WATER SUSTAINABILITY OF CONDOMINIUMS IN SARJAPUR REGION OF BANGALORE

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Content

Objectives of the report

Given the expanding urbanization of the Sarjapur area of Bangalore and the mounting demand on the region's water supplies, the water sustainability of condominiums there is a key concern. Bangalore is experiencing increasing water scarcity as a result of excessive groundwater extraction and erratic rainfall, therefore residential developments like condominiums are essential to controlling water consumption. This study looks at the water supply across sources, water quality, consumption trends, water conservation approaches and water management strategies used by condominiums to support sustainable water use. It does this by conducting a systematic comparative analysis of a small number of condominiums and raising awareness of and utilizing best practices of the solutions adopted to help manage consumption more effectively while also lowering reliance on outside water sources and enhancing the overall sustainability of Bangalore's water ecosystem. The research also dives deep into the water supply chain of Springfield apartments in specific to get to the bottom of the challenges from source to disposal including the environment impact in terms of carbon footprint of the overall process. It also draws attention to the difficulties resident associations face and the necessity of community involvement in ensuring the region's long-term water security, including the interventions and mitigations. The four domain model—physical, operational, financial, and institutional—is taken into consideration in the analysis, which also addresses gaps in the four domains and descriptive and diagnostic analyses.

Introduction

Bangalore is the capital and largest city of the southern Indian state of Karnataka with a population of around 15 million and expands across 741 Km^2 (1), making it India's third most populous city and fourth most populous urban agglomeration. It is the most populous city and largest urban agglomeration in South India. Located on the Deccan Plateau, at a height of over 900 m (3,000 ft) above sea level, Bangalore has a pleasant climate throughout the year, with its parks and green spaces earning it the reputation of India's "Garden City". Its elevation is the highest of India's major cities.

Bangalore is considered to be one of the fastest-growing global major metropolises(2). Recent estimates of the metro economy of its urban area has ranked Bangalore as one of the most productive metro areas of India (3). The city is considered the pivot for high-technology-based heavy manufacturing industry, with numerous large multinational technology corporations setting up their headquarters there. Bangalore is known as the "Silicon Valley of India" because it is the nation's leading software exporter as well as a major semiconductor hub (4). Several state-owned aerospace and defence organisations are in the city.

Bangalore draws water mainly through 2 primary sources, namely: The Cauvery River from which it extracts 1460 million litres per day (MLD) that is pumped 90 Km at an elevation of 350 m to reach Bangalore city and Groundwater, from which Bangalore extracts 700 MLD, almost close to 40% of the water supply (5).

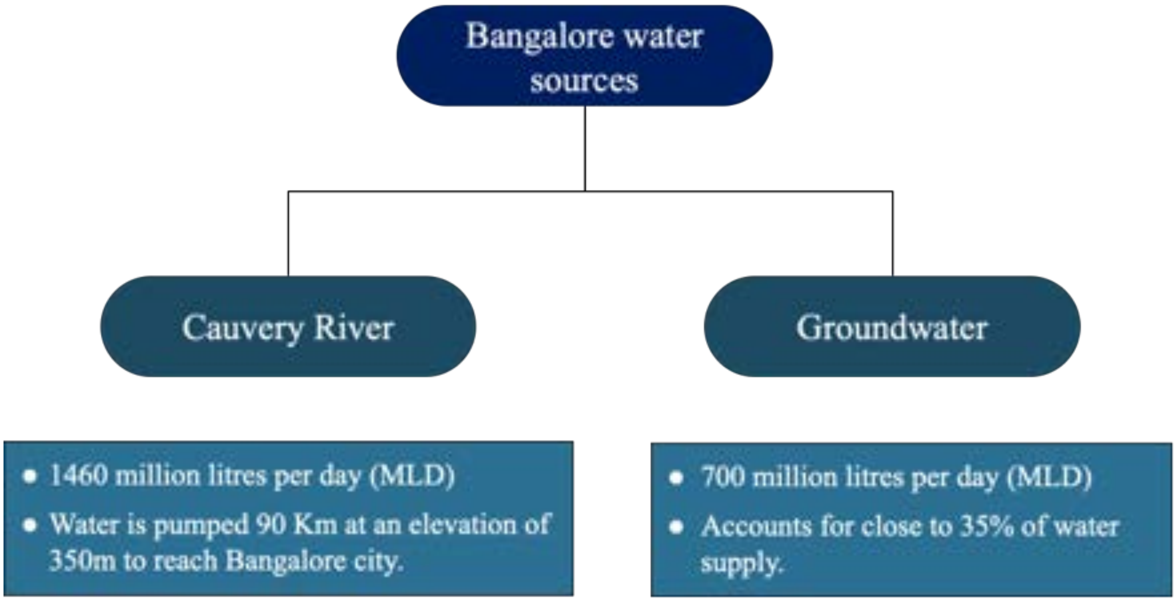


Figure: Water sources in Bangalore

Bangalore Water Supply and Sewerage Board (BWSSB) is an autonomous body formed by the State legislature under Bangalore Water supply and Sewerage Board Act on 10-09-1964 for Water Supply & Sewage disposal. It is one of the first Water supply & Sanitation Utilities in India with jurisdiction of entire Bruhat Bengaluru Mahanagara Palike Area of 800 km^2 (6). The water supply in Bangalore can be categorized into: public and private. Public water supply, managed by BWSSB, is supplied through an existing pipeline network, mainly catering to older areas of Bangalore. Private water supply, from privately owned borewells is distributed through tankers, and is supplied to outskirt areas of Bangalore where the pipeline network does not exist.

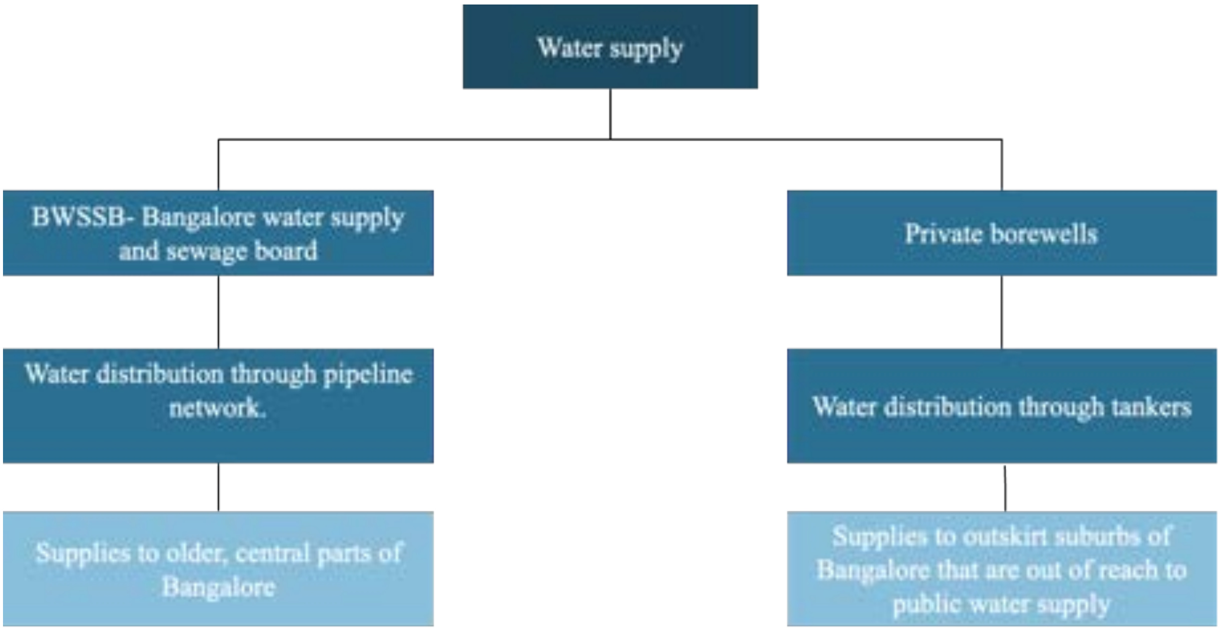


Figure: Water distribution in Bangalore

During the last two decades the city of Bangalore has been experiencing unprecedented growth in the field of Industrial, Commercial and Institutional sectors. This phenomenal growth has resulted in unplanned urban activities surrounding Bangalore and increase in population and construction activities. This fast growth in population is posing tremendous pressure on infrastructure especially on water supply and underground drainage systems. During the last two decades the city of Bangalore has been experiencing unprecedented growth in the field of Industrial, Commercial and Institutional sectors. This phenomenal growth has resulted in unplanned urban activities surrounding Bangalore and increase in population and construction activities. This fast growth in population is posing tremendous pressure on infrastructure especially on water supply and underground drainage system.

