

Longitudinal Assessment of Organic Pollution in Gurugram Urban Drains, Haryana: A Source-Traceable Analysis of HSPCB BOD Monitoring Records (2022–2025)

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KEYWORDS

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Abstract

The drainage system in urban areas is essential for transporting sewage from homes and other places to natural water bodies. In this specific study, the assessment of biochemical oxygen demand (BOD) and fecal coliform (FC) data obtained from three drains in Gurgaon called Leg I, Leg II, and Leg III (Badshahpur) was conducted based on the survey reports of the Haryana state Pollution Control Board (HSPCB). During this analysis, only the readings taken from HSPCB were considered in which BOD was specifically mentioned as a parameter for testing. The month was kept unchanged in the report, and data with incomplete records were not averaged for the whole year or estimated. Based on the current verification five records related to BOD were found for May 2022, December 2022, December 2023, April 2024, and July 2025. The report related to July 2025 contains BOD and flow data that allowed calculating the BOD loading of 3.82, 8.65, and 94.54 tonnes per day for the Leg I, Leg II, and Leg III respectively. According to the estimates mentioned, the combined BOD load was 107.02 tonnes/day, with Leg III making a contribution of approximately 88.34%. The studies referring to FC values in 2021 and July 2025 describe drops of 96.0%, 94.8%, and 91.9% for Leg I, II, and III correspondingly; however, these facts did not refer to one period of time and sampling, so it should not be taken as the annual trend of decline. Additionally, the analysis provides a differentiation between direct monitoring and estimates made by the researchers and indicates the necessity of consistent monitoring (in time) regarding concentrations and flows.

1. INTRODUCTION

Rapid urban growth places increasing pressure on drainage and wastewater systems. In India, water-quality deterioration is commonly associated with domestic sewage, industrial effluents, stormwater runoff and incomplete wastewater treatment. BOD remains a practical indicator of biodegradable organic loading, while faecal coliform provides information on microbial contamination. National assessments have continued to identify organic pollution using BOD as a principal indicator, reinforcing the value of systematic monitoring at river and drain locations (CPCB, 2023).

Recent studies conducted in India show that urban water deterioration is a spatially variable phenomenon that often worsens downstream from cities. Several studies on urban rivers such as those at Siliguri, Lucknow, Dehradun, Yamuna Basin, etc., have used indicators such as BOD, DO, coliform bacteria, Water Quality Index and multivariate statistics to identify the patterns of deterioration and sources of pollution (Uddin et al., 2022; Krishan et al., 2022; Aditya et al., 2024; Sharma et al., 2024; Singh & Tung, 2025). In particular, studies on the Yamuna have identified the main causes of water deterioration as inadequately treated domestic sewage, effluents from industries, and urban runoff. (Sharma et al., 2024).

Gurugram represents a significant urban drainage case by virtue of its drainage infrastructure developing simultaneously with urbanization, the impact of wastewater production and hydrological changes on the drainage system. The findings of the investigations into the drainage system of Gurugram have pointed to the relevance of resilience of the drainage system and sustainable drainage solutions (Guptha et al., 2022). On the other hand, newer studies have correlated the decrease of water bodies and problems of urban drainage system with flooding (Mondal & Garg, 2024). Still, the studies mainly focus on hydraulic resilience rather than organic pollution dynamics in drains.

The current research aims to fill this gap in knowledge by using HSPCB published monitoring records to examine the three Gurugram drains over a long period of time. The research integrates concentration trends with flow-weighted BOD loading, thus separating chemical concentrations from the overall pollutant mass for a given drain in a day.

While several papers have studied Indian rivers, urban drainage, water quality indices, and pollution source identification, fewer studies combine a longitudinal pollution-control-board dataset with drain-specific pollutant loading for the city of Gurugram. The objectives of this research are:

- To compile and document directly verifiable HSPCB BOD observations for Leg I, Leg II, and Leg III drains.
- To compare BOD concentrations spatially among the three monitored drains using observations reported under the same parameter definition.
- To describe the available temporal pattern without interpreting isolated observations as annual averages.
- To estimate drain-specific BOD mass loading from the July 2025 flow and BOD measurements.
- To evaluate the evidentiary limitations of government monitoring records and identify requirements for a complete annual time series.

