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Accessing Domestic Water Consumption Patterns in Sonipat Town, Haryana, India

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ABSTRACT

Urbanization has driven rising water demand and scarcity globally, resulting in reduced per-person water availability, including India, where current availability is 1486 cubic meters and has fallen by about 75% since 1947. If it dips below 1000 cubic meters per person per annum, India will be pushed into becoming a water-scarce country. This situation exacerbated during the recent Covid-19 outbreak in domestic households. Urban areas are the major consumers in the domestic sectors.

The study explores pattern of domestic water consumption in Sonipat town, Haryana, India to understand the actual water use in various activities and associated habits. A survey of 401 households (with 2003 respondents) was investigated during the summer season on water consumption trends, water availability, activity-wise usage, conservation practices, and awareness.

The study found increased water bill revenue in 18.5% of households from 2019 to 2022. Unfortunately, people are consuming much more water (average 181.0 lpcd) than recommended. Showers and conventional flush toilets contribute significantly to water consumption. Households adopted low water conservation practices were found to consume significantly higher amounts of water. 64% of respondents showed readiness to adopt water efficient technologies if the government provides incentives or subsidies.

Proposed strategies: 1) Installing water-saving fixtures with subsidies to improve water efficiency; 2) Urgent information dissemination to encourage water conservation. In conclusion, this study highlights the urgent need for water demand management in urban areas to ensure the sustainable use of water resources while alleviating the challenges posed by increasing water scarcity.

Keywords *Covid-19, urban households, water consumption, water demand management, water saving measures, water scarcity, water-use habits*

INTRODUCTION

The growing water crisis is a significant concern as development continues to accelerate. The increasing population is also contributing to a rise in water demand in the domestic, industrial, and agricultural sectors. According to the United Nations, the world population is projected to increase by 2 billion in the next thirty years, reaching 9.7 billion by 2050 from the current 8 billion. Consequently, more than half of the world's population is expected to face water shortages by 2050 [1]. The reason behind this crisis is the improper management of the fresh water resource [2], which constitutes only 2.5% of the total water available on Earth (333 million cubic miles).

In 2019, the World Resource Institute (WRI) revealed that 17 countries, constituting one-quarter of the world's population, are facing 'extremely high' levels of baseline water stress. In these countries, various sectors withdraw more than 80% of their available water supply on average annually. Among the water-stressed countries, India ranks 13th and has a population of more than three times the combined population of the other 17 highly stressed countries [3].

In 2023, Times of India (ToI) conducted a status check on the seriousness of India's water crisis. The report revealed that the per capita water availability has fallen by about 75% since 1947. Experts warn that the situation could worsen in the coming years, considering the current water use and abuse patterns [4]. India's water availability has shown a declining trend over the years, dropping from 1820 cubic meters in the year 2001 to 1651 in 2011, and further reducing to 1486 in 2021. With only 1486 cubic meters of water available per person per year, India is currently categorized as a water-stressed country. There is a concern that if this trend continues, India could potentially turn into a water-scarce country. To prevent such a situation, it is crucial to manage water resources sustainably [5].

The manner of water consumption has compounded the water crisis problem in India. Both ground and surface water resources in the country are in a dangerous condition, which could lead to water scarcity in the next 40 years. According to the Central Ground Water Board (CGWB), indiscriminate use of ground water resources has resulted in 4% of the total 7089 units assessed being classified as 'critical' and 14% as 'over-exploited'. The situation was even worse in 2011, when 16.2% of units were classified as over-exploited [6,7].

Government organizations are actively working on the water crisis issue to reduce the pressure on fresh water resources [8]. Efforts made for water conservation and recharge, such as Jal Shakti Abhiyan (JSA) and Atal Bhujal Youjna, have improved the situation of water-stressed areas. However, despite these efforts, the concentration of over-exploited units in the states of Tamil Nadu (31%), Rajasthan (73%), Punjab (76%), and Haryana (62%) remains high [3].

Out of the available 4% of the world's freshwater resources, India predominantly utilizes water for agricultural purposes (91%), followed by industrial (7%) and domestic use (2%). The domestic sector consumes 56 cubic meters of water every year, with the majority of water being used by urban areas. On average, the urban population in India consumes 195 liters per capita per day, compared to the global average of 135 lpcd [9]. The urban population in India is projected to increase from 600 million in 2030 to 877 million by 2050, which will impose further pressure on water resources [10].

The significant increase in household water demand in urban areas is attributed to the rise in disposable income, leading to a change in water consumption patterns, with the use of more water-intensive products [11]. The household water using habits and water demand is growing due to increased water consumption in personal hygiene and use of more water consuming appliances as a result of increasing standard of living [12]. Reducing water consumption and improving water efficiency in households are crucial steps towards sustainable water management [13]. To achieve this, it is essential to understand how water is being used per person for various purposes. The need for such studies has increased in recent years for policymaking and providing tailor-made solutions for targeted households [14]. The study aims to investigate the current domestic water consumption pattern in Sonipat town, Haryana, India for effective water demand management in urban households. Water demand Management (WDM) aims at reducing average water consumption in order to improve sustainable use of water resources by managing water more efficiently and responsibly [15,16]. If utilized effectively, it can increase water supply by reducing water wastage, optimizing usage, and improving overall water efficiency by utilizing existing water resources more effectively. Further, helps alleviate water stress in water scarce regions.

