Co-creating solutions for Mumbai's water challenges

A Creator Space™ White Paper

BASF
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Acknowledgements

The following water experts have given many valuable comments and inputs to BASF's Creator Space™ program on water in Mumbai in January 2015 or this White Paper:

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Dr. Sneha Palnitkar, All India Institute of Local Self Government

Please find a list of all participants of the BASF Creator Space™ Water Summit at the end of this document.

Purpose

Over the past 18 months, BASF has worked with numerous experts in Mumbai to explore challenges and co-develop solutions that can improve access to safe, affordable water in Metro Mumbai through changes in technology, policy and behavior. This effort culminated in a two-day water summit, which took place in January 2015 as part of BASF's co-creation program, Creator Space™.

This paper is an interim report. It summarizes our findings on Mumbai's water challenges and outlines a potential path forward to improve the city's ability to give its citizens access to safe, affordable water. The white paper will be used as the basis for further discussion and planning by BASF locally and globally together with existing but also new cooperation partners and stakeholders. One of the most important among these will be public authorities responsible for water supply. One key goal is to agree on the roles and contributions of all stakeholders to best support improving Mumbai's water supply.

As a diversified chemical company, BASF provides dozens of products that are used for water infrastructure, treatment, purification, as well as storage and recharging. However, getting these and other available technologies to work for citizens requires the contribution of multiple stakeholder groups to help scope the challenges and design solutions. Before, during and after the Creator Space™ Mumbai water summit, BASF co-created with the Municipal Corporation of Greater Mumbai (MCGM), the Tata Institute of Social Sciences (TISS), the National Environmental Engineering Institute (NEERI), Save the Children, Suez Environnement and many other organizations. The platform created is our offer to co-create and develop concrete actionable plans that can be followed up on by all contributors.

The recommendations outlined in this white paper point to an urgent need to develop models involving industry, government and civil society. These may be for profit or non-profit. Such models can enable economic, environmental and social progress in the area of water supply and thus help Mumbai maintain and expand its attractiveness as a place to live and work. They can also give ideas to other companies for potential corporate citizenship projects under the new mandatory investment requirements under the Companies Act in India.

In the 150th year of its existence in 2015, BASF chose to celebrate by connecting people and ideas around the globe. This co-creation program called Creator Space™ aims to address challenges of urban living, energy and food with existing and new partners. The global Creator Space™ tour takes over creative locations in six cities Mumbai, Shanghai, New York City, São Paulo, Barcelona and Ludwigshafen. At each tour stop, Creator Space™ connects industry experts, scientists, representatives from government, NGOs and society as well as artists to co-create solutions for a locally relevant challenge. The Creator Space™ white paper series consolidates the findings of each tour stop as a basis for continued collaboration. At Creator Space™ Mumbai in January 2015 the participants worked on the question: "How can we improve access to safe, affordable water through change in technology, policy and behaviour?"

Mumbai's water challenges

1

Some of the challenges for Mumbai's water supply are unique to this rapidly growing metropolitan area, others are typical for many large Indian cities and to some extent for emerging-market megacities worldwide.

1. Mumbai's water challenges

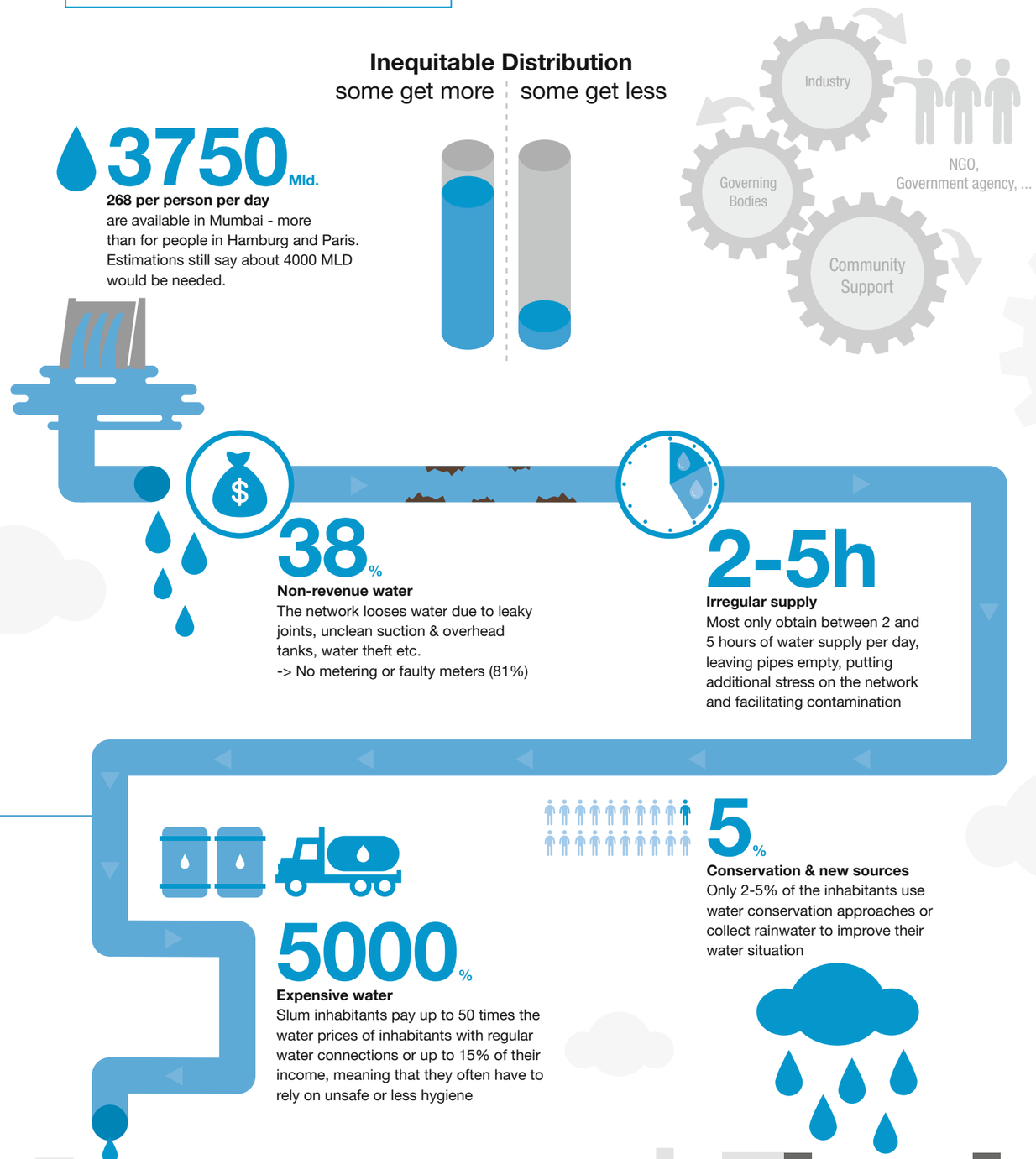
Some of the challenges for Mumbai's water supply are unique to this rapidly growing metropolitan area, others are typical for many large Indian cities and to some extent for emerging-market megacities worldwide. Faced with an exploding population, especially in slum areas, the city's water infrastructure is unable to provide all citizens access to safe water. Currently, unequal distribution rather than inadequate quantity is the main problem. However, there are indications that quenching Mumbai's growing thirst for water is having serious knock-on effects on neighbouring rural, farming communities and the environment.

