Research Article

Assessment of Physicochemical and Heavy Metal Characteristics of River Water at Selected Locations in Ujjain, Madhya Pradesh, India

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Abstract

Water quality is shaped by natural conditions and human activities, and its assessment requires examination of both general physicochemical properties and selected trace metals. This study presents a comparative assessment of river water samples collected at three locations in Ujjain, Madhya Pradesh: the Kshipra River near Hariyakhadi Village, the NVDA outlet at Nagphani, and Gambhir Dam near the exiting intake well. The analysis is based on laboratory reports issued by the Regional Laboratory, Madhya Pradesh Pollution Control Board, Ujjain, for samples collected on 27 November 2025 and analysed using methods referenced to the 24th edition of Standard Methods/APHA (2023). Parameters included pH, turbidity, chloride, alkalinity, hardness, calcium, magnesium, total dissolved solids (TDS), nitrate, sulphate, fluoride, colour, odour, and selected metals. The reported pH values were 7.98, 7.82, and 7.96, respectively. TDS was highest at the Kshipra River site (818 mg/L), followed by the NVDA outlet (294 mg/L) and Gambhir Dam (398 mg/L). Lead was reported at 0.006 mg/L at the Kshipra River site and not detected at the other two locations; copper was reported at 0.002 mg/L at the Kshipra site and not detected elsewhere. These results show variation among the sampled locations, particularly in turbidity, dissolved solids, and major-ion indicators. Interpretation is limited to the three samples and the parameters reported; the data do not establish seasonal conditions or drinking-water safety on their own.

Keywords: water quality, river water, physicochemical parameters, trace metals, Ujjain, Madhya Pradesh.

1. Introduction

Freshwater resources support domestic use, agriculture, ecosystems, and economic activity. Their quality may change with geology, runoff, wastewater inputs, sediment movement, and other local influences. A significant environmental concern is the growing volume of organic waste produced by homes and the food processing industry.
Monitoring therefore benefits from measuring a combination of physical indicators, such as turbidity and total dissolved solids, chemical indicators, such as pH, alkalinity, chloride, and hardness, and selected metals.

Ujjain and its surrounding region depend on surface-water systems that serve multiple purposes. A comparison of river, outlet, and dam water can provide a snapshot of how measured characteristics differ among locations. Such a comparison is useful for identifying parameters that merit continued monitoring, although a single sampling event cannot establish long-term trends or identify the cause of observed differences.

The present paper uses three water-analysis reports issued by the Regional Laboratory, Madhya Pradesh Pollution Control Board (M.P. PCB), Ujjain. The reports identify the samples as river water from the Kshipra River near Hariyakhadi Village, river water from the NVDA outlet at Nagphani, and river/dam water from Gambhir Dam near the exiting intake well. The purpose is to organize and interpret the reported results in a concise scientific format without adding measurements that were not present in the source.

2. Aim and Objectives

The main aim was to assess and compare selected physicochemical and metal characteristics of water samples from three locations in Ujjain.

- To compile the laboratory-reported values for each sampling location.
- To compare pH, turbidity, major-ion indicators, and total dissolved solids among the sites.
- To summarize the reported colour, odour, and selected metal results.
- To identify parameters that may warrant follow-up monitoring while acknowledging the limits of a single sampling event.

3. Materials and Methods

3.1 Study locations and sampling

The dataset comprised three samples: (i) Kshipra River near Hariyakhadi Village, Ujjain; (ii) NVDA outlet at Nagphani, Ujjain; and (iii) Gambhir Dam near the exiting intake well. According to the laboratory reports, all samples were collected on 27 November 2025, with a sample volume of 2 litres. The reports state that the samples were received in plastic bottles and glass bottles, with plastic bottle specified in the collection details, and that samples were received in sealed condition. The reports identify collection by NCC Ltd., C-66, Vidya Nagar, Bhopal.