Material and methods

Description of the Study area

The study has been carried out in Sonipat town, a Municipal Corporation (MC), situated at $77^{0}01$ Longitude

and $28^{0}57$ Latitude (Fig-1). It has a population of approximately 427,270 inhabitants, and around 85,454 households [17]. The town covers a land area of about 103.90 km². The city's economy relies heavily on industry and agriculture.
The Yamuna River flows to the east of Sonipat city, serving as the boundary line separating Haryana and Uttar Pradesh. The city's topography is mostly flat, and the area is characterized by fertile alluvial soil known as Khaddar. Rainwater within the city is collected in drains and ultimately discharged into the Yamuna River [18]. The region falls within the sub-tropical region of Haryana, India. In this area, the summer season spans from March to October, featuring high temperatures, while the winter season, from November to February, brings colder temperatures. Notably, the Yamuna River, flowing to the east of Sonipat city, also acts as the boundary line between Haryana and Uttar Pradesh

Sonipat town is located around 50 kilometers by road and 44 kilometers by rail from Delhi. It is situated on National Highway 44 (NH-44) and has excellent connectivity with major cities such as Delhi, Panipat, and Chandigarh. The city has witnessed a significant influx of population from Delhi due to the development of infrastructure projects such as the western peripheral (Kundli-Manesar-Palwal) and eastern peripheral (Kundli-Ghaziabad-Palwal) expressways, as well as the establishment of industrial activities. This growth has led to a significant demand for residential properties in recent years, creating challenges in water supply services in certain areas. Additionally, the recent COVID-19 pandemic has further exacerbated the situation, leading to water shortages in specific areas as reported by Municipal Corporation (MC) and Haryana Shahri Vikas Pradhikaran (HSVP).

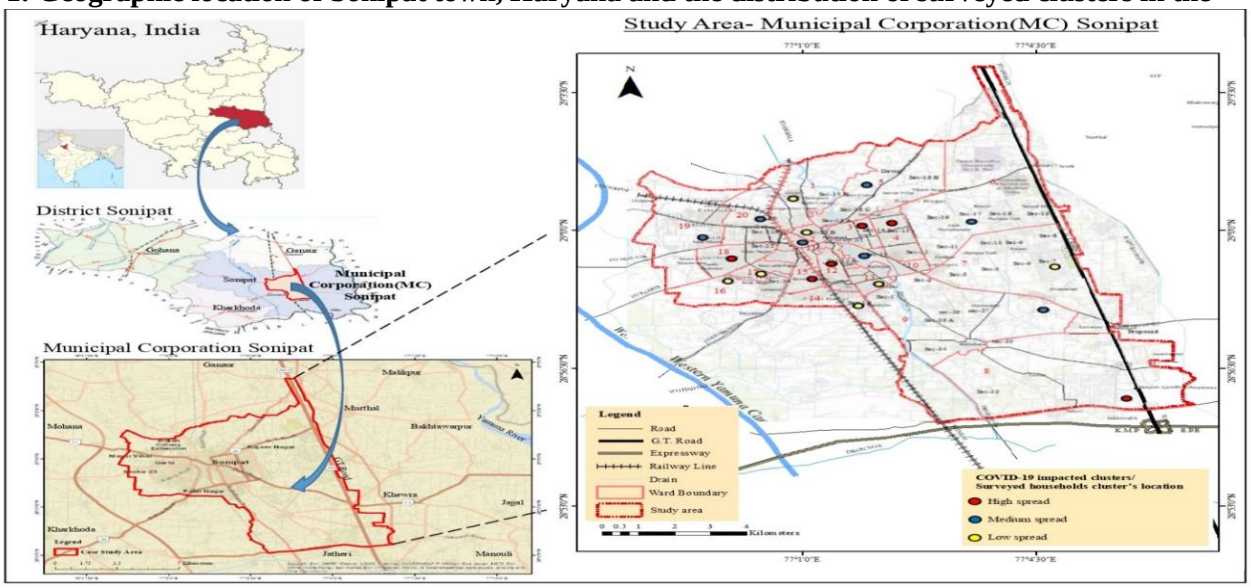
The water utilities supply a domestic water of 60.2 million liters per day through various water sources, including ranney wells, the western Yamuna canal, and tube wells. However, the town falls short in terms of domestic water supply coverage and metering requirements, as it fails to meet the standards set by Central Public Health and Environmental Engineering Organization (CPHEEO) service level benchmarking [19, 20]

Sample selection

Out of the 85,454 households in Sonipat town, 700 were selected (approx. 35 households from each ward) to achieve a sample size of around 383 households. This selection considered a 5% margin of error, a 95% confidence level, and an expected response rate of 50-60%. However, only 401 households provided responses, resulting in a total of 2003 respondents from these households.

The Sonipat municipal corporation consists of twenty wards. The wards were categorized according to three different clusters, (i) High Covid-19 spread clusters, (ii) Medium Covid-19 spread clusters, and (iii) Low Covid-19 spread clusters. Within these identified clusters, a random sampling of households from electoral rolls was undertaken (Fig-1).

Fig-1: Geographic location of Sonipat town, Haryana and the distribution of surveyed clusters in the



town.

Data Collection Method.

This study utilizes an interdisciplinary, mixed-method, and cross-sectional design approach. A primary survey was conducted to investigate per capita water consumption pattern. The survey took place during the summer season in two phases, from July 2022 to August 2022. In order to quantify the seasonality impact, there is a need to conduct a similar study in the same region to report variations in water consumption during winter season. The survey instruments were created in both English and Hindi to accommodate the local population of Sonipat town.