Developing a collaborative roadmap

Although many technologies are available to address problems and various roadmaps for improvement have been developed, the challenges still remain. To achieve the same standards as many other megacities worldwide, the long-term goal needs to be to ensure 24/7 water supply for all citizens of Greater Mumbai supported by an equitable and transparent consumption and pricing policy as well as engagement of all stakeholders. The contributors to this white paper are convinced that a roadmap can only succeed if it looks at technology, policy and behaviour in equal measure.
Pragmatism is needed to bring short- and mid-term gains. Such short-term measures may include creating intermediate and local water storage and distribution systems as well as purification systems that are run by local communities or non-profits. Other promising medium-term measures include introducing technologies and incentives to reduce the consumption of potable water, recycling sewage and recharging the underground water table.

Drivers of change for a better water supply in Mumbai

Water distribution challenges 1



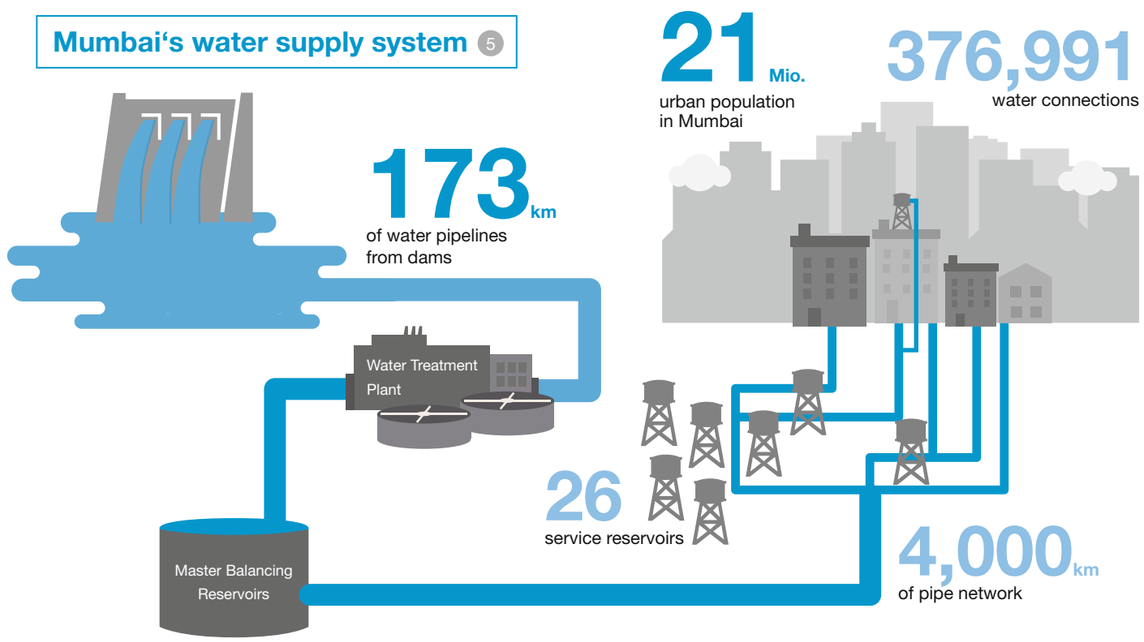
Tangled water grid From lake to tap

Mumbai's water service provider is the "Municipal Corporation of Greater Mumbai" (MCGM, former BMC), providing **376,991** connections [2] to Mumbai's roughly **21** million residents. [3] Mumbai gets its water supply almost exclusively from lakes created by manmade dams across rivers and valleys at locations as far as 173 km away. Two 'State of the Art' water treatment plants produce drinking quality water from this lake water. The treated water is then stored in Master Balancing Reservoirs and is further distributed to **26** service reservoirs spread through the city by a complex network of inlet mains, which remain charged for 24 hours. [2]

Almost all of Mumbai's water quality problems stem from the next distribution steps: From these service reservoirs, water is supplied to consumers through a pipe network in different water supply zones for varying amounts of time, usually two to six hours a day depending upon the area, consumption, season, topography and other factors.