Population and Water supply requirements

Year	Population (Mn)	Water demand (MLD)	Water supply (MLD)	Water shortfall (MLD)
2021	10.6	2100	1450	650
2031	14.3	2900	2070	1450
2041	17.1	3400	2070	1950
2051	20.6	4100	2070	2650

Source: BWSSB

2050 Vision Document

- The availability of dependable resources
- Sustainable Water Quality & Quantity
- Effective Wastewater collection, transmission & treatment for safe disposal
- Water reuse for multipurpose usages with different modes and strategies

Figure: There is a plan to address the gap in water demand supply (7)

Bangalore comprises of 3 major valley systems, and 2 minor valley systems. Namely: Koramangala-Challaghatta valley (K-C valley), Vrishabhavati valley (V- valley) and Hebbal valley. The Rajakaluves or stormwater drains were built with the purpose of preventing rainwater flooding in areas. The surface runover would flow several kilometers through the Rajakaluves into lakes. The lakes in Bangalore are part of a cascading system, to help water flow from higher to lower elevations.

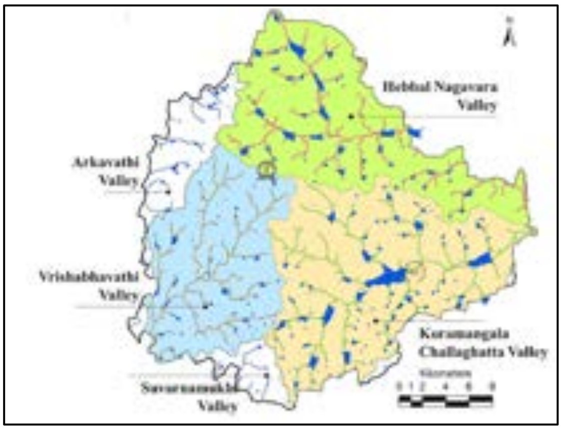
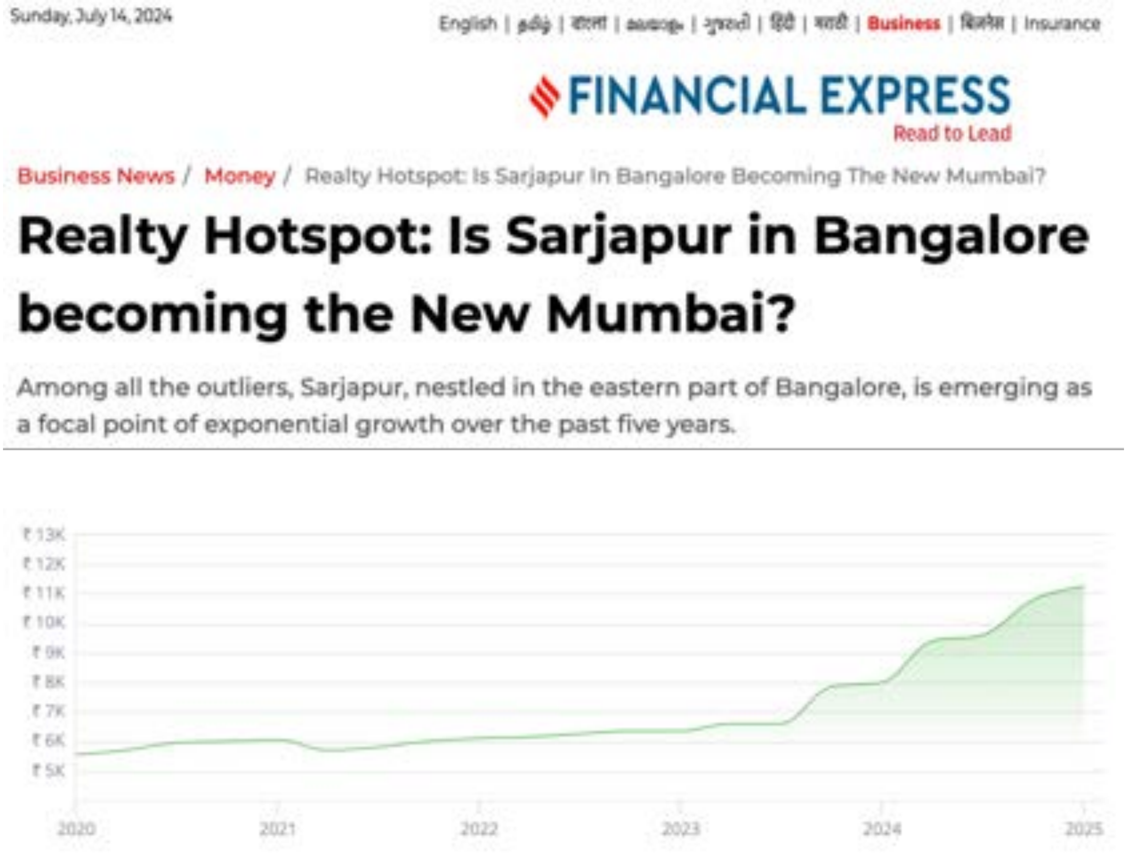


Fig. 4.2: Various lake series joining Bellandur and Varthur lakes

Figure: Adjoining lake ecosystem (8)

This research specifically aims to explore the Sarjapur region in Bangalore. This is a fast-developing part of Bangalore with good connectivity to the major IT areas such as Whitefield, Koramangala, HSR Layout, Marathahalli, Electronic City and the Outer Ring Road (ORR). Buyers considering various aspects when purchasing a property, such as its proximity to workplace locations, accessibility to schools and colleges, proximity to medical facilities, and convenient access to shopping and entertainment options.


Sunday, July 14, 2024

FINANCIAL EXPRESS
Read to Lead

Business News / Money / Realty Hotspot: Is Sarjapur In Bangalore Becoming The New Mumbai?

Realty Hotspot: Is Sarjapur in Bangalore becoming the New Mumbai?

Among all the outliers, Sarjapur, nestled in the eastern part of Bangalore, is emerging as a focal point of exponential growth over the past five years.

Figure: Real estate price escalation in Sarjapur Road due to demand surge (9)

While one part of Sarjapur is booming with apartments, much of the area is not provided with Cauvery water by BWSSB as it does not fall under its jurisdiction. As a result, there is full dependence on private tankers.

Springfield Apartments: A brief context

With this context the research focuses on a deep dive analysis on Springfields Apartments, one of the large and vibrant residential condominium. The Springfield apartment is a private gated residential layout that is representative of an increasingly common land-use pattern in growing cities like Bengaluru. It is 8-acre layout which has a total of about 550 apartments. The development of the Springfield apartment by the builder began around the year 2000 and the occupancy began by 2006.

Figure: Map showing Sarjapur locality with the yellow dot indicating Springfields

This research framework considered four domain model - Physical, Operational, Financial and Institutional and undertaken descriptive analysis, diagnostic analysis and gaps in four domains. The figure above depicts the numerous lakes in this locality, now consists of majority lakes dumped with untreated sewage and industrial effluents. An example of this, is the Bellandur lake, which has experienced foaming and frothing due to toxins. Springfields Apartment houses ~2200 residents and a good representation of a large-scale condominiums.

Total land area	8 acres
Number of households	550
Total residents	2,200 (approx.)
Recreational facilities	Clubhouse, Swimming pool, tennis court, basketball court, children play area (2), football field, garden (2)
Water facilities	1 STP, 1 WTP
Number of blocks	10 (Phase-1: A,B,C Phase-2: D,E,F Phase-3: G,H,I,J)

Figure: Demographics of Springfield apartments

Most real estate development and occupied properties in this area depend on private borewells and/or tanker water markets – more often both sources. Tanker operators get water from borewells both within this area and outside this area, from further away from the city. Tanker water rates have steadily risen as demand for water has increased calling for an immediate cap in the cost of tanker water supply. People's narratives in the area make it clear that borewells have been drying up and new borewells have to be dug to greater depths for them to yield water.

Water supply and management at condominium level- Springfields Apartment

In this section various aspects, including water sourcing, distribution, consumption, and wastewater treatment are baselined to not only understand the existing processes but also keeping in the four-domain model and the possible improvements and efficiencies in the future for Springfield apartment. This condominium has absolutely no formal water supply from the Bengaluru's water utility, the BWSSB, completely dependent on its borewells as a water source and private tankers. Groundwater in this area has been stressed since early 2000's creating water scarcity problems. The builder had drilled three borewells which were the source of water for the layout. The borewells left by the builder began to dry up.