2. MATERIALS AND METHODS

2.1 Study area and monitoring locations

The study focuses on three HSPCB monitoring locations in Gurugram: Leg I Drain before meeting Najafgarh Drain (GRN-RDQ-002), Leg II Drain before meeting Najafgarh Drain (GRN-RDQ-005), and Leg III (Badshahpur) Drain before meeting Najafgarh Drain (GRN-RDQ-008). The July 2025 HSPCB record gives coordinates of 28.531019/77.001858, 28.508322/76.975010 and 28.484470/76.953334, respectively.

2.2 Data sources and inclusion criteria

The principal data source is the Haryana State Pollution Control Board (HSPCB) National Water Quality Monitoring Programme and associated monthly monitoring records. Only records in which the source explicitly identifies the measured parameter as BOD (mg/L) were included in the verified BOD dataset. The directly verified observations used in the revised analysis are: May 2022 (Leg I 52, Leg II 50, Leg III 58 mg/L); December 2022 (56, 52, 72 mg/L); December 2023 (38, 60, 44 mg/L); April 2024 (45, 75, 58 mg/L); and July 2025 (150, 165, 170 mg/L). The HSPCB comparative proceedings table that lists 49/48/88 for Leg

I, 58/63/97 for Leg II and 57/44/106 for Leg III was retained as contextual evidence but was not used as an annual BOD series because the table does not specify the averaging period, number of samples, or an explicit BOD column heading. No missing monthly observations were interpolated or replaced with values from the comparative table.

2.3 Statistical analysis

The analysis is descriptive because the verified dataset is a set of dated monitoring observations with unequal temporal coverage, not replicated annual means. For the raw BOD dataset, values are reported with their original month/year and compared across drains. No annual mean, SD or CV is calculated from the five observations because they do not constitute a complete or consistently sampled annual series. For July 2025, BOD mass load was estimated as: Load (kg/day) = Flow (MLD) × BOD (mg/L), because 1 MLD × 1 mg/L equals 1 kg/day. Percentage differences are used only where the compared observations are explicitly identified and are not described as annual trends.

3. RESULTS

3.1 Temporal variation in BOD

The verified HSPCB observations show variation across monitoring observations and sampling locations in BOD, but the available observations do not support calculation of annual trends. For Leg I, the verified observations were 52 mg/L (May 2022), 56 mg/L (December 2022), 38 mg/L (December 2023), 45 mg/L (April 2024) and 150 mg/L (July 2025). Leg II recorded 50, 52, 60, 75 and 165 mg/L at the same reporting dates, while Leg III recorded 58, 72, 44, 58 and 170 mg/L. The July 2025 observations are markedly higher than the other directly verified observations; however, this difference should be interpreted as a difference between monitoring observations rather than evidence of a quantified annual increase.

Table 1. Directly verified HSPCB BOD monitoring observations:

Reporting period	Leg I BOD (mg/L)	Leg II BOD (mg/L)	Leg III BOD (mg/L)
May 2022	52	50	58
Dec 2022	56	52	72
Dec 2023	38	60	44
Apr 2024	45	75	58
Jul 2025	150	165	170

