DOI: 10.15613/hijrh/2025/v12i1/52701
ISSN (Print): 2349-4778
***HuSS*: International Journal of Research in Humanities and Social Sciences,** *Vol 12(1), 49-56, 2025* *ISSN (Online): 2349-8900*

Assessing the Impact of Domestic Wastewater in Tirupattur Urban Region

A. Royal Edward Williams[1*], R. Paranthaman[2] and D. Jeevan Vignesh[3]

Associate Professor[1] and Ph.D Research Scholars[2,3], Department of Economics, Sacred Heart College (A), Tirupattur – 635601, Tamil Nadu, India; royaledward@shctpt.edu

Abstract

The study investigates the impact of domestic wastewater patterns on public health in the Tirupattur urban region, a rapidly urbanising area facing significant challenges in water and wastewater management. As the population grows, the volume of domestic wastewater often increases without proper treatment or partial disposal in the open space. The research aims to analyse household water consumption levels, identify patterns of domestic wastewater generation, and assess the implications of wastewater quality on public health. A comprehensive survey has been conducted across multiple households to gather data on water sources, domestic consumption habits, wastewater disposal methods, and the prevalence of waterborne diseases. The stratified random sampling method has been adopted to select the sample. Accordingly, data have been collected from 530 respondents in Tiruppatur urban region comprising 4 municipalities, namely Tiruppatur, Jolarpettai, Vaniyambadi and Ambur. The study underscores the urgent need for infrastructure improvements, including robust wastewater treatment facilities, better water source management, and public awareness campaigns to address the health risks posed by domestic wastewater.

Keywords: Consumption, Health Impact, Waste Water, Water Contamination, Waterborne Diseases

1. Introduction

Domestic wastewater is the wastewater source that is generated from household activities such as bathing, cooking, cleaning, washing, and flushing toilets. It includes water from sinks, showers, bathtubs, toilets, washing machines, dishwashers, and other household appliances. Domestic wastewater, also commonly called sewage or grey water, when not treated properly, can have significant environmental, social, and economic impacts. These impacts depend on factors such as the volume of wastewater, the quality of treatment, and the receiving environment's ability to absorb and process the contaminants.

According to the United Nations World Water Development Report (2021)[1], nearly 80% of the world's wastewater is released into the environment without adequate treatment. This statistic highlights the widespread issue of untreated wastewater, which is a significant environmental and public health concern. The world produces approximately 359.4 billion cubic meters of wastewater annually, which is equivalent to 49 cubic meters per person per year.

India has 1,093 sewage treatment plants. The government has been implementing programmes and schemes to improve the wastewater and sewerage infrastructure in the country. India has a total sewage treatment capacity of approximately 39,000 MLD, while the total sewage generation is about 72,368 MLD (CPCB, 2022)[2]. Tamil Nadu's sewage generation capacity is 6,421 million litres per day (MLD). The state's total treatment capacity, including planned and proposed capacity, is 1,492 MLD. (TNPCB, 2021)[3].

The urban population in Tirupattur heavily relies on piped water supply systems. Based on the standard calculation of 135 Litres Per Capita per Day (LPCD), with a population exceeding 80,000, the total sewage generation in Tirupattur Municipality is estimated to be 8–9 MLD. However, the current capacity of the Sewage Treatment Plant (STP) serves only around 35-40% of the total sewage generated. This leaves approximately 5–6 MLD of sewage untreated, which is often discharged into open drains or nearby water bodies, contributing significantly to environmental pollution. In Jolarpettai Municipality, a small STP is under construction, with an estimated capacity of 1–2 MLD, primarily serving

*Author for correspondence

sewage from selected connected areas. The gap in sewage treatment capacity here is between 6–7 MLD. Vaniyambadi Municipality is constructing an STP with a capacity of around 3–4 MLD, while daily sewage generation is estimated at 6–8 MLD. In Ambur, the STP has a treatment capacity of 8 MLD, but the daily sewage generation is estimated at 9–10 MLD, leading to periodic overflows and the discharge of untreated wastewater into local water bodies[4]. This indicates significant gaps in sewage treatment infrastructure across the region, posing environmental and health risks.

