International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 06 | June - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Seasonal and Spatial Dynamics of Total Dissolved Solids and Total Suspended Solids in Sewage from Sironj, Vidisha, India (2024)

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Abstract - This study examined the seasonal and spatial variations in Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) in sewage samples collected from five suburban sites in Sironj Tehsil, district Vidisha, India, during 2024. Samples from Kahra Bazar, Kathali, Bhawani Nagar, Katra Mohalla, and Hajipur were analyzed using standard gravimetric methods (APHA 2540 C and D, 2017). TDS levels ranged from 683.71 to 735.21 mg/L, peaking in summer (mean: 733.30 mg/L) due to evaporation and decreasing in the monsoon (mean: 688.08 mg/L) due to rainfall dilution. TSS levels varied from 154.84 to 312.78 mg/L, with a monsoon peak (mean: 282.47 mg/L) driven by runoff and a winter low (mean: 164.14 mg/L). Two-way ANOVA confirmed significant seasonal effects on both TDS ($F(3,80)=72.84$, $p<0.001$) and TSS ($F(3,80)=13.984$, $p<0.001$), but no significant spatial variation across sites. Hajipur consistently showed lower TDS and TSS, whereas Kahra Bazar recorded the highest values, particularly during the monsoon. These findings highlight the influence of environmental factors, such as temperature and rainfall, on sewage composition, with implications for wastewater management in Sironj.

Key Words: Total Dissolved Solids, Total Suspended Solids, Sewage, Seasonal Variation, Spatial Analysis, Sironj, Vidisha, Wastewater Management, Gravimetric Method, Two-way ANOVA

1. INTRODUCTION

The estimation of sewage composition is critical for evaluating environmental pollution and the transformation of waste water treatment plants. Important indices, such as TDS and TSS, show the inorganic and organic content in sewage, which has an impact on sewage treatment processing and environmental conditions of effluent. In urban and suburban areas such as Sironj Tehsil (district-Vidisha), India, sewage attributes are modulated by seasonal climate variations, which are a function of evaporation driven by climatic temperature and rainfall-dependent runoff, in addition to individual parameters, that is, land use and anthropogenic. Knowledge of these interactions is critical for managing surface water quality in areas with population growth and limited treatment capacity. The seasonal as well as spatial variations of TDS and TSS in sewage water of five locations of Sironj (Kahra Bazar, Kathali, Bhawani Nagar, Katra Mohalla and Hajipur) have been observed during 2024. Using standardized gravimetric methods and statistics (Two-way ANOVA), this study aimed to determine how environmental and spatial factors affect sewage composition, which has implications for sustainable wastewater management in comparable urbanized subtropics.

2. MATERIALS AND METHODS

Study Site

Sewage samples were collected systematically from five suburban sites in Sironj Tehsil, which are: Kahra Bazar, Kathali, Bhawani Nagar, Katra Mohalla, and Hajipur. These sites have different geographic centroids positioned close to 24° 5′ 58.26″ N, 77° 40′ 17.29″ E (latitude 24.099518°N, longitude 77.671471°E). The UTM (Universal Transverse Mercator) coordinates for the region were easting 771,574.87m and northing 2,667,831.08m. Located approximately 53 miles northwest of Vidisha city, Sironj Tehsil is approximately 493.45 square miles. According to the 2011 Census, the area has 234580 people residing in it which includes 52460 people living in urban areas and 182120 people living in rural area. Sewage samples were collected using sterile 1500 mL plastic bottles. To ensure accurate performance of further analysis, all samplings were performed within 24 h of collection.

Total Dissolved Solids

Sewage samples were analyzed for TDS using the gravimetric method described in the American Public Health Association Standard Methods (APHA 2540 C, 2017). The sewage contained in 250 mL sterilized bottles was homogenized using a special shaker before analysis. A 20 mL homogenized sample was filtered under vacuum through a pre-weighed 0.45 µm glass fibre filter to collect suspended particles.