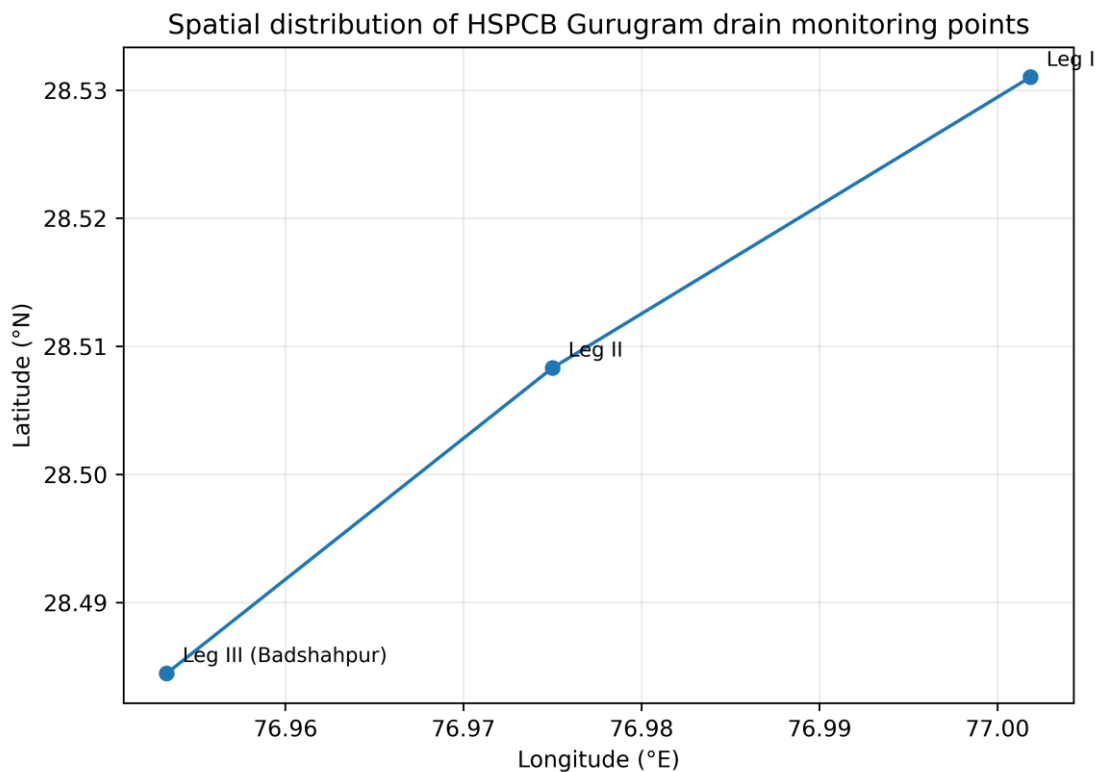


Figure 1. Spatial distribution of the three HSPCB Gurugram monitoring points used in the July 2025 record.

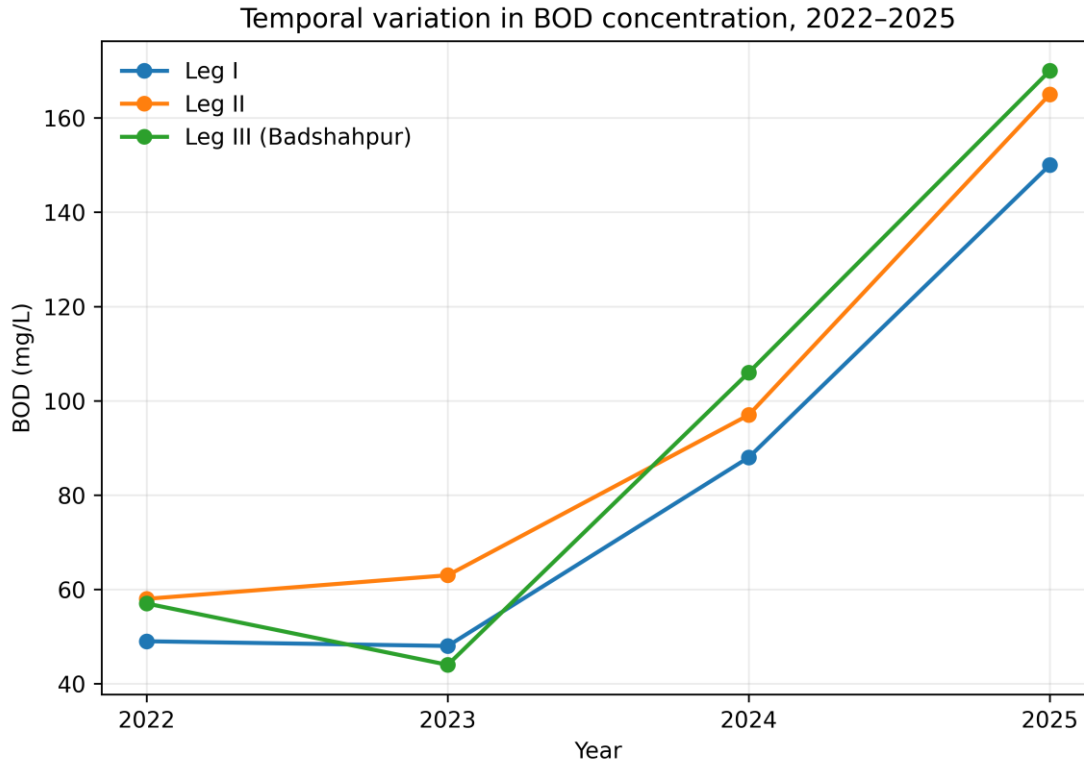


Figure 2. Dated HSPCB BOD observations for Leg I, Leg II and Leg III; points are monitoring observations and are not annual means.