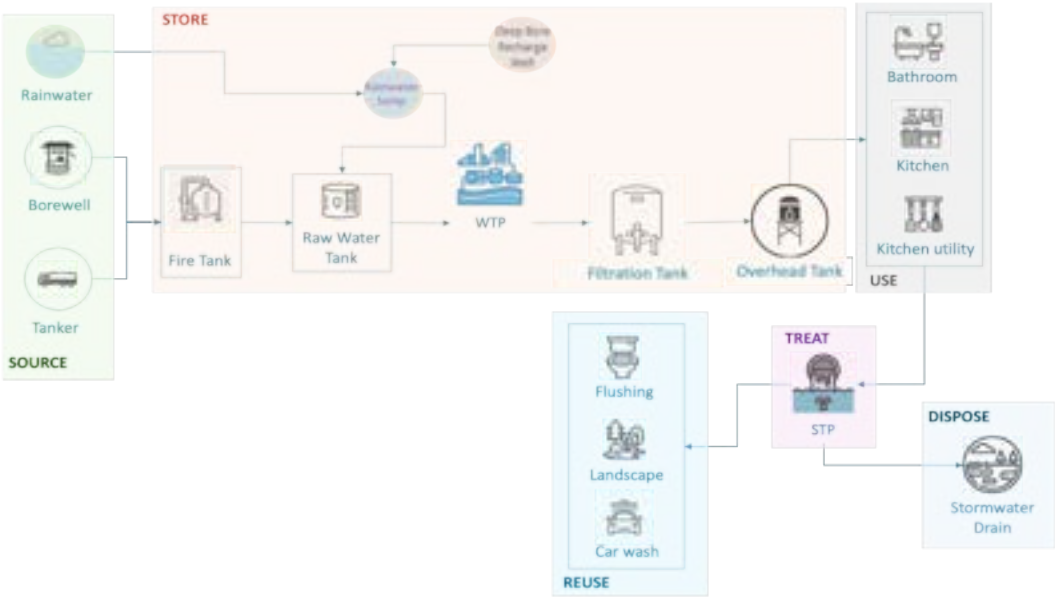


Figure: Water supply and distribution in Springfield apartment

Water source

Currently Springfield apartment is not provided with Cauvery water by BWSSB and the borewell provided by the builders provide very less to almost no supply to the households. As a result, there is full dependence on private tankers. Water monitoring is done using 4 individual meters, measuring the intake of water from tankers and the details are also recorded in a physical register daily by the security guards as another check. Located at the inlets of the pipeline network. The water is sourced from 2 private vendors, who source the water from 3-4 privately owned borewells. Due to lack of consent, the names of the vendors have not been mentioned.

<u>Tanker details:</u>

Tanker volumes:	6,000, 12,000- and 24,000-liters
Tanker quantity:	~ 15-20 tankers enter Springfields per day
Tanker frequency:	Across the day, more in the night to avoid day traffic.

Fire tank

Fire tanks are water storage containers that provide water to a fire pump for an emergency unforeseen situation like a fire is quite important. The fire tanks play a vital role in the safety and protection of the condominium. They are used to store an adequate amount of water to be used by fire sprinkler systems or other firefighting measures. These fire water tanks needs to comply with all major fire safety guidelines specified by the government for attaining a no objection certificate.

Capacity of the fire tank in Springfield apartment is 1,00,000 liters and this is the first tank to be filled before the overflow water is used for water circulation (as per govt. requirement)

Figure: Fire Tank

For reference, the guideline and the no objection certificate is also included below (10).

Office of the Director General of Police
Commandant General, Home Guards & Director of Civil Defence and Director General Karnataka State Fire & Emergency Services
No. 1, Annaswamy Mudaliar Road
Banglore - 560 042

Phone : 25570733
: 22971501
Fax : 22971512

KARNATAKA STATE FIRE & EMERGENCY SERVICES

NO OBJECTION CERTIFICATE

No. KSFES/GBC(1)/175

Docket No. KSFES/NOC/136/2021

Dated : 05/08/2021 13:19

To,

Commissioner,
Bengaluru Development Authority,
Kumara Park West,
T.Chowdaiah Road,
Bengaluru-560020.

Sir

Sub : Issue of No Objection Certificate for the construction of Residential building at AT SY.NO, 57(P),58(P),61(P),49/3,46/1,46/2,46/3,46/4,46/5 & 47 OF DOMMASANDRA VILLAGE AND SY.NO, 107/1 OF KUMBENA AGRAHARA VILLAGE,BIDARAHALLI HOBLI,BANGLORE EAST TALUK,BANGLORE, Bangalore East, BANGALORE - 560049

Underground static water storage tank combined capacity for wet riser, yard hydrant and sprinklers per set of pumps

NBC-2016, Part-4, Table 7 (11) Underground Static Water Storage Tank Combined Capacity for Wet Riser, Yard hydrant and Sprinklers per set of Pumps shall be provided for,

Apartment Houses (A-4)

1. Above 35 m but not exceeding 45 m. In height – 75,000 lts.
2. Above 45 m but not exceeding 60 m. In height – 1,50,000 lts.
3. Above 60 m in height. – 2,00,000 lts.

Note: Fire tank to be always filled with water. Over flow of fire tank to be taken to domestic tank. Arrangement should be such that any incoming water should first fill-up fire tank, then overflow to

Figure: Karnataka no objection certification, specifying the compulsion of a fire tank

Raw water tank

Raw water tank is the secondary storage of water and this acts as the source of water to Water Treatment Plant (WTP). Overflow from fire tank flows into the raw water tank. The tank contains 10 steps in the tank to measure the volume of water is at any point of time (this is based on the number of steps are under water). For example, if 1 step is above water level then 90% of the raw water tank is full. Cable of wires in the tank, sends a beeping signal to the maintenance rooms when the raw water tank overflows.

Figure: Steps in raw water tank

Figure: Cable of wires in raw water tank

Water treatment plant (WTP)

Water Treatment Plants play a vital role in providing clean and safe water to the residents of a society. They remove impurities and contaminants, such as bacteria, viruses, heavy metals, and other dissolved solids, from various water sources like borewell, tanker, or even municipal supplies. A properly functioning WTP ensures that the water is safe for drinking, cooking, and other household uses. The WTP in Springfield apartment consists of 2 stages of water purification: pressure sand filter (to remove odor, color and heavy solid sediments that settle at the bottom of the tank) and softener (to reduce hardness of water). It has a **softener tank** contains the softener resin tablets, salt water is supplied continuously from the salt tank, to reactivate the resin. There are 4 outlet pumps- phase 1 (blocks A, B and C), phase 2 (D, E and F) and phase 3 (G, H, I and J), one for common usage (swimming pool, common kitchen).

Figure: Saltwater tank

Figure: Pumps to overhead tanks

Figure: Centrifugal pumps

Figure: Water softener, pressure sand filter

Filtration tank

This is the storage of the treated water from the water treatment plant. Water is pumped to the overhead tanks of each block 2 times a day, due to limited capacity. The remainder of time treated water is pumped to filtration tank for storage. Has similar steps and cable wire to raw water tank.

Figure: Filtration tank

Overhead tank and balancing tank

The main of the **overhead tank** purpose is to achieve an even distribution and it maintains constant pressure and flows, at the time of discharge when the water comes down from a certain height it has a sufficient increase in pressure that makes it serves at a constant rate. Each block from A-J has one overhead tank for treated sewage, and one overhead tank for filtered water. The pumps in the WTP supply to the overhead tanks of blocks C, G and J. The overflow of treated water from these blocks' flows into the remaining blocks of the phase. To prevent delay in supply of treated water between blocks, plumbing work is done to allow flow equally. (Still to be understood in detail).

The **balancing tank** acts as a sump for treated water entering the swimming pool from the filtration tank. Chlorination of the water is done inside the swimming pool every Tuesday (frequency changes based on need). At times, water is directly pumped using pipes from the water tankers to balancing tank, to save energy and time.

Figure: Overhead tank

Figure: Swimming pool

Household water consumption

Like anywhere in urban India, an average household in Springfield apartments typically use water at home throughout the day in various ways. Here’s a breakdown of water usage:

Direct consumption

People drink water across the day to rehydrate and boost metabolism with meals or otherwise and the quantity varies with seasons.

Personal Hygiene

Water is used for rinsing and brushing along with showers and consumption is based on duration and flow rate.

Cooking and Breakfast

Water is used for cooking breakfast items like oatmeal or boiling eggs, as well as for making tea or coffee.

Household Cleaning

Cleaning floors or surfaces may involve using buckets of water, volume depends on the size of the area of the apartment.

Miscellaneous Uses

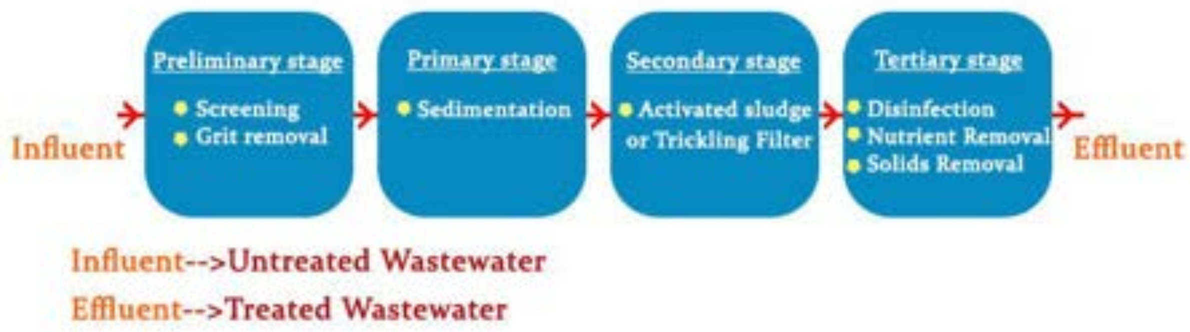
Water may be used for activities like washing clothes or cleaning utensils, depending on individual household practices and this can be manual or automated through machines and also watering plants where ever applicable.

