal Electricity Commission).

Tenorio Project

The Tenorio WWTP is the largest plant in the metropolitan area of San Luis Potosí, treating 45 percent of the total wastewater generated by the city. The treated wastewater is used for three purposes: (a) for cooling purposes in a nearby thermal power plant instead of using groundwater; (b) for agricultural irrigation instead of using wastewater and groundwater; and (c) for environmental enhancement to improve the quality in the Tenorio tank, which has been modified to perform as a wetland (see figure 1).

The plant uses different processes for the varying reuse purposes, becoming the first project in Mexico to produce multiquality recycled water. First, the suspended matters are removed before the water is discharged into the Tenorio tank. The water for irrigation from Tenorio tank meets the standards established by the Mexican government regarding total suspended solids (TSS), biochemical oxygen demand (BOD), and fecal coliforms. The water treated for the power plant meets the standards agreed with the Federal Electricity Commission (Comisión Federal de Electricidad, or CFE) to ensure at least the same concentration cycles in the cooling towers as with the groundwater.

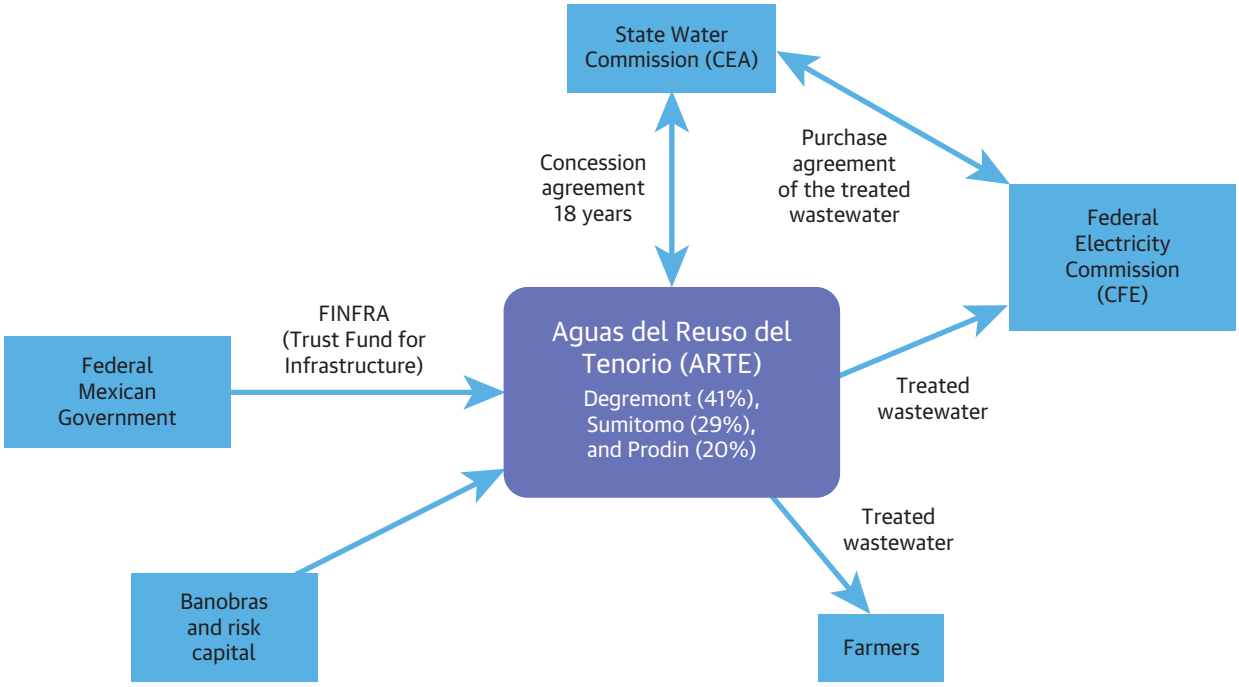
Wastewater reuse is not something new; it is done in many WWTPs in the world. The innovative aspects of the Tenorio Project are the multiquality use of the treated wastewater to meet the different end users' needs, and the contractual agreement with the industrial user, which ensure a constant revenue stream and enhance the financial sustainability of the project.

Financial and Contractual Agreements

The infrastructure needed for the Tenorio project required an investment of US$67 million (2004). Costs included the wastewater treatment plant, 59 km of sewer pipes, a 39-km water distribution system to the power plant, and an irrigation system for 500 ha. The Mexican federal government provided 40 percent of the capital costs as a grant (Fondos FINFRA) with the remaining 60 percent financed through private funding (debt and equity).