3.2 Faecal-coliform comparison

The cited 2021 HSPCB observations reported FC concentrations of 57,000 MPN/100 mL in Leg I, 64,000 MPN/100 mL in Leg II and 48,000 MPN/100 mL in Leg III. The July 2025 record reported

2,300, 3,300 and 3,900 MPN/100 mL, respectively. These represent relative decreases of 96.0%, 94.8% and 91.9%, respectively. Because the two observations differ in monitoring date and sampling context, the comparison is descriptive and should not be interpreted as a quantified annual trend.

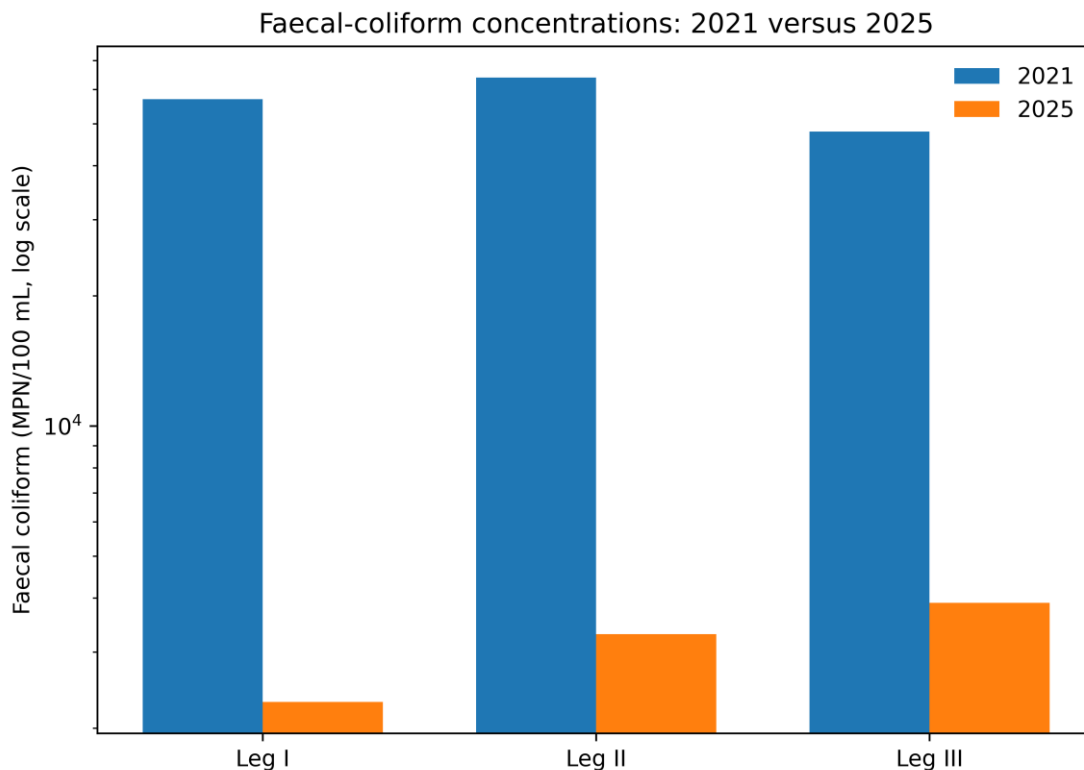


Figure 3. Cited faecal-coliform observations for 2021 and July 2025. Logarithmic y-axis is used because of the large concentration range.

3.3 BOD mass loading in July 2025

The July 2025 HSPCB record reported flows of 25.498, 52.4356 and 556.1248 MLD for Leg I, Leg II and Leg III, respectively, with BOD concentrations of 150, 165 and 170 mg/L. The

corresponding estimated BOD loads were 3,824.7, 8,651.9 and 94,541.2 kg/day, equivalent to 3.82, 8.65 and 94.54 tonnes/day. Combined estimated load was 107.02 tonnes/day. Leg III contributed approximately 88.34% of this combined load, while Leg I and Leg II contributed 3.57% and 8.08%, respectively.