The Tirupattur urban region, like many rapidly developing areas, faces significant challenges related to domestic wastewater management and public health. As urbanisation accelerates, the volume of domestic wastewater generated has increased, putting immense pressure on existing infrastructure. Many households in the region rely on untreated or poorly treated water sources, such as bore wells and municipal water supplies, which often make them susceptible to contamination. The improper disposal of domestic wastewater further exacerbates these issues, as untreated wastewater often seeps into local water systems, leading to widespread contamination. It aims to assess the consumption patterns of domestic wastewater, examining how different water usage behaviours contribute to the growing public health concerns in the region. This research seeks to highlight the need for improved wastewater management systems and public health interventions, ultimately contributing to a sustainable, healthier urban environment in Tirupattur.

2. Review of Literature

Bindhy Wasini Pandey *et al.*[5] found that water pollution created many diseases, which spread easily during the rainy season due to the bad quality of drainage as well as untreated effluent wastewater discharge into the water source. Around 25% of all the known human illnesses occurred due to environment-related pollution. Nearly 2.3 billion people suffer from water-borne diseases across the world. In many developing countries, many diseases like diarrhoea, cholera, asthma, dysentery, typhoid, and enteric fever are due to poor quality of drinking water. Iheukwumere S. Oji, *et al.*[6] investigated treatment and reuse of domestic wastewater, as well as the willingness and awareness of the public on domestic wastewater treatment, personal reuse and for other purposes such as irrigation in Awka urban area of Anambra State, Nigeria. The survey method of research was applied, while statistical analysis involved the use of Percentage, Weighted mean, and the Mann-Whitney test. About 51.39% objected to the treatment of domestic wastewater, while 53.40% and 56.68% would not want to use treated wastewater or support agricultural products irrigated with treated wastewater, respectively. Saurabh S. Joshi *et al.*[7] observed that, out of the various parameters deliberated from different locations, exceeded the standard required values. Pollution of channels with contaminated substances and excessive nutrients, as well as destructive land use practices in areas surrounding freshwater ecosystems, led to deterioration of water quality. There was also a need for public education and awareness to decentralise the treatment of sewage at the household and apartment level, which could be useful to reduce pollution of the river. Kavindra Kumar[8] found that water scarcity was one of the major problems in the world, and millions of people had no access to freshwater. This led to serious environmental and public health concerns. Instead of using untreated wastewater, treated wastewater has been found more applicable and eco-friendly option. Yasir M. Al-Mawla *et al.*[9] detailed the characteristics and treatment of domestic wastewater. It focused on untreated domestic wastewater received by the Tigris River. Domestic wastewater characteristics were heavily impacted by people's lifestyles, social and cultural behaviours, water supply, and consumption. For humans to grow and develop properly, they require a reliable and sufficient water supply. The gap between available water supply and demand widens. Proper sanitation, particularly a decentralised strategy that could be performed through the reuse of household effluent, might solve water supply and wastewater management problems.

3. Objectives of the Study

- To analyse the domestic water consumption pattern and level in the study area.
- To assess the impact of domestic wastewater on human health within the study area.

4. Research Methodology

This is a descriptive and analytical study aimed at understanding the impact of domestic wastewater on public health in the Tirupattur urban region. The study

employs a mixed-methods approach, combining both quantitative and qualitative data for a comprehensive analysis. Data was collected through surveys from households, local administrators, and wastewater management units within the Tirupattur urban region. A stratified random sampling method was used to ensure a representative sample of respondents, and the sample size is 530, including the residents of 4 municipalities, namely Tiruppatur, Jolarpettai, Vaniyambadi and Ambur in Tiruppatur urban region. This approach allows for an in-depth examination of the key factors impacting wastewater management and provides valuable insights into the local challenges and needs for improvement. Simple Percentage analysis and Multiple Regression analysis have been used to determine the results of the study.