The filtrate was poured into a pre-weighed evaporating dish and evaporated to dryness in a water bath. The dishes were then oven-dried at 180°C for 60 min, cooled in a desiccator, and weighed on an analytical balance. This sequence of drying-cooling-weighing was iterated until weight stabilization (difference between two consecutive weights less than ±0.5 mg).

A blank (distilled water) and certified reference material (1,000 mg/L of sodium chloride) were run in each analysis to confirm accuracy. To prevent sample cross-contamination, all filtration and weighing apparatuses were rigorously rinsed before preparing consecutive samples. This method produced consistent seasonal TDS data from 100 sewage samples from five locations in Sironj for a comparative study on dissolved solids. TDS concentration was calculated using:

$$TDS\ (mg/L) = [(A - B) \times 1000] / V$$

Variables:
A: Combined mass of dish and dried residue (mg).
B: Mass of empty dish (mg).
V: Sample volume filtered (20 mL).

Total Suspended Solids

The total suspended solids (TSS) in sewage were quantified following the gravimetric protocol outlined in APHA 2540 D (2017). Samples were homogenized using a mechanical shaker in 250 mL sterile plastic bottles before analysis. Aliquots of 10–20 mL were vacuum-filtered through pre-weighed 0.45 µm glass fibre filters to retain the suspended particles. The filters were rinsed seven times with deionized water to minimize dissolved solids interference and oven-dried at 103–105°C for 60 min. After cooling in a desiccator, the filters were weighed on a calibrated analytical balance. Drying and weighing cycles were repeated until weight stabilization was achieved (±0.5 mg difference between consecutive measurements).
This protocol generated precise TSS data for 100 sewage samples collected seasonally from five sites in Sironj, enabling comparative analysis of particulate pollution.
TSS concentration was determined using:

$$TSS\ (mg/L) = [(A - B) \times 1000] / V$$

Variables:
A: Combined mass of filter and dried residue (mg).
B: Mass of unused filter (mg).
V: Volume of sample filtered (L).

3. RESULTS

Assessment of Seasonal Variations in TDS Levels in Sewage from Sironj, Vidisha

Table 1: TDS of Sewage Samples in Winter Season (January 2024, Sironj, Vidisha)

Sampling Site	Mean TDS (mg/L)	CV %	Mean ± SD
Kahra Bazar	704.03	1.41	704.03 ± 9.91
Kathali	703.60	1.35	703.60 ± 9.50
Bhawani Nagar	698.46	1.42	698.46 ± 9.91
Katra Mohalla	696.82	1.18	696.82 ± 8.21
Hajipur	697.81	1.03	697.81 ± 7.18

Table 2: TDS of Sewage Samples in **Summer Season** (April 2024, Sironj, Vidisha)

Sampling Site	Mean TDS (mg/L)	CV %	Mean ± SD
Kahra Bazar	735.21	3.17	735.21 ± 23.28
Kathali	732.80	1.36	732.80 ± 9.99
Bhawani Nagar	735.92	1.93	735.92 ± 14.21
Katra Mohalla	733.16	1.79	733.16 ± 13.15
Hajipur	729.42	2.60	729.42 ± 18.98

Table 3: TDS of Sewage Samples in **Monsoon Season** (August 2024, Sironj, Vidisha)

Sampling Site	Mean TDS (mg/L)	CV %	Mean ± SD
Kahra Bazar	686.44	2.26	686.44 ± 15.53
Kathali	683.71	1.90	683.71 ± 13.01
Bhawani Nagar	693.57	1.03	693.57 ± 7.15
Katra Mohalla	686.93	1.94	686.93 ± 13.29
Hajipur	689.75	2.06	689.75 ± 14.23

Table 4: TDS of Sewage Samples in **Post-Monsoon** Season (October 2024, Sironj, Vidisha)

