pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20262725

Original Research Article

An assessment of water quality and handling technique among residents of a selected urban slum in the Doiwala block of district Dehradun

Adarsh Jakhmola[1], Himanshu Mamgain[2], Akash Krishali[3]*, Ritika Sharma[4]

[1]School of Public Policy and Governance, Dr. B.R Ambedkar University, Delhi, India
[2]Department of Community Medicine, Government Doon Medical College, Dehrakhas, Dehradun, Uttarakhand, India
[3]Department of Community Medicine, Himalayan Institute of Medical Sciences, Swami Rama Himalayan University, Dehradun, Uttarakhand, India
[4]Department of Anaesthesia, Government Medical College Rudrapur, Uttarakhand, India

Received: 01 June 2026
Revised: 22 July 2026
Accepted: 25 July 2026

***Correspondence:**
Akash Krishali,
E-mail: akashkrishali27@gmail.com

ABSTRACT

Background: Urban slum communities in developing countries face significant water quality challenges, with inadequate supply and contamination posing major public health risks. This study assessed water quality parameters and their association with waterborne disease burden in Keshavpuri Basti, an urban slum in Doiwala block, Dehradun, located near the polluted Song River.

Methods: A population-based cross-sectional study was conducted among 180 systematically sampled households. A total of 87 water samples were collected using stratified spatial gridding from household taps, storage containers, public handpumps, five Song River sites, and commercial water tankers. Physical and chemical parameters were assessed using EPA-compliant methods. A semi-structured questionnaire collected socio-demographic information and residents' two-week disease history.

Results: Water quality analysis showed that pH (6.3), hardness (216.67 ppm), mercury (0.0024 ppm), sulphate (256.57 ppm), and alkalinity (200.64 ppm) exceeded permissible limits. Lead and nitrate levels approached safety thresholds. Among 180 households, diarrhoea was reported by 34.44% of respondents, skin problems by 28.34%, and ear infections by 11.11% during the preceding two weeks. Under-5 mortality was 11.11%. Notably, 96.11% of residents used no recognized water purification method.

Conclusions: The findings indicate substantial water quality degradation and a considerable disease burden in Keshavpuri Basti. Urgent interventions are needed to improve water infrastructure, promote household water treatment, and strengthen public health policies targeting vulnerable urban slum populations.

Keywords: Water quality, Urban slum, Waterborne diseases, Dehradun, India, Cross-sectional study, Heavy metals, SDG 6

INTRODUCTION

Access to safe drinking water is a fundamental human right, formally recognized by the United Nations Committee on Economic, Social and Cultural Rights (CESCR) in 2002.[1] Sustainable Development Goal 6 (SDG 6) calls for universal and equitable access to safe and affordable drinking water for all by 2030.[2] Despite this global commitment, approximately one-fifth of urban populations in developing countries and three-quarters of rural populations continue to lack access to generally safe water sources.[3]

In India, the burden of inadequate water access is particularly acute in urban informal settlements (slums), which are characterized by high population density, inadequate sanitation infrastructure, and proximity to polluted waterbodies. With over 30 million groundwater access points nationally, groundwater serves as primary drinking water source for 85% of rural communities and meets 48% of urban water needs.[4] However, rapid industrialization, domestic waste discharge, and agricultural runoff have severely compromised the quality of both surface and groundwater supplies.

Diarrheal disease, the most prevalent waterborne illness, represents 2nd leading cause of mortality in children under 5 globally, responsible for approximately 760,000 deaths annually.[5] In India, states facing drought have reported a 22% increase in school dropout rates, disproportionately affecting girls who bear the burden of water collection.[6] These epidemiological realities are especially concentrated in slum environments, where income poverty, low educational attainment, and absence of piped water supply intersect with high disease vulnerability.

Keshavpuri Basti, located in the Doiwala block of Dehradun district, Uttarakhand, is a peri-urban slum community adjacent to the Song River, a waterbody known to receive industrial discharge, domestic waste, and agricultural runoff. Despite previous media reporting on water shortages in this area, no systematic scientific investigation of water quality and associated health outcomes has been conducted.[7] This study addresses this gap by (a) quantifying water quality parameters across multiple source types, (b) estimating the prevalence of waterborne disease symptoms among residents, and (c) characterizing water handling and purification practices to identify actionable intervention points.

