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Formal approaches to wastewater reuse in Bangalore, India

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Water scarcity and pollution appear to be driving the need for wastewater treatment and use in Bangalore. The result is that two government agencies, the Bangalore Water Supply and Sewerage Board (BWSSB) and the Karnataka State Pollution Control Board (KSPCB) have initiated waste treatment and use. The BWSSB is motivated by their mandate to provide water and sewerage to the city, while KSPCB's motivation is their remit of pollution control and protection of water bodies. The systems are respectively large-scale treatment and sale of wastewater to industry and on-site treatment and use in apartments and commercial properties. Both have considerable merit but some limitations need to be overcome in order to reach their potential. For centralized systems this includes costs, public perception and infrastructure. For on-site treatment this includes public perception, stringent legislation and lack of technical expertise.

Introduction

Bangalore, like many cities in South Asia, is experiencing rapid population growth and consequent water shortages, water supply problems, sanitation deficiencies and water pollution. One solution to this could be the treatment and use of domestic[1] wastewater. This study has identified a number of such reuse practices, both formal and informal, and analysed the policy and institutional settings within which they operate. This paper presents two of these approaches and describes the institutional arrangements for their establishment and management, as well as their benefits and limitations. One of the approaches is that of sewerage and large-scale wastewater treatment (WWT) followed by sale of treated water to industry. This is implemented by the public water utility, the Bangalore Water Supply and Sewerage Board (BWSSB). The other approach is that of private on-site sewage treatment plants (STPs) in apartments and commercial properties. This is required and enforced by the Karnataka State Pollution Control Board (KSPCB), with the aim of pollution control. The paper describes the BWSSB and KSPCB's reasons for instigating WWT and use, and key elements of legislation and policy that surround them. It also identifies shortcomings in the current systems that need to be addressed if water reuse is to meet its potential.

Methodology

This paper draws on policy and legal documents, key person interviews and secondary literature to understand the current legislation around water supply, and WWT and use. The perceptions of relevant state agencies, STP owners and the STP supply sector were gained from interviews with BWSSB, KSPCB, apartment residence welfare associations (RWAs) and an expert who advises the KSPCB and provides managerial services for private STP operation. Secondary literature and news media have been extensively gathered to understand the history of, and plans for, water supply and wastewater management in Bangalore, as well as opinions on WWT and reuse and related policy decisions.

The Bangalore water, wastewater and RRR context

Water scarcity is an important feature of the water supply, sanitation and reuse landscape in Bangalore. The residents of the city are dependent on water from the Cauvery River over 100 km away and its tributary, the

Arkavathy River which feeds the Thippagondanahalli (TG Halli) reservoir; privately owned wells; or water tankers selling groundwater. The core of the city is predominantly provided with piped water supplied by the BWSSB, while the periphery relies on expensive tanker supplies and wells. Rapid urbanization and the expansion of the official city boundaries in 2007, have led to a doubling of the population between 2001 and 2011 (Census, 2011) compounding the water scarcity and supply problem.

The BWSSB, provides around 1,170 MLD of piped water to Bangalore derived from surface water (1,120 MLD) and ground water (70 MLD) but the 8.8 million people that live in Bangalore Metropolitan Area (BMA) are expected to have a water demand of 1,720 MLD by 2015 rising to 2,550 MLD by 2036, with predicted shortfalls of 220 MLD and 1,050 MLD respectively (Kelkar and Thippeswamy, 2012; Kelkar et al., 2012). The actual quantity of water used is higher due to private supplies. The quantity of wastewater generated is approximately 1,200 MLD of which 120-350 MLD is treated (Kelkar and Thippeswamy, 2012). Around 45% of households in Bangalore are connected to sewers, with the remainder having septic tanks, pit latrines or disposing directly to the environment (Census, 2011). Consequently water pollution is severe.

Given the scarcity of water in the region and fears of groundwater over exploitation, inadequate sanitation facilities and water pollution; water reuse is undoubtedly part of the solution.

BWSSB's approach

This is recognized by the BWSSB who, with central government and donor support, have established and operate 14 STPs, some of which sell treated water to industrial users (Table 1). The industries pay to connect to the STP to receive a regular supply of water of adequate quality for their purposes at a cost that is below the usual cost of water supplied to industry by BWSSB.