In the first phase, a questionnaire survey was conducted to gather information on household size, water availability, activity-wise water consumption habits, water conservation practices, and awareness levels. The questionnaire included a combination of closed and open-ended questions. Due to the variability in activity-wise water consumption habits and awareness levels, face-to-face interviews was conducted with each household member while some common questions were asked from the head of the household. Sundays were chosen as survey days, with interviews scheduled after 10:00 am to increase the likelihood of availability among working respondents.

This was followed by a diary survey in phase-2 among the same respondents. They were provided with a weekly diary form to keep a log of their daily water consumption and habits over period of seven days to analyze the variability if any across various activities, such as toilet, bathing, laundry, hand washing, kitchen, garden watering, vehicle washing, drinking, and any other relevant activities. The diary form included closed-ended questions on each water consuming activity constituted questions on frequency of performing an activity, method used/technological preferences, duration of an activity, flow rate (quantity of water coming out in liter per minute), volume of vessel/bucket/ bottle used to store water, type of faucet (e.g., old style or aerator), flush tank capacity, and mug capacity. Households were visited twice to verify their logbook details regarding various activities through direct field observation and measurement. The filled diary forms were collected after one week to determine the average water consumption per person. This primary survey method was employed due to the lack of 'smart water meters' technology in most developing countries, such as India. Smart water meter identifies the pattern of water usage in real-time and assigns these patterns to specific end-use with the help of pre-installed software. These smart water meters also have the provision of transferring the data obtained, to electrical devices without any human assistance [21]. The data thus obtained from these smart devices are useful in devising better water conservation strategies and water planning for a better water distribution system to households in urban settings [22]. During the questionnaire survey, respondents fully participated and provided information without expressing any explicit resistance. However, in the diary survey, the response rate was 60%, indicating that 40% of the surveyed respondents were unable to provide

a response on the quantity of water consumed by them.

However, a secondary survey was conducted to collect the water bills of the surveyed households from the Haryana Shahari Vikas Pradhikaran (HSVP) and the Public Health Engineering Department, Haryana (PHED). This data was used to analyze the water consumption trend from the year 2019 to 2022. The collected data was analyzed using SPSS IBM Statistics with the help of descriptive statistics analysis tool.

Estimation of water consumption

The total water consumption for various activities such as cooking, drinking, gardening, vehicle washing, and house cleaning was determined by multiplying the number of vessels/buckets used daily with their respective volumes on a household basis and later on, it was divided by the total number of household members. For activities involving running tap water or showers, the quantity of water coming out per minute was multiplied by the duration and frequency of the activity daily. In case of bucket bathing, number of buckets used daily, along with their volumes, was taken into account. Water consumption for flushing toilets was calculated by measuring the flush tank or bucket capacity and multiplying it by the frequency of flushing. Cloth washing using a washing machine was assessed based on the daily average water consumption, considering factors like load capacity, type of washing machine, washing frequency, and household size. Subsequently, the average water consumption per day was divided by the total number of households to find out per capita water consumption. In the calculation, every effort was made to ensure the accuracy of the assessment. These estimates on water use in different activities may include uncertainties caused by seasonal variations in consumption.

RESULTS AND DISCUSSION

Daily domestic consumption of water

The daily domestic water consumption by the individuals of Sonipat town has been estimated as 362,570 liters (0.36 MLD). The average number of members per household was found to be five in the majority of the samples. Table 1 represent the water consumption of the surveyed respondents across twenty wards of the Sonipat town. The wards with the highest daily per capita water consumption, over 200 liters, were ward numbers 3, 10, 12, and 18. These wards are located in the city core, which has the maximum population density compared to other wards (Fig-2). This higher consumption is may be due to the reason that 65% of the households in these wards are using sizable amount of water use appliances, 45.3% of them are not using any of the water conservation measures and 50.2 % have low level of awareness regarding water sources, GW availability and conservation measures.

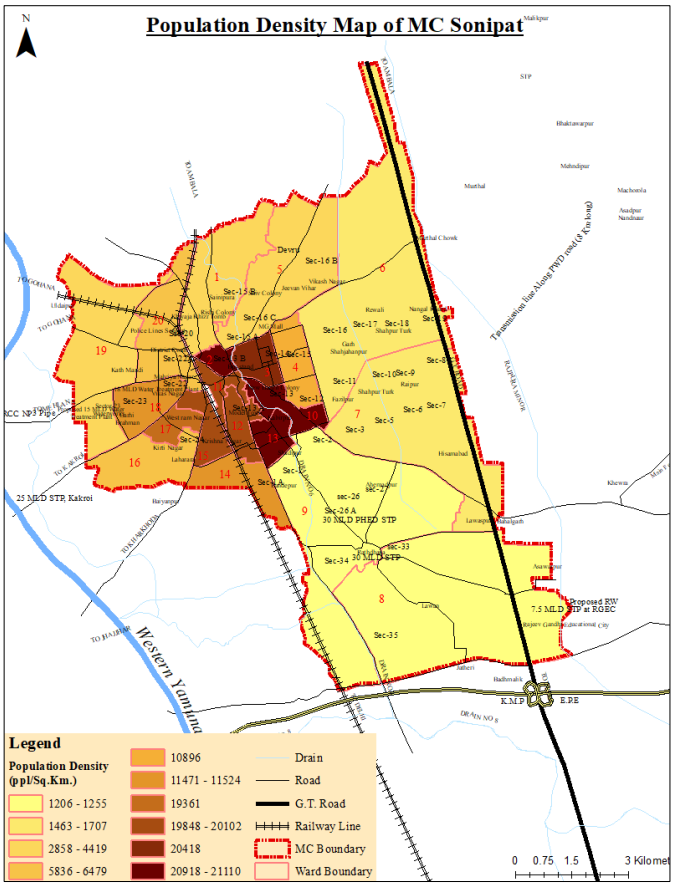
On the other hand, wards no. 6 had the least water consumption, avg. 82 lpcd. This may be due to water accessibility concerns (outside premises) in 67% of the households in this ward (Table 1).