3.2 Laboratory analysis

The reports list APHA, 24th edition (2023), as the reference for sampling/analysis. The reported methods include electrometric measurement for pH, nephelometric measurement for turbidity, argentometric measurement for chloride, titrimetric methods for alkalinity and hardness, EDTA titration for calcium, calculation for magnesium, gravimetric measurement for TDS, spectrometric measurement for nitrate, turbidimetric measurement for sulphate, and standard methods for fluoride. Colour and selected metals (copper, zinc, lead, total chromium, and iron) were reported using standard methods referenced to APHA 2023, including Standard Method 3111 B for the metals.

3.3 Data handling

Values were transcribed from the three supplied laboratory reports. Units are retained as printed. “ND” means not detected, as defined in the reports; it should not be interpreted as absolute zero. Colour is reported in Pt-Co units and turbidity in NTU. The reports do not provide a fluoride result for the Gambhir Dam sample in the visible parameter table; this is recorded as “Not reported” rather than inferred.

4. Results

4.1 Physicochemical characteristics

Parameter	Unit	Kshipra River (Hariyakhadi)	NVDA outlet (Nagphani)	Gambhir Dam
pH	pH units	7.98	7.82	7.96
Turbidity	NTU	33.2	2.22	7.2
Chloride as Cl	mg/L	194	17	62
Total alkalinity as $CaCO_3$	mg/L	404	192	232
Total hardness as $CaCO_3$	mg/L	658	226	306
Calcium hardness as $CaCO_3$	mg/L	412	160	210
Magnesium hardness as $CaCO_3$	mg/L	246	66	96
Total dissolved solids (TDS)	mg/L	818	294	398
Nitrate as NO_3^-	mg/L	1.12	0.917	22.6
Sulphate as SO_4^{2-}	mg/L	40.6	10.6	0.169
Fluoride	mg/L	0.179	0.172	Not reported

Across the three samples, pH was near neutral to mildly alkaline, ranging from 7.82 to 7.98. The Kshipra River sample had the highest turbidity (33.2 NTU), chloride (194 mg/L), alkalinity (404 mg/L as $CaCO_3$), hardness (658 mg/L as $CaCO_3$), magnesium hardness (246 mg/L as $CaCO_3$), and TDS (818 mg/L). The NVDA outlet showed the lowest reported turbidity (2.22 NTU), chloride (17 mg/L), total hardness (226 mg/L), and TDS (294 mg/L). Gambhir Dam had intermediate turbidity, chloride, hardness, and TDS values, while its reported nitrate concentration (22.6 mg/L) was higher than the other two samples.

4.2 Colour, odour, and metals

Parameter	Unit	Kshipra River	NVDA outlet	Gambhir Dam
Colour	Pt-Co units	10	5	5
Odour	—	Odourless	Odourless	Odourless
Copper (as Cu)	mg/L	0.002	ND	ND
Zinc (as Zn)	mg/L	ND	ND	ND
Lead (Pb)	mg/L	0.006	ND	ND
Total chromium (as Cr)	mg/L	ND	ND	ND
Iron (as Fe)	mg/L	ND	ND	ND

The laboratory reports described all three samples as odourless. Colour was reported as 10 Pt-Co units for the Kshipra River sample and 5 Pt-Co units for both the NVDA outlet and Gambhir Dam. Copper was detected at 0.002 mg/L and lead at 0.006 mg/L in the Kshipra River sample; both were reported as ND in the other two samples. Zinc, total chromium, and iron were reported as ND at all three locations.

5. Discussion

5.1 Variation in general water-quality indicators

The pH values (7.82–7.98) were relatively close across the sites, indicating limited variation in this parameter during the sampling event. pH alone, however, is not a complete measure of water quality and should be interpreted alongside other chemical and physical indicators.

The most pronounced contrast was observed in turbidity. The Kshipra River sample (33.2 NTU) exceeded the values reported for the NVDA outlet (2.22 NTU) and Gambhir Dam (7.2 NTU). Turbidity can reflect suspended material, but the present dataset does not identify its source. Sediment, runoff, or other local inputs are possible explanations, yet these remain hypotheses and would require field observations and repeated sampling.

TDS, hardness, alkalinity, and chloride were also highest in the Kshipra River sample. These parameters describe dissolved constituents and mineral-related characteristics, but the laboratory values alone cannot distinguish natural geochemical contributions from anthropogenic inputs. The NVDA outlet had substantially lower values for these parameters, while Gambhir Dam generally fell between the other sites.

