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Estimation of Water Utilized for Washing Vehicles in Shrigonda Town, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The rapid growth of urbanization leads to the demand for new vehicles. With increasing numbers of new vehicles, vehicle washing centers also increased. Most of these washing centers are used groundwater. As a result, the groundwater level is decreasing, leading to a shortage in the volume of groundwater. Therefore, the present study has observed 13 vehicle washing centers during the dry and wet seasons to calculate the water used to wash vehicles. The student t-test and one-way ANOVA test have been applied to test seasonal variation in water use for wash vehicles using SPSS software. During the study, 762 and 982 vehicles were observed in the dry and wet seasons, respectively. The result revealed that in the dry season, the mean water used to wash motorbikes was (95.83L), cars (219.62L), light motor vehicles (235.64L), and heavy transport vehicles (300.79L). On the other hand, during the wet season, the mean water volume used to wash motorbikes was (128.28L), cars (258.79), light motor vehicles (290.89), and heavy transport vehicles (415.40). During the dry season, 102301 liters per day, and in the wet season, 168114

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liters per day of groundwater was used at the vehicle washing centers in Shrigonda town and discharged wastewater into the sewer system. The local Municipality has no guidelines, regulations, or monitoring mechanisms for effluent discharge in a sewer system. Therefore, an attempt has been made to calculate the quantity of groundwater utilized by all washing centers in Shrigonda town, which will be helpful to the Municipality in taking appropriate action.

Keywords: Groundwater; washing centers; wastewater; seasonal variation.

1. INTRODUCTION

With the increasing population and urbanization increase, the demand for potable water [1]. Due to anthropogenic activities, water resources are exposed to pollution, leading to water shortage [2]. Now a day's, various techniques are proposed and used to deal with water shortage, viz recycling wastewater, rainwater harvesting, etc. [3]. Amongst the water-saving option, wastewater recycling through treatment is significant [4]. Vehicle washing is a leading industry with high water consumption and wastewater generation with several pollutants [5]. The variety of vehicle washing facilities is rapidly growing with the number of automobiles. Washing is essential for maintaining the vehicles in good condition. The washing of vehicles needs a massive quantity of water. After washing, it releases dangerous chemical compounds due to the use of the cleansing solution in the surrounding through the release of unprocessed wastewater solvent-based chemicals, oil, grease, and detergent harm living organisms. The properties of effluent water were also greatly affected by soil on a vehicle [6]. Generally, vehicle washes wastewater contains suspended solids, oils, grease, detergent, and cleansing solutions [7]. All vehicle washing centers in Shrigonda town discharge effluent to the sewer system without any treatment. The local Municipality has no guidelines, regulations, or monitoring mechanisms for effluent discharge in a sewer system.

About 150 to 350 liters/day/vehicle of wastewater is generated from vehicle washing. All this untreated wastewater is discarded into a sewer system. Therefore, it is dangerous to aquatic and terrestrial ecosystems. The pollution level in vehicle washing wastewater is lower than wastewater from industrial wastewater. However, the direct discharge of sewage holding soil and sand particles, grease and oil, chemical agents, washing powder, hydrofluoric acid, and phosphates is boosting the level of pollution [8]. The treatment of wastewater purification is an easier procedure and can be treated efficiently with minimum efforts at the source site rather than released into a sewer and treated together. However, a large volume of wastewater was generated after every vehicle wash, and potable water was turned into mainly contaminated water, which ultimately added to natural waterways. In addition, in the discharge of vehicle wastewater into waterbodies, the washing powder containing wastewater creates foams, which diminished the amount of oxygen and demolished fish mucus covering [9].

Non-judicious use of water by vehicle washing centers endangers the health of an urban ecosystem and decreases water security. In the case of this context, policymakers in developed countries have imposed regulations to address these issues. Germany and Austria have made mandatory recycling of wastewater generated, whereas, in Belgium, 15% of vehicle wash centers recycle their wastewater [10]. The Netherlands and Scandinavian countries have restricted water use for vehicle wash [10]. Brazil also has implemented strict environmental regulations for recycling vehicle-wash wastewater. In developing counties, few initiatives have been taken for policy action and regulations to control wasteful water use. In India, according to the prevention and control of pollution act 1974 (amended 1988), before the discharge of effluent into a sewer or natural stream, content checking is necessary [11]. The Maharashtra pollution control board warned service centers for violating environmental norms [12]. The Pune Municipal Corporation has banned potable and groundwater or vehicle washing [13]. Still, it seems that laws and orders are not implemented, and there was no monitoring mechanism for observing these activities.