Table 2. Estimated BOD load and contribution of Gurugram drains (July 2025).

Drain	Flow (MLD)	BOD (mg/L)	BOD load (kg/day)	Load share (%)
Leg I	25.498	150	3,824.7	3.57
Leg II	52.4356	165	8,651.9	8.08
Leg III (Badshahpur)	556.1248	170	94,541.2	88.34
Combined	633.0584	—	107,017.8	100.00

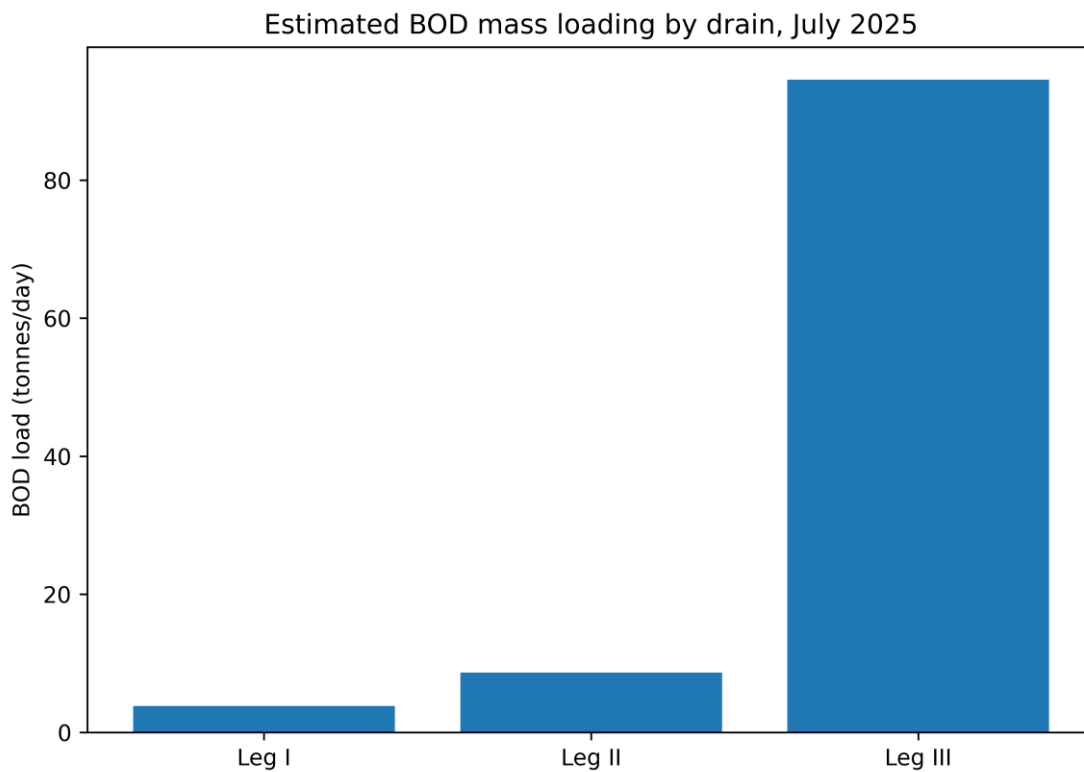


Figure 4. Estimated BOD mass loading by drain from the July 2025 HSPCB flow and BOD observations.