Table 1: Number of surveyed respondents and their water consumption across various wards in Sonipat town

Ward No.	Avg. water consumption (lpcd)	Total water consumption (L)
1	197	19671 (5%)
2	176	17626 (5%)
3	217	21724 (6%)
4	196	19623 (5%)
5	173	17336 (5%)
6	82	8248 (2%)
7	154	15443 (4%)
8	155	15452 (4%)

Fig-2: Population density map of Sonipat town, Haryana

9	195	19501 (5%)
10	215	21509 (6%)
11	169	16907 (5%)
12	201	20130 (6%)
13	195	19506 (5%)
14	196	19567 (5%)
15	194	19404 (5%)
16	202	20204 (6%)
17	143	14251 (4%)
18	201	20133 (6%)
19	184	18445 (5%)
20	174	17890 (5%)
Total	181	362570 (100%)



Water consumption trend analysis

The water consumption trend in the sample households was analyzed over the period from 2019 to 2022. This analysis became even more important due to the recent COVID-19 pandemic. The Junior Engineer, Civil, MC, reported that they had borrowed 2 MLD of water from HSVP to balance the uncontrolled domestic water demand caused by the sudden hike in COVID-19 related precautionary measures [20]. However, due to limited records, the analysis was based on water bills from about 200 households for the study area's projection.

During 2019, the total water bill of 200 households was Rs. 341498. In the following year, 2020, there was a significant hike of 22% in water bill revenue compared to the base year of 2019. In 2021, there was still a noticeable hike of 14.3% from the base year, but it was lower than the increase observed in 2020. Finally, in 2022, the water bill revenue showed a minimal hike of 1.7% compared to the base year 2019, with a total revenue of Rs. 347,547, making it similar to the status in 2019 (Fig 3).

During the period from 2020 to 2022, it was also noticed that the revenue from water bills subsequently increased in 18.5% of households, which may be attributed to the increase in hygiene-related precautionary measures due to the recent pandemic. It is important to note that there was no change in the water tariff during the mentioned years.

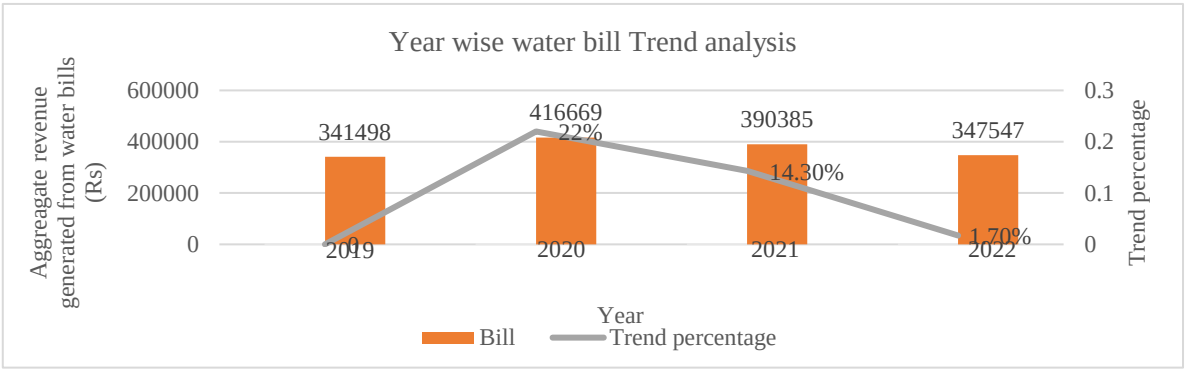


Fig-3: Households' water consumption trend analysis from the year 2019 to 2022

Water availability status

Fig 4 showing a histogram comprising the distribution of the daily average per capita water consumption for the whole sample, suggesting that an average per capita domestic water consumption in the town is approximately 181 liters per day. In spite of the CPHEEO water supply standards are being followed in Sonipat city (135 lpcd, MC Sonipat), this study found that the average water consumption of Sonipat town is 181 lpcd. 41% of the respondents are consuming water over and above 200 lpcd while approx. 16% are consuming water below 135 lpcd (Table-2).

The Central Public Health and Environmental Engineering Organization (CPHEEO) defined water supply level of 135 lpcd for cities provided with piped water supply where sewerage system is existing [23]. As per the Bureau of Indian Standards, IS 1172:1993, a minimum water supply of 150 to 200 liters per head per day (lphd) should be provided for communities with a population above 100,000, along with a full flushing system. Also mentions, for houses in Low-Income Groups (LIG) and Economically Weaker Sections of Society (EWS), the water supply may be reduced to 135 liters per head per day, depending upon prevailing conditions. Additionally, a minimum of 70 to 100 lpcd may be considered adequate for the domestic needs of urban communities, excluding non-domestic needs such as flushing requirements [24]. The World Health Organization (WHO) classified the water used in the home into four access level categories: (i) inadequate access (quantity collected can be below 5.3 L/person/day) (ii) Basic access (average quantity unlikely to exceed 20 L/person/day) (iii) Intermediate access (average quantity about 50 L/ person/day) (iv) Optimal access (average quantity more than 100 L/ person/day) [25].