The vehicle washing industry uses deep bore wells illegally to extract groundwater for vehicle cleaning. Consequently, the volume of water is turned into polluted water. The Shrigonda Municipality does not regulate the exploitation of groundwater laws for commercial use and

effluent discharge due to the ignorance of the Municipality authority about the massive amount of groundwater used for the vehicle washing industry. Therefore, the present study was conducted to calculate the amount of groundwater used by washing centers in Shrigonda town.

2. MATERIALS AND METHODS

2.1 Study Area

Shrigonda town, the present study area, is located at 18^0 36' 48" North latitude and 74^0 42' 00" East Longitude with an average altitude of 552 meters and comprises 9 wards covering 79 square kilometer area including *Gavthan (*old town), the suburb area (Yellow Zone), and the green zone. It accommodates 32000 populations as per the 2001 census and 6000 constructions (residential, commercial) as per google images data of 2019. It is a drought-prone area of Maharashtra located south of Ahmednagar city. It has developed as a residential town. The town depends on surface and groundwater for domestic and commercial use. But these sources of water decrease rapidly in the dry season. There are thirteen vehicle washing centers in Shrigonda town. Due to the scarcity of tar and concert roads, vehicle owners need to wash vehicles frequently, and the frequency of washing increases in the monsoon season due to muddy roads.

2.2 Status of Water Resources of Shrigonda Town

Shrigonda town lies in the drought-prone area of Maharashtra, India, south of Ahmednagar district. It receives 447 mm [14] average annual rainfall. Shrigonda Municipality constructed a water treatment plant (WTP) in 2018 under the Urban Infrastructure Development Scheme for small and medium towns by investing 4595.63 lakhs [15] for supplying domestic, drinking, and commercial use. The WTPs water purification capacity is 11 MLD. The water is lifted through the pipeline from Ghod Dam to WTPs built near Anandkar mala, west of Shrigonda town, for treatment.

