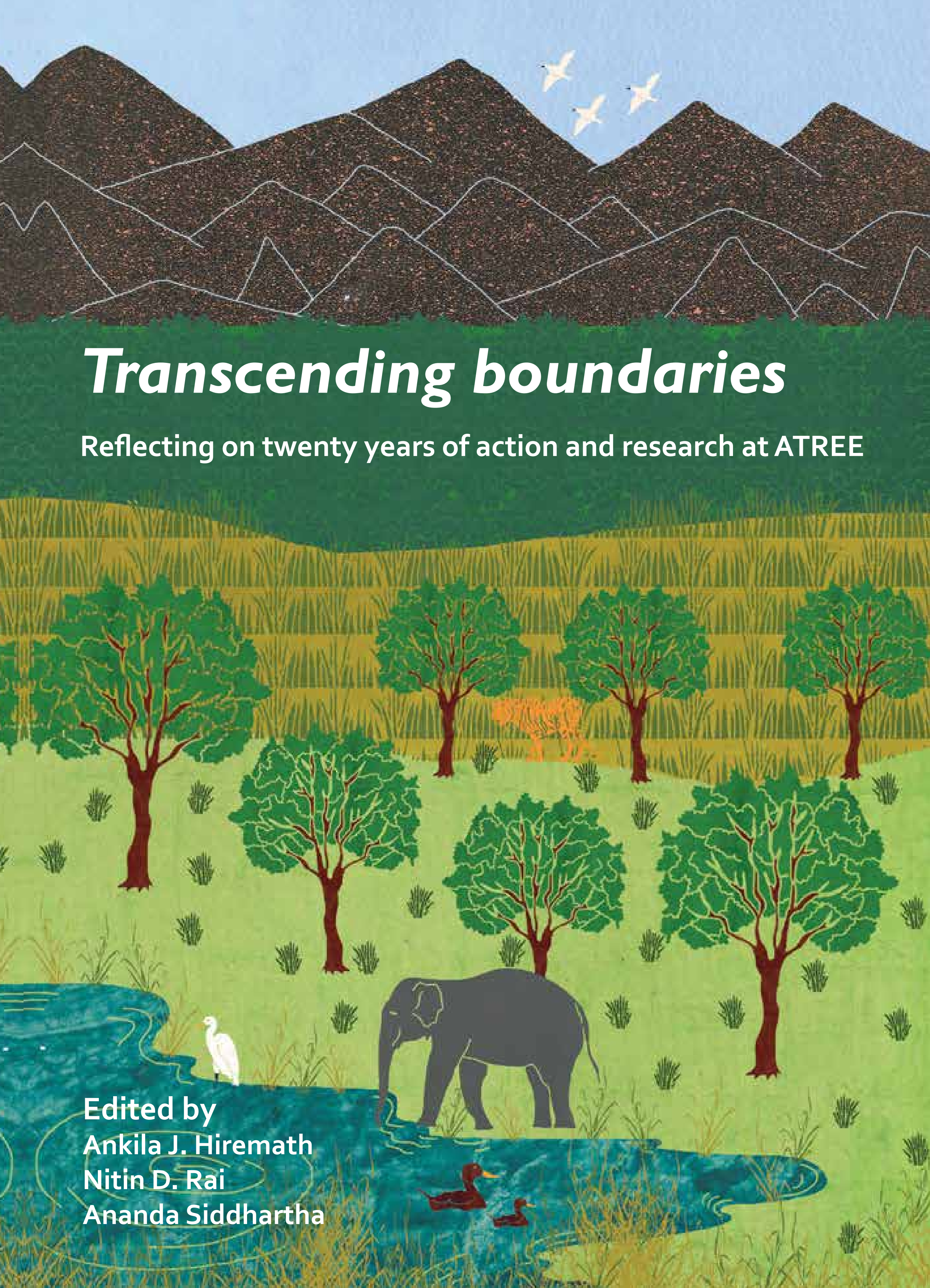

Transcending boundaries

Reflecting on twenty years of action and research at ATREE

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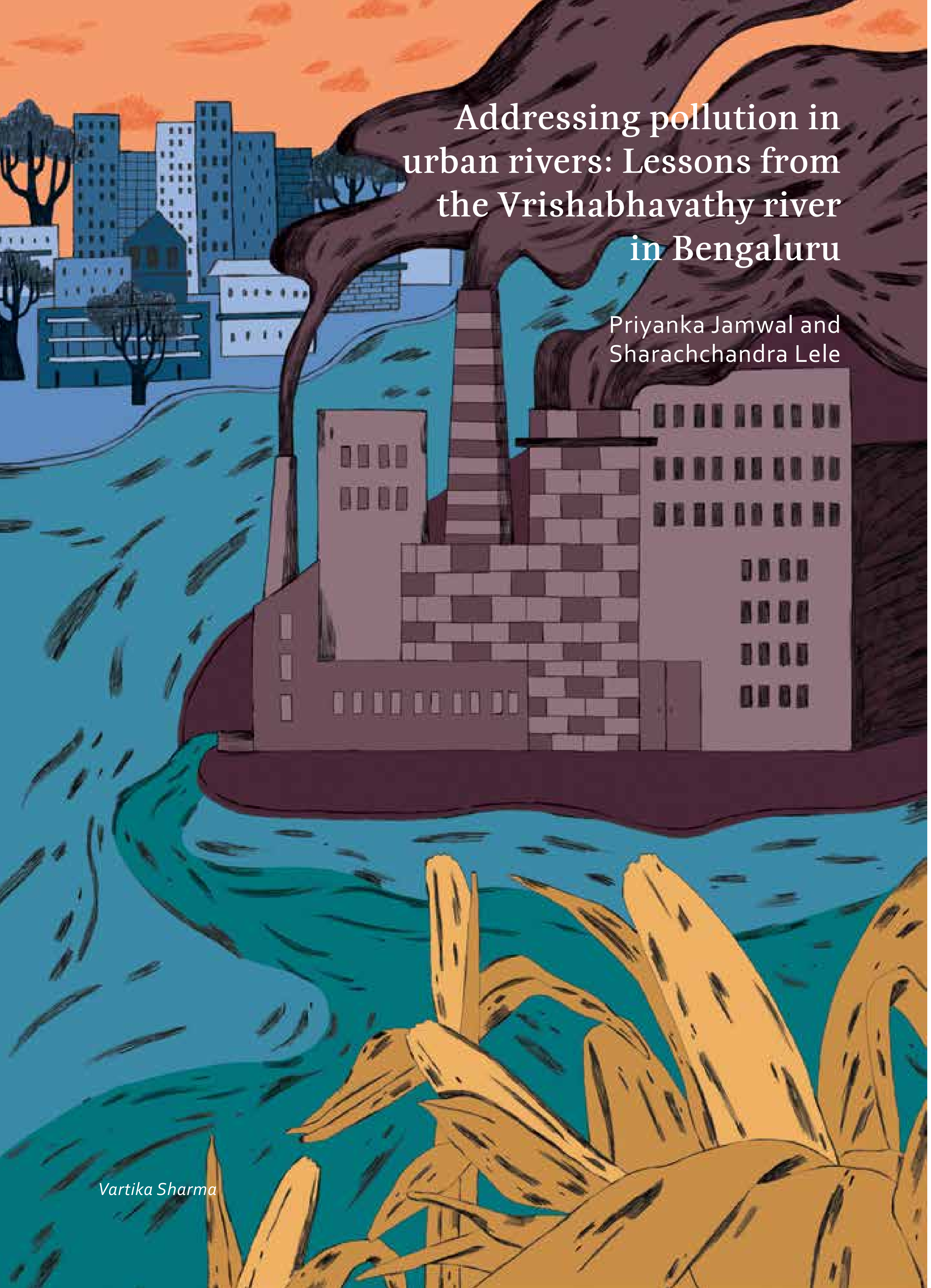
Contents

2 Ecosystems in transition

3 Perspectives on conservation and development

Addressing pollution in urban rivers: Lessons from the Vrishabhavathy river in Bengaluru

Priyanka Jamwal and Sharachchandra Lele



INTRODUCTION

The sight of black, foaming, and stinking rivers is a familiar sight in urban India. We hear about the pollution of the Ganga and Yamuna rivers. Some may have also heard about certain (in)famous cases such as the Palar river in Tamil Nadu (polluted by tanneries), or the Tungabhadra river in Karnataka (polluted by a pulp and rayon factory), which are celebrated in the environmental literature for the social movements they sparked. The Central Pollution Control Board reported, in 2015, that 67% of the river stretches in its monitoring network are polluted.

Why is river pollution so ubiquitous in India? More than 35% of India's 1.25 billion people live in urban areas. In the absence of infrastructure to treat wastewater, these urban centres let out untreated effluents into nearby rivers and lakes. Moreover, with industrialisation going hand-in-hand with urbanisation, and with the domestic use of industrial and chemical products increasing dramatically, pollution is no longer just biological in nature (i.e., sewage), but contains a variety of chemicals, including heavy metals.

The consequences of river pollution depend upon how this water is utilised downstream. In many cases, farmers downstream of an urban centre use the polluted water for irrigation. If the water contains industrial effluents, it can damage the crops, or the heavy metals can accumulate surreptitiously in the food chain, leading to serious health consequences for consumers. There is, of course, an elaborate legal framework and apparatus for regulating surface water pollution in the country. The pertinent question then is, why are Indian rivers and their users facing such high levels of exposure to contaminants?

