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Physicochemical Characteristics Of Surface Water And Groundwater Around Akhada Balapur, Hingoli District (Maharashtra): A Review Of The Kayadhu River, Ponds And Bore Wells

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Abstract

Villages of Kalamnuri tehsil, including Akhada Balapur, use bore wells, dug wells, village ponds and the Kayadhu river for drinking and irrigation, all within Deccan basalt terrain. This review compiles published and official data on sixteen physicochemical parameters, namely temperature, pH, electrical conductivity, total dissolved solids, turbidity, total alkalinity, total hardness, calcium, magnesium, chloride, sulphate, nitrate, fluoride, dissolved oxygen, biochemical oxygen demand and chemical oxygen demand, and compares them with IS 10500:2012 and CPCB criteria. Groundwater of the district is mildly alkaline and mostly hard, with bicarbonate as the dominant anion. Salinity, chloride and sulphate generally remain within acceptable limits, whereas nitrate and, in some wells, fluoride and magnesium exceed desirable limits, more often before the monsoon. No peer-reviewed physicochemical dataset could be traced for the Kayadhu river; the Penganga, its parent river, shows low dissolved oxygen and high BOD at several monitoring stations. Data for local ponds are also lacking, and regional lake studies point to turbidity, hardness and heavy metals as concerns. Seasonal, village-level monitoring of the Kayadhu, ponds and bore wells is recommended.

Keywords: *Akhada Balapur, Kayadhu river, Groundwater quality, Hingoli, IS 10500:2012, Water quality index*

Introduction

In the Marathwada region, rural households depend largely on groundwater because perennial surface water is scarce and monsoon rainfall is uneven. In Hingoli district, both domestic supply and irrigation lean on dug wells and bore wells tapping the weathered and fractured Deccan basalt (CGWB, 2013). Intensive fertiliser use, unlined sanitation and repeated drought years can alter the chemistry of these shallow aquifers, and nitrate and fluoride have already been flagged in other parts of the Godavari basin (Marghade et al., 2021). Monitoring a fixed set of physicochemical parameters is therefore the first step in deciding whether a source is fit for drinking (WHO, 2022).

This review brings together the available information on water around Akhada Balapur (Kalamnuri tehsil), covering the Kayadhu river, village ponds and bore wells. Its aims are (i) to summarise reported values of the main physicochemical parameters, (ii) to compare them with national drinking-water and surface-water standards, and (iii) to point out data gaps for local researchers.

Study Area

Akhada Balapur lies in Kalamnuri tehsil of Hingoli district in the Kayadhu basin. The Kayadhu rises in the Washim hills, flows south-east through Hingoli and joins the Penganga in Nanded district; its basin is carved entirely in Deccan Trap lava flows (Ghute & Babar, 2021). Groundwater occurs under phreatic conditions in the weathered zone and under semi-confined conditions in jointed and vesicular basalt, with thin alluvium along stream courses (CGWB, 2013). The CGWB hydrograph station at Balapur Akhada showed only a marginal long-term fall in pre-monsoon water level, about 0.005 m per year (CGWB, 2013). In 2023 the district received about 23% less monsoon rainfall than normal, which increases dependence on wells (CGWB, 2025).

Material And Methods

Almost all the studies reviewed collected samples in clean polyethylene bottles and analysed them following standard methods: pH and EC with probes, alkalinity, hardness, calcium, magnesium and chloride by titration, sulphate by turbidimetry, nitrate and fluoride by spectrophotometry or ion-selective electrode, and DO, BOD and COD by Winkler, five-day incubation and dichromate reflux respectively (APHA, 2017). Results were compared with IS 10500:2012 for drinking water (BIS, 2012) and with designated-best-use classes for surface

water (CPCB, n.d.). Several authors also condensed the parameters into a Water Quality Index (WQI), an approach introduced by Horton (1965) and later refined by Brown et al. (1970).

Results And Discussion

Parameters and their significance

Table 1 lists the sixteen parameters, the BIS limits and their main significance. EC and temperature have no BIS limit, while DO, BOD and COD are assessed for surface water through CPCB criteria rather than drinking-water standards (BIS, 2012; CPCB, n.d.).