A 24/7 water supply is only available in a few areas. Some areas face difficult terrain, many structures and whole areas are not legalized and are therefore not connected to the central water supply system. A 2011 study found that 95% of the households in slum areas in Mumbai's Kaula Bunder district use less than the WHO-recommended minimum of 50 litres per capita per day in some seasons. [4]

Mumbai's water supply system [5]



Ground water usage

Besides water supply from the grid, ground water exploitation is reported in Mumbai for commercial as well as domestic usage and declining ground water level trends have been recorded. Private users bore wells, mostly with the permission of MCGM. Especially borewells in coastal and low lying areas are affected by saline water intrusion.

The ripple effect

"I would like to have more time to do what I like, such as sewing"

Like most inhabitants, Aisha, an unemployed 28 year old housewife living in Thane, Naupada has to get up between 4am and 6am every day to open the water tap and collect water in several steel pots and cans. In the early afternoon between 2pm and 3pm she collects additional water for the evening use. Time lost due to waiting for and gathering water keeps women from working or tending to their families and decreases India's productivity overall.

Mumbai's informal water sector

Already today, in Mumbai about 10,000 private tankers and about 30 MCGM water tankers are a necessary addition to the central distribution system. However, this water distribution system is almost exclusively in the hands of informal distributors who provide slum households and many illegal buildings in middle and upper class neighbourhoods with water at rates which are 30 to 50 times more expensive than the standard municipal charge of Indian rupees 4.32 to 17.28 per 1000 litres, depending on consumption. This is the price for water in residential areas, in slums it is Indian rupees 3.49. [6] Water sold via the fleet of private tankers and ten thousands of illegal pipe connections represents a yearly turnover of billions of Rupees. In some areas, the informal water sector has a monopoly on the sale of water. Also, the water tankers source their water from unknown sources and their handling of water can lead to water contaminants being introduced, even if the source was clean. On the other hand, in some places people have found ways to get superior water quality by building their own informal local distribution network, thus eliminating contaminants and the problem of low pipe pressure. The project group learned this from interviews with inhabitants of the Dharavi slum who tap into fire hydrants.

Water losses and their financial effects

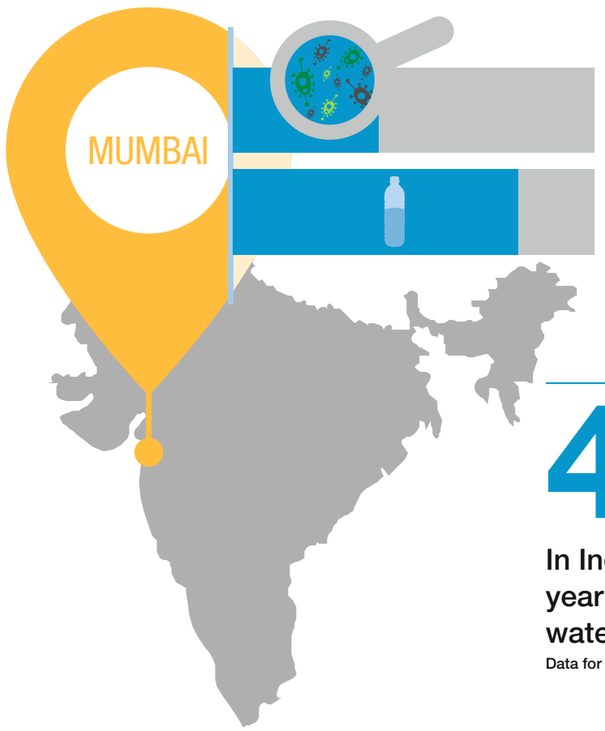
Water pilferage together with leaking joints and fittings due to ageing and corroded pipes are the underlying causes of water losses and result in the irregular water supply. All these factors together with inadequate and faulty meter readings or sabotaged meters lead to non-revenue water losses of 38% of the overall water supply. These losses seriously impact MCGM's available budget, limiting its ability to improve its network fast and efficiently.

Fear of water shortages

"We don't know if water comes next time"

Nand Kumar and his wife Vaishnavi live with their three children in a small two-storied apartment in Mumbai´s C Ward. Every day, Vaishnavi stores up to 1000 liters of water, of which 500 liters is stored in a loft tank and the rest in numerous steel buckets (refilled twice a day) or in plastic bottles lying on the floor. In a household of five people living in 200 sq feet, water storage takes up a lot of space.

Water quality challenges [7]



42% ...up to 42% of water samples taken from taps across Mumbai showed bacterial contamination.

76% ...up to 76% of the water stored in slum households is contaminated with coliform bacteria

400,000

In India, almost 400,000 children die every year of diarrhoea, with contaminated water being one of the causes.

Data for Mumbai not publicly available.