5. Findings and Discussion

5.1 Domestic Water Consumption Pattern

The level of domestic water consumption per month by the residents of the selected municipalities is given in Table 1.

Table 1 reveals that the largest group of respondents (49.4%) uses between 401 to 600 l of water per month, with Vaniyambadi showing the highest proportion (51.1%) in this category, followed closely by Ambur (48.0%). The second-largest group (38.3%) uses 601 to 800 l, with a similar distribution across municipalities, led by Ambur (39.3%) and Jolarpettai (41.7%). A smaller percentage of respondents (7.7%) use between 201 to 400 l, with Ambur again reporting the highest usage (36.6%). Only 2.3% of respondents use more than 800 l, with a notable proportion in Vaniyambadi (33.3%) and Ambur (33.3%) for this category. A small fraction (2.3%) use up to 200 l, with Vaniyambadi showing the highest (50.0%) and Ambur none in this category. This data indicates that most households across the municipalities tend to use moderate to high quantities of water (401-800 l), and those with lower usage are fewer in number.

5.2 Contamination of Water Source

The cross-sectional analysis of water contamination data across the urban-regions of Tirupattur District was analysed with the following municipalities: Tirupattur,

Table 1. Water usage for domestic purposes

Water usage in litres per month	Municipality (No. of respondents)				Total
	Tirupattur	Jolarpettai	Vaniyambadi	Ambur	
Up to 200 l	3	3	6	0	**12**
	25.0%	25.0%	50.0%	0.0%	**100.0%**
	2.1%	5.0%	3.3%	0.0%	**2.3%**
201 to 400 l	11	4	11	15	**41**
	26.8%	9.8%	26.8%	36.6%	**100.0%**
	7.9%	6.7%	6.1%	10.0%	**7.7%**
401 to 600 l	71	27	92	72	**262**
	27.1%	10.3%	35.1%	27.5%	**100.0%**
	50.7%	45.0%	51.1%	48.0%	**49.4%**
601 to 800 l	52	25	67	59	**203**
	25.6%	12.3%	33.0%	29.1%	**100.0%**
	37.1%	41.7%	37.2%	39.3%	**38.3%**
Above 801 l	3	1	4	4	**12**
	25.0%	8.3%	33.3%	33.3%	**100.0%**
	2.1%	1.7%	2.2%	2.7%	**2.3%**
Total	**140**	**60**	**180**	**150**	**530**
	26.4%	**11.3%**	**34.0%**	**28.3%**	**100.0%**
	100.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Source: Computed

Jolarpettai, Vaniyambadi, and Ambur and is shown in Table 2.

Table 2 provides a clear picture of the widespread issue of water contamination in these areas. The majority of respondents (71.9%) reported contamination in the water sources, with the highest percentage in Tirupattur (72.9%) and the lowest in Ambur (69.3%). In terms of municipalities, the proportion of individuals experiencing contaminated water is relatively high across all areas, ranging from 69.3% in Ambur to 78.3% in Jolarpettai. On the other hand, 28.1% of respondents reported that their water sources are not contaminated, with the highest percentage in Ambur (30.7%) and the lowest in Jolarpettai (21.7%). Vaniyambadi shows a significant 71.1% contamination rate. It also has a relatively higher share of households reporting clean water (28.9%), which can be attributed to underdeveloped water management systems or reliance on informal water sources like public bore wells. The contamination levels indicate that the local water supply may be insufficiently regulated or that poor

Table 2. Area-wise contamination of the water source

Contamination of Water	Municipality (No. of respondents)				Total
	Tirupattur	Jolarpettai	Vaniyambadi	Ambur	
Yes	102	47	128	104	**381**
	26.8%	12.3%	33.6%	27.3%	**100.0%**
	72.9%	78.3%	71.1%	69.3%	**71.9%**
No	38	13	52	46	**149**
	25.5%	8.7%	34.9%	30.9%	**100.0%**
	27.1%	21.7%	28.9%	30.7%	**28.1%**
Total	**140**	**60**	**180**	**150**	**530**
	26.4%	**11.3%**	**34.0%**	**28.3%**	**100.0%**
	100.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Source: Computed