In this chapter, we summarise the findings of 4 years of research by ATREE on the Vrishabhavathy river, which originates in the city of Bengaluru. We then use this to illustrate the multiple dimensions of river water pollution and its associated problems in an urbanising context.

THE STATE OF THE VRISHABHAVATHY AND ITS CONSEQUENCES

The Vrishabhavathy river originates in Bengaluru and flows south–southwest for ~50 km before joining the Arkavathy river (Figure 1). The city of Bengaluru, about a third of which is located within the Vrishabhavathy catchment, is one of the fastest growing cities in India. The city has grown from a population of 4.2 million in 2001 to nearly 10 million today. About two-thirds of the water used in the city today, i.e., about 1350 million litres per day (MLD), is drawn from the Cauvery river 100 km away, with the rest coming from local groundwater pumping. This generates an estimated 1400 MLD of wastewater, a third of which then drains into the Vrishabhavathy.

An irrigation reservoir that was constructed across the Vrishabhavathy in 1943, at Byramangala village (about 15 km downstream of where the city ends today), has today become a receptacle for this wastewater, which is then used to irrigate almost 2000 ha of agricultural land. Continuous inflows of wastewater into the reservoir have led to anaerobic conditions that spread a foul stench over the surrounding villages. The water in the reservoir is black in colour and large amounts of froth form at both the inlet and the outlet of the reservoir.

In our study, conducted between 2013 and 2015, water samples were collected monthly at three sites located in the Peenya catchment—Chowdeshwari (CHO), Sumanahalli (SUM), and Bangalore University campus (VRH)—for a period of 1 year. In addition, soil, irrigation water, groundwater, and milk samples were also collected monthly from three villages downstream—Chikkakuttenahalli (CKT), Bannigiri (BNG), and M Goppahalli

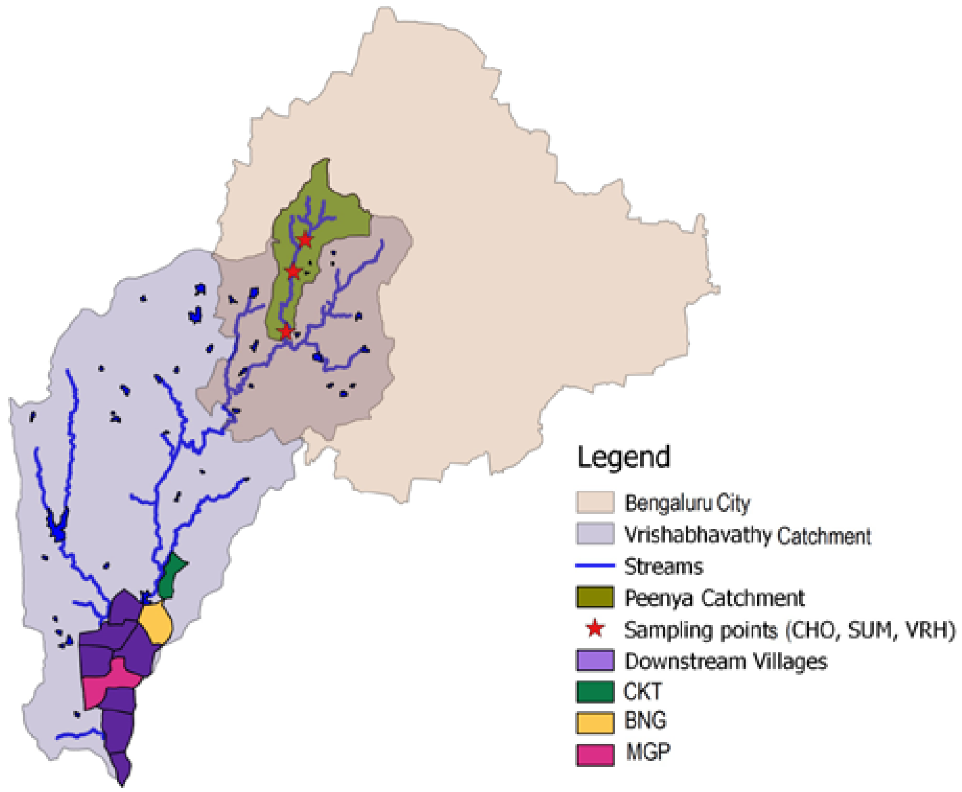


Figure 1: Vrishabhavathy river's urban catchment, and the area irrigated by the Byramangala reservoir. Upstream sampling locations were Chowdeshwari (CHO), Sumanahalli (SUM), and Bangalore University (VRH); sampled villages downstream were Chikkakuntanahalli (CKT), Bannigiri (BNG), M Gopalahalli (MGP).