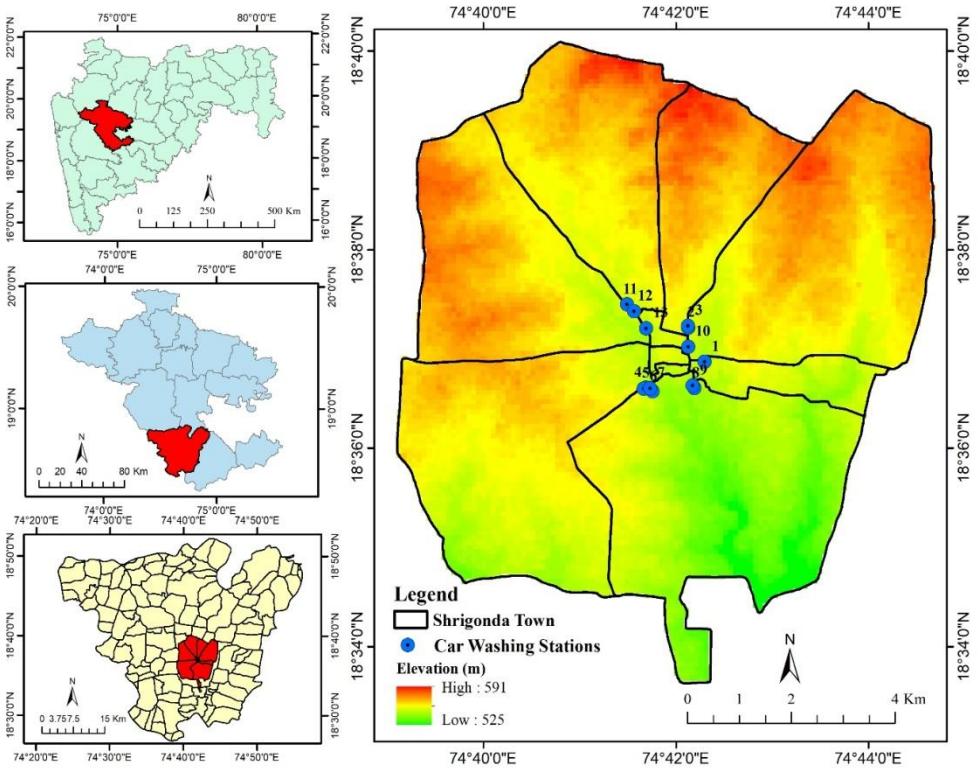

Fig. 1. Location map of washing centers in Shrigonda Town

Finally, treated water is distributed and stored in different overhead water storage tanks constructed across the various parts of the town. The Municipality supplies water for commercial purposes by a separate connection, but owners of vehicle washing centers are not interested due to the freely available massive groundwater. No single-vehicle washing center has taken Municipality's water supply connections for washing vehicles. On the other hand, the Municipality's water supply amount and frequency decrease in dry due to the water bodies' sinking of the Ghod Dam. Therefore, all washing centers use groundwater for their commercial activities. Further, water yield from the bore well also rapidly decreases during extreme dry. There are two small-sized surface water bodies, Bazar Talav, and Autewadi Talav, adjacent to Shrigonda town, but water is not directly utilized for commercial and domestic purposes.

2.3 Field Survey

Field observations were carried out with field inventory to determine the water requirement for vehicle washing and the volume of wastewater generation of vehicle wash centers in Shrigonda town. Thirteen Vehicle wash centers were observed during the field survey. The collected data included locations, sources of water, type of vehicle washed, the time required for vehicle wash, number of vehicles washed, and types of washing surface. All vehicle washing centers were observed daily (7 am - 6 pm) for the appropriate samples, including Sunday, one week each month. The per day number of vehicles washed and the amount of water used to wash different vehicles were obtained from all thirteen car wash centers. Vehicles at all washing centers were observed during the dry and wet seasons because the number of vehicles washed daily increases rapidly due to muddy roads in wet season.

2.4 Types of Vehicles and Method of Wash

Field observation shows vehicles are categorized into two-wheelers and four-wheelers. Two-wheelers included motorbikes; four-wheelers included cars and light and heavy transport vehicles. Very few heavy transport vehicles are washed at the washing centers. Primarily cars and motorbikes are washed all over the vehicle washing centers in Shrigonda town. All vehicle washing centers use the semi-manual method of washing. It refers to hand-held spray with the spray gun and hand washes with the brush, cotton cloth, and foam-making detergent solution. A plastic bucket is used to make foam.

2.5 Amount of Water used to wash per Vehicle was computed using the following Method [16]

$$\boldsymbol{V_w = q_w t + \sum_{i=1}^{n} V_i}$$

Where:

V_w = Total amount of water utilized to wash vehicle (L)
q_w = Volumetric flow rate of HTP Sprayer pump (L/s)
t = time required to wash vehicle using HTP Sprayer pump
v_i = volume of water in the graduated bucket at the i^{th} time of use (L)
n = number of buckets used for the entire car wash

The total volume of water utilized to wash each Category of a vehicle is computed separately.

3. RESULTS AND DISCUSSION

3.1 Vehicle Washing Characteristics and Pattern at Vehicle Washing Centers

Vehicle washing centers in Shrigonda town are mainly located along essential roads. Almost all the vehicle wash centers depend on groundwater (Bore well) due to free available groundwater. None of the vehicle wash centers use the Municipality supplied water. Almost all vehicle wash centers (100%) N=13 use hand-held spray guns, and none have a wastewater recycling mechanism. Overall, 764 in the dry season and 982 in the wet season vehicles are washed at thirteen vehicle wash centers during the day. Out of these in the dry season, 46.98% were motorbikes, 36.78% were cars,11.12% were LTVs, and 5.10% were HTVs. Whereas in the wet season, 42.87% were motorbikes,40.93% were cars,11.40% were LTVs, and 4.78% were HTVs. The motorbike is the highest Category of vehicle washed at all thirteen centers.

3.2 Water Quantity Used for a Different Vehicle

In the dry and wet seasons, 764 and 982 vehicles were monitored in thirteen centers to

find water use per vehicle. The water volume utilized to wash per vehicle during the dry and wet seasons is shown in Figs. 2 and 3.

The average amount of water used to wash per vehicle differs between 95.83L-300.79L in the dry season and 128.28L -415.40L in the wet season. More oversized vehicles need more water, and smaller vehicles need less water to wash the vehicle. Seasonal variations in mean water volume are used for washing different vehicles.