Water quality on grid

There are several points at which water treated with the most modern technology can become contaminated before it comes out of the tap: old, leaking pipes that run next to sewage pipes and are only under pressure part of the day; water vendors who create illegal entry points in the fire brigade/ municipal pipes from which water is extracted; other workers who damage water pipes while maintaining electricity, telephone or other lines, introducing contamination.

According to the Environmental Status Report of Greater Mumbai 2012-13 [8], the contamination level of water supplied to the city in that period was between 14% and 42%, with contamination usually coming from bacteria. A very high level of water contamination was found in the areas between Marine Lines and Charni Road (C ward — 42%) followed by Goregaon (P-south — 31%), while a lower percent of contaminated samples were collected from Malad (P-north — 14%), followed by Ghatkopar (N-ward — 15%). In almost all civic wards across the city, water contamination rose in 2012-13 compared to the previous year. The average water contamination level was 20%.

The practice of storing water in all kinds of vessels, which is something slum dwellers often do, worsens the situation even more. A 2008 and a 2011 study conducted in the Kaula Bunder slum of Mumbai found 76% of the stored drinking water samples contaminated with dangerous coliform bacteria in all seasons. It also found that 59.2% of the households in that area do not use any method of water purification and that a fourth uses unreliable cloth filters to cleanse their water.[9]

Contaminated water is a major health risk, waterborne diseases, such as gastroenteritis, typhoid and hepatitis (A and E) are recorded in Mumbai city every year especially during monsoons. Small children are the most vulnerable. According to a joint study of WHO and UNICEF published in 2009, 386,600 children die in India every year of diarrhoea, with contaminated water being the main source of infection.[10]

Water wastage

The irregular water to hoarding: Most of Mumbai's citizens store more water than they consume and empty and refill their many household storage tanks whenever water is available.

Pricing

In India, there is a wide spread cultural notion of a human right to have water for free. This has led to low water prices, even when those prices are adjusted for local purchasing power. Mumbai's water prices are Indian rupees 4.32 to 17.28 per 1000 litres (depending on consumption) for residential areas excluding slums and Indian rupees 3.49 per 1000 litres for slum dwellers (as of June 16, 2015). In Europe, the average water price is Euros 3.25 per 1000 litres [11] which translates to almost Indian rupees 230 - about 50 times higher than Mumbai's water price.

Filter-it-yourself

"My daughter-in-law doesn't like the taste of boiled water, so we use filter with cloth"

The Bhanushali family, who lives in Mumbai Chembur Colony, has a strong taste sensitivity for water. As they did not like the taste of boiled water, they now filter it with a cloth. It is not uncommon to see families that compromise on quality parameters if the taste is good.

"The cloth is folded into four layers. It filters better than purifier which has only one layer"

Ongoing work

Still, centralized water supply remains the most relied upon source with the lowest costs for Mumbai's citizens. MCGM has launched the Water Distribution Improvement Program (WDIP). As part of this program, MCGM is working with Suez Environnement on medium and long-term recommendations to improve zoning, network mapping and modelling and leakage detection. It is also working to gain an accurate overview of the customers it serves and to place customer information in a database, to improve asset management, develop water solutions for slums and create a quality issue reporting system.

Water quality: a gap between perception and reality?

"98% of water is drinkable, but …"

The attitude of an engineer working for MCGM shows the lack of trust Mumbai residents have in MCGM. Although he claimed that 98% of water is drinkable, he admitted having a water purifier at home … just to be on the safe side!

A better water supply for Mumbai - now and in the future

2

Based on the research, collaborative ideation and field work conducted as part of the Creator Space™ program to date, a holistic approach has been developed and several measures have been identified with the potential to augment MCGM's plans to revamp the city's on-grid water infrastructure.

2. A better water supply – Now and in the future

Based on the research, collaborative ideation and field work conducted as part of the Creator Space™ program to date, a holistic approach has been developed and several measures have been identified with the potential to augment MCGM's plans to revamp the city's on-grid water infrastructure. To make quality water available 24/7, long term improvements such as replacing the pipe network or including areas without grid supply into the network should and are still being pursued. However, short- and medium term solutions can help to achieve accelerated improvements. In order to broaden the stakeholder base, the informal water sector should be included in this process.

Short-term solutions

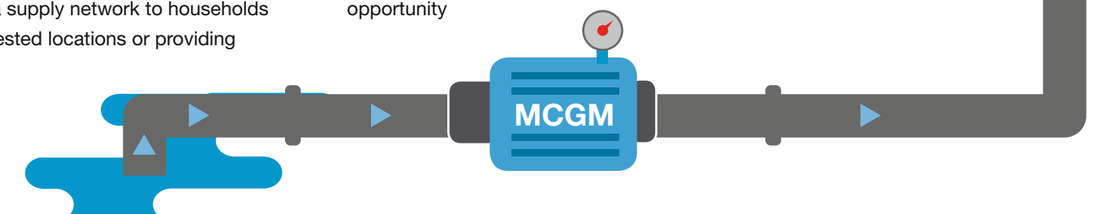
Community water storage and decentralized treatment facilities

Community water storage and decentralized treatment facilities for example in the form **of elevated service reservoirs or water towers** in combination with **on-site filtering** and water ATMs to ensure metered quality water output can be a part of a short term solution. Water **ATMs** are automated water dispensing units accessed with a smart card or app-based interface to ensure price consistency and proper accounting of amounts distributed.

