21 The Economics of Municipal Sewage Water Recycling and Reuse in India

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Defining the Wastewater Problem: Challenges and Opportunities

Together, India's largest cities generate more than 38,254 million litres of sewage[1] each day. Of this, it is estimated that less than 30 per cent of what is collected undergoes treatment before it is disposed into freshwater bodies or the sea. Worryingly, these figures exclude sewage generated in informal settlements and in smaller cities and towns where an acute lack of municipal infrastructure for water supply and sewage collection makes data hard to find.

As per Central Pollution Control Board (CPCB) rules, a city or town's municipality or water authority[2] is responsible for collecting and treating 100 per cent of the sewage generated within its jurisdiction. The level to which the sewage has to be treated depends on where it will be disposed—treatment standards are higher for disposal into freshwater bodies than the sea (See Figure 21.1). However, typically even where sewage treatment plants (STPs) exist, sewage collection networks are inadequate so only a small portion goes for treatment. The rest flows into *nallahs* and drains from where it is pumped into surface water bodies. Sometimes wastewater stagnates in pools from where it leaches into the groundwater table and contaminates underground aquifers. Often, informal industry and peri-urban agriculture add industrial and agricultural waste to the mix.

As a rule of thumb, about 80 per cent of household water is released as wastewater. As India's per capita water consumption grows rapidly, the concurrent

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[1] Sewage or 'black water' is actually a sub-set of household wastewater that contains urine, feaces, and other biological waste. The other portion is 'grey water' generated from activities, such as bathing and cooking. While grey water can generally be safely reused for gardening or flushing toilets, the former contains pathogenic micro-organisms that must be treated prior to reuse. However, in India both streams of wastewater are collected together and hence the term sewage is often used to describe all household wastewater.

[2] In some cities, the municipality is responsible for water supply and sewerage while in others, it is a separate water supply and sanitation board. For the purpose of this chapter the responsible agency is referred to as water authority (WA).

sewage problem poses both a significant cost and an opportunity to water authorities (WAs). On the one hand, untreated sewage is the single most important contributor to surface and groundwater pollution in the country. As a result water-borne diseases like diarrhoea, caused by consuming faecally contaminated water, are the largest cause of child mortality in India.[3] A 2010 study by the World Bank's Water and Sanitation Program calculates the per capita economic cost of inadequate sanitation (including mortality impact) at Rs 2,180 (HPEC 2011). There are additional costs that are seldom valued. For example, water pollution poses costly threats to the ecology, to aquatic life, and the fishing industry. Most importantly, pollution of freshwater bodies is inextricably linked to growing water scarcity as polluted water is more expensive and unsafe to use directly.

On the other hand, the large volume of sewage offers tremendous potential for WAs to recycle water within their cities and reduce their reliance on bulk freshwater sources. While freshwater is needed for human consumption, sewage can be treated to the minimum quality required for its subsequent use and safely reused for many non-potable industrial and agricultural uses. As this chapter explores, it is often cheaper and more reliable for WAs to meet non-potable water demand through sewage treated water (STW) than by pumping freshwater over long distances. Where cost differentials exist, they should be weighed against the WA's imperative to preserve freshwater for growing potable water demands. Since WAs are required to treat their sewage anyway, selling STW at full or partial treatment costs can also unlock a sizeable revenue stream.

At present, a majority of the WAs in the country neither have the installed capacity nor the collection networks to undertake sewage recycling. A 2010 Centre for Science and Environment report puts installed treatment capacity at only 19 per cent of total sewage generation and even this limited capacity reportedly runs at 72 per cent utilization (CSE 2010). A 2007 CPCB sample survey of existing STPs classified the performance of only 10 per cent as 'good' with 54 per cent falling into the 'poor' and 'very poor' categories. A number of reasons are cited for this, including lack of qualified staff, poor maintenance, overloading of facilities, irregular power supply, and apathy. However, the lack of funding for O&M appears to be a significant impediment. STPs are generally not self-financing and given that WAs are often in poor financial condition, STPs must depend on unreliable state government transfers instead.

Already several industries have taken the initiative to use STW. Some like Saint Gobain Glass (Sriperumbudur), Wipro, and Shree Cement (Beawar) recycle the sewage that they generate. The resultant freshwater savings are significant. For example, the M&M Auto (Nashik) plant meets up to 30 per cent of its total water consumption with STW (Iyer 2011).