Table 1. BWSSB sewage treatment plants for water reuse

STP	Intended use	Planned reuse (MLD)
V valley	Supplied to a power plant and industries	60
Hebbal valley	Released to Nagavara lake	60*
Madivala	Water reclamation plant to replenish the lake	4*
Kempambudhi	Water reclamation plant to replenish the lake	1*
Yelahanka	Supplied to airport and industries	10
Cubbon Park	Park watering	1.5
Lalbagh Park	Park watering	1.5

Source: Adapted from BWSSB (no date). *Wastewater is intended to replenish a water supply source.

The BWSSB has further plans, through its recently established 'New Initiatives and Design Division', to develop treatment and use in Vrishabhavathi Valley (V Valley). The treated water will be discharged into the Arkavathy River and flow to a water treatment plant on the TG Halli reservoir. In October 2012, the BWSSB signed an agreement with the Singapore government's Temasek Foundation to aid in the public outreach and stakeholder acceptance aspects of the project, as the BWSSB acknowledges that public perception is a major obstacle to reuse, mainly due to misperceptions and apprehensions about quality and health.

KSPCB's approach

It has been estimated that there are some 600 private STPs in Bangalore in apartments (331), tech parks (123), hotels (42), hospitals (49), commercial and retail complexes (44), educational institutions (15) and residential layouts (7). Combined, these have a capacity of around 109 MLD but only operate at 75 % of their capacity (Shankar and Yathish, 2012). The main impetus for STP implementation has come from legislation issued by the KSPCB with the purpose of pollution control and conservation of water bodies. The law requires residential apartments and complexes, and commercial establishments of certain sizes to construct and operate on-site STPs and meet effluent discharge and reuse standards stipulated by the State

(Table 2). The State legislation issued by KSPCB, is in accordance with the Water (Prevention and Control of Pollution) Rules, 1976 and the Environment (Protection) Rules, 1986.

Table 2. Properties that require STPs and consent forms

Area	Type and size	Requirement
BWSSB sewered areas	Residential apartments, built-up area > 20,000 m^2	Must have an on-site STP
	Residential apartments, built-up area < 20,000 m^2	Must obtain permission from and pay fees to the BWSSB for disposal into the sewer
Outside BWSSB area (unsewered)	Residential apartments, built-up area > 5,000 m^2	Must have an on-site STP
	Commercial establishments > 2,000 m^2	Must have an on-site STP

Source: Shankar and Yathish, 2012.

The KSPCB's rules are enforced and monitored through a system of applications for consent, which requires construction companies to apply for consent for establishment (CFE) prior to building a property, followed by a consent for operation (CFO) prior to commissioning the STP. The CFE must include plans and specifications for treatment and the CFO is used to check that the builders have implemented the STP as proposed. Consent must be obtained annually and STP owners must provide evidence that their STP is operating successfully and meeting the discharge standards (KSPCB, 2004). More recently, the KSPCB has released urban reuse norms, set from a human health perspective that apply to domestic sewage treatment, treated wastewater quality and wastewater discharge in new real-estate developments (Table 3). These make the reuse of treated water for non-potable purposes within apartments and commercial buildings mandatory and stipulate that there should be zero disposal (KSPCB Memorandum No.3080, Dated: 16.8.2012).

Table 3. Selected KSPCB urban reuse standards

Parameter	Previous standard	New urban reuse standard
pH	6.5-8.5	6.0 -9.0
BOD	< 20 mg/L	< 10 mg/L
Turbidity	Not specified	< 2 NTU
E. Coli	Not specified	NIL
Residual Chlorine	Not specified	> 1 PPM

Source: Kodavasal, 2011

Limitations to and benefits of these approaches

On-site reuse in practice

Violation of KSPCB's rules on treatment and reuse is evident all over the city according to Mr. A. Kodavasal (2013, pers. comm., 17 July) who identified several private STPs that were not built according to the specifications agreed in the CFE, which were incorrectly sized for the load or that had conspicuous bypass pipes. In his opinion, reasons for violation include inadequate technical expertise; stringent and unrealistic legal requirements; and the public's disinterest in WWT.