Despite the recommendations provided by various organizations, it is important to note here that every municipal corporation/municipality in India has defined daily domestic water requirements per person differently. Notably, industrial and commercial development in towns, cities, and mega-cities can lead to varying water demands due to different industrial processes and commercial activities. In contrast, the requirement for domestic water use is unlikely to vary significantly [26].
For instance, the municipal corporation of Nagpur (NMC) has defined a per capita water supply of 100-110 liters per day [27], whereas the Delhi Jal Board (DJB) targets a water supply of 225 lpcd to meet the demand for potable water for domestic use [28]. Additionally, in the Haryana Sub-Region, the daily water supply per person in urban centers varies from 110 lpcd to 145 lpcd, with an average of 135 liters of water per capita per day in the study area [29].

Table 2: Domestic water availability status in Sonipat town

Water consumption (lpcd)	Respondents count (N=2003)	(%)
<100	232	11.6
100-134.9	95	4.7
135-150	114	5.7
150.1-200	741	37
>200	821	41

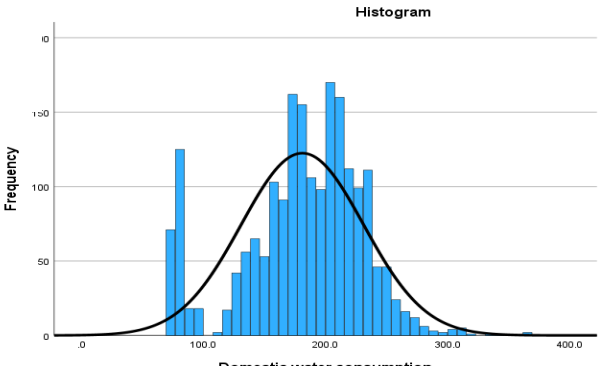


Fig-4: Frequency distribution of average per capita water consumption in Sonipat town(l/p/d)

A comparative analysis: Activity-wise per capita water use variations and CPHEEO water use break-up

A household domestic water consumption was classified into number of activities, such as bathing, toilet flushing, hand washing, utensils washing, laundry, house cleaning, drinking, cooking, garden watering, and vehicle washing. It was observed that bathing accounted for the highest amount of water consumption per capita per day, making up 32% of the total consumption.

Table 3: A comparative analysis between activity-wise distribution of water use per capita per day in Sonipat town and CPHEEO daily per capita water use break- up

Activities	Daily water consumption (lpcd)	CPHEEO water use breakup (lpcd)
Bathing	58 (32%)	55
Toilet flushing	38.4 (21.1%)	30
Hand washing	24 (13.2%)	x
Utensils washing	20 (11%)	10
Laundry	18.5 (10.3%)	20
House Cleaning	6.3 (3.6%)	10
Drinking	6 (3.3%)	5
Cooking	5 (2.8%)	5
Garden watering	3.3 (3%)	x
Vehicle washing	1.1 (0.6%)	x
Total	181	135

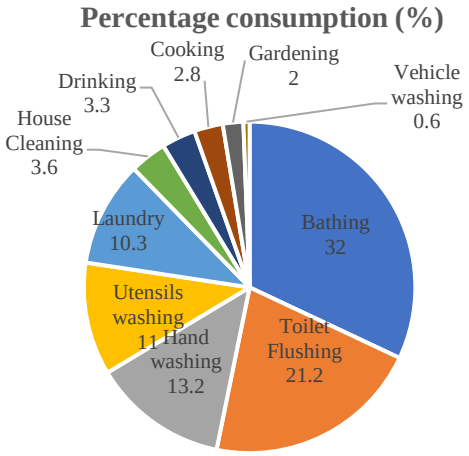


Fig-5: Percentage distribution of water consumption for various activities in Sonipat town

This is followed by water consumption in flushing (21.2%), hand washing (13.2%), utensils washing (11%), laundry (10.3%) and house cleaning (3.6%). On an average, 6.1% of the water was used for cooking and drinking purposes. The per capita water consumption for outdoor activities, such as gardening and vehicles washing, was found to be the least, 2.6% of the total consumption (Table 3, Fig 5).

Table 3 presents the recommendations of Central Public Health and Environmental Engineering Organization (CPHEEO) regarding the breakdown of 135 liters per capita per day (lpcd) of domestic water consumption [30]. The survey results revealed that the quantity of water used by the respondents for bathing, toilet flushing, and utensil washing exceeded the recommended standards. On the other hand, water consumption for laundry, house cleaning, drinking, and cooking was found to be close to the recommended standards. To investigate the reasons behind these findings, individual water consumption habits were further analyzed.

The respondents reported an avg. 28.4 lpcd of water consumption in other activities such as handwashing, garden watering and vehicle washing. However, the standards do not specify a particular value for water use in handwashing, garden watering, and vehicle washing. Interestingly, a significant increase in water consumption for handwashing, possibly influenced by changes in habits due to hygiene-related practices that emerged from the arrival of the Covid-19 pandemic.

Activity-wise water use habits

This is important to study the individual water consumption habits within the household which leads to better understanding of household water consumption patterns and trends [31] (Fig-6). The key findings of each water consuming activity are explained in the following sections.

Shower and bath

Showering and bathing constitute highest water consumption in the households, making up 32%(58 lpcd) of the total consumption per person. In many counties, taking showers is becoming the norm representing a transition from bucket bathing and flannel washing [32]. In spite of the fact that people are shifting on shower, bucket bathing is still the common bathing mode among the residents [33]. The same practice was observed in the study

area, 83% of the participants taking bath using buckets and only 17% use showers for full body wash. Individuals typically spend around on average 5 minutes per shower.