Water towers can provide solutions for improving water supply in Mumbai where MCGM faces water supply challenges, such as providing water at sufficient pressure in hilly areas, establishing a supply network to households in congested locations or providing water to illegal structures. As a response to a Public Interest Litigation (PIL), the Mumbai High court directed MCGM to come up with a policy to provide water to the illegally erected slums in Mumbai. Most of the dwellings in the slums are located on terrain that is difficult to build on. Public elevated service reservoirs or water towers provide many advantages over existing public and private underground suction tanks, including:

- easy leakage identification and repair
- more economic energy usage for pumping
- less prone to contamination
- supports for water pressure distribution, especially in difficult terrain
- facilitated water metering and theft avoidance
- community engagement and social business cooperation opportunity

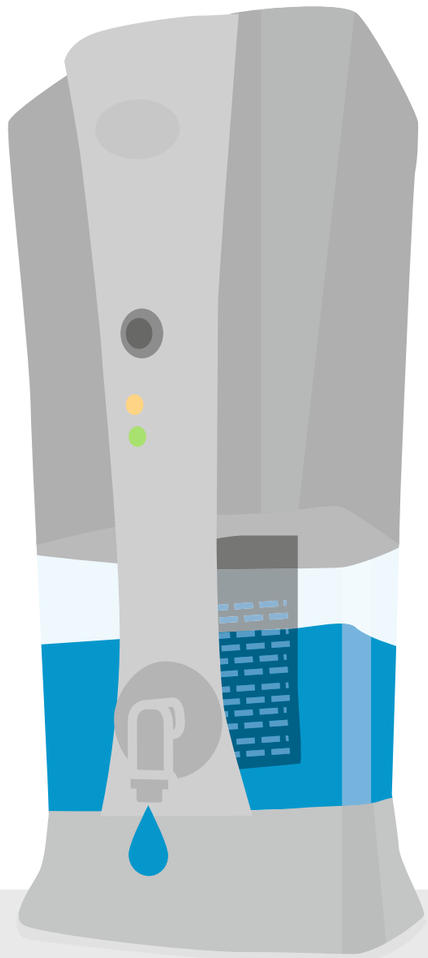
Elevated reservoirs can be constructed in municipal gardens or any other suitable locations on land owned by MCGM, or, in some cases on existing buildings. The model could be implemented with and without water ATM and treatment facility. To make sure that the structures are maintained, training and water usage education should be provided. Innovative tanks are another idea for providing short-term improvement of the water storage situation at the household level. In Mumbai, space is a premium, and using it for storing water due to the lack of a 24hours supply makes life difficult. Also, transport containers for water can be unsanitary and difficult to carry. Storage and water transport innovations, for example "squeeze tanks" that make use of even tight spaces could be beneficial.



Short-term solutions

Affordable water purification systems

While Mumbai's water treatment facilities provide drinking quality water, it can be contaminated in the distribution network for multiple reasons. To support households in consuming safe water, the widespread adoption of **affordable and reliable household or multi-household filter systems** would be the fastest, most effective way to address the public health issue of contaminated water and to save lives especially those of children, pregnant women and the elderly. Already today, most middle-class homes have water purifiers in place, and sometimes water treatment units are installed in schools, public and private establishments. The product line ranges from attachment to taps (simple filters), non-electricity based purifiers or purifiers working on electricity. The purification technologies used are filtration (cartridge filters, activated carbon filters), ultrafiltration, reverse osmosis and UV disinfection. Still, only 40% of Mumbai's population filters their water at all – and especially in the slums, water filters are the exception, making it a huge public health issue and an untapped market for affordable, electricity-free, easy-to-use filters requiring little and cheap maintenance.



Medium-term solutions

Recycling and recharging

Mumbai's water requirements cannot be met entirely with centralised water distribution. Any roadmap to improve access to safe water also needs to look at developing **decentralised water** sources at least for water that is not for drinking purposes. Therefore, the contributors to this white paper recommend the rapid improvement of alternate sources. Promising measures include introducing technologies to enable **reuse of grey water and sewage and rain water harvesting.**