There appears to be tremendous scope for WAs to do the same and provide STW to commercial, industrial, and even household users. Yet while there is undoubtedly an environmental imperative to reuse STW, from a purely economic perspective WAs would prefer to supply STW over freshwater only if the cost of doing so is cheaper. Similarly, large-scale adoption of STW by industry and other users also hinges on economic feasibility. This chapter compares the cost of producing STW and freshwater and looks at the costs currently incurred by potential STW users to understand whether and to what extent STW is a cost-effective option.

This chapter is structured as follows: it first gives a brief review of STP technology options. This is followed by a discussion on the range of costs for producing STW. The next section looks at the current costs faced by potential STW users. Cost estimates for producing freshwater follow. Finally the chapter concludes with recommendations for encouraging the use of STW.

Technology Options

Sewage water is treated in stages to progressively improve its quality. The most important water quality characteristics in the case of sewage are biological oxygen demand (BOD), chemical oxygen demand, total suspended solids (TSS), and nutrients (nitrates and phosphates).

[3] It is estimated that the cost to the country from diarrhoeal disease alone is Rs 500 crore in terms of disability adjusted life years (DALYs). DALYs are a metric developed in conjunction with the World Bank and the World Health Organization as a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability, or early death.

There are numerous technologies to treat wastewater. At the more basic level are technologies, such as waste stabilization ponds (WSP) and duckweed ponds that rely primarily on biological processes [See Chapter 19 for more details]. However, for numerous reasons, including variable output quality, the inability to manage mixed industrial and domestic effluent, fixed capacity and land intensity, these technologies tend to be better suited to rural areas where energy and capital may be scarce but land is easily available. Being more suited to small-scale treatment, they have largely been replaced by more advanced technologies at the municipal level.

Among the more common and cost-effective technologies preferred by municipalities or large industries are conventional activated sludge process (ASP) and sequential batch reactor (SBR). These processes are at least partly automated and are designed to meet specific output quality parameters. Although their processes are also primarily biological they typically involve some use of chemicals, particularly at the tertiary treatment level in the case of ASP. Both technologies are suited to Indian conditions as they can effectively treat both diluted and concentrated wastewater as well as mixed household and industrial waste.

SBR is regarded as an advanced form of ASP. Since treatment takes place in a single basin it requires up to 33–50 per cent less land and has 40 per cent lower civil construction expenditure than conventional ASP plants (CSE 2010). Being fully automated, it consumes 35–45 per cent less power than conventional ASP, has low chemical requirements, and reduces manpower costs significantly. SBR has inbuilt nutrient removal although this can be added to conventional ASP.

For most non-potable uses, water must have certain minimum quality characteristics (see Figure 21.1). CPCB norms for discharge into surface water bodies fall short of these quality requirements. Sewage water treated by SBR can be directly reused. While secondary level ASP treatment typically produces output quality as shown in Figure 21.1, some tertiary treatment is usually required to bring it up to low-end industrial use standards. However, some industry experts argue that while it is cheaper to use SBR to meet reuse standards than conventional ASP, the latter is marginally cheaper in meeting CPCB norms.

The Cost of Treating Sewage Water

WAs across the country will incur slightly different costs of treating their sewage. This will depend on factors, such as technology choice, quality of their existing treatment facilities, and the potential for economies of scale. In addition to treatment costs, these agencies must also consider the cost of building or augmenting their sewage collection networks. At present only a handful of cities like Chennai, have achieved 100 per cent sewage collection. However, since the investment requirement for the network depends crucially on the size and density of the city, the cost of sewage collection is hard to generalize. Therefore, this section focuses mainly on treatment using existing cases from WAs and industry to estimate a possible range of treatment costs across the more common technologies.

SBR Treatment

The Navi Mumbai Municipal Corporation (NMMC) has been proactive in treating and attempting to reuse its sewage. It has chosen to use SBR technology for its STPs. NMMC's first plant at Nerul was built in 2008 at a capital cost of Rs 67.9 crore for 100 million litres a day (MLD) capacity. By the end of 2011, when work is completed on the last three plants, NMMC will have a total of 6 plants and a total treatment capacity of 420 MLD. To run its three operational plants, NMMC has given service contracts to private operators, but pays the electricity bills directly. The current 3-year O&M contract is for Rs 70 lakh per year, and will be bid out again possibly at a revised rate, when it expires next year.