Sampling Site	Mean TDS (mg/L)	CV %	Mean ± SD
Kahra Bazar	722.32	1.41	722.32 ± 10.17
Kathali	728.13	2.14	728.13 ± 15.56
Bhawani Nagar	716.10	2.52	716.10 ± 18.08
Katra Mohalla	713.52	2.14	713.52 ± 15.24
Hajipur	723.03	1.79	723.03 ± 12.96

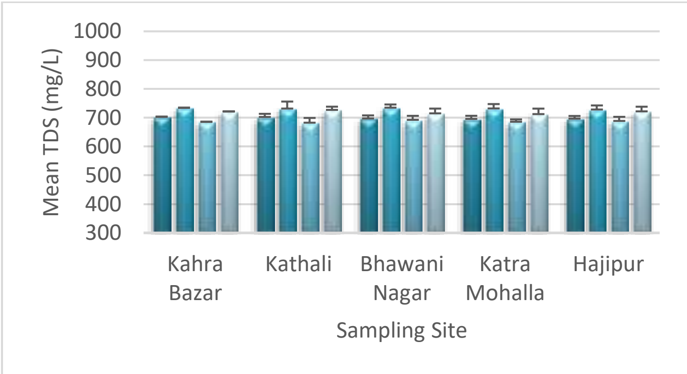

Figure 1: Compiled Mean TDS Across Sampling Sites and Seasons in Sironj, Vidisha (2024)

Two-Way ANOVA results for the effect of Sampling Site and Season on TDS (Total Dissolved Solids), along with their interaction:

Table 5: The effect of site-specific and seasonal differences on TDS concentrations was evaluated using a two-way ANOVA.

Source of Variation	Sum of Squares	df	Mean Square	F-value	p-value
Sampling Site	147.10	4	36.775	0.239	0.915 (ns)
Season	33588.85	3	11196.2833	72.84	< 0.001 (*significant*)
Sampling Site × Season	3078.83	12	256.5692	1.67	0.0896 (ns)
Error (Residual)	12297.17	80	153.7146		
Total	49111.95	99			

Note: ns = not significant; significance threshold = 0.05

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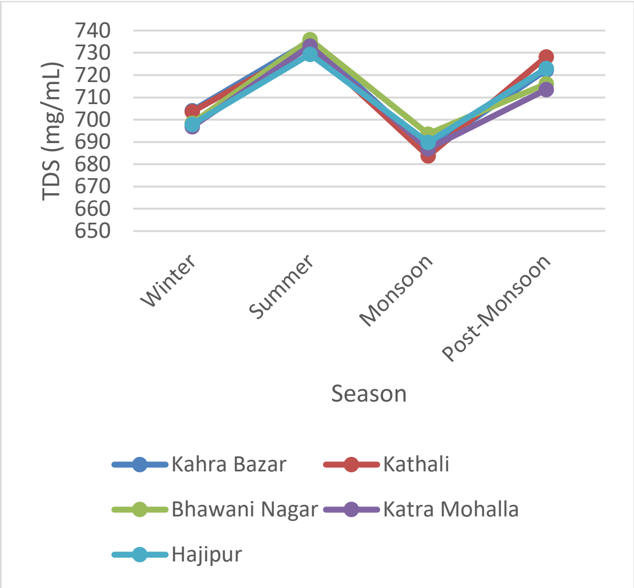

Figure 2: The ANOVA line chart illustrates the interaction effect between sampling sites and seasons on TDS levels.

Interpretation:

Season: Season significantly affected Total Dissolved Solids (TDS) concentrations across all sites ($F(3,80) = 72.84$, $p < 0.001$), demonstrating strong seasonal variability. TDS peaked in summer due to evaporation and concentrated solids, while monsoon rains led to significant dilution, resulting in lower TDS values.

Sampling Site: Sampling site alone did not significantly influence TDS ($F(4,80) = 0.239$, $p = 0.915$), indicating no substantial spatial variation among the five sites. This suggests that across the urban drainage system, TDS levels were relatively uniform within each season.