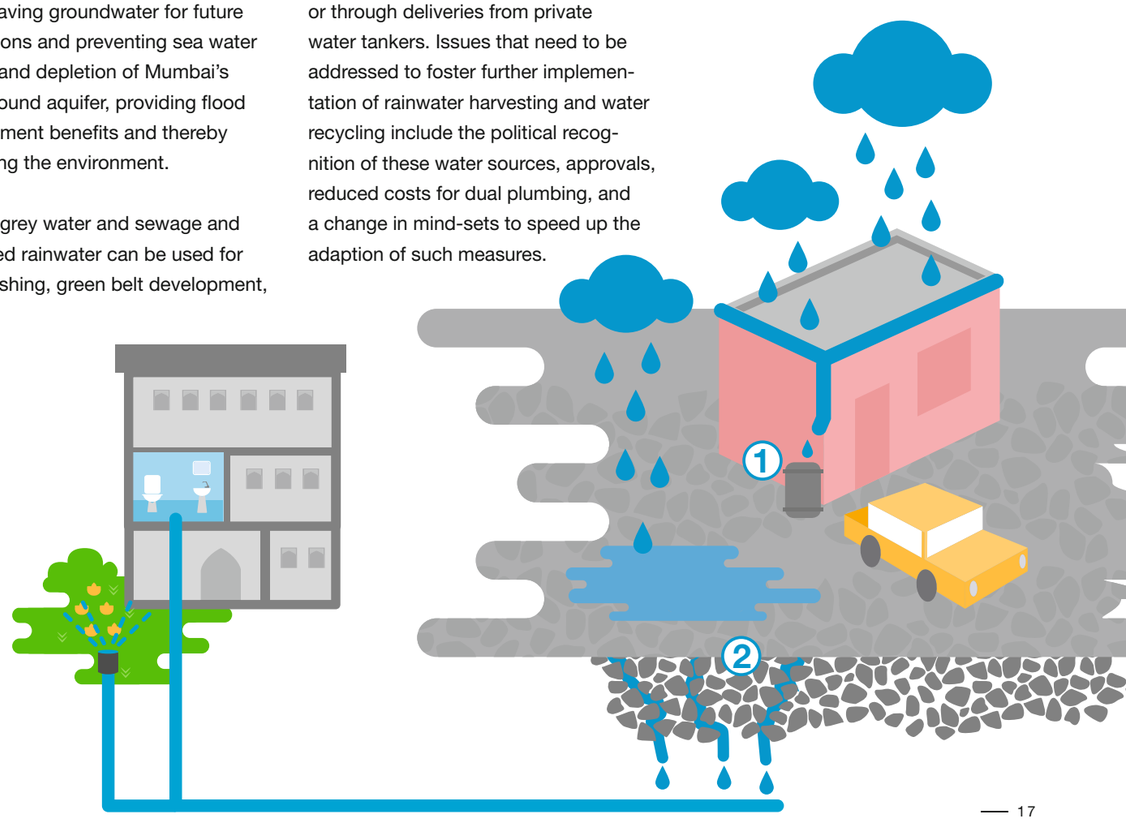
Cheaper and more sustainable than tanker supply, recycling sewage water and harvesting rainwater can create decentralized sources and have additional benefits such as saving drinking water, saving groundwater for future generations and preventing sea water ingress and depletion of Mumbai's underground aquifer, providing flood management benefits and thereby protecting the environment.

Treated grey water and sewage and harvested rainwater can be used for toilet flushing, green belt development, vehicle and clothing washing and for the construction industry. Additionally rainwater can be used for replenishing ground water.

Since 2002, regulations require newly built individual buildings to harvest rain water or recycle sewage for water flushing requirements, and plans are to introduce this requirement to existing buildings on more than 300m2 of land in the near future. Water recycling has been made compulsory for buildings with centralized water-cooled air conditioning plants. Under these regulations, MCGM limits the water supply to these buildings to 90 litres instead of 150 litres per capita per day. The balance is to be filled with recycled water or rainwater. Still, only some new buildings have installed efficient and effective means of water recycling. All others address the limited water supply by constructing bore wells within the premises or through deliveries from private water tankers. Issues that need to be addressed to foster further implementation of rainwater harvesting and water recycling include the political recognition of these water sources, approvals, reduced costs for dual plumbing, and a change in mind-sets to speed up the adaption of such measures.

Harversting rain water from concrete surfaces

In addition to traditional rooftop harvesting methods, rainwater can also be harvested from paved surfaces such as parking lots using pervious concrete. It is a special type of concrete with a high porosity that allows water from precipitation to pass directly through, thereby reducing the runoff from a site, allowing rainwater collection and groundwater recharge and reducing storm water flooding. Pervious concrete also reduces the heat island effect of concrete by absorbing less heat from solar radiation than other types of pavements. Pervious concrete can be used in parking areas, areas with light traffic, residential streets, pedestrian walkways, and in greenhouses.