The Nerul plant is currently operating at 45 MLD. At this level of utilization, the O&M cost inclusive of electricity is Rs 1.20/KL. However, this cost does not account for the significant capital expenditure incurred. Table 21.1 calculates the 'levelized' production cost if capital and O&M expenditure are included. A levelized cost essentially divides the net present value of the total investment in a project into an equal, annual, per unit cost. In other words, if NMMC were to sell its STW at this constant levelized cost each year for the life of the project, it would recoup its total expenditure. In calculating the levelized costs, two scenarios are envisioned. In the first, the WA undertakes recycling and does not make a profit, whereas in the second the private sector operates the plant and factors in a 16 per cent return on

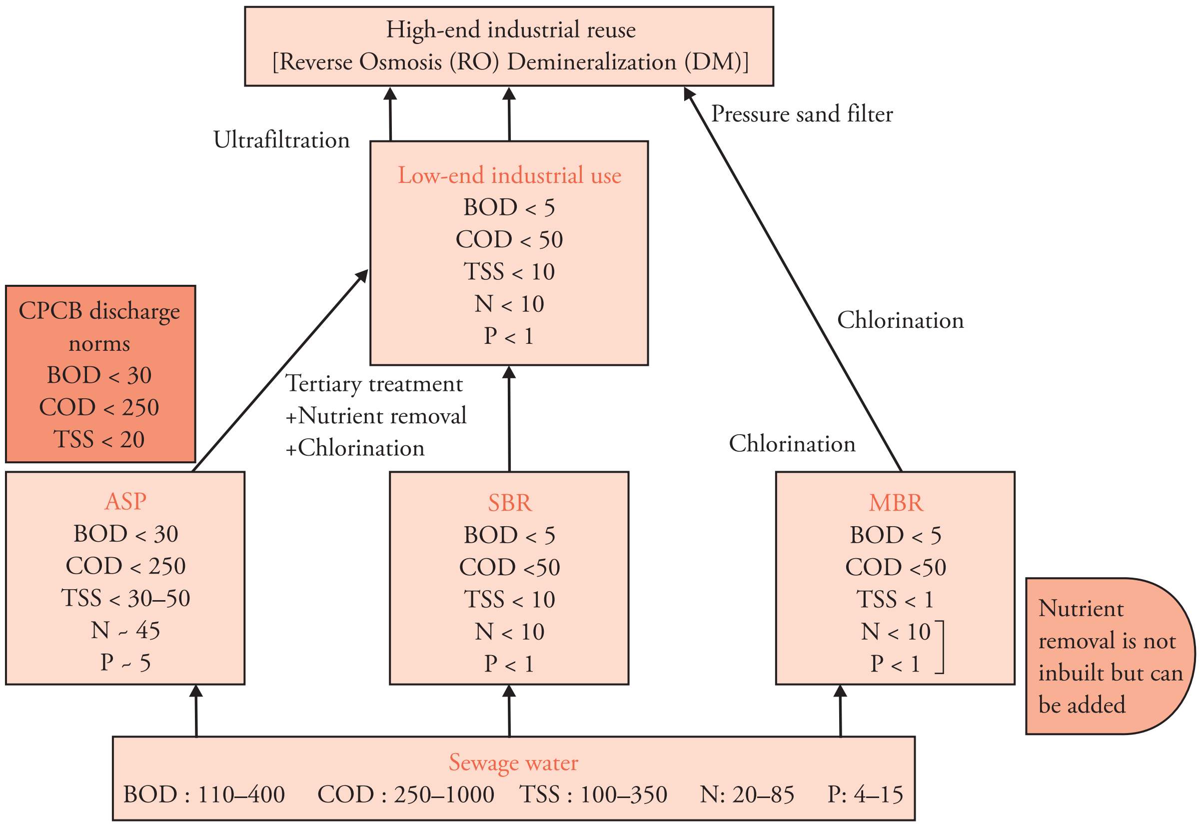

Figure 21.1 Treatment Technology and Reuse Standards

Source: Interviews with SFC Environmental Technologies Ltd. (interviewed on 27 May 2011), Central Pollution Control Board (interviewed on 29 March 2011); Author's analysis based on IDFC Appraisal.

Note: BOD and COD are indirect measures of the amount of organic and inorganic material in sewage water. TSS measures the concentration of suspended, non-filterable solids. Nutrients (N=Nitrogen, P=Phosphorous) are measured as they encourage growth of algae and other aquatic plants.

MBR or membrane bio reactor is an additional treatment technology which is currently much more expensive than SBR and ASP in India.

equity. Table 21.1 also models these scenarios assuming that the plant is running at full capacity. Doing so reveals that economies of scale significantly reduce the cost of treatment.