Based on the one-way ANOVA test mean water volume used to wash during the dry and wet seasons is statistically significant (p=<0.05). A higher water volume is required to wash vehicles during the wet season (281.75-259.94), and slight variation among the thirteen washing centers (Table 1). It is mainly because of unpaved/earthen roads. A large amount of mud is stuck to the vehicle and needs a relatively higher amount of water to remove it. During the dry season, less water (242.61 L-210.78 L) is needed to wash vehicles because dry roads accumulate dust on vehicles. There is also center-wise variation in the average volume of water used to wash the vehicle, depending on the person washing the vehicle.

3.3 Daily Vehicle Washes and Water used for Washing Vehicle

Heavy vehicles need more water, but very few are washed daily over the washing centers (N=13). The correlation between the number of vehicles washed daily and the water used for washing vehicles at different washing centers (Figs. 4 and 5) has a negative correlation. It means that vehicle washing centers wash more vehicles daily, requiring less water, and vice versa.

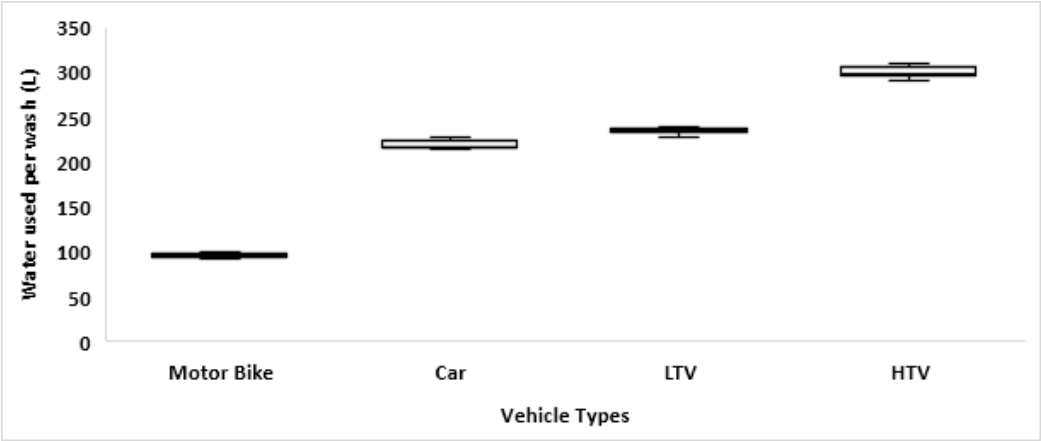

Fig. 2. Amount of water used to wash vehicles in the dry season

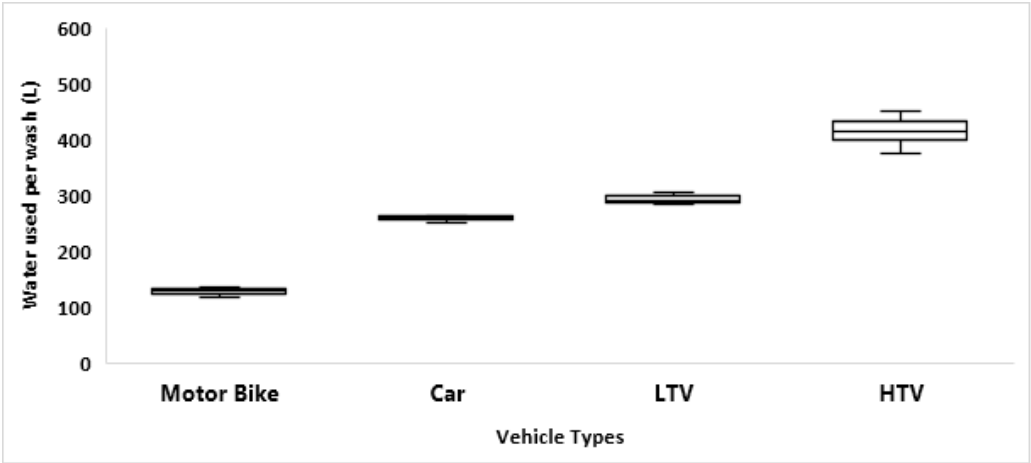

Fig. 3. Amount of water used to wash vehicles in the wet season

Table 1. Season-wise water volume used for washing different vehicles

Washing Centers	Dry Season			Wet Season			P-value	P-value
	No. of Vehicles	Mean water volume (L)	SD	No. of Vehicles	Mean water volume (L)	SD		
1	79	242.61	81.12	106	271.02	109.88	0.033876647	<0.05
2	53	215.03	87.46	71	275.96	115.08	0.006185219	<0.05
3	66	212.13	84.58	82	279.60	119.29	0.021188406	<0.05
4	71	213.50	87.91	81	281.75	122.69	0.02411822	<0.05
5	55	212.11	88.58	74	278.95	134.53	0.02059185	<0.05