At present many private STPs are constructed by builders who have little or no knowledge of WWT but who build them to fulfil their legal responsibilities. In many cases the STP design/supply companies have no subsequent involvement with the plant, which is handed over to the RWA to manage. These RWAs are often disinterested in WWT and lack technical expertise. This means that they are unable to satisfactorily manage the STP themselves and may contract an STP operator. Often, they too lack the necessary

experience and skills. All this contributes to poor management, bad odours, inadequate treatment, STP failure and ultimately dissatisfaction with on-site treatment.

Another issue is that the legislation requires 100% on-site reuse but suitable use options are limited to applications that avoid direct human contact such as toilet flushing, gardening and car washing. These can only account for around 30-75% of the treated wastewater, making disposal inevitable (Shankar and Yathish, 2012; Kodavasal, 2011b). Furthermore, the water quality standards stipulated are rigorous and perhaps too strict for certain parameters, making the treatment more difficult and costly. All these factors can contribute to negative public perceptions of on-site treatment and use.

Despite these difficulties there is evidence that perceptions may be changing due to residents observing the benefits of an additional water source and savings in water bills, which can be significant. Apartments within the city pay around three times more than other domestic properties, with the lowest rate being 19 INR/KL. However most (98%) of apartments in the city do not have BWSSB connections and rely on tankers, paying anything from 75 to 100 INR/KL (BWSSB, 2012; Nayya, 2012; Special Correspondent; 2013). Once the financial benefit of reusing water is observed residents are more willing to invest in good STP management and share their positive experiences with others. If STPs are operated effectively and dual plumbing systems are in place the payback period is only 3-8 years, based on average costs of 20 INR/KL for an activated sludge plant (the most commonly used in Bangalore) and dependent on size (Mr. A. Kodavasal, 2013, pers comm., 7 July).

Dedicated STP design and management companies are also gaining ground and picking up more contracts to build, rehabilitate and manage STPs on behalf of RWAs; and estate developers are recognizing the benefits and selling point of a well-functioning STP linked to a reuse system. The situation becomes self-perpetuating because as more people experience the benefits of a functioning STP and reuse system there is more demand for private STP companies.

Centralised treatment in practice

Like on-site WWT, centralized treatment and use is seeing some success but has not been take up to the extent planned. In the opinion of Dr. P.N. Ravindra, Executive Engineer, New Initiatives and Design Division (2013, pers. comm., 9 July), there is considerable scope for reuse due to water scarcity and demand but at present only a portion of the installed capacity is being sold. This is despite the apparent financial benefits of buying treated wastewater. The cost to industries of secondary treated water is 10 INR/KL if supplied by tanker or 15 INR/KL if supplied by pipe. Tertiary treated water costs 15 INR/KL and 25 INR/KL for tanker and piped water respectively. By comparison non-domestic tariffs for the supply of fresh water are 36-60 INR/KL depending on the quantity consumed, making the use of treated wastewater a financially interesting option (BWSSB, 2012).

However, a tanker supply, though less expensive, may be intermittent and inconvenient, while at present the piped network does not exist to reach many of the industries that may have a demand for treated wastewater. Furthermore, the current pricing requires these industries to construct their own pipelines to receive treated water, which depending on the distance to be covered, can be considerable. For such an investment, water quality, quantity and price must be acceptable and assured. Expanding the network of STPs would help to address this by reducing the distance from treated wastewater source to point of use. Many industries recycle on-site and see the financial benefits of this (C.D. Kumar, 2013, pers. comm. 18 July) which may reduce their interest in receiving external treated water supplies, except for consumptive industries and/or where water constraints are severe.

There are also constraints to expansion from BWSSB's side but it appears that financially it may be beneficial to provide customers with treated wastewater rather than importing freshwater from increasingly distant sources, such as the Cauvery. The cost to BWSSB of supplying treated river water is approximately 26-46 INR/KL (BWSSB unpublished figures) compared to 10-12 INR/KL for treatment of wastewater (Kumar, 2011; cited in CSE, 2006). The revenue derived by BWSSB from the sale of treated water is estimated to be around INR 5,000,000 per year (Dr. S. Vishwanath, 2013, pers. comm., 9 July).