SBR treatment costs should be reasonably consistent across the country as it is a proprietary technology. However, the levelized costs would vary depending on the structure of debt incurred by the WA, local electricity costs, desired return on equity, and other such factors assumed in our model.

ASP Treatment

Chennai Metro Water (CMW), the water supply and sanitation authority in Chennai, is a progressive water board that has actively pursued its sewage collection and treatment targets. CMW uses secondary level ASP plants to treat its sewage slightly beyond CPCB standards for freshwater discharge. Of the 486 MLD of STW currently produced CMW sells 36 MLD to three large industries located in the north of the city. The STW is sold for Rs 10.20/KL and includes the cost of pumping the STW to the plant gates.

Between the 1970s to the early 1990s, Chennai built six conventional ASP and trickling filter plants. Between 2005 and 2006, it built four additional conventional ASP plants with funds from the Chennai City River Conservation Project (CCRCP). By 2013, three more ASP plants will be built under the Jawaharlal Nehru

Table 21.1 Estimated Range of Costs for Producing Secondary Level STW

Technology	*Source*	*Capacity (MLD)*	*Current O&M*	*Levelized annual total costs*	
				Public	*Private*
ASP	PPCL CMW Other ASP	20 5–100 60–80	4 –3.5* –1.3**	15	17
SBR	Nerul Nerul	45 100	1.2 –1.2***	7 4	9 5
Mix (Include collection costs)# HPEC Report	Class IA Class IB Class IC Class II Class III Class IV+	 9 7 5 5 3.5	10		
Range			1.2–10#	4–15	5–17

Source: Interviews with SFC Environmental Technologies Ltd. (interviewed on 27 May 2011), Degrémont (interviewed on 29 March 2011), and Pragati Power Corporation Ltd. (interviewed on 28 March 2011); Delhi Electricity Regulatory Commission Tariff Order (2008–11); High Powered Expert Committee Report on Indian Urban Infrastructure and Services (2011); Tokyo Engineering Consultants (2004); author's analysis based on IDFC appraisal.

Note: *This includes about two-third of the total manpower costs of Rs 1.58/KL, to be conservative.

** The range of costs is Rs 1.07/KL to Rs 1.34/KL. Figures were adjusted to 2003 rupees using the wholesale price index.

*** We assume that current O&M costs for 100 MLD operations increase proportionately. However, it is likely that this figure will be lower due to scale economies.

HPEC estimates include the O&M cost for the sewerage network, which is Rs 3.3/KL on average.

Assumption for PPCL and Nerul: All non-fixed costs escalate at 5.5 per cent per year over 30 years. Capital expenditure for the Nerul STP is Rs 67.9 crore, for PPCL it is Rs 2.5 crore per MLD. 'Public' assumes no return on equity, whereas 'Private' does: it is 16 per cent for Nerul and a DERC-approved 14 per cent rate for PPCL. Debt: equity ratio for all is 70:30, loan is for 10 years at 12.5 per cent interest. PPCL estimates include pumping costs from the STP to PPCL power plant.

National Urban Renewal Mission (JNNURM) funding for a total treatment capacity of 740 MLD. Given the varying age of the plants, CMW reports an average O&M cost for collection and treatment across all its plants of Rs 8.90/KL. The O&M cost of treatment alone is estimated to be approximately Rs 4.08/KL.

Due to the age of some of its plants, CMW does not include capital expenditure in its treatment costs. It is interesting to note that CMW's four newest plants are completely powered by internally generated biogas for nine months of the year which reduces electricity costs significantly by about Rs 0.45/KL.

An alternative estimate of costs comes from industry. In 2004, the government-owned Pragati Power Corporation Limited (PPCL) a Delhi-based power station was denied a freshwater linkage to operate its 330 MW gas-based power plant. Instead, PPCL was given the option to operate two of the Delhi Jal Board's (DJB) 10 MLD each STPs to meet their industrial water requirement.

PPCL has outsourced the O&M to Degrémont, an international water treatment company. The contract is renegotiated every two years and Rs 1.26 crore per year for the period 2010–12. In addition, electricity costs for 2011 were Rs 1.6 crore. Like CMW, STW output quality is slightly higher than CPCB standards. STW is pumped to the PPCL power plant where it undergoes further treatment to be used in boilers and coolers. However, this additional treatment would be necessary even if freshwater were used. Current O&M for PPCL is Rs 4.0/KL. Table 21.1 also calculates levelized total costs using an estimated capital expenditure.