Sewage treatment plant (STP)

The wastewater discharged from households is termed as sewage or wastewater. It includes waste liquid from toilets, baths, showers, kitchens, and sinks draining into sewers. Sewage treatment refers to the process of removing contaminants, micro-organisms and other type of pollutants from wastewater, primarily from household sewage. Sewage treatment includes physical, chemical, and biological methods to remove contaminants and produce environmentally safe treated wastewater to make it usable again. The main purpose is to remove wastewater from points of origin to a treatment facility or place of disposal. Treating sewage/wastewater from the apartment has the aim to produce an effluent that will do as little harm as possible when discharged to the surrounding environment, thereby preventing pollution compared to releasing untreated wastewater into the environment.

Sewage from the apartment can be treated by implanting Sewage Treatment System or Sewage Treatment Plant (STP) which involves following stages (11):

- Preliminary Treatment
- Primary Treatment
- Secondary Treatment
- Tertiary Treatment



The Springfield resident association early on realized that wastewater treatment is a very critical component of its overall water management, and reusing treated wastewater could greatly contribute to the layouts self-reliance on water and also realized that given that demand management practices were in place.

The technology used in this case is Activated sludge process (ASP). Total capacity of the STP is 3,80,000 liters with a daily STP treatment is of 3,20,000 liters capacity. Sewage enters equalization (EQ) tank (capacity: 70 KLD), through the bar screen. The role of the bar screen to remove big objects such as shampoo bottles, tree branches, metal cans etc. Here, the incoming sewage is collected at widely fluctuating rates, and is passed on to the aeration tank at a steady, average flow rate. In the aeration tank, oxygen inlets are present to enable biological processes, through already existing microorganisms that consume biodegradable, soluble contaminants. Settling/Sedimentation tank allows heavy, inorganic solids (sludge) to settle at the bottom, while grease, oil, soap, and other lighter solids (scum) move up.

Figure: Aerobic air inlet pipes

Figure: Settling/sedimentation tank

Figure: Aeration tank

Figure: Equalizing tank

From settling tank, the sewage goes to Pressure sand filter (PSF) activated carbon filter (ACF) to remove color and odor, pathogens, Nitrogen, Phosphorus, and other inorganic compounds chemically, through ultraviolet light or microfiltration, making it suitable for reuse. Treated sewage is then stored in the treated sewage tank, before being pumped to overhead tanks. Like the WTP, treated sewage is pumped up to the overhead tanks of the blocks, periodically, depending on consumption. This reading can be displayed on the automatic sensors fitted in the STP, that can be automatically controlled. For the remainder of the time, treated sewage is stored in the treated sewage tank. The sludge produced in STP's is sent to the sludge filter press machine to get dewatered and form sludge cakes, which are then used as fertilizers for gardening within Springfields. These machines contain a series of filter plates that are compressed, allowing the filtrate to pass through, retaining the dehydrated solids or sludge cakes. The filtrate passes through the blue pipe and connects to the final treated sewage tank, while air vents in the STP prevents congestion and allow ventilation.

Figure: *ACF and PSF filters*

Figure: *Sludge filter press*

Figure: *Air vent*

Figure: *Automatic sensor*

Figure: *Sewage pumps to overhead tanks*

Usage of the treated sewage

The treated sewage from the overhead tanks, flows down to the flushes of individual households. The overflow of the treated sewage from the STP is also used for gardening purposes and washing of cars withing Springfields.

Figure: Gardens, green spaces

Water quality

Potable water in India needs to meet the needs set by the Bureau of Indian Standards (BIS), which propose the parameters first established in 1983, revised in 1991 and again in 2012, to meet the international specifications set by the WHO (12). It specifies the physical, chemical, bacteriological parameters of potable water.

Table 1 Organoleptic and Physical Parameters
(*Foreword* and *Clause* 4)

Sl No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit in the Absence of Alternate Source	Method of Test, Ref to Part of IS 3025	Remarks
(1)	(2)	(3)	(4)	(5)	(6)
i)	Colour, Hazen units, *Max*	5	15	Part 4	Extended to 15 only, if toxic substances are not suspected in absence of alternate sources
ii)	Odour	Agreeable	Agreeable	Part 5	a) Test cold and when heated b) Test at several dilutions
iii)	*p*H value	6.5-8.5	No relaxation	Part 11	—
iv)	Taste	Agreeable	Agreeable	Parts 7 and 8	Test to be conducted only after safety has been established
v)	Turbidity, NTU, *Max*	1	5	Part 10	—
vi)	Total dissolved solids, mg/l, *Max*	500	2 000	Part 16	—

NOTE — It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under 'acceptable' render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under 'permissible limit in the absence of alternate source' in col 4, above which the sources will have to be rejected.

Table 6 Bacteriological Quality of Drinking Water[1)]

(*Clause* 4.1.1)

Sl No. (1)	Organisms (2)	Requirements (3)
i)	*All water intended for drinking:*	
	a) *E. coli* or thermotolerant coliform bacteria[2), 3)]	Shall not be detectable in any 100 ml sample
ii)	*Treated water entering the distribution system:*	
	a) *E. coli* or thermotolerant coliform bacteria[2)]	Shall not be detectable in any 100 ml sample
	b) Total coliform bacteria	Shall not be detectable in any 100 ml sample
iii)	*Treated water in the distribution system:*	
	a) *E. coli* or thermotolerant coliform bacteria	Shall not be detectable in any 100 ml sample
	b) Total coliform bacteria	Shall not be detectable in any 100 ml sample

[1)]Immediate investigative action shall be taken if either *E.coli* or total coliform bacteria are detected. The minimum action in the case of total coliform bacteria is repeat sampling; if these bacteria are detected in the repeat sample, the cause shall be determined by immediate further investigation.

[2)]Although, *E. coli* is the more precise indicator of faecal pollution, the count of thermotolerant coliform bacteria is an acceptable alternative. If necessary, proper confirmatory tests shall be carried out. Total coliform bacteria are not acceptable indicators of the sanitary quality of rural water supplies, particularly in tropical areas where many bacteria of no sanitary significance occur in almost all untreated supplies.

[3)]It is recognized that, in the great majority of rural water supplies in developing countries, faecal contamination is widespread. Under these conditions, the national surveillance agency should set medium-term targets for progressive improvement of water supplies.

Table 3 Parameters Concerning Toxic Substances

(*Foreword* and *Clause* 4)

Sl No. (1)	Characteristic (2)	Requirement (Acceptable Limit) (3)	Permissible Limit in the Absence of Alternate Source (4)	Method of Test, Ref to (5)	Remarks (6)
i)	Cadmium (as Cd), mg/l, *Max*	0.003	No relaxation	IS 3025 (Part 41)	—
ii)	Cyanide (as CN), mg/l, *Max*	0.05	No relaxation	IS 3025 (Part 27)	—
iii)	Lead (as Pb), mg/l, *Max*	0.01	No relaxation	IS 3025 (Part 47)	—
iv)	Mercury (as Hg), mg/l, *Max*	0.001	No relaxation	IS 3025 (Part 48)/ Mercury analyser	—
v)	Molybdenum (as Mo), mg/l, *Max*	0.07	No relaxation	IS 3025 (Part 2)	—
vi)	Nickel (as Ni), mg/l, *Max*	0.02	No relaxation	IS 3025 (Part 54)	—
vii)	Pesticides, µg/l, *Max*	See Table 5	No relaxation	See Table 5	—
viii)	Polychlorinated biphenyls, mg/l, *Max*	0.000 5	No relaxation	ASTM 5175*	— or APHA 6630
ix)	Polynuclear aromatic hydro-carbons (as PAH), mg/l, *Max*	0.000 1	No relaxation	APHA 6440	—
x)	Total arsenic (as As), mg/l, *Max*	0.01	0.05	IS 3025 (Part 37)	—
xi)	Total chromium (as Cr), mg/l, *Max*	0.05	No relaxation	IS 3025 (Part 52)	—
xii)	Trihalomethanes:				
	a) Bromoform, mg/l, *Max*	0.1	No relaxation	ASTM D 3973-85* or APHA 6232	—
	b) Dibromochloromethane, mg/l, *Max*	0.1	No relaxation	ASTM D 3973-85* or APHA 6232	—
	c) Bromodichloromethane, mg/l, *Max*	0.06	No relaxation	ASTM D 3973-85* or APHA 6232	—
	d) Chloroform, mg/l, *Max*	0.2	No relaxation	ASTM D 3973-85* or APHA 6232	—

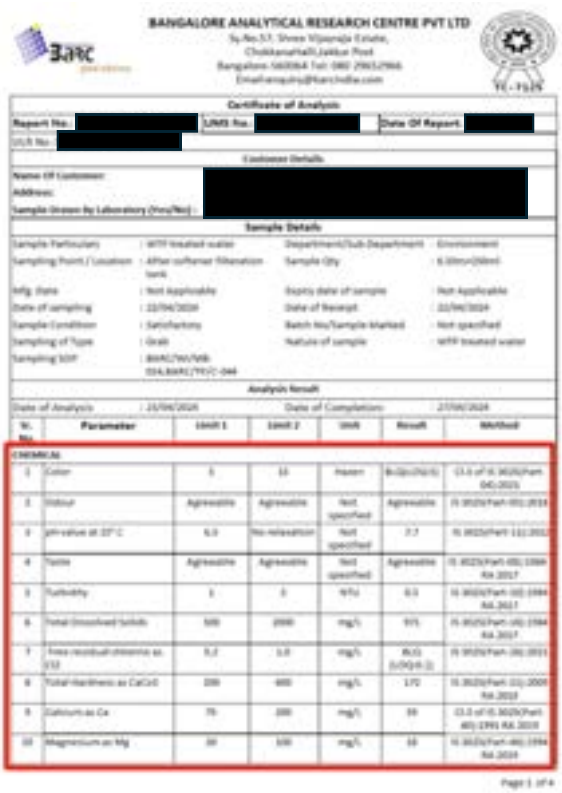
NOTES

1 In case of dispute, the method indicated by '*' shall be the referee method.

2 It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under 'acceptable' render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under 'permissible limit in the absence of alternate source' in col 4, above which the sources will have to be rejected.