Interestingly, during the survey, it was noticed that 59% of the respondents prefer baths/showers twice per day. 38% bath/shower once a day, while 3% bath/shower thrice a day. Despite the higher usage of buckets, the water consumption of showers remains significantly higher, at 92.9 lpcd, compared to bucket baths, which is 51 lpcd. This is due to the reason that the majority of the participants still has old type of shower heads in their house that utilize on average10 liters per minute. It was also reported that the type of shower and duration of shower directly impacts on the amount of water consumption [33]. This can be reduced by adopting water-efficient showers which can save approximately 4 to 20 liters per minute by using flow restriction technology [30] (Table 4). It is noteworthy that none of the selected respondents were observed to use bath tubs for bathing.

Toilet flushing

Flushing accounted for the second-highest water consuming activity among the households, which is 21.2% (38.4 lpcd) of the total water consumption per person. The frequency of toilet flushing was found to be approximately five times a day (two full flushes + three half flushes). It was observed that, on average, 3 liters per flush are utilized in pour flushing, followed by dual flush toilets, which consume an average of 6 liters in full flushes and 3 liters in half flushes. Further, single flush toilets use about 10 liters per flush. The reason for the second-highest water consumption under flushing activity is attributed to nearly half of the respondents still using conventional single flush cisterns (69%). This is followed by dual flush (20%) and pour flush toilets (11%). This can be reduced using water efficient retrofit devices and fittings such as cistern displacement or variable flush devices reduce flush volumes of old water closets [33]. The water efficient toilets use only 6 liters per flush, can reduce that figure to 30 liters per capita per day [34, 35, 47]. Additionally, application of water efficient retrofit devices and fittings such as cistern displacement or variable flush devices reduce flush volumes of old water closets [33] (Table 4).

Hand washing

The questions related to hand washing frequency were asked, such as whether people wash their hands after using the toilet, before meals, after meals, before cooking, after cooking, before touching eyes/nose, after touching eyes/nose, etc. In the study area hand washing accounted for 13.2% (24 lpcd) of the total water consumption per person. People wash their hands on average for 30-40 seconds per hand washing. Remarkably, 95% of the people responded that they wash their hands more than five times a day.

In terms of hand washing habits, 84% of respondents prefer to use running taps, while only 4% use the tap with intermittent closing. Additionally, 12% of respondents use a mug for hand washing. The maximum water consumption was observed in hand washing with running tap and without aerator faucets. Additionally, by installing aerators in sink faucets in short term (table 4). Aerators break the flowing water into fine droplets and entrain air while maintaining wetting effectiveness. Thus reduces the water consumption by 60% while still maintaining a strong flow [34, 35, 47]. Additionally, spreading awareness among the inhabitants regarding the scarcity of water resources and by encouraging changes in handwashing habits, such as intermittent closing of taps while washing hands, may contribute in the long term.

Utensils washing

Utensils washing accounts around 11% (20 lpcd) of the per capita total water consumption. It was observed that manual dish washing is the common practice among the households instead of mechanical dishwasher technology. Each utensil washing activity took an average of 10-15 minutes per household or 3 minutes per person. Washing utensils twice a day was a common practice in households. The least water consumption was observed in respondents using a tub/bucket for utensils washing. 79% of respondents use old-style faucets and running water for washing utensils, resulting in maximum water consumption. The flow reduction in these taps can be achieved by using faucet aerators [34], which can save water up to 50% in kitchens [35] (Table 4). Manual dish washing consumes more water as compared to fully loaded dishwasher [36]. Therefore, changing habits of utensils washing by intermittently closing faucets and by adopting water-efficient fixtures would be an appropriate option for water conservation. However, it is important to note here that the cost of dishwashers is still very high for many people in India.

Laundry

Washing clothes constitutes 10.2% (18.5%) of the total water consumption per person. Nearly half of the respondents prefer doing laundry once every two days (four times per week), followed by 31% of the respondents who prefer washing clothes once a day (seven times per week). Meanwhile, 10.7% wash their clothes 14 times a week and 2 times a week. Among the participants, 62% use a washing machine for clothes washing, while 38% wash clothes manually. Among washing machine users, those with top-loading machines (18%) consume the

highest amount of water (135 liters/wash), followed by those with semi-automatic machines (25%, 115 liters/wash) and front-loading machines (19%, 58 liters/wash).

The majority of the respondents stated that they generally run the washing machine at half load. Washing clothes when the machine is fully loaded is more efficient than manually washing clothes [33]. Further, front-loading washing machines are more efficient, both in terms of energy consumption and water use, using only half the water compared to top loaders [37, 34] (Table 4).

House cleaning

Cleaning of house accounts around 3.6% (6.3 lpcd) of the per capita total water consumption. House cleaning using bucket was mainly observed in the households in the Sonipat town. Cleaning of house at least once a day was the prevalent practice found in 87% of the households. Even 13% of the respondents did the cleaning of their house once in two days. Domestic wastewater constitutes of waste water from kitchen, laundry and air conditioning is called grey water. It can be used by households for house cleaning and other innovative ideas to save water [34].

Drinking and Cooking

Drinking and cooking constitutes 3.3% (6 lpcd) and 2.8% (5 lpcd) of the total water consumption per person respectively. Overall, there was no such variation found under cooking and drinking water consumption among the respondents. Average water consumption found under the cooking was 5 lpcd and under drinking was 6 lpcd in the surveyed households.