6	51	212.78	85.16	77	275.48	116.04	0.009795341	<0.05
7	33	213.71	89.22	31	278.85	131.68	0.013369114	<0.05
8	89	211.64	87.10	108	269.81	115.48	0.012804889	<0.05
9	55	212.05	85.36	81	263.54	102.14	0.003856433	<0.05
10	56	210.78	83.93	68	276.57	130.29	0.022379547	<0.05
11	44	215.59	84.85	61	274.57	122.08	0.027411469	<0.05
12	62	213.74	86.25	73	259.94	106.56	0.034875404	<0.05
13	48	211.36	83.18	69	270.21	109.90	0.012224445	<0.05

(Source: Computed by researcher)

Table 2. Paired Samples Test

Washing Center	Paired Differences					t	df	Sig. (2-tailed)	P-value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference					
				Lower	Upper				
1	-44.769	42.946	4.832	-54.389	-35.150	-9.266	78	**.000**	<0.05
2	-75.968	72.957	10.021	-96.078	-55.859	-7.581	52	**.000**	<0.05
3	-22.942	53.289	6.559	-36.043	-9.842	-3.498	65	**.001**	<0.05
4	-24.639	60.788	7.214	-39.028	-10.251	-3.415	70	**.001**	<0.05
5	-39.632	32.627	4.284	-48.211	-31.053	-9.251	57	**.000**	<0.05
6	-33.381	35.259	4.937	-43.298	-23.464	-6.761	50	**.000**	<0.05
7	-32.444	33.518	5.834	-44.329	-20.559	-5.561	32	**.000**	<0.05
8	-21.473	46.398	4.918	-31.247	-11.699	-4.366	88	**.000**	<0.05
9	-36.644	35.488	4.785	-46.238	-27.050	-7.658	54	**.000**	<0.05
10	-56.517	53.178	7.106	-70.758	-42.275	-7.953	55	**.000**	<0.05
11	-58.919	40.652	6.128	-71.279	-46.560	-9.614	43	**.000**	<0.05
12	-39.671	48.116	6.110	-51.891	-27.452	-6.492	61	**.000**	<0.05
13	-33.130	35.921	5.184	-43.561	-22.700	-6.390	47	**.000**	<0.05

(Source: Computed by researcher)

Table 3. Correlation of water volume utilized to wash vehicles in the Dry season

Types of Vehicles	Mean no. of Vehicles	Water/Liter/Vehicle
Motor Bike	28	95.83
Car	22	219.62
Light Transport vehicle (Pickup, Tata Chhota Hatti)	7	235.64
Heavy Transport Vehicle (Trucks)	3	300.79

(Source: Computed by researcher)