(MGP)—for a period of one year (Figure 1). The samples were brought back to ATREE's soil and water quality lab to test for biological and chemical contamination. Because the water is used for irrigation, the observed water quality was compared with standards for irrigation water.

Our assessment of the water quality in the urban river stretch, the Byramangala reservoir, the irrigation channels, and groundwater in the command area points to serious biological and chemical contamination. This poses grave health risks to the farmers who grow, and the urban consumers who consume, the agricultural produce[1].

BIOLOGICAL AND CHEMICAL QUALITY

Biological contamination is often measured using levels of faecal coliforms in the water. Fecal coliform (FC) are a group of gram negative bacteria that indicate the presence of pathogens (disease-causing organisms) in water. According to the World Health Organisation (WHO) guidelines, the level of FC should be less than 10^3 most probable number (MPN)/100 ml if wastewater is reused for irrigation. In our study, FC levels at the upstream and downstream locations in the Vrishabhavathy river were found to be 10^8 MPN/100 ml and 10^5 MPN/100 ml respectively, i.e., 100,000 and 100 times greater, respectively, than guidelines set by WHO. Thus, although the level of FC decreases as the water flows downstream, it is still much higher than the standards set by WHO for safe irrigation practices.

The chemical quality of water in the Vrishabhavathy river, both at the upstream and the downstream ends of the catchment, is very poor. The upstream stretch of the river has high levels of non-biodegradable chemicals, as well heavy metals exceeding the industrial effluent discharge standards. As the river flows, because of dilution, sedimentation, and other instream processes, the levels of heavy metals in the water reduce. But even after this reduction the levels, observed in the water at the point of use for irrigation at the three study villages, are higher than the guidelines set by the UN Food and Agricultural Organisation (FAO), especially for manganese and nickel (Figure 2).

The use of heavy-metal laden wastewater for irrigation eventually results in the bioaccumulation of these metals in soil, dairy products, and vegetables. Significant heavy metal concentrations were found in the fodder, milk, and vegetables that are produced in these villages.

HEALTH RISK

Exposure to biological contaminants can lead to various gastrointestinal and skin infections, and chronic exposure to heavy metals can cause neurological and developmental disorders in children, and can increase the risk of cancer in adults. We identified the multiple pathways through which these contaminants create public health risks, and found them to broadly fall in two categories (Figure 3). The farmers, who come into contact with irrigation water, and also consume some of the agricultural produce and the local drinking water, are at risk of disease from the pathogens and skin infections from the heavy metals in the irrigation

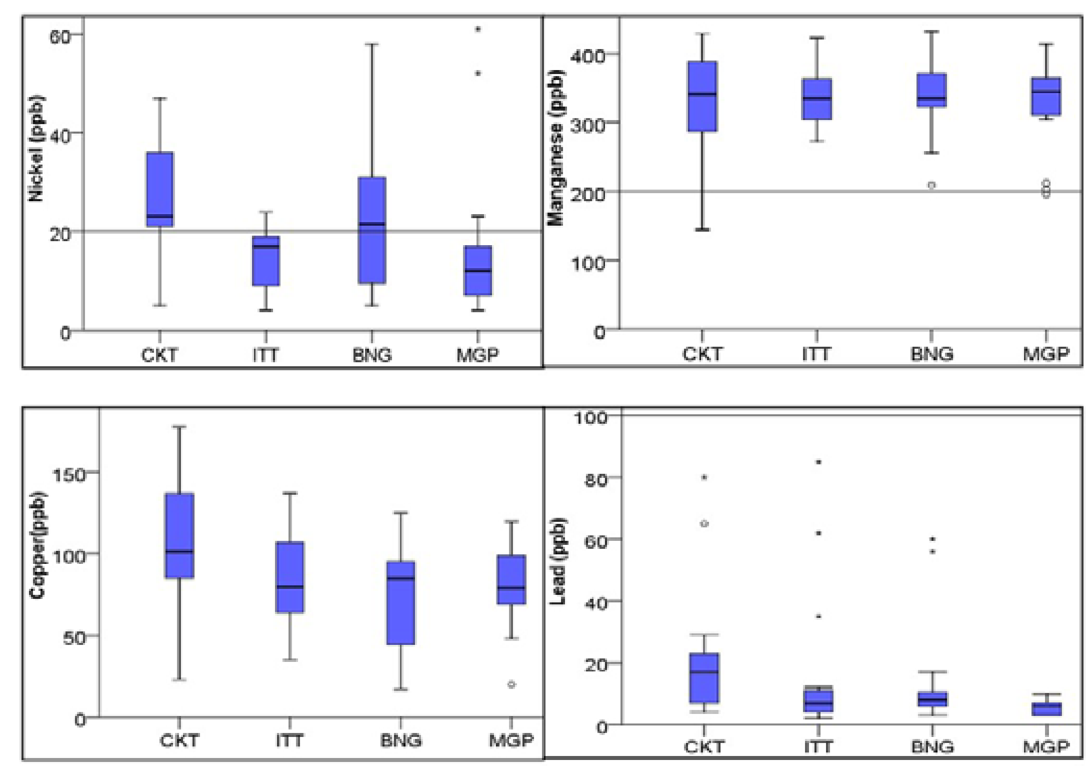


Figure 2. Heavy metals levels in irrigation water at Byranmangla tank (ITT) and three villages (CKT, BNG and MGP) located in its command area (ppm=parts per million). Horizontal lines indicate permissible levels (as per FAO guidelines).