Garden watering

On average 2% (3.3 lpcd) of the total water consumption per person per day was accounted for by watering the house garden or lawn. More than half of the respondents have a lawn, plants, or a garden on their premises. Out of them, almost 31% of the respondent's water plants once in every two days (3-4 times a week), followed by 17% who water twice a day (14 times a week) and only 7% water once a day (7 times a week). Nearly half of respondents use a pipe for watering the garden rather than a bucket. The maximum water consumption was observed with the use of a pipe compared to the bucket. On average, respondents invest 5 minutes in watering plants. No household was found using sprinklers or other water-saving modes for watering. The best way to save water in gardening is to practice appropriate garden watering practices, watering plants during the best times between 4 to 8 am or 8 pm and midnight [34].

Vehicle washing

Vehicle washing constitutes of 0.6% (1.1 lpcd) of the total water consumption per person. On an average, respondents invest 8.5 minutes in vehicle washing on their own using pipe. It is important to note here that, 87% of the respondents owned a vehicle and among them only 15% households prefer to wash their vehicle from outside and nearly half of the respondents wash vehicle once/twice a month using pipe and 22% wash once a week. No household was found using bucket or wet cloth or other mode of washing to save water. It is recommended using wet cloth and to patronize public car wash services that reuses water [34].

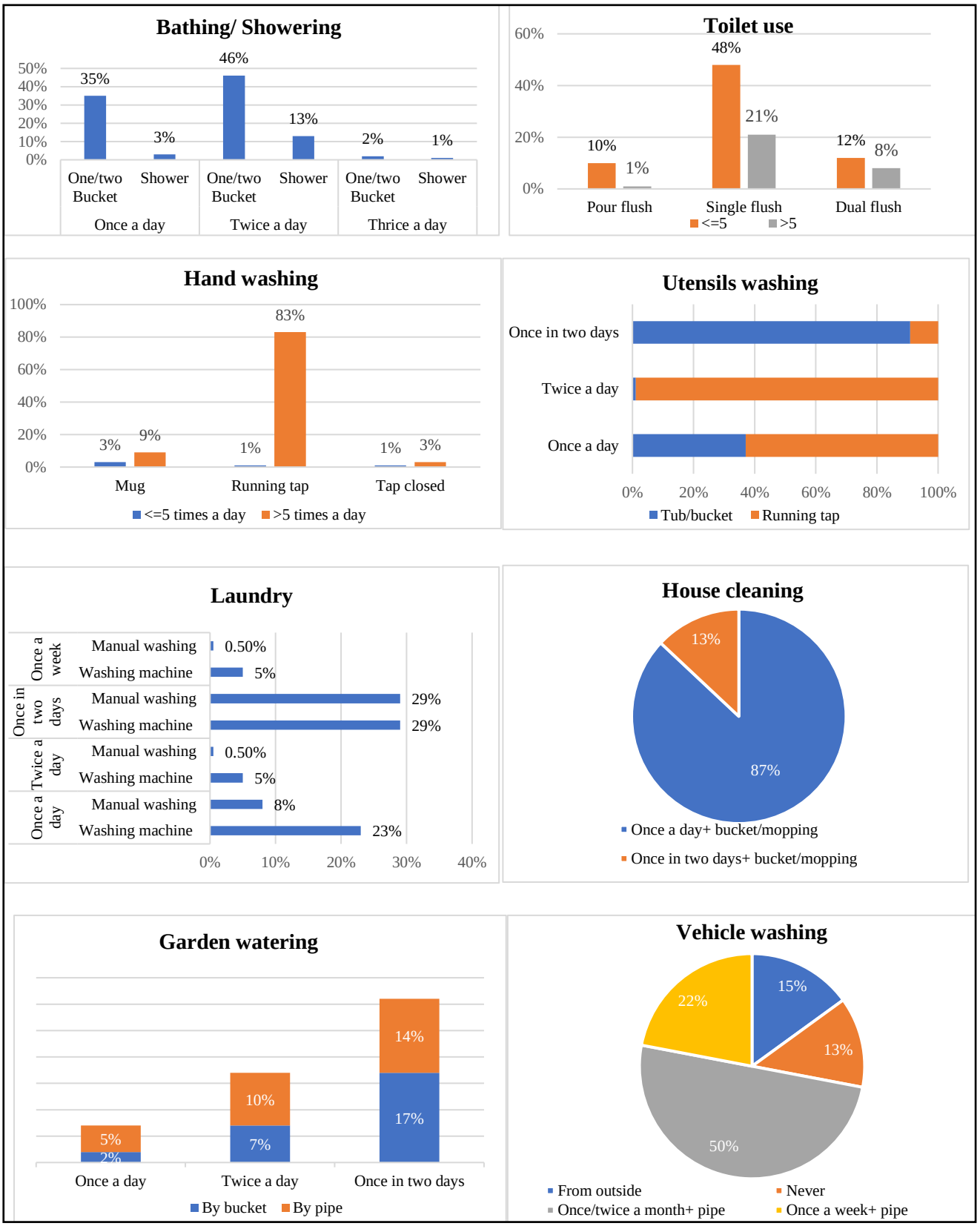


Fig-6: Results of activity-wise water use habits

Table 4: Comparison of water use practices/devices installed in Sonipat town with the water use practices/water-efficient devices recommended by various agencies

