Closing the Loop: Innovation for Increased Efficiency in the Food-Water-Energy Nexus

Nagpur in Context

Nagpur is one of the largest cities in the State of Maharashtra. With a population of over 2.5 million, the city spans across 217 sq.km [1]. The city derives its name from the 'Nag River' and is located at the geographical center of the country. Known as the "Orange City", Nagpur is famous for the oranges it cultivates and trades. The city is home to the Multi-Modal International passenger and cargo Hub Airport at Nagpur (MIHAN) which comprises of an international airport and a multiproduct special economic zone IT Park. Nagpur is one of the fastest growing cities in India and has one of the highest levels of per capita income. These factors contribute to its potential to become a cosmopolitan city.

Food-Water-Energy Nexus in Nagpur

Being the third largest urban agglomeration in Maharashtra in terms of population size [2], Nagpur accounted for 6% of the state's total population in 2011 [2]. In the past four decades, the population has almost increased threefold, being 0.87 million in 1971 and 2.4 million in 2011 [2]. In the past, Nagpur has attracted both a migratory and floating population from the neighboring districts of Maharashtra because of its opportunities in education, employment, and business. The increase in population results in increased demand for water. This is exacerbated by the demand from the periphery which primarily comprises of agro-based industries and power plants.

Facts & Figures

Population
2,405,665 (2011) [4]

Annual population growth rate
17.24% [2]

GDP of Nagpur
USD 12.3 billion [5]

Population Density
10,873 persons/km^2

Nagpur Municipal Corporation (NMC) is responsible for providing water to the citizens in its jurisdiction. In 2008, the total water supply to the city was over 500 million liters per day (MLD). This was distributed via 225,000 connections. However, due to the growing population, water supply increased to 765 MLD via 350,000 connections in 2015 [1]. It is evident that this growing demand from the population is causing the city to face the major challenge of achieving efficient and equal distribution of water throughout the year. In addition, it is important to note that the 525 MLD of sewage which the city generated in 2018 is increasing due to the rising population [6].

Rapid urban growth has also led to a greater demand for energy. Growing power demand prompted Maharashtra State Power Generation Company (MahaGenCo) to begin plans for expanding the capacity of Koradi Thermal Power Plant in the year 2008 to the capacity of 1980 MW [7]. However, an additional 130 MLD of freshwater was required to increase electricity generation in the power plant. MahaGenCo requested an increase in water allocation from the Irrigation Department of the Government of Maharashtra which was granted but projected to be insufficient. MahaGenCo was unable to obtain additional freshwater from any other sources. In this way, industries and power plants have amplified issues pertaining to urban water stress by adding to the demand for water.

There is an urgent need to mitigate the severity of urban water stress by creating innovative alternatives to fresh water. Previously (2008-2009), NMC had one wastewater treatment plant with a capacity of 100 MLD [9]. Given the water scarcity in the region and the heavy water demand from the upcoming power plant at Koradi, MahaGenCo decided to expand its capacity for treating water. To do this, MahaGenCo partnered with NMC to explore the use of wastewater from Nagpur for its operations. A Memorandum of Understanding (MoU) was signed by both parties in 2008 for 'Construction and Operating Agreement of Treatment and Transmission Facilities for Reclaimed Water Usage'. The project aimed to supply treated wastewater to nearby thermal power plants for non-potable use.

The project came into operation in 2018 and reuses 200 MLD of municipal treated wastewater from Nagpur for cooling purposes in the new power plant built at Koradi [10]. The project helps to recover the potable water which would have been used by thermal power plants and instead uses it to meet the city's drinking water and irrigation demand. It is estimated that the additional potable water will cater to at least 1.5 million people in the city, thereby providing environmental, health and social benefits [10]. The overall concept of treating wastewater for thermal power plants clearly promotes the concept of 'Nexus' as it enhances resource use efficiency while addressing externalities across sectors. The project has also contributed to the formulation of the Maharashtra state policy on wastewater reuse [11].

Figure 1 – Koradi Thermal Power Plant [8]

A story of Innovation: innovation for closing the loop

The Nagpur district has five thermal power plants [12], the majority of which consume large quantities of fresh water for cooling and washing purposes which puts pressure on the fresh water designated for drinking and agricultural purposes. Due to the increase in demand for power, MahaGenCo planned an expansion in the year 2008 to the capacity of 1,980 MW across three plants. However, the existing freshwater allocation from the thermal power plants at Koradi of 75 Million Cubic Metres (MCM) per year was found to be insufficient for the new expansions, and there was no additional freshwater available.