Figure: Source: Bureau of Indian Standards (11)

Raw and Treated water gets tested once a quarter. Samples sent to Bangalore Analytical Research Center (BARC).



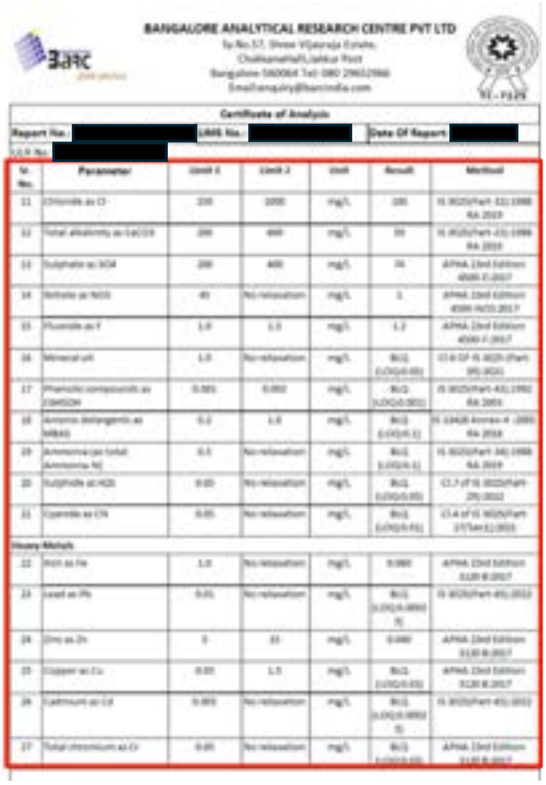


Figure: Report of treated water 2024. Red highlighted boxes represent the chemical, physical and microbiological parameters tested. Green box represents the conclusion of the report. Similar report done for raw water

BWSSB Regulations of decentralized STPs

In 2016, the BWSSB mandated that apartments with 20 or more units and 2000 m^2 or more, and existing apartments with 50 or more units or 5000 m^2 or more, install STPs. The purpose of this directive was to reduce water pollution and scarcity in the city by reusing treated wastewater.

The BWSSB has several regulations for decentralized STPs with respect to location, ventilation, leakage, tests, reuse, components and monitoring.

Upon clicking the purple circles shown in the Figure, the details such as the location, capacity, and name of the STP are displayed.

Upon clicking view STP Dashboard, the treated sewage quality against the parameters such as dissolved oxygen, temperature are displayed

DATETIME	DISSOLVED OXYGEN
11-07-2024 09:30	6.31
11-07-2024 09:25	6.31
11-07-2024 09:20	6.31
11-07-2024 09:15	6.31
11-07-2024 09:10	6.31
11-07-2024 09:05	6.31
11-07-2024 09:00	6.31
11-07-2024 08:55	6.31
11-07-2024 08:50	6.31
11-07-2024 08:45	6.31

Upon further clicking on any parameter, a 5-minute periodic reading is displayed on the screen, with the real time data value

Figure: Map showing BWSSB owned STPs’

Based on these guidelines, there is a standard operating process (SOP) for managing and maintaining the STP in Springfields with there is a member of the managing committee who is accountable for the same. Some of the SOP items are mentioned below:

- To avoid swarms of mosquitoes in the facility, 2 types of mosquito repellents are used: mosquito repellent spray in the afternoon (for narrow corners), mosquito fogging in the evening (wider areas).
- 1 CCTV installed to monitor the facility.
- Surplus of treated sewage is around 170 KLD, is sent to main sewage drainage system/storm water drain.
- Black water or Biochemical oxygen demand (BOD) contains human waste and greywater, or Chemical oxygen demand (COD) contains water from bathing, washing clothes, utensils, sinks etc.
- Both grey and black water are treated in the STP, they have the same inlet, and thus are treated to the same level of quality, which is considered relatively optimum.
- Testing of treated sewage quality is done regularly, as it is a statutory requirement by the government. For records and parameters measured, will have to ask Mr. Sriram.

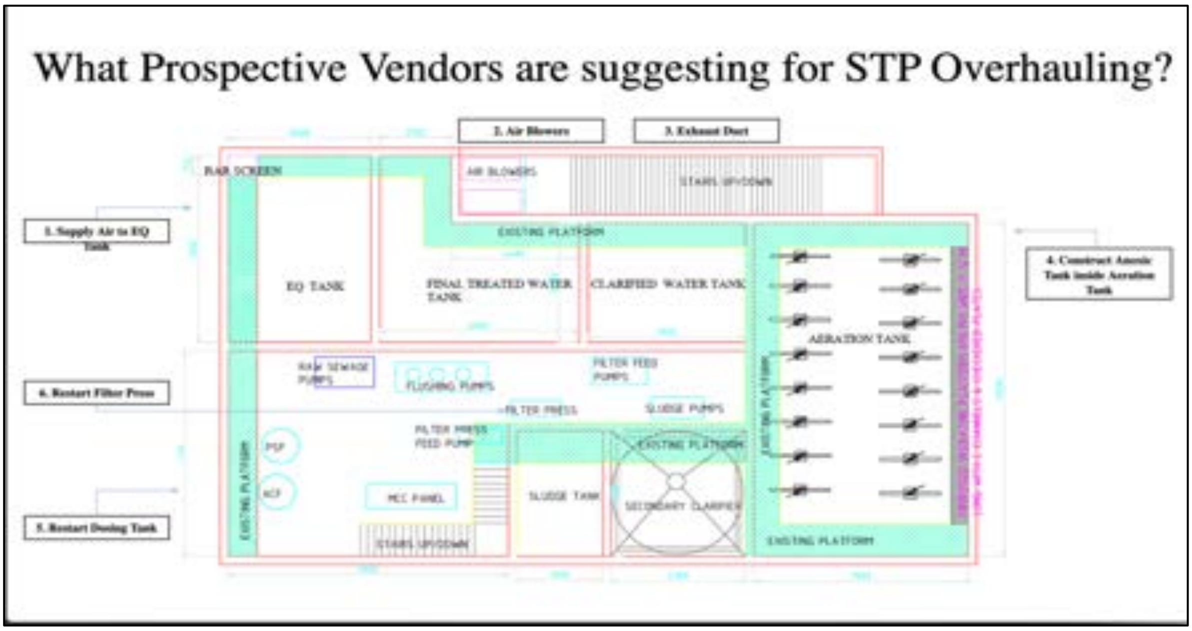


Figure: Prospective overhauling of STP as suggested by vendors. Source: Springfield apartment STP report

Water charges

The Bangalore Water Supply and Sewerage Board (BWSSB) water charges include (12):

- **Slab system**: For buildings up to four floors, the water charge is a flat rate of Rs 7 for up to 8,000 liters of water consumed. For water consumed between 8,000 and 25,000 liters, the rate is Rs 11 per 1,000 liters.
- **High-rise building:** For high-rise buildings, the minimum payment is Rs 22 per 1,000 liters of water consumed.
- **Sanitary charges:** The minimum sanitary charge is Rs 100 or 25% of the water bill, whichever is higher. For water usage between 0 and 8,000 liters, the sanitary fee is Rs 14 per connection.
- **New water connection charge:** For residential apartments, the charges are Rs 200 per square meter plus a sanitary point fee of Rs 120 for each point. For commercial buildings, the charges are Rs 300 per square meter plus a sanitary point fee of Rs 120 for each point.

- **Additional charges**: If a building uses borewells or water tankers to supplement the water supply from the board, an additional sanitary charge of Rs 50 per flat per month is applied.