METHODS

Study design and setting

A population-based cross-sectional study was conducted in Keshavpuri Basti (latitude 30°10'10" N, longitude 78°07'40" E, altitude 495.58 m), a selected urban slum in Doiwala block, Dehradun district, Uttarakhand, India. The site was selected purposively based on its proximity to the heavily polluted Song River and documented absence of piped treated water in households (Figure 1). The study was conducted over a four-month period in 2024 (February-June).

Figure 1: Satellite image of study area.

Sample size and sampling strategy

For the population survey, sample size was calculated using the formula

$$N=Z^2pq/e^2$$

Based on a waterborne diarrhoea prevalence of 34% in comparable Indian urban slum populations, 95% confidence interval (Z=1.96), and 10% margin of error.[8] This yielded a minimum sample size of 162, with a 10% non-response adjustment, the final target was 180 households.

Systematic random sampling was applied to 1,070 estimated households (total slum population 5,352/average family size 5). A sampling interval of six was calculated, with a random starting household selected by lottery. One adult respondent per selected household was interviewed.

For water sampling, the study area was divided into 36 spatial grids using latitudinal and longitudinal lines. From each grid, one household tap and one storage container were sampled (n=72). Additional samples were collected from five public handpumps, five river sites (500 m upstream and downstream of the slum's extent, and three mid-stream points), and five commercial water tankers, yielding a total of 87 water samples.

Data collection instruments

A semi-structured questionnaire captured socio-demographic information (age, sex, education, occupation, family type, income by B.G. Prasad Index, housing status, livestock ownership) and a two-week disease history (diarrhoea, fever, vomiting, skin problems, ear infections, jaundice, typhoid). Operational case definitions were standardized, diarrhoea was defined as more than three episodes of loose stool in the preceding two weeks, typhoid as self-reported fever ≥38°C with gastrointestinal symptoms; and skin problems as any rash, itching, or discoloration. Under-5 child mortality was documented as death of any child under five years in the household.

Water quality testing

Physical and chemical parameters were assessed using EPA-compliant Varify multi-parameter test strips (EPA Standard), which simultaneously evaluated color, turbidity, odor, pH, hardness, hydrogen sulfide, iron, copper, lead, manganese, total chlorine, mercury, nitrate, nitrite, sulfate, zinc, fluoride, sodium chloride, and alkalinity. Colorimetric readings were matched to standard reference charts under natural light within 30-40 seconds of immersion.

Samples were collected in sterilized Winchester Quartz bottles (for physicochemical analysis) and 200-250 ml sterilized glass-stoppered bottles containing, transported at ≤4°C, and analysed within 48 hours of collection. Results were compared against WHO drinking water quality standards.

Statistical analysis

Data were entered into Microsoft Excel and analysed using SPSS version 24.0 (IBM Inc., Chicago, USA). Categorical variables were expressed as frequencies and percentages. Normality was assessed using the Kolmogorov-Smirnov test; chi-square tests were applied for associations between categorical variables. Water quality measurements were tabulated and compared against WHO permissible limits.

Ethical considerations

Ethical approval was obtained from the institutional ethics committee of Himalayan Institute of Medical Sciences, Swami Rama Himalayan University. Written informed consent was obtained from all participants prior to data collection. Participation was entirely voluntary, and participants were free to withdraw without consequence.

RESULTS

Socio-demographic profile

A total of 180 households were surveyed. The sample was predominantly female (117 respondents; 65.0%) and skewed towards younger adults, with 34.7% of female and 32.3% of male respondents in the 25-35 years age group, while Female of age 15-25 age group also has significant contribution in female population of study at 33.04 percent, together women of age group 15-35 years have 45.5 percent contribution to total study population, meanwhile Male participants are only (63 respondent, 35%) of total population (Table 1). The majority of the study population was illiterate (88 respondents; 48.9%), with only 9 graduates (5.0%) and 1 postgraduate (0.6%). Nuclear family structure predominated (55%) (Table 2).

Table 1: Gender wise distribution of study participants.

Age group (in years)	Female, n=117 (%)	Male, n=63 (%)	Total, n=180 (%)
15-25	41 (35)	13 (20.63)	54 (30)
25-35	41 (35)	21 (33.3)	62 (34.5)
35-45	21 (17.9)	7 (11.1)	28 (15.5)
45-55	6 (5.1)	12 (19.1)	18 (10)
55-65	8 (6.8)	10 (15.8)	18 (10)

Table 2: Education status and family type.