Activities	Available fixtures in Sonipat town	Avg.water consumption in Sonipat town		Recommended water efficient measures	Water use	Water saved
Bathing (58 lpcd)	Bucket (83%)	51 lpcd	18 L/ bath			-
	Old type shower (17%)	92.9 lpcd	11 L/ minute	Bathing with low flow showerhead CSE, 2011 *or* Bathing with bucket [47]	18 liter/bath	4-20 liters/minute *or* 74.9 lpcd
Toilet (38.4 lpcd)	Single Flush (69%)	48.4 lpcd	10 L/ flush	Dual flush [47]	6 L/flush	4 liters/flush
	Dual Flush (20%)	20 lpcd	4.2 L/ flush			
	Pour Flush-Mug/ Bucket (11%)	9.6 lpcd	3 L/ flush			
Dish washing (20 lpcd)	Conventional tap fittings (79%)	22.3 lpcd	8 L/ minute	Using aerator faucets (secondary survey)	5 L/minute	3 L/minute
	Aerator taps (9%)	14.2 lpcd	5 L/ minute			
	Tub/bucket					
Hand washing (24 lpcd) (avg time 30-40 seconds/wash)	Running tap (84%)	27.1 lpcd	4L/wash	Washing hands with mug [47] *or* Installed sensors tap [35]	0.5 L/wash *or* 2L/minute	2-3.5 liters
	Intermittent closing (4%)	13.8 lpcd	2L/wash			
	Mug (12%)	5.7 lpcd	1L/wash			
Laundry (18.5 lpcd)	Washing cloths using top loading washing machine (18%)	26.1 lpcd	135 L / housh.	Washing cloths using front loading washing machine (secondary survey)	58 liter/load	2-3.5 liters
	Washing machine fully automatic-front loading (19%)	10.2 lpcd	58 L/ housh.			
	Washing machine Semi-automatic (25%)	13.7 lpcd	115 L/ housh.			
	Manual washing (38%)	22.1 lpcd	36 lcpd / wash			

Impact of water conservation practices adopted on average water consumption

In this study, the level of water conservation practices adopted was categorized as low, moderate, and high based on the calculated score of the respondent's responses regarding water conservation practices/fixtures they had adopted (such as low-flow showerheads, dual flush toilets, aerator faucets, front-loading washing machines, hand washing with intermittent closing, use of grey water) (Table 5). Additionally, the average water consumption was calculated for each category to assess the impact of the water conservation practices on overall water consumption.

The p-value result, which was less than .05, revealed that households that had installed a wide range of water-saving fixtures consumed significantly less water per capita per day. In contrast, households with minimal or limited water conservation practices in place were found to consume significantly higher amounts of water. It is presumably attributed to their lack of awareness regarding water conservation.

Table 5: Relation of water conservation practices adopted and average water consumption per capita

Water conservation practices adoption categories	Respondents count (n=2003)	Average water consumption (lpcd)
Low	1839 (92%)	184
Moderate	128 (6%)	155
High	36 (2%)	138
p-value <.05		

Proposal- Water conservation by changing water use habits (long term plan) and installing water saving fixtures (short term plan)

Adoption of water-efficient devices can significantly reduce water consumption in short term. Currently, fewer people have installed water-efficient fixtures, and there is also limited awareness regarding water conservation technologies. However, they have shown readiness to adopt these technologies if the government provides subsidies or incentives.

The water saving potential from the application of these technologies is clearly evident in Table 4, which shows that the installation of these devices would result in substantial water savings in various water use activities. Devices such as low-flow showerheads, dual flush toilets, aerator faucets, dishwashers, and front-loading washing machines can play an important role in reducing water consumption by using water more efficiently. The maximum water savings can be achieved in bathing, utensil washing, and laundry activities in Sonipat town. The survey on the 'adoption of affordable water-saving devices/fixtures' revealed that 64.2% (257/400) of the households are willing to apply water saving devices if the government provides subsidies or incentives for water conservation fixtures. This clearly indicates their readiness for advancements in water-saving technology and the need for certain initiatives in this regard. Currently, fewer people have installed water-efficient fixtures. Adoption of water-efficient devices can significantly reduce water consumption in short term.

However, the survey on the 'awareness level' (water conservation, water sources and ground water availability) observed low level of awareness in 55% of the households. Additionally, a great impact can be achieved if people start noticing their water use habits and reduce water wastage in activities such as washing hands with running water, brushing teeth with running water, shaving with running water, long showers, etc. An awareness campaign about the best practices in these activities can play a significant role in conserving water in the long term. By devising strategies and policies centered around disseminating information on water use habits and the installation of water-efficient fixtures, not only reduce water consumption significantly, but also help in alleviating water stress in water-scarce regions by increasing water supply in such areas.

CONCLUSIONS

Although fresh water is recycled by nature, it is a limited resource. Urbanization-led water demand is the major cause of the reduction in per capita water availability. Various municipal corporations/municipalities/authorities, such as Delhi Jal Board and Town and Country Planning Haryana, have progressively reduced per capita water supply over the years due to the fast pace of urbanization, high rates of groundwater withdrawal, and lack of groundwater recharging. The problem has accelerated due to the migration of people to urban areas in search of livelihood. In Sonipat town, a significant influx of population was observed from Delhi due to infrastructure development as well as the establishment of industrial activities. This large influx of urban population imposes further pressure on water resources.

It was observed that the majority of the respondents in Sonipat town are consuming water above the norms laid by Central Public Health and Environmental Engineering Organization. The high consumption is attributed to a lack of awareness regarding water conservation habits and the implementation of water-efficient devices that could significantly reduce water consumption in various activities. Subsidies and incentives may also be useful in reducing water use by effectively installing water-efficient fixtures.

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