Tariff for Domestic connections				
Slab	Water Tariff, Rs	Sanitary	Sanitary for Borewell, Rs	Meter Cost (15mm), Rs
0-8000	7	Rs.14/-	Rs.100	30
8001-25000	11	25%		50
25001-50000	26			75
Above 50000	45			150

Figure: Monthly water rates of BWSSB supply. Applicable to residential areas, religious/worship places, student hostels run by education institutions, orphanages, charitable hospitals and government premises (14)

In Springfields, the water charges are calculated based of the total cost of tanker water for a quarter. For each household, the cost depends on the number of bedrooms. For instance, using Figure 1, a 3 BHK flat will always be charged Rs 6,663 per quarter unless there is an increase in tanker cost. Similarly, a 4 BHK flat will always be charged Rs 7,995 per quarter regardless of difference in square foot, family members and even individual water consumption.

Thus, the per bedroom per day charges can be calculated as follows:

$$= \frac{total\ tanker\ cost\ (Rs)}{total\ no.\ of\ bedrooms \times 90\ (days)}$$

Q1 2024 -2025 Maintenance Invoices		
Description	HSN/SAC	Amount
CAM- calculation: (1995.0 SQFT) * (9.616 per SQFT for 3 Month(s))	999598	19,184.00
Water Charges	999598	6,663.00
Special Project- calculation: (1995.0 SQFT) * (1.2225 per SQFT for 3 Month(s))	999598	2,439.00
Events	999598	300.00
Sinking Fund- calculation: (1995.0 SQFT) * (0.75 per SQFT for 3 Month(s))	999598	1,496.00
SGST Output @ 9.00 % - Q1 2024 -2025 Maintenance Invoices		682.38
CGST Output @ 9.00 % - Q1 2024 -2025 Maintenance Invoices		682.38
(Total Taxable: 30,082.00 | Total Non Taxable: 0.00 | Total GST: 1,364.76)	**SUB TOTAL**	**31,446.76**

Figure: Water charges for 3BHK house

Distance travelled by tanker (km)	Volume of tanker (liter)	Cost incurred (Rs)
0-5	6,000	600
0-5	8,000	700
0-5	12,000	1,000

Figure: Price cap set by Karnataka govt on tanker water supply per day

Comparing the BWSSB and Springfield water rates:

BWSSB	TANKER
Consumption of 18,000L per month, falls under the 2nd slab. This means the water tariff of Rs. 11 must be multiplied by 18 KL. $11 \times 18 = Rs. 198$ Assuming, Springfields also sources water from its privately owned borewell, an additional sanitary charge of Rs. 100 must be added. $198 + 100 = Rs. 298$ The meter cost of Rs. 50 is also added. $298 + 50 = Rs. 348$ 25% of this cost, must be added as sanitary for the centralized STP. $348 + 87 = Rs. 435$ Thus, monthly cost of water is: **Rs. 435**	Per liter cost of tanker water is 0.1. This value is derived from the price cap set by the government. Rs. 600 for a 6,000 L tanker. Thus, consumption of 18,000 L per month, would be multiplied by 0.1 $18{,}000 \times 0.1 = Rs. 1{,}800$ Thus, monthly cost of water is: **Rs. 1,800**

Assumption: Monthly consumption of a family of 3 is 18,000 L. This implies, per individual consumption per day is 200 LPCD.

Conclusion: Cost of private tanker water is close to 4x times the cost of BWSSB water supply.

Environmental impacts

Water tanker can have several environmental impacts, including:

- **Energy use**: Transporting water by truck uses three to seven times more energy than generating freshwater by reverse osmosis. This contributes to greenhouse gas emissions.
- **Water pollution**: Leaking tanks can contaminate water bodies, soil, and drinking water wells.
- **Air pollution**: Pollutants from tank storage terminals can contribute to toxic fog, smog, and acid rain.

The distance between the VWS borewells and Springfields is 10 Km up and down. 1 L of diesel is consumed in 2 Km of a 24,000 L tanker travelling. : (1 L = 1 Kg = 1,000 g) (Source: Tanker driver). Thus, 10 Km worth of distance, will consume 5 L of diesel per day, per trip up and down. This same tanker takes 6 trips a day to Springfields to supply water. Thus, the total volume of diesel consumed will be $5 \times 6 = 30\ KL$ by this tanker.

1. Number of moles of $C_{12}H_{23} = \frac{given\ mass}{molar\ mass} \Longrightarrow \frac{30{,}000}{167.23} = 179.4$ moles.

2. Using the molar ratio in the equation (1:12) Number of moles of CO_2= 179.4×12 = 2152.8 moles.

3. Mass of CO_2 emitted= $2152.8 \times 44 = 94{,}723\ g \sim 95{,}000\ g = \mathbf{95\ Kg\ of\ CO_2}$ **emitted per day.**

4. Volume of water consumer per day: 2,50,000 L

Thus, the CO_2 emitted per liter of water $\Longrightarrow \frac{95}{2{,}50{,}000} = \mathbf{3.8 \times 10^{-4} Kg}$

5. From this, the CO_2 emitted per liter of water is $= \frac{95}{30{,}000} = \mathbf{0.0032\ Kg\ L^{-1}}$.

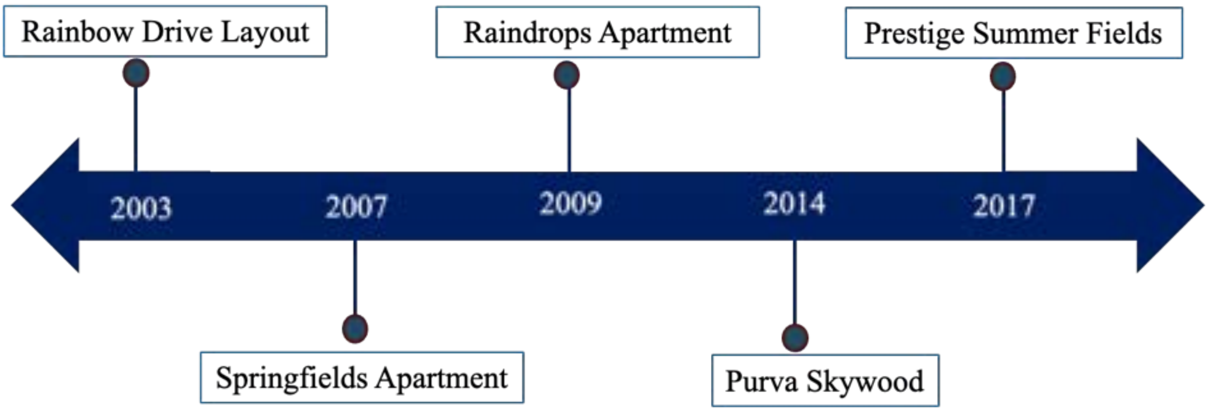
6. According to monthly consumption data depicts a consumption of 3000KL in Springfields. Thus, CO_2 per month is $\mathbf{0.0032\ Kg\ L^{-1} \times 3000KL = 9{,}600Kg}$.

7. Equation of combustion of diesel in air

$$4\ C_{12}H_{23} + 71\ O_2 \rightarrow 48\ CO_2 + 46\ H_2O$$

Primary data collection

We must segment condominiums in this region based on the year of readiness and occupancy as the state of the complexes are similar. For representation I will consider a timeline ranging from 2003- 2022, including 10 urban condominiums in the Sarjapur area. I will delve deeper into the state, evolution, challenges and best practices followed in each of these condominiums, to draw a comparison and to adopt appropriate interventions.



Rainbow Drive Layout
Sarjapur Main Road, Bangalore – 560035

- **Project Size:** 34 Acres
- **Launch date:** June 2nd, 2003
- **Total units/plots:** 380, only 320 occupied currently
- **Sources of water:** 50% Cauvery connection, 50% in-situ borewells, some residents opt for both. Individual plots can opt for tanker water supply, but not reliable, and costs are higher.
- **Approximate population:** 1,280
- **Borewells:** 2 borewells yielding sufficient water, depth is 250 feet,

- **Water charges:** Water slabs are based on KL of water consumed per month, approximately Rs.16-17 per KL. This cost includes cost of sourcing, maintenance of STP, WTP and electrical costs.
- **Recharge wells and Rainwater harvesting:** Each plot is now obligated to have a recharge well, and a terrace rainwater harvesting system. The rainwater trickles down to the recharge wells, which act as sumps. This water is used to recharge the common borewells, excess is disposed through storm water drains outside the complex.
- **Meters:** Individual plots have water meters for each inlet. Water consumption is tracked. Water demand has decreased from 246 LPCD to 150 LPCD, as of August 2015, and continues to decrease despite increase in occupancy.
- **Treated sewage:** Sewage is treated in STP with Phytorid Technology, treated sewage is used for gardening and landscaping for common uses as well as for individual plots, or is stored in an overhead STP tank.
- **Reforms:** Partnered with BIOME to adopt a rainwater harvesting initiative for each villa. Consumption and water quality records shared with residents, to incentivize lower consumption.
- **Water and STP quality:** Monthly testing done, samples sent to lab, according to specifications set by an organization (name to be confirmed).