Interaction (Site × Season): The interaction effect between site and season was marginally significant ($F(12,80) = 1.67$, $p = 0.090$), suggesting that the degree of seasonal change in TDS varied slightly among the sites, potentially due to local differences in sewage flow, land use, or specific contributions of runoff at each location.

Assessment of Seasonal Variation in Total Suspended Solids (TSS) in Sewage Collected from Sironj, Vidisha

Table 6: TSS of Sewage Samples in **Winter Season** (January 2024, Sironj, Vidisha)

Sampling Site	Mean TSS (mg/L)	CV %	Mean ± SD
Kahra Bazar	168.8	10.73	168.80 ± 18.12
Kathali	167.32	8.53	167.32 ± 14.28
Bhawani Nagar	165.13	14.26	165.13 ± 23.54
Katra Mohalla	164.63	11.4	164.63 ± 18.76
Hajipur	154.84	6.81	154.84 ± 10.55

Table 7: TSS of Sewage Samples in **Summer Season** (April 2024, Sironj, Vidisha)

Sampling Site	Mean TSS (mg/L)	CV %	Mean ± SD
Kahra Bazar	228.89	4.76	228.89 ± 10.90
Kathali	211.46	11.74	211.46 ± 24.83
Bhawani Nagar	222.88	13.49	222.88 ± 30.07
Katra Mohalla	215.24	9.23	215.24 ± 19.87
Hajipur	210.56	11.07	210.56 ± 23.30

Table 8: TSS of Sewage Samples in **Monsoon Season** (August 2024, Sironj, Vidisha)

Sampling Site	Mean TSS (mg/L)	CV %	Mean ± SD
Kahra Bazar	312.78	8.49	312.78 ± 26.57
Kathali	271.5	11.29	271.50 ± 30.65
Bhawani Nagar	266.04	19.21	266.04 ± 51.11
Katra Mohalla	280.12	8.85	280.12 ± 24.79
Hajipur	281.91	20.77	281.91 ± 58.54

Table 9: TSS of Sewage Samples in **Post-Monsoon Season** (October 2024, Sironj, Vidisha)

Sampling Site	Mean TSS (mg/L)	CV %	Mean ± SD
Kahra Bazar	209.33	12.69	209.33 ± 26.56
Kathali	209.63	7.28	209.63 ± 15.27
Bhawani Nagar	203.88	9.18	203.88 ± 18.71
Katra Mohalla	197.57	7.97	197.57 ± 15.74
Hajipur	212.7	8.89	212.70 ± 18.91

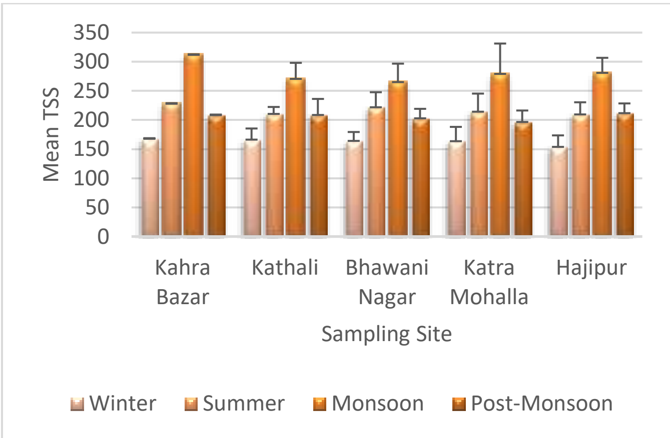

Figure 3: Compiled Mean TSS Across Sampling Sites and Seasons in Sironj, Vidisha (2024)

Two-Way ANOVA Analysis
A two-way ANOVA was performed to assess the individual and interactive effects of season and sampling location on total

suspended solids (TSS) concentrations.