Variables		N	Percentage (%)
Education status	Illiterate	88	48.9
	Primary school	31	12.6
	Middle school	23	9.3
	High school	25	10.2
	Intermediate	3	1.2
	Graduate	9	5.0
	Postgraduate	1	0.6
Family type	Nuclear	99	55
	joint	81	45

Table 3 presents the physicochemical parameters of water samples collected in Keshavpuri Basti compared to WHO permissible limits. Several parameters of public health concern exceeded recommended thresholds.

Table 3: Physicochemical water quality parameters, Keshavpuri Basti, (n=87 samples).

Parameters	Observed value	WHO limits	Status
Color	Colorless	Colorless	Within limit
Turbidity	Clear	Clear	Within limit
Odor	No odor	No odor	Within limit
pH	6.3	6.5-8.5	Below limit
Hardness (ppm)	216.67	50-100	Exceeds limit
Hydrogen sulfide (ppm)	0.073	0	Within limit
Iron (ppm)	0.118	0-0.3	Within limit
Copper (ppm)	0.062	0-1	Within limit
Lead (ppb)	4.8	0-5	Near upper limit
Manganese (ppm)	0.003	0-0.1	Within limit
Total chlorine (ppm)	0.101	0-3	Within limit
Mercury (ppm)	0.0024	0-0.002	Exceeds limit
Nitrate (ppm)	9.95	0-10	Near upper limit
Nitrite (ppm)	0.76	0-1	Within limit
Sulphate (ppm)	256.57	0-200	Exceeds limit
Zinc (ppm)	3.43	0-5	Within limit
Fluoride (ppm)	2.71	0-4	Within limit
NaCl (ppm)	12.12	0-250	Within limit
Alkalinity (ppm)	200.64	40-180	Exceeds limit

Values compared against WHO drinking water standards. Highlighted rows indicate parameters of immediate public health concern. Mercury levels exceeded the WHO limit of 0.002 ppm (observed: 0.0024 ppm), posing risks of nephrotoxicity and neurological damage. Sulphate levels (256.57 ppm) exceeded the 200 ppm WHO guideline, with potential to cause osmotic diarrhoea. Alkalinity (200.64 ppm) exceeded the 40-180 ppm recommended range. Water hardness (216.67 ppm) was more than double the optimal limit of 50-100 ppm, which may impact domestic plumbing and appliances, though it is not a direct health hazard at these concentrations. Lead was detected at 4.8 ppb, approaching the WHO maximum of 5 ppb, presenting particular risk for children. Nitrate at 9.95 ppm was near the 10 ppm limit, which is associated with methemoglobinemia in infants. The water pH of 6.3 fell below the WHO-recommended range of 6.5-8.5, indicating mild acidity that may facilitate metal leaching from pipes and increase bioavailability of heavy metals (Figure 1).

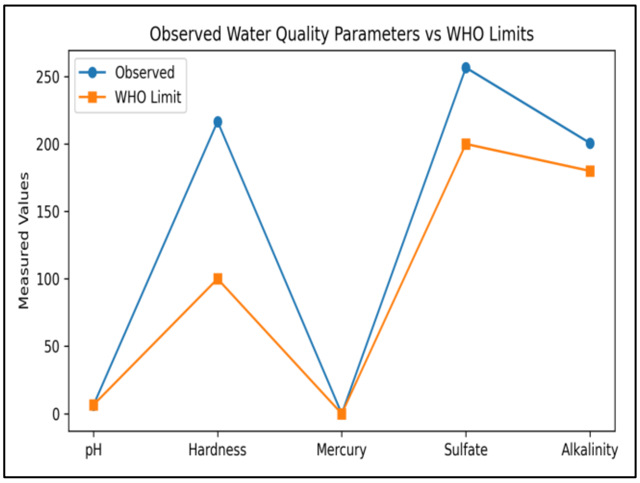

Figure 1: Comparison of selected physicochemical parameters with WHO permissible limits.

Table 4: Prevalence of waterborne and water-related disease outcomes, (n=180).