Total Environment Raindrops Apartment
10-1/2, Haralur Main Road, Ambalipura, Bangalore – 560102

- **Project Size:** 4 Acres
- **Launch date:** December 6th, 2009
- **Total units/plots:** 120 apartments
- **Sources of water:** 20% in-situ borewells, 80% tanker water supply
- **Approximate population:** 250
- **Average monthly water consumption:** 10,00,000 L
- **Borewells:** 2 borewells yielding sufficient water.
- **Water charges:** Water slabs are based on KL of water consumed per month.
- **Recharge wells and Rainwater harvesting:** 1 tower with large open terrace area, where rainwater harvesting is practiced. Facing issues with cat litter, fixed later. Runs down into common recharge well. 2 Recharge wells, number of borewells to be confirmed. In built sand filter, then to WTP then to houses.
- **Meters:** Individual house meters were installed for each inlet in each house. Data showed water consumption fell by 10-15%.
- **Treated sewage:** Used for gardening and flushes. No excess or surplus. Washing and cleaning of campus.
- **Average monthly consumption:** 10,00,000 L
- **Consumption per day:** 35 KL down to 30 KL.
- **Reforms:** Weekly consumption analysis shared with residents to incentivize water conservation.
- **Water quality testing:** Tested once a quarter from S&N Labs. Aeration of water done regularly in WTP.

Prestige Summer Fields
Bhoganhalli, Outer Ring Road, Bangalore – 560103



- **Project Size:** 12 Acres
- **Launch date:** December 12th, 2017
- **Total units/plots:** 84 villas
- **Sources of water:** 100% in-situ borewells, tanker supply only for 1 month during peak summer.
- **Approximate population:** To be confirmed
- **Average monthly water consumption:** 26,00,000 L
- **Borewells:** 3 borewells: 2 yielding sufficient water, 1 is yielding lesser quantity of water, not good quality used for gardening.
- **Water charges:** Water slabs are based on KL of water consumed per month.
- **Recharge wells and Rainwater harvesting:** Plans to make rainwater chambers/ pits near borewells, to recharge groundwater
- **Meters:** Individual house meters were installed for each inlet in each house.
- **Treated sewage:** Used for gardening and flushes. No excess or surplus. Sometimes scarce Washing and cleaning of campus.
- **Consumption per day:** Range from 100-160 LPCD
- **Reforms:** Borewells run for 2 hours, followed by a gap of 1-2 hours to recharge groundwater. Empty villas that show meter readings are turned off during the night, no

construction work is required, helps to conserve water. Reading of meters of all villas done in installments: 12 AM, 8:30 AM, 6 PM and 8:30 PM, to catch leakages.

- **Water quality testing:** pH levels measured everyday; filter tanks cleaned once in 2 years. Salt treatment to reduce hardness twice a day.

Purva Skywood
Survey No 92, Silver County Road, Kudlu, Haralur, Bangalore – 560068



- **Project Size:** 12.3 Acres
- **Launch date:**_June 10th, 2014
- **Total units/plots:** 728 apartments
- **Sources of water:** No fixed split. Cauvery water supply (not everyday), Majority of tanker water (30 visits of 18,000L per day) supply, in-situ borewell supply as well.
- **Average monthly water consumption:** 108,00,000 L
- **Borewells:** 3 borewells: 1 yielding sufficient water (capacity is 10,000L), 2 are not yielding.
- **Water charges:**_Water slabs are based on per square foot
- **Recharge wells and Rainwater harvesting:** No recharge wells. Rainwater harvesting is practiced, water goes to rainwater overhead tank, then to WTP and to households.
- **Meters:** No Individual house meters installed. Only inflow volume is metered.
- **Treated sewage:**_Used for gardening and flushes. No excess or surplus. Sometimes scarce Washing and cleaning of campus.

- **Consumption per day:** 3,60,000L
- **Reforms:** No additional reforms
- **Water quality testing:** Quality only tested when in doubt, samples sent to lab. Or when there is a change of water vendor.

Springfield apartment
Sarjapur Main Road, Bangalore – 560102


- **Project Size:** 8 Acres
- **Launch date:** June 2nd, 2006
- **Total units/plots:** 550
- **Sources of water:** 100% water tankers.
- **Approximate population:** 2,200
- **Borewells:** 2 borewells yielding sufficient water, depth is 250 feet,
- **Water charges:** Water slabs are based on KL of water consumed per month, approximately Rs.16-17 per KL. This cost includes cost of sourcing, maintenance of STP, WTP and electrical costs.
- **Recharge wells and Rainwater harvesting:** Each plot is now obligated to have a recharge well, and a terrace rainwater harvesting system. The rainwater trickles down to the recharge wells, which act as sumps. This water is used to recharge the common borewells, excess is disposed through storm water drains outside the complex.
- **Meters:** Currently water consumption is not tracked at an individual household level.

- **Treated sewage:** Sewage is treated in STP and the treated sewage is used for flushing, car wash and gardening/ landscaping for common uses.
- **Reforms:** There have been many reforms over the last many years across the water supply chain but many of the planned items are pending because of limitations of the residential complex.
- **Water and STP quality:** Currently the testing is more adhoc and not periodically done, there are plans to make this more structured.

Enhance water efficiency in condominiums in and around Sarjapur region in Bangalore

Water efficiency involves optimising the use of water to achieve the desired outcome while minimising waste. The findings of the research can be applied to condominiums in and around Sarjapur region of Bangalore, including water sourcing, distribution, consumption, and wastewater treatment. The proposal is aligned to the four domain model - Physical, Operational, Financial and Institutional.

<u>Operational</u>

- Tools and equipment used for functioning, such as pumps, valves etc.
- Materials required such as salts, for WTP.
- Monitoring and recording of data.

<u>Physical</u>

- Sources of water in Bangalore.
- Supply of water depending on location, infrastructure cost etc.
- Inlets and outlets of water within condominiums.

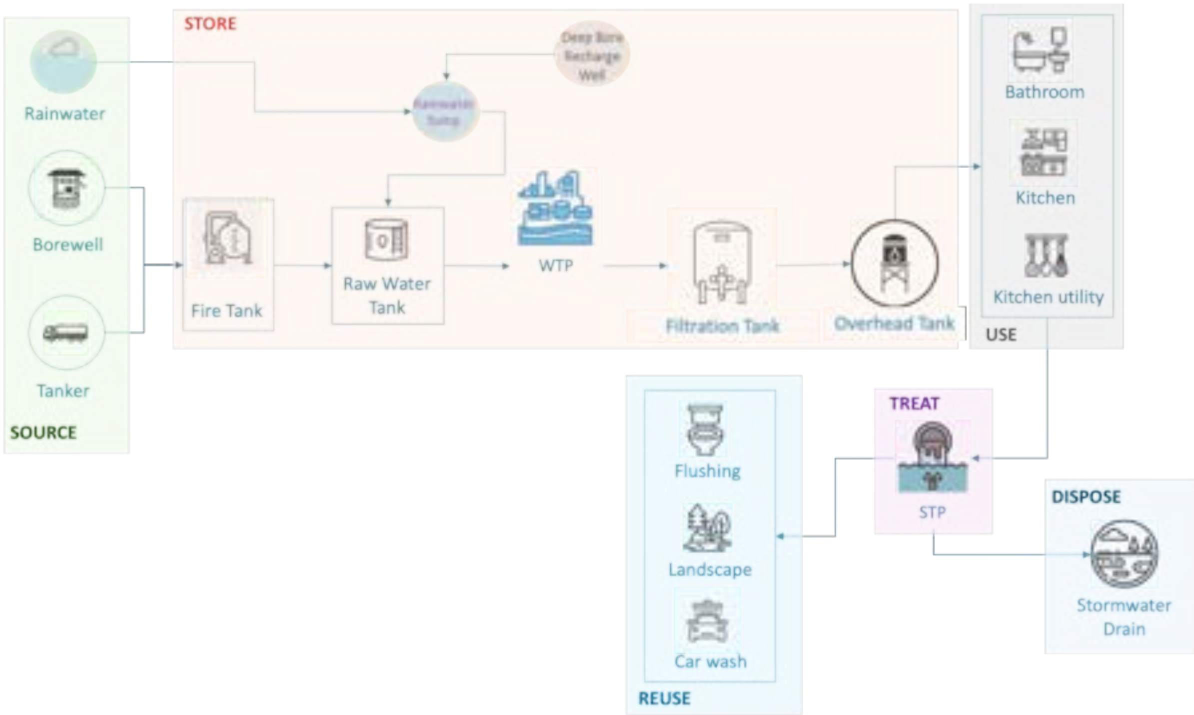
<u>Financials</u>

- Costs of sourcing water through pipeline network, private tankers etc.
- Costs of treating and disposing sewage and water in STP’s and WTP’s.

- Costs of installations, maintenance of equipment and tools.

Institutional

- Role of BWWSB, private water vendors.
- In communities, members of Management Committee (MC) responsible for operations within condominiums.



Source

Findings and challenges

The situation is alarming as groundwater recharge rates significantly lag extraction rates. Over reliance on ground water will lead to a situation with no mitigation and alternative. Because of this cost of ground water will increase as the current borewells will not be sufficient as a source because of the ground water depletion and will need to go to places further and the transport costs will rise.