Perhaps the main limitation for BWSSB is their dependence on central government and donor funds for capital costs. The laying of pipes to transport and deliver water to potential users also requires significant cross agency coordination, such as permissions to dig under roads or railway lines, and can prove to be very challenging (V.C. Kumar, 2013, pers. comm. 19 June).

Recommendations

To some extent necessity may provide the impetus for wastewater use - as water scarcity increases and demand cannot be met or supplies become more expensive, industries and domestic consumers will be more inclined to treat and reuse water. However, this process can be stimulated by improving the current reuse systems.

For BWSSB-supplied treated wastewater three critical factors must be addressed: price; infrastructure; and perceptions. The latter two are already being tackled. BWSSB has initiated a study into perceptions and behaviour change, and is engaging with the Temasek Foundation to aid in the public outreach and stakeholder acceptance aspects as well as capacity building for this within BWSSB. It is also planning to build an infrastructure "backbone" to the distribution system, especially in areas where STPs already exist but do not sell all their treated water (P.N. Ravindra, 2013, pers. comm. 19 July).

For on-site treatment to be more effective in domestic and commercial premises the KSPCB needs to consider addressing: the lack of technical expertise in the city; compliance and enforcement; aspects of the legislation; and public perceptions. The KSPCB representatives and private STP business owners interviewed all cited inadequate knowledge of STP design, construction and operation across the city as a problem. In partial response to this issue, the KSPCB has published some guidance on STP construction and management and it is likely that more will follow. A further recommendation from interviewees was that certified courses should be established in the STP sector, from design engineering through to training for plant operators. Training and certification could be facilitated by KSPCB and BWSSB; and the publications could draw on expertise within both organizations.

Compliance and enforcement will always be difficult issues, especially for poorly resourced government departments, but supporting a system of treatment and use that provides tangible, financial benefits to residents will facilitate self-regulation. Linked to this should be some re-consideration of the legislation, for example, allowing apartments to dispose of treated wastewater to open water bodies, share it with neighbouring properties or even provide it back to the water supply system. These options may require financial and infrastructure support from local government or the BWSSB but could benefit the city overall. Currently such practices are prohibited despite the fact that the reuse standards are more stringent than those given for disposal of wastewater to open water bodies in the Environment (Protection) Rules, 1986 (Shankar and Yathish, 2012). Any review of options should retain public health as a core concern. If these factors are addressed the STP users will perceive the benefits and become ambassadors for effective STP operation, as has been the case with the RWAs interviewed for this project.

Finally, some of the interviewees raised the concern that BWSSB prefers large centralized treatment, constructed and managed by them or other large companies and is not favourable towards small decentralized STPs being established by a large numbers of small players. If this is the case, this attitude is understandable given their remit to provide water and sewerage to the citizens of Bangalore but it may be counterproductive in the long run. Acknowledging and supporting smaller players could play an important part in overall water management for the city (Mr. Thippeswamy, 2013, pers. comm., 10 June) with limited drain on BWSSB resources. Furthermore, as BWSSB extends its area of coverage into areas currently served by a number of on-site STPs it would make sense to factor this existing treatment into the plan.

Summary

The former Chairman of the KSPCB, A.S. Sadashivaiah believes that an inescapable imperative of towns and cities in India is to conserve water, treat wastewater, renovate, recycle and reuse (Kodavasal, 2011) and the BWSSB clearly supports wastewater use through its New Initiatives Division. Both organizations have been proactive in introducing and supporting WWT and use in their own way and in line with their mandates, making Bangalore something of a showcase city for wastewater use in South Asia. However, more could be done to spread RRR and for it to reach its full potential, benefitting the maximum number of people and the environment. BWSSB needs to acknowledge the benefits of on-site treatment and private sector involvement, and factor this into their planning, especially in relation to sewage network extension. KSPCB needs to consider their regulations and the implications for users, as well as their own ability to regulate. Both agencies could benefit from improving public perceptions of reuse and engaging the community more widely around a treatment and use agenda.

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Note/s

[1] Industrial wastewater treatment and use is also taking place and industries are required by law to treat effluent on-site, but for a number of reasons, including health and safety, this research focuses on domestic wastewater.

[2] Domestic rates start at 6 INR/KL for 1,000 L and rise to 36 INR/KL over 100,000 L (BWSSB, 2012).

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