[1] Jamwal, P., PR Urs., and D. Nayak. *Urbanisation and its impact on peri-urban areas: a case study of Bengaluru city* (unpublished manuscript)

water. Urban consumers (mostly in Bengaluru) face risks from the heavy metals in the milk and vegetables, although the extent of risk is hard to assess, given complexities of produce movement and food habits among these consumers. Farmers in the villages around, and downstream of, the Byramangala reservoir of course know from sight, smell, and skin irritation, that their water is polluted, and our study further communicated the less-visible risks, such as heavy metals. Yet the farmers face a conundrum. While the health risks are undoubtedly there, this wastewater is also their economic lifeline. As Bengaluru grew, it increased the water drawn from the Cauvery, and its increased effluents have made the Vrishabhavathy river perennial, enabling year-round irrigated cultivation in the Byramangala region at no cost—a luxury in an otherwise dry region that is experiencing declining groundwater levels. Moreover, these wastewater flows are rich in nutrients like nitrogen and phosphorous, which further benefit agriculture. Thus, it is unlikely that the farmers will cease using this wastewater on their own. Pollution mitigation must happen upstream.

REASONS: LACUNAE IN MONITORING, REGULATION AND GOVERNANCE

So why is there so much biological and chemical pollution in the Vrishabhavathy? Why do current laws and enforcement mechanisms not work? To begin with, it is important to understand that the two forms of pollution—biological and chemical—have somewhat different sources. Biological contamination comes from sewage being added, without treatment, to the river from all parts of Bengaluru. Heavy metals, on the other hand, emerge from certain kinds of industries that are not found in all parts of Bengaluru. We traced the source of heavy metals to the Peenya sub-catchment, which overlaps with Peenya Industrial Area, the largest industrial zone in Bengaluru, and one that houses several potentially polluting industries such as electroplaters, alloy and metal works, battery refurbishers, and so on.

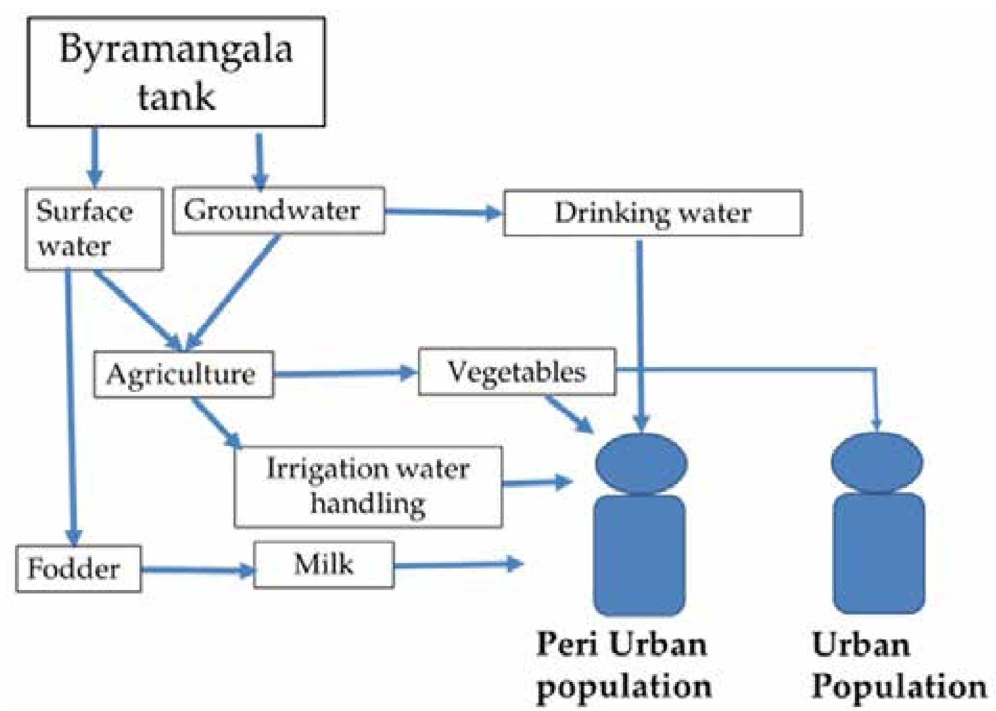


Figure 3: Multiple pathways of toxic heavy metal exposure experienced by peri-urban and urban populations. Risk to the peri-urban population is much higher than the urban population as the former is exposed to multiple contaminants via multiple pathways.