In order to resolve the issue of water availability, with the help of USAID, MahaGenCo initiated a study (2005-2007) to assess the demand and feasibility of alternative water sources. The study evaluated the use of high-quality tertiary treated water from the wastewater treatment plant of NMC. In addition, under the same study a pilot plant was developed (2005-2007) to showcase the potential water quality and the possibility of using treated wastewater. The pilot plant

was also used to attract buy-in from both NMC and MahaGenCo. Finally, MahaGenCo signed an MoU in 2008 with NMC to assist in building a new sewage treatment plant of 130 MLD capacity at Bhandewadi, a tertiary treatment plant, and the transmission network all at a cost of INR 1.95 billion. NMC agreed to supply 130 MLD of treated wastewater to the nearby thermal power plants and generate revenue depending on the rate decided by the parties involved i.e. NMC and MahaGenCo/National Thermal Power Corporation Limited (NTPC). As a royalty for the water, MahaGenCo agreed to pay INR 150 million per year to NMC; the city corporation shares 50% of the cost of a new sewage treatment plant from a grant provided by the Central Government under one of the national mission programs. The cost of the royalty will be increased at a rate of 10% every three years. The partnership takes the form of a build-operate-transfer (BOT) model with a 30-year concession period.

Thus, in the case of expanding the MahaGenCo powerplants, an innovative solution was adopted to overcome the resource constraints in a sustainable manner. The initiative promoted reuse of treated wastewater in the thermal power plant and reduced the pressure on freshwater being diverted for electricity generation. The expansion of MahaGenCo is an example of how the nexus approach can not only reduce the stress on fresh water but also generate local government revenue. Some of the co-benefits of the initiative include:

- Opening up the possibility of utilizing treated wastewater rather than fresh water for direct usage in industries, thermal power plants etc., thereby making freshwater available for drinking purposes.
- Achieving a revenue of INR 150 Million (21, 88,650.00 USD) [7] per annum to NMC with a 10% rise every three years.
- Providing a reliable and economically viable source of water for the power plant.
- Creating savings of 130 MLD of fresh water which is sufficient to cater to a population of 1.5 million.
- The improvement of aquatic habitats.

Considering the economic, environmental and social benefits from the project, the Government of India decided to replicate this solution across India and have developed the Tariff Policy, 2016 [14] for promoting the reuse and recycling of wastewater. The policy means it is mandatory for thermal power plants located within 50 km of the sewage treatment plant to buy and use treated wastewater for their non-potable requirements.

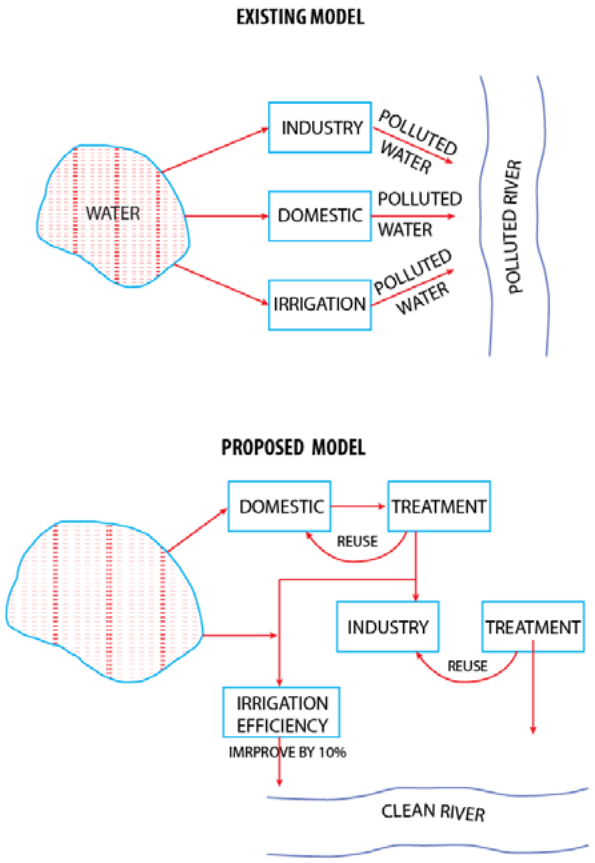

Figure 2 – Schematic of the proposed model [12]

"In the near future, Nagpur Municipal Corporation aims to treat 100% of sewage water. With an increase in the number of Sewage Treatment Plants (STPs) in the city, the three major rivers can be expected to be cleaner than before"

Ms. Nanda Jichkar, Former Mayor, Nagpur

Enabling Environments & Capabilities

The technical and institutional capabilities of Nagpur Municipal Corporation and the State Government of Maharashtra played an important role in the successful implementation of the project.