To ensure the sustainability of the project, the State Water Commission (Comisión Estatal del Agua, or CEA) signed two contracts: one with the private company ARTE for the construction and maintenance of the wastewater treatment plant for two construction years and 18 years of operation (under a build-own-operate-transfer scheme); and a purchase agreement of the treated wastewater with the CFE for the supply of water for the power plant (see figure 2).

FIGURE 2. Stakeholders of the Project



Benefits

Economic

- *For the power plant.* The treated wastewater is 33 percent cheaper, more consistent (quality and quantity), and more sustainable than the groundwater the power plant used previously. The power plant has saved US$18 million in six years.
- *For the WWTP.* The extra revenue stream from treated wastewater fees covers almost all operation and maintenance costs.
- *For the farmers.* The treated wastewater is of better quality than the untreated wastewater that farmers used previously. That has led to an increase in agriculture production and has allowed farmers to diversify or switch to higher value crops.
- *For the farmers and industry.* Reduced risk due to the increased resilience to droughts and competition through the alternative water resource.

Environmental and social

- Net reduction of groundwater extractions; indirect augmentation of drinking water resources and rehabilitation of the aquifer
- Larger biodiversity as a consequence of the improved water quality in the Tenorio tank wetland, especially migratory birds
- Environmental remediation
- Health improvements include decrease of gastrointestinal and skin diseases rate in the area previously irrigated with raw wastewater
- Reference case of wastewater reuse, encouraging other industries to explore wastewater reuse
- Improved living standard for the population near the wastewater treatment plant as the ecological environment of the zone was enhanced

PROFILE

NAME

Tenorio-Villa de Reyes Wastewater Treatment Plant

LOCATION

San Luis Potosí, Mexico

SIZE

91,000 m^3/day (capacity)

MAIN INNOVATIONS

Integrated wastewater management plan

Multiquality recycled water

Innovative contract agreement and finance

TECHNOLOGY

Screening and advanced primary treatment in lamellar clarifiers enhanced with chemicals → removal of suspended matters and discharge into Tenorio tank wetland

Natural engineered treatment and polishing in the wetland with a total surface area of 2 million m^2 → agricultural reuse irrigation of fodder crops

Secondary treatment by activated sludge with nitrogen removal + tertiary treatment with lime softening, sand filtration, ion exchange for silica, and hardness removal and chlorine disinfection → industrial reuse

Complex distribution system with several pumping stations and an equalization tank to adjust to the industrial hourly demand for the power plant

The guaranteed demand for treated wastewater from the power plant allowed the CEA to undertake the investment risks. The CEA and CFE agreed that the fee for the wastewater would be 67 percent of the price of groundwater for industrial purposes in the state. Waster cost for industrial uses in San Luis Potosí is one of the most expensive in the country. Therefore, the agreement between CEA and CFE benefited both parties: it reduced operational costs both for the power plant and wastewater treatment plant and it protected the aquifer.

Key Factors for Success

- **Government support and leadership.** Federal and state policies promote and regulate the use of treated wastewater. Moreover, local water prices for industry that reflect the cost and scarcity of the area have incentivized the use of alternative sources.
- **Stakeholder engagement and compromise.** For example, the CEA had to engage and negotiate with the farmers because they believed that treating the wastewater would reduce the nutrient content that served as fertilizer for them. CEA ensured them that the water would be of better quality and explained them the benefits of using treated water.
- **Creative finance and contract**
  - *Seeking local opportunities.* Given that water fees for industrial uses in San Luis Potosí are very high, there was an opportunity to engage with those final water users and offer them treated wastewater at a better price.
  - *Proof of concept*. As part of the agreement, the first contract between CFE and CEA was only for one year to prove the reliability of the wastewater supply. Once CFE was convinced of the quality of the water and the service, contracts were signed for two-year periods.
  - *Clear bidding rules, defining responsibilities*
- **Quality and timing of the construction**
- **Public outreach, raising awareness of uses of treated wastewater**
- **Multi-quality of wastewater tailored for the different uses (fit to purpose)**
- **Consistent quality of the treated wastewater**
- **Right mix of expertise.** Degremont, Sumitomo, and Prodin formed Aguas del Reuso del Tenorio (ARTE) to leverage each organization's respective financial capacities and technical expertise.

Conclusion

In San Luis Potosí, the right mix of local conditions and political support combined with a creative project

funding and design that incentivized wastewater reuse, which made wastewater treatment economically and environmentally sustainable. The Tenorio Project is an example of how a well-implemented plan can benefit both the private and the public sector and have environmental benefits at the same time. After six years of operation, groundwater extractions were reduced by 48 million cubic meters, which is equivalent to nearly 20,000 Olympic-sized swimming pools.

References

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