Table 3. Mode of domestic wastewater discharge

Mode of domestic wastewater discharge	Municipality (No. of Respondents)				Total
	Tirupattur	Jolarpettai	Vaniyambadi	Ambur	
Open area	19	7	18	16	**60**
	31.7%	11.7%	30.0%	26.7%	**100.0%**
	13.6%	11.7%	10.0%	10.7%	**11.3%**
Public drainage	79	36	111	86	**312**
	25.3%	11.5%	35.6%	27.6%	**100.0%**
	56.4%	60.0%	61.7%	57.3%	**58.9%**
Water bodies	32	12	43	36	**123**
	26.0%	9.8%	35.0%	29.3%	**100.0%**
	22.9%	20.0%	23.9%	24.0%	**23.2%**
Dumping in own pit	10	5	8	12	**35**
	28.6%	14.3%	22.9%	34.3%	**100.0%**
	7.1%	8.3%	4.4%	8.0%	**6.6%**
Total	**140**	**60**	**180**	**150**	**530**
	26.4%	**11.3%**	**34.0%**	**28.3%**	**100.0%**
	100.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Source: Computed

wastewater management practices are contaminating the water supply.

5.3 Mode of Domestic Water Discharge

Without proper wastewater treatment, contaminants can seep into local water sources, affecting public health. Table 3 shows the distribution of the respondents based on the mode of domestic wastewater discharge.

Table 3 shows that public drainage is the most common disposal method across all municipalities, with 58.9% of respondents using it. Vaniyambadi leads with 61.7% of respondents using public drainage, followed by Ambur (57.3%), Tirupattur (56.4%), and Jolarpettai (60%). The second most common method is discharging wastewater into water bodies, which accounts for 23.2% of all respondents. Vaniyambadi has the highest percentage (23.9%), while Ambur (24%) and Tirupattur (22.9%) follow closely. Jolarpettai reports the lowest percentage at 20%. The third most common method is the discharge of wastewater into open areas, with 11.3% of respondents overall. Tirupattur has the highest proportion of open-area discharge (13.6%), while Vaniyambadi (10%) and Ambur (10.7%) have slightly lower figures. The least common method is dumping wastewater into private pits, with only 6.6% of respondents choosing this option. Ambur (8%) and Jolarpettai (8.3%) have the highest percentages of pit dumping, while Tirupattur (7.1%) and Vaniyambadi (4.4%) are lower. Overall, public drainage is the dominant method, with water bodies and open areas also playing significant roles in wastewater disposal.

5.4 Diseases Affecting the Family Members

Table 4 provides an overview of diseases prevalent in all four municipalities, such as Tirupattur, Jolarpettai, Vaniyambadi, and Ambur and how they contribute to total disease cases.

Table 4 evinces that Cholera stands out as the most widespread disease, accounting for 30.8% of total cases, with Vaniyambadi (33.1%) and Tirupattur (32.5%) showing the highest percentages. Typhoid fever follows closely, with Vaniyambadi (33.8%) and Tirupattur (28.6%) having notable rates, contributing 25.1% of total cases. Skin allergies are more common in Vaniyambadi (36.2%) and Ambur (30.8%), representing 24.5% of all cases. Viral

Table 4. Diseases affecting the family members

Diseases	Municipality				Total
	Tirupattur	Jolarpettai	Vaniyambadi	Ambur	
Typhoid Fever	38	17	45	33	**133**
	28.6%	12.8%	33.8%	24.8%	**100.0%**
	27.1%	28.3%	25.0%	22.0%	**25.1%**
Diarrhea	8	3	7	11	**29**
	27.6%	10.3%	24.1%	37.9%	**100.0%**
	5.7%	5.0%	3.9%	7.3%	**5.5%**
Cholera	53	22	54	34	**163**
	32.5%	13.5%	33.1%	20.9%	**100.0%**
	37.9%	36.7%	30.0%	22.7%	**30.8%**
Skin allergy	32	11	47	40	**130**
	24.6%	8.5%	36.2%	30.8%	**100.0%**
	22.9%	18.3%	26.1%	26.7%	**24.5%**
Viral fever	9	7	27	32	**75**
	12.0%	9.3%	36.0%	42.7%	**100.0%**
	6.4%	11.7%	15.0%	21.3%	**14.2%**
Total	**140**	**60**	**180**	**150**	**530**
	26.4%	**11.3%**	**34.0%**	**28.3%**	**100.0%**
	100.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Source: Computed