Table 1. Physicochemical parameters, standards and significance (mg/L unless stated) (WHO, 2022; BIS, 2012; CPCB, n.d.).

Parameter	BIS acceptable / permissible	Significance
Temperature	—	Controls gas solubility and reaction rates
pH	6.5–8.5 (no relaxation)	High pH reduces chlorination efficiency; low pH corrodes pipes
EC (µS/cm)	— (≈ TDS/0.64)	Quick indicator of total ionic load
TDS	500 / 2000	Taste, scaling; reflects salinity
Turbidity (NTU)	1 / 5	Shields microbes from disinfection
Total alkalinity (as $CaCO_3$)	200 / 600	Mainly HCO_3^- from basalt weathering; bitter taste
Total hardness (as $CaCO_3$)	200 / 600	Scaling, soap consumption
Calcium	75 / 200	Main hardness cation; scaling
Magnesium	30 / 100	Laxative effect at high levels
Chloride	250 / 1000	Salty taste; sewage indicator
Sulphate	200 / 400	Gastro-intestinal irritation
Nitrate (NO_3^-)	45 (no relaxation)	Methaemoglobinaemia in infants; fertiliser/sewage
Fluoride	1.0 / 1.5	Dental and skeletal fluorosis above 1.5
DO	CPCB Class A ≥ 6; Class C ≥ 4	Indicator of aquatic health
BOD	CPCB Class A ≤ 2; Class C ≤ 3	Biodegradable organic load
COD	No BIS/CPCB class limit	Total oxidisable (incl. non-biodegradable) load

Bore wells and dug wells

CGWB analysis of May 2010 samples from Hingoli monitoring wells showed alkaline water (pH 7.9–8.5) with EC of 550–760 µS/cm at most sites, rising to 2200 µS/cm at Alegaon. Total hardness was 180–440 mg/L, total alkalinity 195–270 mg/L and fluoride below 1 mg/L, whereas nitrate reached 83 mg/L at Hatta, almost twice the BIS limit (CGWB, 2013). The 2024 groundwater yearbook again recorded wide EC ranges in Hingoli (528–2435 µS/cm before and 870–2190 µS/cm after the monsoon), with fluoride of 0.35–1.23 mg/L and no sample above 3000 µS/cm EC or 1.5 mg/L fluoride (CGWB, 2025).

The most detailed recent dataset comes from Aundha Nagnath tehsil, adjoining Kalamnuri, where Raut et al. (2025) tested 60 sources (dug wells, bore wells, hand pumps and Siddheshwar dam) before and after the 2022 monsoon. pH ranged from 6.9 to 8.9 and TDS from 146 to 545 mg/L before the monsoon, increasing to as much as 1720 mg/L afterwards. Total hardness (72–782 mg/L) exceeded the desirable limit in half the pre-monsoon samples, and magnesium (18–61 mg/L) did so in about 62%. Chloride (10–125 mg/L) and sulphate (8–102 mg/L) remained well below limits throughout. Nitrate (3–55 mg/L) crossed 45 mg/L in about 17% of pre-monsoon samples but in under 2% after the monsoon, while fluoride reached 2.6 mg/L, exceeding 1.5 mg/L in about 8% of post-monsoon samples (Raut et al., 2025). Bicarbonate (100–900 mg/L) dominated the anions, and SAR values placed all samples in the excellent class for irrigation (Raut et al., 2025).

An earlier survey of 53 wells around Hingoli likewise judged groundwater suitable for drinking and irrigation, with SAR below 10 and Kelly's ratio below 1 in nearly all samples (Mahendra, 2014). At Akhada Balapur itself, a short study of bore wells sampled in October 2019 analysed pH, dissolved oxygen, free CO_2, chloride and TDS and compared them with drinking-water standards; however, the data represent only one post-monsoon season (Bhujbal, 2020).

Regional studies explain these trends. In the Godavari basin of Maharashtra, nitrate exceeded 45 mg/L in about 65% of samples and fluoride crossed its limit in about 13%, both linked to agriculture and rock–water interaction (Marghade et al., 2021). In Nanded city, shallow basalt aquifers stayed within fluoride limits whereas deeper granite aquifers carried up to 4.9 mg/L (Pandith et al., 2017). WQI-based assessments in Aurangabad rated nearly half the samples poor to very poor (Walde et al., 2025), while the semi-arid Morna basin had mostly excellent-to-good water with clear seasonal change (Pande et al., 2025).