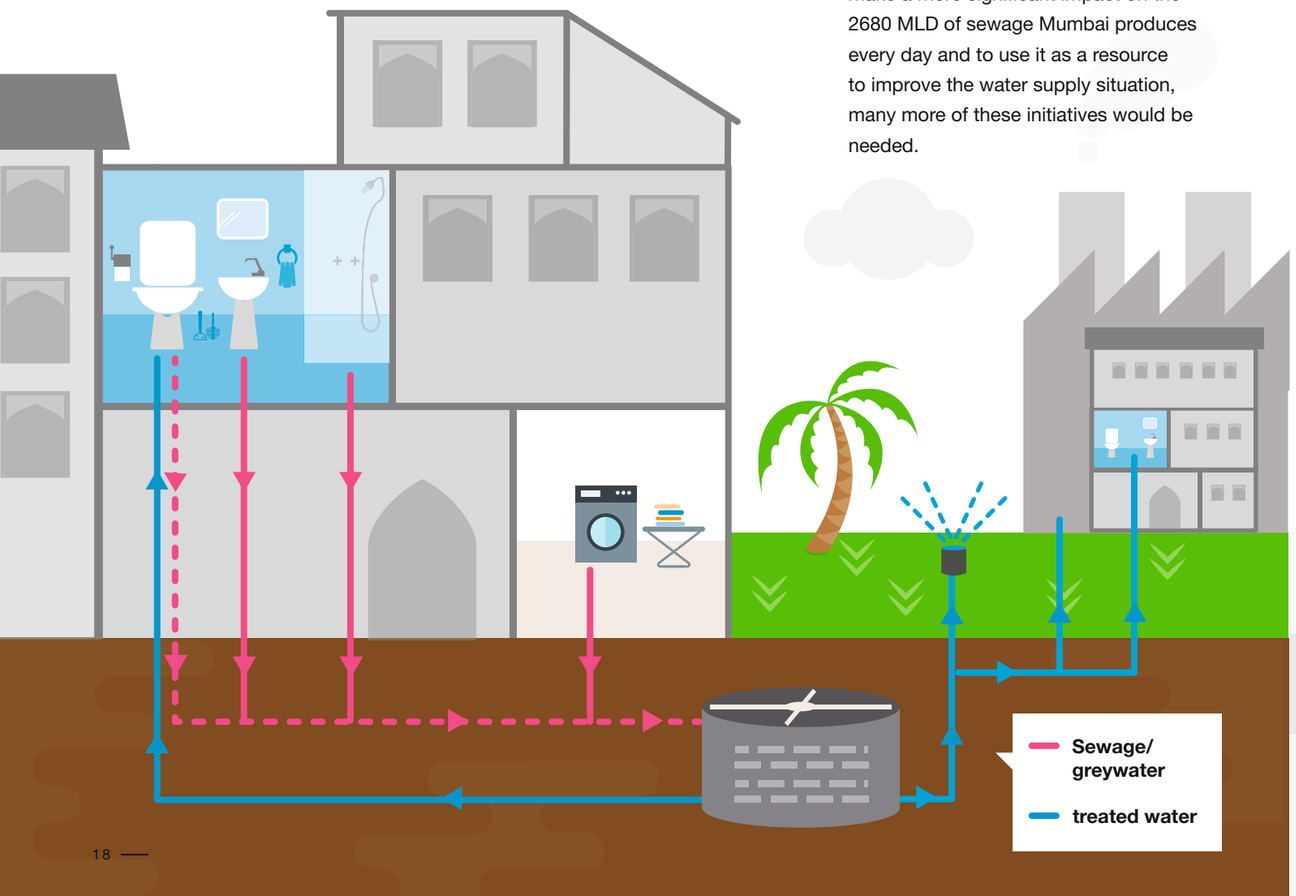


Medium-term solutions

Recycling sewage and grey water

As only a fraction of Mumbai's sewage is treated today, the sewage dumped into the ocean damages the ecosystems in the coastal areas, creeks and rivers. Yet treated sewage and grey water might represent a supply of water that is even cheaper than fresh water, especially compared to the prices of water for industrial usage. The construction industry, which is growing at 7-8% per year in India and requires large quantities of water, could be a big user of treated greywater and sewage. Today, the construction industry uses drinking water supplied by MCGM or ground water. Its official water costs are Indian rupees 43.20 per 1000 litres whereas sewage treatment costs are estimated at Indian rupees 5-6 per 1000 litres. Since the MCGM and ground water board's permission is required to use water, authorities could impose regulation that requires switching to treated greywater/sewage for such purposes.

Cities like Bangalore and Chennai already recycle city sewage for industrial purposes on a large scale and Mumbai has commissioned a plant featuring a sewage treatment capacity of 1.5 million litres per day (MLD) to supply water for the green belt of Raj Bhavan, Kamala Nehru Park, Priyadarshani park, State Ministers' garden and other nearby areas. Major companies such as Bharat Petroleum Corporation Limited (BPCL) and Rashtriya Chemicals and Fertilizers Limited (RCF) already treat city sewage and recycle for industrial use and are building a new 22.75 MLD sewage treatment plant. Hindustan Coca-Cola Beverages Pvt. Ltd (HCCBPL) has funded a 1 MLD sewage treatment plant at Mahim Causeway Pumping Station. Treated sewage water will be distributed by tankers for green belt development, cleaning of public places and other non-drinking and non-household purposes for which fresh water is currently being used. To make a more significant impact on the 2680 MLD of sewage Mumbai produces every day and to use it as a resource to improve the water supply situation, many more of these initiatives would be needed.



Testing the water quality at household level

Bacteriological contamination of drinking water is the biggest challenge for the citizens of Mumbai. Today, testing of the bacterial contamination of water is mostly done by experts in the laboratory. Testing methods are tedious and costly: To properly test bacteriological contamination, tests need between 8 and 16 hours. During this time, the water quality can already have changed again several times.
There are some testing kits available for use in the field, but they are not capable of providing a quick direct proof of the presence or absence of bacteria. They rely on the absence of residual chlorine as an indicator of the possibility of bacterial contamination. More affordable and quicker household-level **water testing kits** would provide additional consumer safety.

For on-grid supply, one suggestion is to have **water quality sensors** embedded in the pipeline that can activate the sending of an SMS if water becomes non-potable and cause the release food-grade colouring into the water to indicate contamination. This would help the municipality to take counter measures fast and consumers to protect themselves.

Eye & smell test first

"The quality of water has improved by 5% as per my visual inspection"

Water testing is subjective and not evidence based. Most families judge water based on smell and color. During the Monsoon season the perception of low-quality is higher because of some turbidity in the water.

Fostering public awareness

In addition to technology, measures to increase public awareness and thus to change behaviour are recommended. Despite the supply gap, India and Mumbai's population in particular waste a lot of water: **Public awareness campaigns** can prompt consumers to use water more efficiently and deploy water conservation mechanisms. An increase in **water prices** could fund such campaigns and help pay for planned infrastructure investments. Additional incentives could be the introduction of **water credits** resulting in tax benefits for reducing water usage or for recycling water. The existing MCGM water app or a **new smartphone application** could help with water-saving tips, leakage reporting with photos, provide SMS updates on water quality and availability or even suggest local plumbers or water guardians (see below) as solution providers.