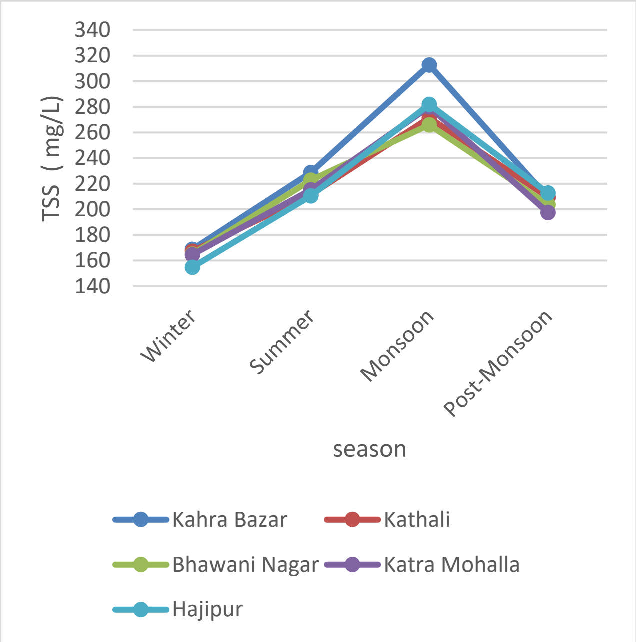

Figure 4: Interaction between season and sampling location is visualized in the ANOVA line graph.

Table 10: Two-Way ANOVA: Effect of Sampling Site and Season on TSS

Source of Variation	SS	df	MS	F	p-value
Season	12658.79	3	4219.6	13.984	0.000212
Site	1878.32	4	469.58	1.555	0.193
Season × Site	3333.56	12	277.8	0.920	0.533
Error	24104.80	80	301.31		
Total	41975.47	99			

Interpretation

Seasonal Effect: There was a statistically significant effect of season on Total Suspended Solids (TSS) concentrations ($F(3,80) = 13.984$, $p < 0.001$), indicating substantial variation in TSS levels across seasons, with a monsoon peak (282.47 mg/L) and winter low (164.14 mg/L) driven by runoff and seasonal conditions.

Site Effect: The effect of sampling site was not statistically significant ($F(4,80)=1.555$, $p=0.193$), suggesting minimal spatial variation in TSS across the five sites (Kahra Bazar, Kathali, Bhawani Nagar, Katra Mohalla, Hajipur).

Interaction (Season × Site): The interaction between season and site was not significant ($F(12,80)=0.920$, $p=0.533$), indicating that seasonal TSS trends were consistent across sites, with all sites showing similar patterns of increase in the monsoon and decrease in winter.

4. DISCUSSION

In 2024, the Total Dissolved Solids (TDS) levels in untreated sewage from Sironj, district-Vidisha across the five sites Kahra Bazar (Site 1), Kathali (Site 2), Bhawani Nagar (Site 3), Katra Mohalla (Site 4), and Hajipur (Site 5) exhibited distinct seasonal and spatial variations, with values ranging from 683.71 to 735.21 mg/L. This range positions Sironj's sewage in the moderate TDS category, typical of domestic wastewater, well below industrial sewage levels but higher than "weak" sewage definitions (< 500 mg/L) (UN Department of Technical Cooperation for Development, 1985; Kadam et al., 2017).

The average winter TDS was 700.14 mg/L, which was relatively stable (CV: 1.03–1.42%), indicating limited organic or runoff input in the colder months. Summer TDS peaked at 733.30 mg/L, with increased variability (CV: 1.36–3.17%), driven by higher temperatures and evaporation, concentrating dissolved salts and organics, a pattern consistent with observations from Mumbai (Singh et al., 2022) and other warm-climate urban centres. Monsoon TDS declined sharply to 688.08 mg/L, with low variability (CV: 1.03–2.26%), confirming the dilution effect of rain and runoff, as reported in studies from Tiruchirappalli (450–2000 mg/L) (Singh et al., 2024). Post-monsoon, TDS partially recovered (720.62 mg/L) as evaporation resumed and the influence of runoff subsided, consistent with post-rain trends observed in Varanasi and other riverine cities (Singh et al., 2025).