Kayadhu river

No peer-reviewed study reporting physicochemical data for the Kayadhu river near Akhada Balapur could be located; this is a clear gap. The closest monitored stream is its parent river, the Penganga, where pH of about 6.5–8.9, DO as low as 2.8 mg/L and BOD of up to about 20 mg/L were recorded at stations such as Mehkar and Umarkhed during 2017–2021, leading to its listing as a Priority-III polluted stretch (MPCB, 2021). Most of these values fail Class C criteria of DO ≥ 4 mg/L and BOD ≤ 3 mg/L (CPCB, n.d.). Because the Kayadhu receives runoff from towns and farmland of Hingoli, similar DO and BOD stress is possible in the dry season, but it remains to be measured.

Ponds and lakes

Village ponds near Akhada Balapur have not been studied. A survey of fifteen lakes in Vidarbha and Marathwada found turbidity of up to 25 NTU, total hardness up to 400 mg/L (Kharpudi, Jalna) and cadmium above BIS limits in most lakes, while nitrate was detected only at Lonar and Harsul (Diwate et al., 2025). Since village ponds are shallow, open to cattle and fed by farm runoff, turbidity, hardness, BOD and nutrients are likely to be the main issues; they should be monitored before the water is used for drinking or for domestic animals. The reported ranges for all three source types are summarised in Table 2.

Table 2. Summary of reported ranges in and around Hingoli district (mg/L unless stated).

Parameter	Bore/dug wells, Hingoli (CGWB, 2013, 2025; Raut et al., 2025)	Penganga river (MPCB, 2021)	Lakes, Marathwada–Vidarbha (Diwate et al., 2025)	Remark
pH	6.9–8.9	≈ 6.5–8.9	up to 12 (Lonar)	Mostly alkaline
EC (µS/cm)	250–2435	—	—	Wide; seasonal
TDS	146–1720	—	—	Some > 500
Turbidity (NTU)	—	—	up to 25	Ponds at risk
Total alkalinity	195–270	—	—	Often > 200
Total hardness	66–1066	—	up to 400	Often > 200
Calcium	16–196	—	—	Mostly < 200
Magnesium	7–91	—	—	Often > 30
Chloride	10–125	—	—	Safe
Sulphate	8–102	—	—	Safe
Nitrate	3–83	—	ND–45	Hot spots > 45
Fluoride	BDL–2.6	—	up to 2 (Lonar)	Isolated > 1.5
DO	—	≈ 2.8–8.2	—	Low at some stations
BOD	—	≈ 2.8–20	—	Fails Class C
Temperature, COD	Not reported	Not reported	—	Data gap

Research gaps and recommendations

(i) No published physicochemical record exists for the Kayadhu river or for ponds around Akhada Balapur; temperature, turbidity, DO, BOD and COD are therefore entirely unreported for local surface water. (ii) Village-level groundwater data are limited to a single-season study (Bhujbal, 2020). (iii) Nitrate and fluoride hot spots in a neighbouring tehsil (Raut et al., 2025) justify testing every drinking-water bore well at least twice a year. (iv) Bacteriological and heavy-metal analyses should accompany physicochemical tests, given the metal findings in regional lakes (Diwate et al., 2025). (v) Results should be expressed as a WQI and mapped with GIS so that village panchayats can act on them (Brown et al., 1970; Pande et al., 2025).

Conclusion

Groundwater around Akhada Balapur, as indicated by district and adjoining-tehsil data, is mildly alkaline, hard and bicarbonate-dominated, and is generally acceptable for drinking and irrigation. Chloride, sulphate and salinity pose little risk, but nitrate, magnesium, hardness and, in a few wells, fluoride can exceed BIS limits, especially before the monsoon. Surface water is the weakest link in present knowledge: the Kayadhu river and local ponds have no published data, while the downstream Penganga shows organic pollution. A seasonal monitoring programme covering all sixteen parameters is needed to protect public health in the area.

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