Health outcome	Affected, n (%)	Not affected, n (%)
Diarrhea (past 2 weeks)	62 (34.44)	118 (65.56)
Skin problems (past 2 weeks)	51 (28.34)	129 (71.66)
Ear infections (past 2 weeks)	20 (11.11)	160 (88.89)
Under-5 child mortality	20 (11.11)	160 (88.89)

All outcomes recorded over the two-week recall period preceding interview, except under-5 child mortality (household-level recall). Diarrhea was the most prevalent reported illness, affecting 62 households (34.44%). The under-5 child mortality of 11.11% substantially exceeds the WHO global estimate of 8.6% (2019), It is important to consider this area is very underprivileged so the u5mr is significantly higher than average suggesting elevated vulnerability in this community. Skin problems (28.34%) may reflect both waterborne dermatological exposure and contact with the polluted river, which residents use for bathing and washing. Ear infections (11.11%), while primarily of viral and bacterial aetiology, may be compounded by bathing in contaminated water (Table 4).

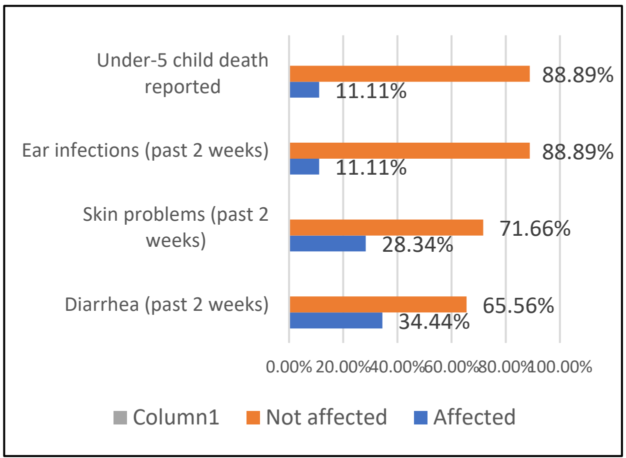

Figure 2: Prevalence of waterborne and water-related diseases among surveyed households.

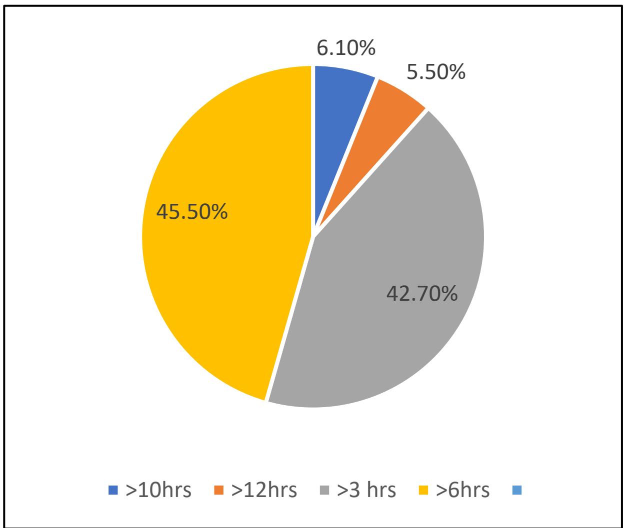

Figure 3: Duration of availability of water of primary source.

The findings indicate varying levels of water availability among households in Keshavpuri Basti. The largest proportion of respondents, 82 out of 180 households (45.5%), reported that water from their primary source was available for more than 6 hours but less than 12 hours daily, suggesting relatively moderate access to water. Similarly, 77 households (42.7%) reported water availability for more than 3 hours but less than 6 hours per day, reflecting that a substantial segment of the population still experiences limited daily access to water.

Only a small proportion of respondents reported prolonged water availability, with 11 households (6.1%) having access for more than 10 hours daily and 10 households (5.5%) reporting availability for more than 12 hours. These findings suggest that while some households experience relatively stable water access, uninterrupted or near-continuous supply remains uncommon in the study area (Figure 3).

Water purification practices were conspicuously absent: 173 respondents (96.11%) reported using no recognized purification method, only 2 (1.1%) reported boiling and 5 (2.7%) used filtration or reverse osmosis (Figure 4).