Corresponding to these two forms of pollution (i.e., biological and chemical), and their sources, we investigated the efforts of the Bangalore Water Supply and Sewerage Board (BWSSB) towards treatment of sewage in the whole catchment. We also investigated the level of compliance of industries in the Peenya catchment with effluent disposal norms, and the Karnataka State Pollution Control Board's (KSPCB) efforts to monitor pollution and enforce the law vis-à-vis both the BWSSB and the industries. We also looked at whether the legal framework itself is adequate. The findings were quite revealing.

Sewage mismanagement

BWSSB is a para-statal agency set up to provide water supply and sewerage facilities to the city of Bengaluru. However, full treatment of sewage has not been much of a priority for them for a long time, and that reflects their 'out of sight, out of mind' approach towards handling of sewage. When coupled with the incredible pace at which Bengaluru has grown in the past 2 decades, the result is a huge gap between installed sewage treatment capacity (721 MLD) and Bengaluru's need (~1400 MLD).

We also found that the existing treatment plants function far below installed capacity; moreover, they have to draw diluted and chemically contaminated water from the river to make up for the shortfall in raw domestic sewage coming from their underground pipes because of the incomplete, broken, and clogged pipe network. The mixing of river water also leads to malfunctioning of the treatment plants, resulting in 'treated' effluents that do not at all meet discharge standards set by the law[2]. While BWSSB is building more sewage treatment plants, it remains to be seen whether they will address the bottleneck of an inadequate underground network, or rethink their approach to locating and determining the size of plants. Equally, KSPCB's monitoring of these plants seems faulty—even while our tests showed the effluent quality to be below standard, KSPCB's monitoring suggests the quality is acceptable.

[2] Jamwal, P., TM. Zuhail, PR. Urs, V. Srinivasan, and S. Lele. 2015. Contribution of sewage treatment to pollution abatement of urban streams. *Current Science* 108(4): 677–685.

Sampling at VRH	Levels	Mn (mg/l)	Cu (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)
One-time grab sample (KSPCB)	Max	-	0.08	BDL	0.05	0.07
	Min	-	0.00	BDL	0.01	0.06
Hourly composite sample (ATREE)	Max	0.85	0.80	0.50	0.12	0.20
	Min	0.24	0.01	0.01	0.01	0.00

Table 1. Comparison of the levels of heavy metals, manganese (Mn), copper (Cu), chromium (Cr), nickel (Ni), and lead (Pb) detected in samples collected monthly by KSPCB, and those collected hourly by ATREE's water and soil laboratory. (BDL denotes 'below detectable limits'). All samples were collected at Bangalore University campus (VRH). Units are milligrams of heavy metal per litre of water.