5.2 Nitrate and sulphate

Nitrate differed among the samples, with the highest reported concentration at Gambhir Dam (22.6 mg/L), compared with 1.12 mg/L at the Kshipra River and 0.917 mg/L at the NVDA outlet. This difference makes nitrate an appropriate parameter for continued monitoring at the dam location. The report does not provide information on land use, nutrient sources, or seasonal conditions, so no causal explanation can be established.

Sulphate was reported as 40.6 mg/L at the Kshipra River, 10.6 mg/L at the NVDA outlet, and 0.169 mg/L at Gambhir Dam. These are the values as transcribed from the reports; the unusually low dam result should be verified against the original laboratory record before being used in further quantitative analysis or publication.

5.3 Selected metals

The metal results show that copper and lead were reported above the detection status at the Kshipra River location, whereas the other listed metals were ND there and all listed metals were ND at the NVDA outlet and Gambhir Dam. "ND" is dependent on the laboratory detection limit, which is not specified in the supplied report. Therefore, ND results should not be equated with proof that a metal is absent.

The Kshipra River lead result (0.006 mg/L) should be considered in a broader monitoring programme, including confirmation sampling and comparison with the applicable standard for the intended water use. The present study does not declare any sample suitable or unsuitable for drinking because the reports are monitoring analyses, the complete set of drinking-water parameters is not available, and treatment status and intended use are unspecified.

5.4 Overall interpretation

The three sites exhibited different profiles rather than a single uniform pattern. The Kshipra River sample was characterized by higher turbidity, TDS, hardness, chloride, alkalinity, and the reported copper and lead detections. Gambhir Dam showed the highest nitrate value in this dataset. The NVDA outlet had comparatively lower values for several measured parameters. These observations identify monitoring priorities but do not establish pollution sources, seasonal trends, or ecological impacts.

6. Conclusion

This comparative assessment of three water samples from Ujjain, collected on 27 November 2025, found measurable differences in physicochemical characteristics. The Kshipra River near Hariyakhadi Village had the highest reported turbidity (33.2 NTU), TDS (818 mg/L), total hardness (658 mg/L as $CaCO_3$), chloride (194 mg/L), and alkalinity (404 mg/L as $CaCO_3$). The NVDA outlet at Nagphani showed lower values for several of these indicators. Gambhir Dam had the highest reported nitrate concentration (22.6 mg/L). Copper (0.002 mg/L) and lead (0.006 mg/L) were reported in the Kshipra River sample, while selected metals were ND at the other sites.

The findings support continued location-specific monitoring, particularly for turbidity and dissolved constituents at the Kshipra River site, and nitrate at Gambhir Dam. Confirmatory sampling, seasonal repetition, documentation of detection limits, and verification of the sulphate value for Gambhir Dam are recommended. Since this study is based on one sampling date and a limited parameter set, its conclusions should be treated as a snapshot and not as a comprehensive determination of drinking-water safety.

7. Limitations

- Only three samples from one sampling date (27 November 2025) were available; seasonal and temporal variation cannot be assessed.
- Replicate measurements, uncertainty estimates, and laboratory detection limits were not included in the supplied reports.
- The Gambhir Dam fluoride value was not visible/reported in the parameter table, and its sulphate value should be verified against the original report.
- Water-use context, treatment history, field conditions, and potential pollution sources were not provided.
- The study evaluates only the parameters listed in the laboratory reports and cannot independently certify drinking-water potability.

8. Recommendations

- Repeat sampling at all three locations in different seasons and include field replicates where feasible.
- Verify the Gambhir Dam sulphate result and obtain the missing/unclear fluoride result from the laboratory.
- Request detection limits and quality-control information for metals, and confirm lead and copper findings through repeat analysis.

- Include additional relevant parameters and compare results with the applicable Indian drinking-water or surface-water criteria based on the intended use.
- Record rainfall, flow conditions, nearby activities, and sample collection details to support source interpretation.

9. References

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