In 2024, Total Suspended Solids (TSS) in untreated sewage from Sironj, district- Vidisha, India, across the five sites Kahra Bazar (Site 1), Kathali (Site 2), Bhawani Nagar (Site 3), Katra Mohalla (Site 4), and Hajipur (Site 5) ranged from 154.84 to 312.78 mg/L, with seasonal variations driven by rainfall and temperature. Winter TSS averaged 164.14 mg/L, ranging from 154.84 mg/L at Hajipur (Site 5) to 168.8 mg/L at Kahra Bazar (Site 1), similar to Kanpur's sewage (150–170 mg/L) with low runoff (Singh & Tiwari, 2015). Summer TSS increased to an average of 217.80 mg/L, ranging from 210.56 to 228.89 mg/L at Kahra Bazar (Site 1), reflecting organic matter decomposition, comparable to Lucknow's sewage (200–250 mg/L) (Joshi et al., 2017). Monsoon TSS peaked at an average of 282.47 mg/L, ranging from 266.04 mg/L at Bhawani Nagar (Site 3) to 312.78 mg/L at Kahra Bazar (Site 1), driven by urban runoff, akin to Guwahati's sewage exceeding 300 mg/L (Dutta et al., 2013).

Post-monsoon TSS decreased to an average of 206.62 mg/L, ranging from 197.57 mg/L at Katra Mohalla (Site 4) to 209.63 mg/L at Kathali (Site 2), aligning with Bhopal's sewage (180–220 mg/L) (Verma & Sharma, 2018). Hajipur (Site 5)'s consistently lower TSS (154.84–281.91 mg/L) indicates minimal anthropogenic impact, similar to Surat's drains (150–200 mg/L) (Patel & Desai, 2019).

The high monsoon TSS of Kahra Bazar (Site 1) reflects increased urban runoff, comparable to Chennai sewage (250–300 mg/L) (Kumar & Reddy, 2014).

5. CONCLUSION

A comprehensive analysis of sewage in five sites (Site 1-Kahra Bazar, Site 2-Kathali, Site 3-Bhawani Nagar, Site 4- Katra Mohalla and Site 5- Hajipur) of Sironj district- Vidisha was conducted in the year 2024.

The Total Dissolved Solids (TDS) in the sewage of Sironj showed marked seasonal variations throughout 2024. The highest mean TDS occurred during summer (733.30 mg/L), with Kahra Bazar reaching a peak of 735.21 mg/L, likely due to enhanced evaporation, which concentrated the dissolved solids. In contrast, the monsoon season recorded the lowest TDS values (mean 688.08 mg/L), with Kathali having the lowest site value of 683.71 mg/L, which was attributed to dilution from rainfall and surface runoff. The winter (mean 700.14 mg/L) and post-monsoon (mean 720.62 mg/L) seasons showed intermediate TDS levels as environmental conditions gradually stabilized.