Since PPCL's plant uses proprietary ASP technology, its costs may be slightly different from other generic ASP plants. In particular, its capital costs per MLD are higher than generic ASP at Rs 2–2.5 crore per MLD. In 2004, Tokyo Engineering Consultants undertook a study of all the STPs built under the Ganga and Yamuna River Action Plans. The generic ASP plants surveyed were built between 1991 and 2001 and had O&M and electricity costs ranging between Rs 1.07/KL to Rs 1.34/KL. Their capital costs ranged between Rs 22 to 33 lakh per MLD. However, these costs are not directly comparable to the costs for PPCL reported below as they have been adjusted to 2003 rupees using a wholesale price index. The generic plants also have a larger capacity than PPCL at between 60–80 MLD, which brings in economies of scale especially in construction costs.

There are factors to be kept in mind when comparing SBR and ASP. For example differences in plant scale and the fact that since the ASP plants are government run they might not be operating at maximum efficiency.

Lastly, the estimates can be compared with those from the High Powered Expert Committee Report on Indian Urban Infrastructure and Services (HPEC). The report uses detailed project reports (DPRs) submitted by cities to JNNURM. They calculate an average treatment O&M cost of Rs 5.40/KL to produce secondary level STW. This is consistent with the cases presented earlier, especially as the HPEC numbers include technologies other than ASP and SBR. The HPEC estimates in Table 21.1 are for both treatment and collection O&M. On average, collection O&M alone is Rs 3.30/KL. The HPEC estimate for Class IA cities is similar to CMW's cost of collection and treatment of Rs 8.90/KL.

The HPEC Report also disaggregates per capita investment costs for network and treatment. As Table 21.2 shows, the per capita investment costs indicate significant economies of scale in both network and treatment. The unit costs are negatively correlated with the incremental project capacity for treatment plants. The largest component of investments, however, is the network and this cost escalates significantly for smaller cities and towns possibly because density reduces and the quantum of existing infrastructure falls. The per capita O&M costs for treatment range from Rs 145 to Rs 414 per capita.

Table 21.2 Per capita Network and Treatment Costs for Sewage

(*Rs*)

City size class	*Network*	*Treatment*	*Total*
Class IA	2,092	1,268	3,360
Class IB	2,573	1,268	3,841
Class IC	2,338	1,073	3,411
Class II	3,246	2,070	5,316
Class III	3,637	2,012	5,649
Class IV +	4,636	2,012	6,648

Source: HPEC Report (JNNURM project appraisal notes used for cost estimation).

Tertiary Level Treatment

Urban local bodies (ULBs) are not obligated to treat their sewage beyond the secondary level. However, some like the Bangalore Water Supply and Sewerage Board (BWSSB) have chosen to do so. At present, only four of their seven STPs do tertiary level treatment but there are plans to upgrade all the plants to that level. Their reported production cost for the 60 MLD Vrishabhavathi Valley STP is between Rs 10–12/KL. STW is presently supplied to a number of industries and it is proposed that it will be pumped for use in a local power plant.

In the absence of available tertiary treated STW, some industrial units have chosen to buy either raw sewage or secondary STW and treat it further to meet their water purity requirements. For example, Madras Fertilizers Limited (MFL) in Chennai and Rashtriya Chemicals and Fertilizers Limited (RCF) in Mumbai are purchasing STW and raw sewage, respectively from their local water authorities. Both require portions of their water at the tertiary treated, reverse osmosis (RO), and demineralized (DM) levels of purity. MFL utilizes 60 per cent of its water at the tertiary treatment level while 40 per cent is sent for RO and DM. Of the total water it receives from BMC and its STP, RCF uses 73 per cent at the RO level and 27 per cent at DM stage. Stage-wise cost of treatment and weighted average cost of treatment are given in Table 21.3. In the case of MFL, it is actually cheaper to use STW than freshwater both because of the high industrial water tariff in Chennai and because it is more expensive to demineralize freshwater than tertiary level STW. In the case of RCF, while there is a minimal price difference between RO level water which is used interchangeably with fresh water, this is weighed against having a reliable supply of

Table 21.3 MFL and RCF Current Total Treatment Costs

(*Rs/KL*)

	MFL		*RCF*	
	STW	*Fresh water*	*Raw sewage*	*Fresh water*
At plant gate	10	60	0.60	40
At TTP plant	28	Not Req	NA	Not Req
At RO plant	70	Not Req	45	Not Req
At DM plant	100	130	100	100
Weighted avg treatment cost	57	88	60	56