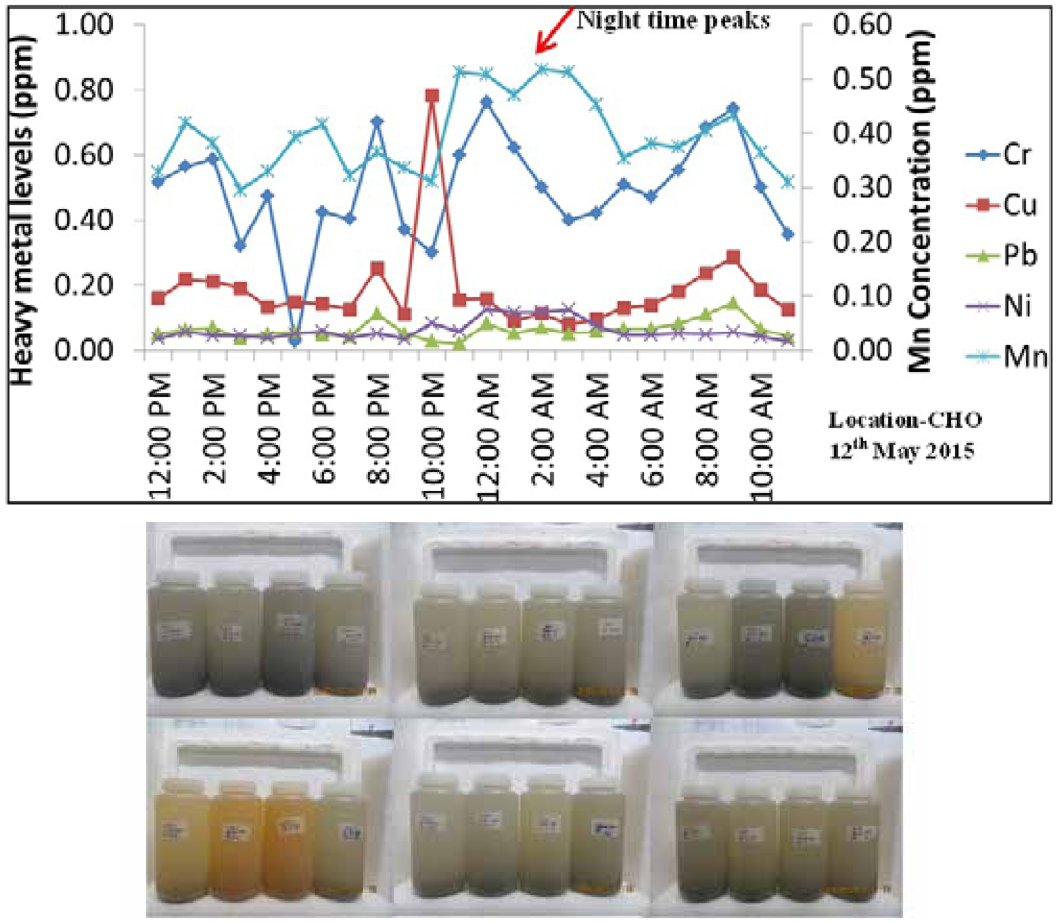


Figure 4. Variations in concentrations of chromium (Cr), copper (Cu), lead (Pb), nickel (Ni), and manganese (Mn) in the Peenya stream at Chowdeshwari Nagar (CHO) over a 24-hour period (ppm is equivalent to milligrams per litre). Concentrations peak at night/early morning (see distinctly different colour of these samples; bottles at bottom left).

Poor enforcement of industrial emission norms

KSPCB's main focus has been on regulating water pollution by industries. To fulfil this mandate, KSPCB uses two main instruments: providing consent for establishment and operation of upcoming/existing industries, and inspecting and enforcing effluent discharge standards on the effluents from industries in operation. In a growing economy, the first function (consent) itself demands a lot of time. As a result, 70–90% of a KSPCB environmental officer's time is spent processing consents—mostly paperwork—rather than on monitoring, inspecting, and taking action against polluters. And KSPCB has not augmented its staff strength to put greater efforts into inspection and enforcement, although it has the financial resources to do so. Moreover, KSPCB has not been very successful at prosecuting polluters. While the slowness of the Indian judicial system is certainly part of the problem (the median time for case disposal being 7 years), KSPCB lost two-thirds of the cases that did get disposed, indicating lacunaea in their prosecution as well[3].

[3] Lele, S., N. Heble, BK. Thomas, and P. Jamwal. 2015. *Regulation and compliance in industrial water pollution: the case of the Vrishabhavathy river, Bangalore.* Bengaluru: Ashoka Trust for Research in Ecology and the Environment.

Inadequate outcome monitoring

If the goal of imposing discharge standards on industries and public sewerage agencies is to make sure that rivers and lakes do not get polluted, then it seems obvious that one would also monitor whether this goal is being ultimately met. Unfortunately, such 'outcome' monitoring by KSPCB began very late and only after pressure from the courts. While biological contamination is visible and also easy to monitor (domestic effluents are discharged continuously), the strategy for monitoring industrial contaminants in the river, initiated by KSPCB in response to court pressure, was found to be seriously inadequate.

KSPCB officials collect one-time 'grab' samples from the river once a month. Our team intensively monitored the Peenya industrial area sub-catchment for 1 year, collecting hourly samples over a 24-hour period, once every month, at three locations on the Peenya stream. Our results show high and legally unacceptable levels of heavy metals in the stream, whereas KSPCB data show lower levels (Table 1). The reason for this mismatch becomes clear from the graph and photograph in Figure 4. The major effluent discharges seem to be happening at night, and in large quantities, but that is not the time when KSPCB collects samples. Clearly, a more thorough and comprehensive monitoring system is needed.

Governance issues

The problem of pollution in the Vrishabhavathy river has been known for a long time, and the limitations faced by KSPCB—inadequacy of staff and poor prosecution—have also been known to the Board, itself, for a while. The lacunae in their monitoring strategies are also fairly obvious. But the agency has been slow in responding to these shortcomings. Our study suggests that this is a symptom of a deeper problem, that of governance structure.

The governing board of KSPCB consists of representatives from various state departments, non-official members nominated by the government to represent agriculture, fisheries, and industries, representatives from urban bodies, and heads of para-state bodies, such as BWSSB, that are responsible for sewerage. Given that these top-level bureaucrats keep changing, and the sewerage boards are actually potential polluters, the governing board has neither stability nor balance. There is no representation for the potential pollutees—the people who will suffer from the pollution. Nor is there any space for independent experts. Moreover, the Member-Secretary of KSPCB, who is effectively the CEO, is an officer of the Indian Forest Service on deputation for a few years. This is the norm in most Pollution Control Boards in India. If the governing board is to hold the CEO of any agency accountable, then the CEO must be a professional hired by the governing board, not someone with a permanent job elsewhere. Thus, at both the governing board and the CEO level, a major restructuring of the way Pollution Control Boards are governed is required[4].