According to Central Groundwater Authority data (15) for 2023, all six assessment units--Bangalore City, Anekal, Yelahanka, Bangalore-East, Bangalore-North and Bangalore-South--in urban Bengaluru are overexploited. Natural groundwater recharge through green spaces and water bodies is as low as 148 MLD--one-tenth of the daily consumption (16). Rapid urbanisation is diminishing the remaining green spaces in the city, which is essential for aquifer recharge. The city's green cover shrunk from 28% in 2010 to 2.9% in 2023. (17) The BWSSB's public water supply is primarily concentrated in the central areas of the city, where the population is lower compared to the rapidly growing suburbs like the one considered (Sarjapur region of Bangalore) in the research.

- Almost equal number of tankers of each capacity (6K, 12K, 24K) comes to Springfields. Key aspects include reliance on over-exploited groundwater, limited access to BWSSB pipelines.
- Rainwater harvesting unit is not used currently
- Less to almost no supply because of the drying borewells
- Do not have piped Cauvery water connections and are affected by severe water shortage at times of extreme summers
- Currently there is no periodic check of the water quality of the incoming ground water.

Recommendation

- Need to look options to reduce the number of tankers of capacity (6K, 12K) and increase the number of tankers of 24K capacity to reduce carbon footprint.
- The current recharge well plus some new ones need to be planned, so that the water collected in the well either percolate into the ground, and recharge shallow aquifers (water-bearing formations that exist about 10-100 ft underground), which usually get replenished during rains or refill the borewells for them to become active sources of water.

- With the current piped Cauvery water connections, it is clear that it cannot be relied upon as the volume is low and cost must be too much in the bargain for limited water supply.
- Need for a "water application" that can digitize the water supply chain from source to disposal.

Store

Findings and challenges

- WTP Water meters get clogged with solid materials from incoming water.
- WTP Motor breakdown because of continuous use (run for whole day and night)
- Springfield is an 18-year-old property and due to ageing of the physical infrastructure, multiple breakdowns happen in the existing Cast iron pipes (CI pipes) because of corrosion of the pipes.
- Currently the aim is only to meet the statutory requirement of the water quality of the water coming out of the WTP.
- The rain harvesting storage is not functional and not used

Recommendation

- The maintenance of the WTP water meters is already streamlined, currently need to open, and clean once in 2 weeks.
- There are total 15+ motors being used in the whole plant almost 24x7. They need to be maintained / repaired in regular intervals. As part of risk mitigation, we keep 1-2 motors as spare and use them during any repairs of the active motors with a frequency of average 1 motor per 2-3 months.
- Periodic check of the water quality of the water coming out of the WTP every month, if not every month then at least every quarter.

- Long term solution is to replace all the CI pipes with PVC pipes, but the cost is prohibitively high. We currently replace in pieces wherever / whenever the breakage is seen.
- Increasing the capacity of the storage, especially the overhead tank storage and rain water harvesting can positively impact the environment by reducing the carbon footprint (lesser transport need and lesser power for water treatment operation)

Use

Findings and challenges

- There are 3 inlets to every apartment, with no water meter in place because of the old physical infrastructure and the cost of change is very high.
- As the physical infrastructure is old, there are no water meters at intermediate points to understand the leakage
- Per capita water consumption is not reducing over a period of time, awareness around this is not available with residents for them to act.

Recommendation

- Organise awareness campaigns and workshops for residents to promote water-efficient practices and responsible water usage.

- Monthly consumption trends to be shared with the residents to create more awareness. A "water application" that can not only digitize the water supply chain from source to disposal but also can push information relevant to this.

- Reduced water usage results in lower energy requirements for water pumping, treating, and heating, contributing to lower carbon emissions and energy conservation

- Install smart water metres to accurately measure individual water consumption and charge residents based on actual usage, promoting responsible water usage.

- Regularly inspect and promptly fix leaks in plumbing systems to prevent water loss and avoid costly damage.

- Water-Efficient Fixtures: Replace older fixtures with water-efficient alternatives, such as low-flow faucets, showerheads, and toilets, to reduce water wastage within apartments.
- Leak Detection and Repair: Regularly inspect and promptly fix leaks in plumbing systems to prevent water loss and avoid costly damage.
- Aerators and Flow Restrictors: Encourage residents to install aerators and flow restrictors on faucets to reduce water consumption while maintaining adequate water pressure.

Treat

Findings and challenges

- Electric Problems: There are complex panels and controls involved in STP. Panels / spare parts like switches / relays etc., are broken (Once in 6 months).
- Motor Breakdown: Like WTP, we user around 7-10 motors in STP. Similar breakdowns are seen in STP too.
- Capacity constraints: In those days of the year when rainfall is high, STP plant runs the risk of overflow. The rainwater pipes are routed to STP. As part of long-term solution, we need to re-engineer those piping structure to route to WTP and make positive use.

- Chemicals: We need to keep stock of various chemicals for STP plan to work smoothly

Recommendation

- As a long-term solution, the rainwater pipes need to re-engineer those piping structure to route to WTP and make positive use.

Reuse

Findings and challenges

- There is not much of fluctuation in consumption volume and the STP output is much more than we can reuse. The treated water from the STP is often wasted after being used for flushing, car wash and gardening.
- Currently there is no periodic check of the water quality of the water coming out of the WTP.

Recommendation

- Treated water can be used beyond Springfields and this will need BBMP intervention.
- Periodic check of the water quality of the water coming out of the STP every month, if not every month then at least every quarter.

Dispose

Findings and challenges

- External tankers are reluctant to transport the excess treated water coming out of the STP

- The un utilized water coming out of the STP gets released into the underground drains because of limited capacity/storage

<u>Recommendation</u>

- There needs to be a way to either sell the STP treated water that is un utilized or bartered with clean consumable water
- The treated water can be used in BBMP parks or even used in construction work
- Once the quality of the treated water is known, there needs to be some effort in making the treated water potable and that can be game changes if that is an accepted practice.

Limitations of the report

While this study provides valuable insights into the water supply chain and distribution systems of condominiums, it is not without limitations. First, the number of condominiums, analyzed in the research, was relatively small and may not fully represent the diverse water management practices across all residential complexes in the region whereas a larger sample size, encompassing more condominiums with varied infrastructure and geographic locations, would provide a more comprehensive understanding of water sustainability trends.

Second, the study relied heavily on self-reported data from condominium management teams and residents regarding water usage, conservation practices, and system efficiency. This introduces the possibility of reporting biases, as respondents may have provided estimates rather than precise measurements. Access to more accurate and real-time water usage data, possibly through automated metering systems, would strengthen the reliability of the findings.

Additionally, external factors such as variations in municipal water supply, government regulations, and weather patterns (e.g., rainfall fluctuations) were not fully controlled for, which may have impacted the water availability and management practices of the condominiums during the study period. A longer-term analysis that accounts for seasonal variations and policy changes would offer deeper insights into the sustainability of the water supply chain.

Finally, the study focused primarily on the technical and infrastructural aspects of water distribution, with limited exploration of the social dynamics that influence water use behaviors, such as community engagement, socioeconomic factors, and resident attitudes towards water conservation. Future research could benefit from integrating these social dimensions to provide a more holistic view of how water sustainability can be achieved in urban condominiums.

Despite these limitations, the research offers a foundational understanding of the water supply chain in condominiums and underscores the need for practices that can enhance efficiencies of the end-to-end water supply chain in condominiums.

Conclusion

In conclusion, the analysis of the water supply chain and distribution in Springfield, compared with few other condominiums, reveals significant insights into the challenges and opportunities for enhancing water sustainability in residential complexes in and around Sarjapur region of Bangalore. The findings demonstrate that while most condominiums rely heavily on external sources such as municipal water and private tankers, there are notable differences in how efficiently they manage water distribution, recycling, and conservation practices. Condominiums with advanced infrastructure for rainwater harvesting, greywater recycling, and efficient water metering showed greater resilience to water shortages and reduced dependency on external sources.

The comparative analysis highlights the importance of integrated water management systems tailored to the specific needs of each condominium. Best practices from high-performing condominiums—such as automated water monitoring, low-flow fixtures, and improved physical water infrastructure — offer scalable solutions that other complexes can adopt. Furthermore, effective water management is not only a matter of infrastructure but also of governance, with condominiums that engaged residents and promoted awareness programs demonstrating better water conservation outcomes.

In moving forward, it is essential for condominiums to collaborate with local authorities, adopt stricter water usage policies, and invest in sustainable technologies to ensure long-term water sustainability. By addressing inefficiencies and enhancing community participation, condominiums can play a pivotal role in mitigating urban water stress and contribute to broader water sustainability goals in the city.

Enhancing water efficiency in apartment complexes in Bangalore is both an environmental responsibility and a wise economic choice. It not only contributes to sustainable water management but also yields significant financial benefits for both management committees and residents. This is leading to actions that are cut out for both the resident associations and also the residents.

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