Source: Interviews with Madras Fertilizers Ltd. (interviewed on 19 May 2011), Rashtriya Chemicals and Fertilizers (interviewed on 9 May 2011), and Chennai Metro Water (interviewed on 18 2011); author's analysis based on IDFC appraisal.

water and control over quality which is highly valued by these kinds of industries. According to *The Hindu* (2009), the financial loss to RCF from disruption to their freshwater supply in 1992 was almost Rs 50 crore. In comparison, in the early 1990s when MFL set up its plant and STP technology costs were significantly higher than what they are today its capital expenditure was just Rs 30 crore. However, since the numbers given in Table 21.3 are internal estimates that may include other overheads, MFL and RCF's cost of production might not be representative of those faced by WAs or even other industries.

Like BWSSB, other water authorities might be able to produce tertiary treated STW at a substantially lower cost. For example, CMW was offered funding from the Japan International Cooperation Agency to set up a tertiary treatment and RO plant to supply water to industry provided the industries signed a guarantee to purchase certain quantities of water.

Cost of Alternatives

For customers to switch to STW it must be priced competitively with alternative water supplies for the same or better level of quality. This section describes the two main categories of potential STW users—bulk industrial or commercial users, and household consumers—and the costs of their alternatives.

Industrial and commercial users of STW have varying needs. Large industrial users, such as power plants require huge volumes of water but most of this is not needed at a high level of purity. Others, such as MFL and RCF require large volumes, but also a significant share of high quality water. However, many of these users must already further treat the freshwater they receive and may be able to absorb the costs of setting up additional treatment facilities or an STP.

Large-scale commercial users, such as malls, theatres, or office complexes need water primarily for air-conditioning and cooling and can utilize STW at low-end industrial reuse standards. However, STW needs to be chlorinated and its nutrient content removed to prevent scale formation and algae growth in their cooling systems. Transport authorities are another important bulk consumer who can use low-end STW. For example, it is reported that the Indian Railways uses 300 MLD of freshwater for washing its train carriages. Smaller industrial users who need good quality water might be more tricky if the STW provided falls short of freshwater standards as they may not have the financial capacity or scale to make additional treatment viable.

At present, most of these users buy their water from WAs at the industrial tariff, purchase tanker water, or pump groundwater themselves.

Retail or household users can use STW for gardening, flushing, or washing cars. According the Centre for Science and Environment (2010) these activities account for almost 40–50 per cent of total water use per individual. At present, most households buy freshwater at domestic water tariffs while some use groundwater or tanker water.

Industrial and Commercial Users

PUBLICLY SUPPLIED

Industrial water tariff in most large cities is typically quite high as industrial tariffs are set high to cross-subsidize drinking water. For example, Chennai's industrial water tariff is Rs 60/KL whereas the domestic water tariff is just Rs 4/KL. According to Prakash (2007) report, industrial tariffs across the larger cities are typically above Rs 45/KL. Given the range of treatment costs described earlier, it appears that WAs could afford to provide STW at below the current industrial tariff.

PRIVATELY SUPPLIED

(a) Tanker Water:

Tanker water costs vary across the country. In the larger metros, these costs range between Rs 50/KL to upwards of Rs90/KL in the dry season. Again, WAs in larger cities should be able to supply STW at competitive rates. For example, NMMC is considering supplying STW for the construction of the Navi Mumbai International Airport which would otherwise require about 500 tankers of water per day (5 MLD) at Rs 50/KL. Given Navi Mumbai's costs of production, this could constitute a considerable saving to the airport authorities while allowing NMMC to cover their treatment costs and earn revenue.

(b) Ground Water:

A challenge to the use of STW comes from industries that use groundwater. For these industries, the cost of water is practically free and dependent on the cost of pumping. Groundwater use can be both legal and illegal. For example, in New Delhi and Chennai, industries must apply to the local groundwater authority and be granted a permissible limit for extraction. However, to a large extent, groundwater extraction takes place illegally. Stricter regulation and availability of low-cost alternatives might encourage a shift away from groundwater use.

Household Users

Given that households receive freshwater at highly subsidized rates, it may not be feasible to supply STW at the levelized cost of production, or even at its O&M cost. However, as described later, the cost of augmenting bulk freshwater supply is usually higher than that of producing STW, meaning less cross-subsidy is required. Moreover, if using STW allows households to have a close to 24×7 water supply by preserving freshwater for its best use, then households might even be willing to pay a slightly higher cost for it.