Legal framework

Our research also indicated that there are gaps in the legal framework that defines water quality and effluent discharge standards[5]. The Environmental Protection Act of 1986, and rules formulated under it (which subsume the older Water Act, 1974) lay down standards used for regulating water pollution in India. These include a set of standards for the quality of water at the point of discharge

[4] Lele, S. and N. Heble. 2016. *Changes in pollution board undermine accountability. Bengaluru*: Deccan Herald. June 16: 11.

[5] Jamwal, P., S. Lele, and M. Menon. 2016. Rethinking water quality standards in the context of urban rivers. In: *Urbanization and the Environment: Eighth Biennial Conference of the Indian Society for Ecological Economics.* Organised by IISc, ATREE and NIAS. Bengaluru. January 4–6, 2016.

from an industry, and a set of standards for the quality of water in surface water bodies, when the water is used for various purposes. Most of the focus in the rules, has been on the former, and so we have 39 parameters, including 14 heavy metals, being specified for when industries discharge (treated) water to surface water bodies. But if treated industrial effluents are used directly for, say, irrigation, then only 10 parameters are regulated, including only one heavy metal, i.e., arsenic.

Even more surprising is the fact that there are no water quality standards in the law for inland water uses other than bathing. So if industries discharge effluents into a river, and then downstream farmers use this water for irrigation, which is now increasingly the case across the country, there are no standards specified for quality of water used for irrigation. All that exists is water quality 'criteria' announced by the Central Pollution Control Board for various uses including drinking, bathing, fisheries and irrigation. Unfortunately, they do not contain any standards for heavy metals other than boron (which is a metalloid), or for any other chemicals. Nor are these standards legally enforceable—farmers cannot demand that the Pollution Control Board ensure the water they receive into their irrigation reservoirs meets irrigation quality criteria.

It is almost as if the law was framed on the assumption that rivers that supply water for these uses have either pristine or rural catchments, where one needs to worry only about biological contamination. Given the fact that most rivers in India today carry both industrial and domestic untreated wastewater, it becomes important to revise these standards substantially, to legally notify them, and to put in place a statutory process for determining (through public participation) what should be the designated use of a particular water body; there should then be a legal requirement that Pollution Control Boards bring that water body to the standard appropriate for that use, within a fixed time frame.

LOOKING AHEAD

It is clear that we need a paradigm shift in the manner in which surface water pollution is regulated and managed in our country. First, at the outset, we need to recognise that the days of primarily rural catchments are behind us, and that industrial and other chemicals (now increasingly used in homes) are present in all catchments. Therefore, our regulatory framework must set standards for what are permissible concentrations of these chemicals.

Second, urban use of water is largely non-consumptive and year-round. Thus, urbanisation often increases local flows, and may make previously seasonal streams and rivers perennial. Downstream communities are therefore increasingly interested in using these flows

for irrigation and fisheries. At the same time, upstream communities (e.g., urban residents) want to use water bodies, such as lakes and rivers, for recreation, environmental amenities, or storage/recharge functions. In all cases, pollution, especially chemical pollution, will pose a serious risk to these users, or to those who consume the products of agriculture or fishing. Therefore, the need of the hour is to set standards for all such uses and designate what use a water body is to be put to, so as to identify the goals of regulation.

Third, more rigorous, innovative, transparent, and participatory approaches to monitoring the status of these water bodies will have to be coupled with equally rigorous and transparent monitoring of individual polluters. Fourth, the states must also pin the responsibility of domestic sewage treatment on the municipalities or para-state bodies that deal with water supply. At the same time, these agencies will have to re-think water treatment, not as a cost but as a benefit, as it can generate substantial water for reuse in increasingly water-scarce regions. A beginning has been made in this direction with the promotion of apartment-level treatment and reuse[6], but much more can, and needs to, be done. Finally, for all this to happen, the restructuring of the Pollution Control Boards is required to make them more accountable. Pollution is too important an issue to be left to the Pollution Control Boards alone.

Further Reading

Amerasinghe, P., RM. Bhardwaj, C. Scott, K. Jella, and F. Marshall. 2013. Urban wastewater and agricultural reuse challenges in India. Research Report. Hyderabad: International Water Management Institute (IWMI).

[6] Kuttuwa, P., S. Lele, and GV. Mendez. *Decentralized wastewater systems in Bengaluru, India: success or failure?* Water Economics and Policy (in press).