fever has the highest concentration in Ambur (42.7%), and Vaniyambadi (36%) shows a significant share, but it accounts for only 14.2% of the total cases. Lastly, diarrhoea is the most prevalent disease in Ambur (37.9%) but makes up just 5.5% of the overall cases. Overall, the data shows that inadequate wastewater management, combined with contaminated water sources, plays a significant role in the spread of waterborne and vector-related diseases, especially in municipalities with poor sanitation infrastructure.

5.5 Barriers to Proper Waste Water Management

Table 5 gives a picture of the barriers to proper wastewater management.

Table 5 infers the barriers for proper wastewater management in the municipalities of Tirupattur, Jolarpettai, Vaniyambadi, and Ambur, which are multifaceted, with the lack of infrastructure being the most significant obstacle. In all four municipalities, the lack of infrastructure, cited by 38.7% of respondents, poses a severe challenge to effective wastewater management, contributing to the contamination of local water sources. This inadequacy in wastewater disposal systems directly impacts public health, leading to the spread of waterborne diseases. Moreover, the high costs associated with wastewater treatment, reported by 29.2% of respondents, exacerbate economic hardship, particularly in low-income households, as they face the dual burden of healthcare costs and treatment for illness caused by untreated or poorly managed wastewater. The lack of awareness, reported by 26.6% of respondents, further compounds these issues, as many may not understand the importance of proper wastewater disposal or the health risks of contamination. Additionally, weak

Table 5. Barriers to proper wastewater management

Barriers	Municipality (No. of respondents)				Total
	Tirupattur	Jolarpettai	Vaniyambadi	Ambur	
Lack of awareness	37	15	47	42	**141**
	26.2%	10.6%	33.3%	29.8%	**100.0%**
	26.4%	25.0%	26.1%	28.0%	**26.6%**
Lack of infrastructure	55	22	69	59	**205**
	26.8%	10.7%	33.7%	28.8%	**100.0%**
	39.3%	36.7%	38.3%	39.3%	**38.7%**
Cost of treatment	39	19	53	44	**155**
	25.2%	12.3%	34.2%	28.4%	**100.0%**
	27.9%	31.7%	29.4%	29.3%	**29.2%**
Lack of enforcement	9	4	11	5	**29**
	31.0%	13.8%	37.9%	17.2%	**100.0%**
	6.4%	6.7%	6.1%	3.3%	**5.5%**
Total	**140**	**60**	**180**	**150**	**530**
	26.4%	**11.3%**	**34.0%**	**28.3%**	**100.0%**
	100.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Source: Computed

Table 6. Results of multiple regression analysis

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0.969[a]	0.940	0.939	0.122
a. Predictors: (Constant), Man-day loss due to health impact, contamination of water, Family size, domestic water usage in Lt				

Source: Computed

enforcement of regulations has been cited by only 5.5% of respondents. Collectively, these barriers not only diminish the quality of life but also strain local economies by increasing healthcare expenditures, productivity losses due to illness, and the financial burden of inadequate sanitation infrastructure.

5.6 Impact of Sewage System on Public Health Outcome

The impact of the sewage system adopted in the selected municipalities on public health outcomes is examined by considering predictor variables, namely man-day loss due to health impact, contamination of water, family size, and domestic water usage in litres. The results of regression analysis given in Tables 6 and 7 clearly reveal the factors influencing the sewage system.