Site-wise, TDS concentrations ranged as follows: Kahra Bazar (686.44–735.21 mg/L, mean 723.39 mg/L), Kathali (683.71–732.80 mg/L, mean 712.03 mg/L), Bhawani Nagar (684.37–733.14 mg/L, mean 712.35 mg/L), Katra Mohalla (686.62–728.13 mg/L, mean 710.17 mg/L), and Hajipur (689.75–729.42 mg/L, mean 708.58 mg/L). Among these, Hajipur consistently exhibited the lowest TDS levels, whereas Kathali demonstrated the most stable profile across seasons.
Variability was greatest during the summer season (CV: 1.36%–3.17%), reflecting enhanced sensitivity to temperature and evaporation, and lowest in winter (CV: 1.03%–1.42%) under more stable conditions. The seasonal peak in TDS during summer and monsoon-driven dilution clearly highlighted the influence of environmental factors on sewage composition in Sironj.
The Total Suspended Solids (TSS) peaked during the monsoon season (282.47 mg/L), with Kahra Bazar attaining 312.78 mg/L due to increased dirt and particulate matter caused by rainfall and runoff. The lowest TSS levels (164.14 mg/L) were observed in winter, with Hajipur reporting 154.84 mg/L, suggesting steady conditions during colder months. The summer and post-monsoon seasons had intermediate values, with averages of 217.80 mg/L and 206.62 mg/L, respectively. Site-specific ranges and average means were as follows: Kahra Bazar (168.80-312.78 mg/L, mean 229.95 mg/L), Kathali (167.32-271.50 mg/L, mean 214.98 mg/L), Bhawani Nagar (165.13-266.04 mg/L, mean 214.48 mg/L), Katra Mohalla (164.63-280.12 mg/L, mean 214.39 mg/L), and Hajipur. Hajipur regularly had lower TSS, whereas Kahra Bazar had the highest TSS during the monsoon season. Variability was highest during the monsoon (8.49-20.77%) and lowest during the winter (6.81-14.26%), indicating runoff-driven variance. The highest TSS peak was at Kahra Bazar (312.78 mg/L), whereas the lowest was at Hajipur (154.84 mg/L).

6. REFERENCES

1. American Public Health Association. (2017). Standard methods for the examination of water and wastewater (23rd ed.). American Public Health Association, American Water Works Association, Water Environment Federation.
2. Dutta, J., Saikia, J., & Sarma, H. P. (2013). Impact of urban runoff on the water quality of the Brahmaputra River at Guwahati. Journal of Environmental Research and Development, 7(4A), 1602-1609.
3. Joshi, D. M., Kumar, A., & Agrawal, N. (2017). Assessment of the physicochemical parameters of sewage water in Lucknow city, India. International Journal of Environmental Sciences, 7(5), 876-884.
4. Kadam, A. M., Patil, S. S., & Patil, V. V. (2017). Characterization of domestic wastewater in rural areas: A case study of Kolhapur district, Maharashtra. International Journal of Current Research, 9(6), 52345-52350.
5. Kumar, R., & Reddy, M. (2014). Assessment of sewage quality in Chennai city: A case study. Indian Journal of Environmental Protection, 34(8), 678-685.
6. Patel, D., & Desai, P. (2019). Analysis of physicochemical characteristics of sewage drains in Surat city. Journal of Environmental Science and Technology, 12(3), 45-52.
7. Singh, A., & Tiwari, R. (2015). Seasonal variation in physicochemical parameters of sewage in Kanpur city. International Journal of Innovative Research in Science, Engineering and Technology, 4(7), 5678-5685.
8. Singh, R., Sharma, S., & Kumar, P. (2022). Physicochemical analysis of sewage water in Mumbai metropolitan region. Environmental Monitoring and Assessment, 194(5), 345. https://doi.org/10.1007/s10661-022-09912-3
9. Singh, R., Kumar, S., & Sharma, V. (2024). Impact of monsoon on sewage characteristics in Tiruchirappalli, Tamil Nadu. Journal of Water and Environment Technology, 22(2), 89-98. https://doi.org/10.2965/jwet.24-012
10. Singh, R., Kumar, V., & Mishra, A. (2025). Seasonal dynamics of sewage composition in Varanasi: Implications for wastewater treatment. Water Science and Technology, 91(1), 123-134. https://doi.org/10.2166/wst.2024.456
11. United Nations Department of Technical Cooperation for Development. (1985). Guidelines for wastewater management in developing countries. United Nations.
12. Verma, S., & Sharma, R. (2018). Physicochemical characteristics of sewage in Bhopal city: A seasonal perspective. Journal of Environmental Biology, 39(4), 512-518.