External Technical Support

The initial feasibility study was conducted with the external technical support from USAID. Information regarding various techno-economic models for internationally and nationally successful sewage treatment plants were assessed. Different expertise was outsourced for preparing the technical, legal and financial models for successful implementation of the project. For example, Pench Project Cell (Sewerage Department of NMC) and the Technical Department of MahaGenCo prepared terms of reference for the project while the Legal department of NMC, in consultation with MahaGenCo, prepared the contract agreement.

Financial and Contractual Agreement

A well-designed contractual agreement established clear project ownership and management by the end-user and the urban local body. The main driver of the project was the end-user's need to obtain secure sources of water at an affordable cost. Funds for implementing the project were sourced from the Government of India and the State Government of Maharashtra who provided financial assistance [16]:

- Grant from the Government of India: 50% of project cost.
- Grant from the State Government of Maharashtra: 20% of project cost.
- MahaGenCo: 30% of project cost.
- NMC contributed 15 acres of land for the project and sewage/wastewater.

Public Private Partnership (PPP)

Models best suited for the sewerage sector were studied and designed for the project. NMC is the owner of the wastewater treatment plant while MahaGenCo is responsible for its operation and maintenance for 30 years from 2015-16, on public private partnership mode BOT. This also ensured that wastewater treatment was conducted according to the requirements of the end-user.

Figure 3 and 4 – 130 MLD Sewage Treatment Plant at Nagpur [14]

Institutional Coordination through Memorandum of Understanding (MoU)

Coordination among various departments at various levels of governance including local, state and national, as well as seeking approvals and permissions was a major challenge. An MoU was signed between NMC and MahaGenCo to ensure smooth coordination for implementation of the project. Strong communication and coordination between the water utility and the end-user helped to fully exploit the synergies of the whole project. Some of the key enabling factors which contributed to the success of the initiative include:

National Programs

The Government of India's national flagship programs such as Jawaharlal Nehru National Urban Renewal Mission (JnNURM) (2005-2014) and related existing framework between Central, State and Local governments, enabled Nagpur Municipal Corporation to take up such a large infrastructure project.

Strong government support and political will

The Government of Maharashtra and NMC were strongly committed to promote wastewater reuse.

Presence of Policy

Some of the key policies promoting wastewater reuse in the country included:

- The Water (Prevention and Control of Pollution) Act (1974) [17] which outlines standards for sewage and industrial effluent discharges. It requires industries and local bodies to treat wastewater to a specified quality before discharging it.
- The National Urban Sanitation Policy (2008) [18] promotes the reuse of recycled water. It suggests a minimum target of 20 percent wastewater reuse in every city.
- The National Water Policy (2012) [19] recognizes the importance of reusing treated wastewater and encourages the reuse of reclaimed water over freshwater through preferential tariffs.

"We envision to transform India's heart-Nagpur into the most liveable, eco-friendly, edu-city that electronically connects people with the government to co-create an inclusive ecosystem".

Ms. Nanda Jichkar, Former Mayor, Nagpur

Synthesis

The project in Nagpur is ongoing and being implemented in phases; a 130 MLD sewage treatment plant was commissioned in July 2016 and NMC is in the process of setting up a new 200 MLD Sewage treatment plant in Bhandewadi. MahaGenCo has signed an MoU with NMC for acquiring 190 MLD of treated sewage for the thermal power plants at Koradi and Khaparkheda [16]. Furthermore, an additional 150 MLD wastewater treatment plant has been proposed to supply the treated wastewater to NTPC at Mouda. With the increase in capacity, water treatment and reuse of sewage will increase to 480 MLD. This equates to 91.42% of total sewage generation and therefore saves freshwater resources.

With rapid urbanization and population growth, India is facing many urban challenges and untreated sewage is one of them. Whilst policy and guiding frameworks in India recognize the need for wastewater recycling, there is a lack of guidance available outlining treatment standards, types of reuse applications, design and operation and maintenance considerations for the management of wastewater recycling projects, as well as tariff structures for the sale of recycled water for various applications. Recycling wastewater and allocating it to industrial users offers an opportunity to make freshwater available to those who need it most. Moreover, the use of treated wastewater provides industries with a reliable source of water that importantly, is cheaper than freshwater. This has great potential to deliver significant cost savings for industrial users which is attractive as water tariffs for industrial use are steep and rising consistently. The example from Nagpur supports the notion that present urban challenges can be resolved through creative ideas and innovative solutions that are both financially and environmentally sustainable. By approaching the issue of increasing demand for water from a nexus perspective, the MahaGenCo expansion harnesses the benefits of energy and water being interlinked as by making sewage treatment more efficient, water usage is in turn, made more efficient.

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