Table 6 indicates a robust model with an R-value of 0.969, showing a very strong correlation between the predictors and the dependent variable. The R-square value of 0.940 means that 94% of the variability in the outcome can be explained by the included factors: man-day loss due to health impacts, water contamination, family size, and domestic water usage. The Adjusted R-square value of 0.939 confirms the model's reliability after adjusting for the number of predictors. The relatively low standard error of 0.122 suggests the model provides accurate predictions, highlighting the significant influence of these variables, particularly improper sewage systems, on public health outcomes.

Table 7 shows the relationship between various predictors and the dependent variable, " sewage systems in the house. "The constant value of 0.056 indicates a baseline effect when all predictors are held at zero. The predictor "man-day loss due to health impact" has a very strong positive effect with a coefficient of 0.967 and a highly significant p-value of 0.000, meaning that for every unit increase in man-day loss due to health impacts, the likelihood of having proper sewage systems increases significantly. This suggests that communities with greater health impacts due to poor sanitation are more likely to implement better sewage systems.

In contrast, family size (B = -0.003, p = 0.565) and water contamination (B = -0.012, p = 0.335) have negative coefficients, but their p-values are greater than 0.05, indicating these variables are not statistically significant predictors. This suggests that, in this particular model, family size and water contamination do not have a meaningful impact on the presence of proper sewage systems. Similarly, domestic water usage (B = 0.00006246, p = 0.253) has a small positive coefficient, but its p-value exceeds 0.05, showing no significant effect. Overall, the most influential predictor of proper sewage systems is the health impact, highlighting the importance of addressing health consequences in driving sanitation improvements.

6. Suggestions

- The majority of respondents, 71.9% reported contamination in their water sources. The contamination levels indicate that the local water supply may be insufficiently regulated or that poor wastewater management practices are contaminating the water supply. Hence, the public authorities have to concentrate on implementing effective wastewater management by combining physical, biological and chemical processes to treat wastewater.
- The largest group of respondents, 49.4% uses between 401 to 600 l of water per month. Without proper

Table 7. Impact of the sewage system on public health outcomes

Coefficients[a]						
Model		Unstandardised coefficients		Standardised coefficients	t	Sig.
	B	Std. Error	Beta			
1	(Constant)	0.056	0.028		2.039	0.042
	Family size	-0.003	0.005	-0.007	-0.576	0.565
	Contamination of the water source	-0.012	0.012	-0.011	-0.965	0.335
	Domestic water usage in Lt	-0.005	0.000	0.018	1.145	0.253
	Man day lost due to health impact	0.967	0.013	0.962	73.341	0.000
a. Dependent Variable: Proper sewage systems in your house						

Source: Computed

wastewater treatment, contaminants can seep into local water sources, affecting public health. Hence, awareness programmes must be conducted to enable the public to understand the outcome of contaminated water.

- The data shows that inadequate wastewater management, combined with contaminated water sources, plays a significant role in the spread of waterborne and vector-related diseases, especially in municipalities with poor sanitation infrastructure. Hence, the public authorities have to implement activities like spraying insecticides, etc., more often.
- The lack of infrastructure, cited by 38.7% of respondents, poses a severe challenge to effective wastewater management, contributing to the contamination of local water sources. This inadequacy in wastewater disposal systems directly impacts public health, leading to the spread of waterborne diseases. Therefore, the Government has to construct and maintain the required infrastructure to dispose of wastewater.

7. Conclusion

The findings underscore a critical link between inadequate domestic wastewater management and the deteriorating health of communities. The alarming 71.9% of respondents reporting contamination in their water sources highlights insufficient regulation and poor wastewater management practices, which exacerbate public health risks. The predominant use of public drainage systems by 58.9% of respondents, coupled with the lack of infrastructure (38.7%), exacerbates wastewater disposal challenges and contributes to contamination. The data also shows the direct economic burden of poor sanitation, with 60% of individuals reporting man-day loss due to illness, emphasising the strain on the workforce, particularly in low-income communities. These findings highlight the need for improved wastewater infrastructure, stricter water quality regulations, and comprehensive ailment prevention strategies to safeguard public health.

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