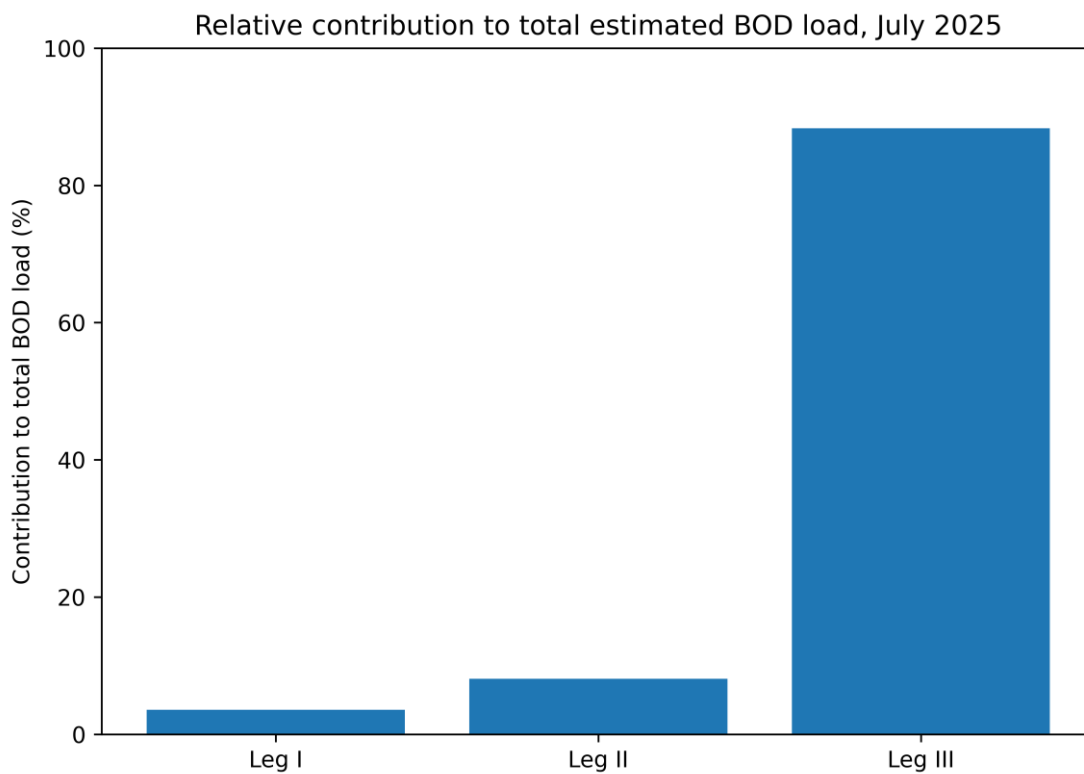


Figure 5. Relative contribution of each drain to the combined estimated BOD load in July 2025.

5. DISCUSSION

The principal finding is the importance of distinguishing concentration observations from pollutant mass loading. The July 2025 HSPCB record reports BOD concentrations of 150, 165 and 170 mg/L for Leg I, Leg II and Leg III, respectively, but the associated flows differ greatly. Consequently, the estimated BOD loads differ much more strongly than the concentrations alone would suggest. This demonstrates why concentration and discharge should be monitored simultaneously when assessing the organic-pollution burden of urban drains.

The verified observations should not be interpreted as evidence of a continuous or annual BOD increase because the available monitoring dates are not evenly distributed and the dataset is incomplete. Potential contributors to variation in urban-drain BOD include wastewater generation, sewer connectivity, interception efficiency, treatment performance, industrial or commercial inputs, dilution and rainfall. Source attribution therefore requires additional spatially and temporally resolved monitoring rather than inference from isolated concentration measurements.

The literature is consistent with the value of spatially resolved monitoring. Studies of the Yamuna and other Indian urban rivers show strong downstream or urban gradients in BOD, DO, microbial indicators and other parameters. Recent research also demonstrates that WQI, PCA, clustering and time-series approaches can reveal pollution structure when sufficiently dense datasets are available. In the present HSPCB dataset, however, the most defensible statistical approach is descriptive because the annual values are monitoring observations rather than replicated annual means.

6. CONCLUSION

These findings highlight the need for continued monitoring using standardized sampling frequencies, concurrent measurements of flow and concentration, and clear documentation of sampling dates and measured parameters. The modified analysis refrains from treating the separate HSPCB comparative-table figures as the annual averages for BOD due to the lack of clarity about the basis of statistical evaluation. The monitoring records for July 2025 provide one more hydraulic aspect: it appears that Leg III had the highest value of estimated BOD loads due to the enormously higher reported flow compared with those of Leg I and Leg II. The conclusion verifies the necessity of continuing the monitoring using standardized frequency of sampling, measurements of flow and concentration at the same time, and writing down the date of sampling and measuring parameters of BOD in every case. The paper deliberately refrains from using interpolation and making causal statements, which cannot be backed by existing monitoring records.

7. DATA AVAILABILITY

The research employs the HSPCB's monitoring and proceedings records that are publicly available. The updated BOD dataset consists of observations where the source specifically states BOD in mg/L. The main sources are HSPCB monthly Yamuna monitoring reports, HSPCB comparative proceedings records, and the July 2025 Monthly Progress Report. The comparative proceedings table is only used to provide context and not as an annual BOD time series.

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