A collaborative approach to implementation

Implementing improved water supply solutions can be facilitated by cooperation with the informal water sector and also new larger scale public private partnerships (PPPs). These solutions do not always bring the desired cost and production efficiency gains, also in India. Unsurprisingly, the privatization of water supply is meeting civil society skepticism and resistance. However, there are best-practice cases: In the Netherlands, water companies are incorporated as private companies, but the local and national governments own the majority of shares. This may provide the best of both worlds - public ownership with operation according to commercial business principles. The entire cost of services provided has to be recovered from the users, but all profits are invested in improving the water supply system and all accounts are open to public scrutiny. In Malé in the Republic of the Maldives, Phnom Penh in Cambodia and Bangkok, Thailand, public ownership is at about 70% with 30% private involvement. What determines consumption in these areas is a relatively high tariff and strict metering, billing, and collection. **Public-private partnerships** should be evaluated for Mumbai – as medium or long-term solution, depending on the scale.
Social business models for water supply, treatment and storage should also be considered. Already in place in other parts of India and the world are water purification installations with bottling units or water stations. Together with Sarvajal which has implemented such a solution in Delhi, Water ATMs could be a success in Mumbai as well. Naandi community water services have also implemented a promising village body and community cooperation to provide reasonably priced decentralized drinking water. The above mentioned models of public-private partnerships and partial privatization of the water supply are encouraging and show that citizens, even in low-income countries, have obtained improvements in water quality and accessibility without huge increases in water tariffs thanks to efficiency gains.
Many citizens of Mumbai perceive the improvement of the water situation to be the sole responsibility of the service provider. There is limited awareness and interest with respect to important water related topics, such as water conservation and sewage recycling practices, the actual cost of water supply, subsidies and pricing, appropriate storage and water quality. Next to establishing Water ATMs and improving the supply with decentralized treatment, we suggest to establish local "Water Guardians" who can fix pipes, advise and sell the cheapest and best water storage and treatment solutions, create awareness for water conservation and promote the attitude of treating water as a precious resource.

Various organizations are actively already working in Mumbai today in areas to reduce malnutrition, improve education, health and sanitation, and in the area of women's empowerment. Since these organisations are already working at the grass root level, they could become partners in developing outreach programs to promote behavioural change.

The Tata Institute of Social Sciences (TISS) will deploy 1500 students and faculty as part of the five year program 'Transforming M-East ward' to improve living conditions by creating a holistic, result-oriented, and inclusive urban development model. Other possible partners are NGOs like the Green Health Foundation (GHF), Apanalaya along with Save the Children (STC) in Shivaji Nagar (M/E ward) and the Society for Nutrition, Education and Health Action (SNEHA).

Training local specialists who are developing social business models can be a promising investment which will not only create jobs and new business opportunities but will make the local population more "water-resilient" in terms of better water quality and equitable supply. This can be the important step towards making Mumbai a truly urban megacity on par with other cities in the world.

Annotations

1 Sources of the data represented in the infographic “water distribution challenges”

- Percentage of inhabitants using water conservation or rain water harvesting: MCGM expert
- Amount of water supplied to Mumbai:
http://mcgm.gov.in/irj/go/km/docs/documents/MCGM%20Department%20List/Hydrallic%20Engineer/RTI%20Manuals/Deputy%20Hydraulic%20Engineer(Operation)/RTI_Hydraulic%20Engineer_05_E01.pdf
- All other data:
http://mcgm.gov.in/irj/go/km/docs/documents/MCGM%20Department%20List/Chief%20Engineer%20%28Development%20Plan%29/Preparatory%20Studies%20Report/PREPARATORY%20STUDIES_PART_2_B.pdf

2 http://mcgm.gov.in/irj/go/km/docs/documents/MCGM%20Department%20List/Chief%20Engineer%20%28Development%20Plan%29/Preparatory%20Studies%20Report/PREPARATORY%20STUDIES_PART_2_B.pdf

3 http://www.un.org/en/development/desa/publications/2014-revision-world-urbanization-prospects.html

4 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3599692/

5 Sources of data represented in the infographic “Mumbai’s water supply system”:

- Population of Mumbai: http://www.un.org/en/development/desa/publications/2014-revision-world-urbanization-prospects.html
- All other data: http://mcgm.gov.in/irj/go/km/docs/documents/MCGM%20Department%20List/Chief%20Engineer%20%28Development%20Plan%29/Preparatory%20Studies%20Report/PREPARATORY%20STUDIES_PART_2_B.pdf

6 http://www.mcgm.gov.in/irj/go/km/docs/documents/MCGM%20Department%20List/Hydrallic%20Engineer/Docs/Water%20Charges%20Rules%20effective%20from%2001.04.2015_Marathi.pdf

7 Sources of the data represented in the infographic “water quality challenges”

- Share of water samples taken at the tap showing bacterial contamination http://www.dnaindia.com/mumbai/report-air-water-and-noise-pollution-is-steadily-going-up-says-environment-status-report-1996020
- Share of samples of stored water showing contamination with coli bacteria http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3599692/
- Number of children dying of diarrhoea in India http://www.unicef.org/media/files/Final_Diarrhoea_Report_October_2009_final.pdf

8 http://www.dnaindia.com/mumbai/report-air-water-and-noise-pollution-is-steadily-going-up-says-environment-status-report-1996020

9 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3599692/

10 http://www.unicef.org/media/files/Final_Diarrhoea_Report_October_2009_final.pdf

11 http://www.caee.utexas.edu/prof/mckinney/ce397/Topics/Water_Pricing/Water_Pricing(2012).pdf

The quotes in the call-outs are from inhabitants of various neighbourhoods of Mumbai. In February 2015 a joint team of BASF and Save the Children met families and shadowed them during the day, observing the how, when, where and why of behaviours related to water.

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