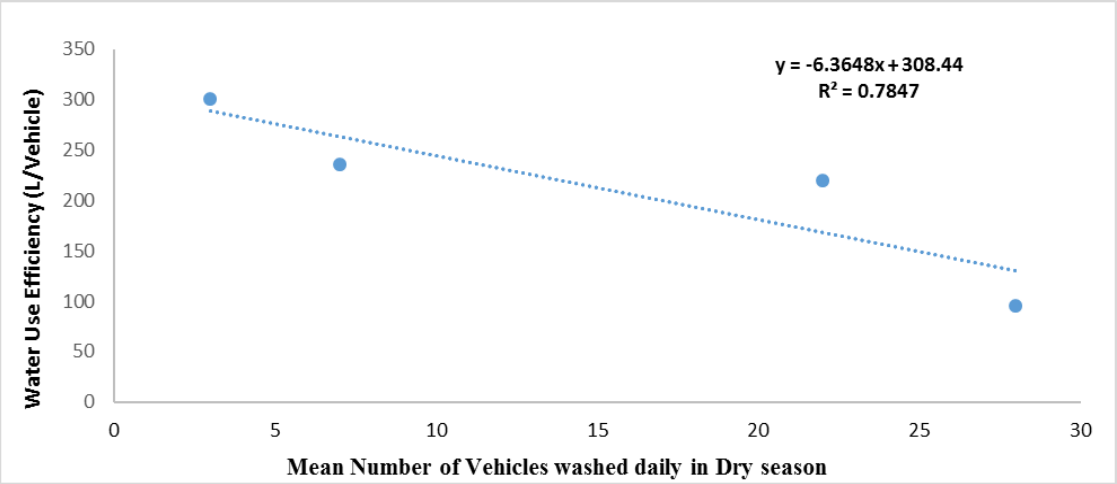

Fig. 4. Correlation of water quantities used to wash vehicles in the Dry season

Table 4. Correlation of volume of water used to wash vehicles in the Wet season

Types of Vehicles	Mean no. of Vehicles	Water/Liter/Vehicle
Motor Bike	33	128.28
Car	31	258.79
Light Transport vehicle (Pickup, Tata Chhota Hatti)	9	290.89
Heavy Transport Vehicle (Trucks)	**4**	**415.40**

(Source: Computed by researcher)

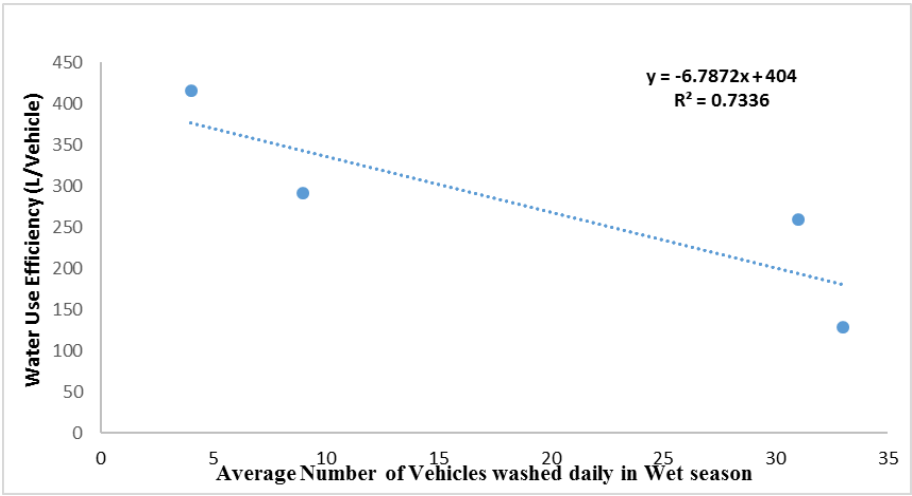

Fig. 5. Correlation of water volume used to wash vehicles in the Wet season

The seasonal variation in water utilization for vehicles washed at each washing center has been analyzed by applying a student t-test. The result revealed that the calculated values of 't' were greater than the table value at all washing centers, and the p-value is 0.000 at the 95% significance level at 11 washing centers. In contrast, only two centers indicated a p-value of 0.01. Therefore, the null hypothesis was rejected, and the alternative hypothesis was accepted. It means there is a significant difference between water used for vehicles washed in dry and wet seasons at every washing center.

4. CONCLUSION

This investigation found that vehicle washing centers in Shrigonda town use semi-manual washing methods. All washing centers (N=13) are extracting groundwater for washing. During

the dry season, daily, 58.61, and in the wet season, 75.53, the average number of vehicles washed all over the washing centers and use the mean 95 Liters to 300.79L water in the dry season and 128.28 Liters to 415.40 Liters of water in the wet season. All (N=13) centers uses 102301 liters of groundwater daily in the dry season and 168114 liters in the wet season. Overall, 270415 L/day of groundwater was used by the vehicle washing centers in Shrigonda town. As per the Bureau of Indian Standards (BIS), a minimum of 70 to 100/ lphd water is adequate for domestic use of urban communities with a complete flushing system (BIS [17]). As per these values, groundwater used is equivalent to the water need of 2704 people daily. The present study recommends to the Municipality authority that existing and new vehicle wash centers be authorized by verifying all environmental impact assessment norms viz site suitability, source of water, amount of daily wastewater generated, recycling mechanism, etc. The tax should be imposed for groundwater extraction based on the volume of water extracted.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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