Cost of Freshwater Supply

As the demand for water grows, WAs must continually augment their bulk water supply. Burgeoning urban populations and the growing imperative to supply water for more than a few hours in a day will all require large investment in water supply infrastructure.

Most large cities in the country pump their water from freshwater bodies at a distance between 50 to 200 km away. Although this water usually needs very little treatment, the infrastructure and operating costs of water supply pipelines are significant. Using estimates for pipeline and pumping costs for a pipe of 1 metre diameter Table 21.4 shows the range of levelized costs for augmenting bulk water supply. These estimates exclude the cost of water treatment plants.

Table 21.4 Levelized Pipeline Costs

(*Rs/KL*)

	*Levelized costs**		
	50 km	*200 km*	*1 km*
Variable costs	–8	–30	–0.15
Total costs	–13	–50	–0.25
Total costs (excl ROE)	–11	–44	–0.22

Source: Interviews with SFC Environmental Technologies Ltd. (interviewed on 27 May 2011); author's analysis based on IDFC appraisal.

Note: Assumptions: We assume all non-fixed costs will escalate at 5.5 per cent every year over 30 years. Total costs include capital expenditure of Rs 3 crore/km, pumping costs of Rs 1 per 10 km, pipeline of 1 metre diameter (carrying capacity of 132 MLD), debt: equity ratio of 70:30 and an return on equity (ROE) of 16 per cent.

In terms of current costs, water supply pipelines of 1 metre diameter cost Rs 3 crore per km to build and it costs Rs 1/KL over 10 km to pump. Levelized costs range between Rs 11/KL to Rs 50/KL. However if water boards receive grant funding or concessional electricity rates for pumping, then these costs might be reduced.

Most cities will already have some bulk water supply infrastructure. Water scarce Chennai has made large investments to supply the required 800 MLD of water supply. Its cost of freshwater supply using both surface and groundwater ranges from Rs 5 to Rs 10.50/KL for surface water and Rs 29/KL for groundwater. In addition, it is now desalinating water under a DBOOT contract, that they purchase at Rs 40/KL. It also has an additional desalination plant coming on line in 2012 which will supply desalinated water at Rs 21/KL.

To obtain a more comprehensive perspective of costs across the country, the *HPEC Report* estimates the O&M cost for bulk water supply as given in Table 21.5.

Table 21.5 O&M Costs of Freshwater Supply

(*Rs/KL*)

City size class	*O&M cost*
Class IA	13.0
Class IB	10.0
Class IC	8.0
Class II	8.0
Class III	6.0
Class IV	4.0

Source: HPEC Report (JNNURM project appraisal notes used for cost estimation).

However, it is important to keep in mind that this may not be the case in every city. Cities like Delhi that have access to perennial water supplies within close proximity might find it cheaper to supply freshwater. However, there too, the DJB reports that the growing need to preserve freshwater has made it take a more proactive stance towards producing and selling STW. The DJB is considering plans to sell STW from its STP located at Rithala to two power plants at approximately Rs 8/KL. However, the details of the arrangement are yet to be finalized.

To summarize, Table 21.6 compares the levelized costs of providing STW versus freshwater under both public and private arrangements.

Table 21.6 Comparative Cost of Producing STW and Freshwater

(*Rs/KL*)

	*Levelized Costs**	
	STW	*Freshwater*
Public	(–) 4–14	(–) 11–44
Private	(–) 5–17	(–) 13–50

Source: HPEC Report, Interviews with SFC Environmental Technologies Ltd, Chennai Metrowater and Pragati Power Corporation Limited; author's analysis based on IDFC appraisal.

* We assume all non-fixed costs will escalate at 5.5 per cent every year over 20 years. Total costs include capital expenditure of Rs 3 crores/km, pumping costs of Rs 1 per 10 km, pipeline of 1 meter diameter (carrying capacity of 132 MLD), debt: equity ratio of 70:30 and a Return on Equity (ROE) of 16 per cent.

Thus overall, it appears that the cost of producing STW suitable for low-end industrial use can be lower, or at least competitive with the cost of freshwater supply. While tertiary treated water, and certainly water treated by reverse osmosis is more expensive than freshwater, extensive use of STW where possible can reduce the overall investment burden for water supply.

Conclusions and Recommendations

To date, there has been much more emphasis on investing in water supply infrastructure than in sewage networks. Even JNNURM funding to date for water supply has been double that of sewage projects. Thus, while treatment costs are not a deterring factor, large upfront investment will be required to bring the current condition of sewerage infrastructure in the country up to the required level.

At present CPCB and state PCBs cannot penalize WAs that violate disposal norms. Partly as a result, only a handful of cities and towns are complying with their obligations. Given the acute lack of funding and the poor condition of many WAs, CPCB and PCBs could be given a budgetary allocation to help the relevant authorities prioritize sewage treatment through long-term loans or grants. In larger or more industrialized cities where there is potential to recover costs of producing STW, pipeline networks could be grant funded while medium or long-term loans could be given for STP construction. In particular, there should be a strong orientation towards O&M cost recovery and operational efficiency to ensure proper use of investment. This means that WAs should be required to meet all O&M costs through sale of STW. For example, CMW has full cost recovery for the STW it sells and earns Rs 12 crore annually from it. To enable this scenario, there should be strict enforcement procedures and concerted Central or state assistance in capacity building and training STP personnel.

Given the cross-cutting nature of benefits offered by STW reuse, there may be multiple agencies willing to fund such projects as the CCRCP did in Chennai. Funding from various agencies could be streamlined through JNNURM to enable maximum funding impact and transparency.

In allocating JNNURM funding, it could be mandatory that all bulk water supply projects be proportionately linked to an increase in sewage infrastructure.

Cities must draw up a phased infrastructure plan in which bulk water source augmentation is planned in conjunction with STP construction and sewage pipeline development. Incentives and funding should be tied to reaching certain STW reuse benchmarks. In the absence of sufficient industry, incentives could be linked to improvements in quality of surface water bodies used for discharge. Possible incentives could include electricity at cost, as the power cost of older plants in particular can be high or increased allocation for investment for household sewerage networks.

As part of their city development plans (CDPs), WAs could be required to broadly profile the water requirements of all bulk users in their jurisdiction and estimate the price at which STW could be supplied to them. This could be based on the cost recovery principle as well as a small premium to subsidize smaller industrial or commercial units. Given the savings to bulk users in particular they must build the connecting pipeline to the nearest STP. Already industrial users are asked to bear the cost of building connecting infrastructure for freshwater. For example, NMMC estimates that even if two large bulk consumers located across the sea in Mumbai built a Rs 200–250 crore undersea pipeline to the NMMC STP, they would recover their costs in 7 to 8 years by buying STW at Rs 8/KL rather than freshwater at the industrial tariff of Rs 40/KL. Alternately, to make this more palatable to industry, WAs could incur the cost of building the pipeline and recoup this by including the cost in their levelized tariff. However, this may require the WAs to take on loans for construction against a guaranteed purchase contract from industry.

Given the cost of sewage networks, CPCB is gradually encouraging decentralized treatment. Thus, for example, all new housing colonies above a certain size in Chennai, are required to set up their own STPs. Similarly, for large industries located further away from urban areas, WAs could mandate that they reuse their own sewage water to meet part of their own overall water requirements. In the case of power plants, captive STPs should be allowed to use the plants' own generated power rather than having to purchase it at commercial rates. WAs should not discourage industries from treating raw sewage themselves. For certain types of users, STW reuse could be mandatory. For example, this could include all public parks and gardens and transport authorities.

Tariff structures could be revised so that STW is provided free but potable water is charged higher. As the experience of ULBs across the country has shown, from a political perspective it might not be possible to raise monthly household bills. Yet it might be possible to design a tariff structure in a way that potable water is charged higher than it is at present and non-potable water is free so that the monthly bill remains the same. Doing this would send a strong price signal that incentivizes less potable water consumption. However, for household users to use STW, significant investment would be required to build a set of dual pipelines to carry both STW and freshwater to properties. While the idea of dual pipelines might seem daunting, some of this cost can be shifted to developers, as has been done with rainwater harvesting. It should also be mandatory to separate 'grey water' from 'black water' so that the former can be directly used for flushing and gardening within the building at least once before entering the WA's sewage network. To ensure this, planning norms for STW reuse should be issued for all new cities, townships, industrial, areas and special economic zones (SEZs). Building codes should mandate dual pipelines to carry STW and freshwater. Lastly, municipalities should be required to allocate land to accommodate STPs, pumping stations, and other related infrastructure.

With estimates of industrial water demand at 8 per cent of freshwater withdrawal and growing rapidly, the need to promote sustainability in freshwater use has become exceedingly important. Although the task ahead appears daunting, India with a large chunk of infrastructure remaining to be built, is actually well poised to plan its development in a way that ensures our water security in the future.

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