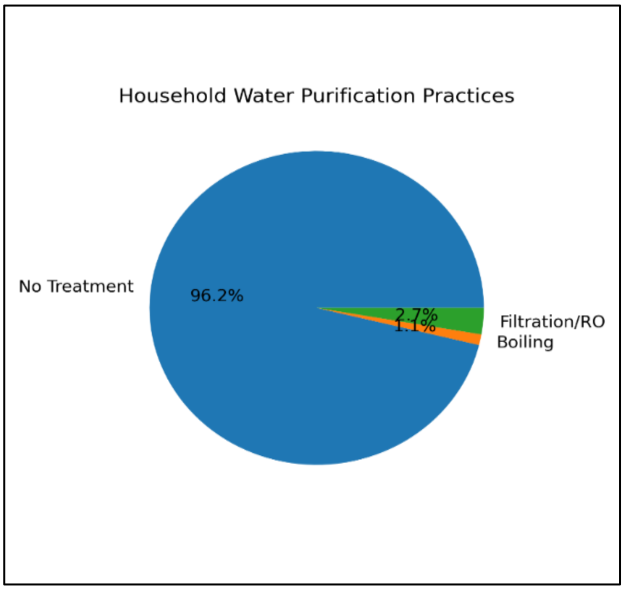

Figure 4: Household water purification practices in Keshavpuri Basti.

The majority of respondents ((75.6%+10.6%=86.2%) rely on private sources (either a private source or a private tap) for their water supply. A smaller portion (13.8%) receive their water from public sources that directly supply water into households. This data suggests a significant reliance on private sources for water supply among the respondents. The distribution between private and public sources indicates varying levels of infrastructure and service provision in the area covered by the research (Figure 5).

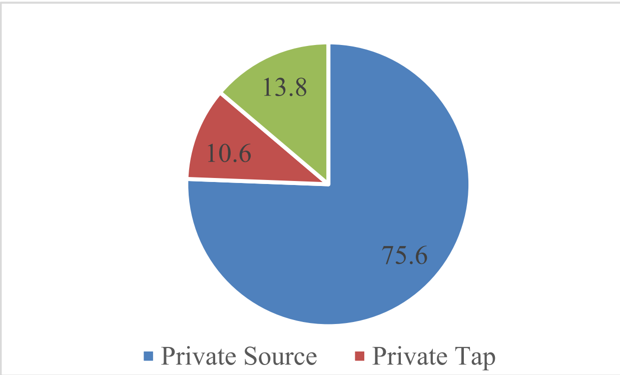

Figure 5: Source of water supply.

The majority (72.22%) reported cleaning storage containers with soap or detergent and water, while 27.78% used water only. Water retrieval methods included pouring (32.2%), long-handled scooping (29.4%), and short-handled scooping (38.3%) the latter being the most contamination-prone method (Table 5).

Table 5: Household water storage cleaning practices and water retrieval methods.

Aspects	Category	N	Percentage (%)
Cleaning of water storage containers	Soap/detergent and water	130	72.22
	Water only	50	27.78
Water retrieval method	Pouring	58	32.22
	Long-handled scooping	53	29.44
	Short-handled scooping	69	38.33
Cleaning of water storage containers	Soap/detergent and water	130	72.22

DISCUSSION

This study presents systematic evidence of water quality degradation and associated health burden in an urban slum community of Dehradun, a city that, despite being the administrative capital of Uttarakhand, harbors informal settlements lacking safe drinking water access. Our findings complement and extend the existing body of literature on WASH vulnerability in Indian urban slums.[9-11] While our study employed field-based test strips, which may carry a modest margin of analytical error, the finding is consistent with the industrial discharge and agricultural runoff dynamics documented along the Song River catchment. Sulphate exceedance (256.57 mg/L vs. 200 mg/L WHO limit) is significant in the context of diarrhoeal disease: sulphate-reducing bacteria and high-sulphate water have been associated with osmotic diarrhoea, particularly in children.[12]

The diarrhoea prevalence of 34.44% over a two-week recall period is strikingly high and aligns closely with the baseline prevalence estimate (34%) used in our sample size calculation, drawn from comparable Indian urban populations.[8] This convergence strengthens the external validity of our findings. The under-5 mortality rate of 11.11%, while derived from household self-report rather than mortality registers and subject to recall bias, substantially exceeds the WHO global benchmark of 8.6%, indicating excess child mortality that may be partly attributable to waterborne disease exposure.[13]

The near-total absence of household water purification (96.11% using no method) is the most actionable finding of this study and resonates with evidence from comparable South Asian settings.[14] In the absence of a reliable piped supply, the default option for the majority of residents is untreated water from private sources of unknown quality. This creates a vicious cycle in which water insecurity drives reliance on contaminated alternatives, perpetuating the disease burden already reflected in high diarrhoea and skin problem prevalence.

The under-5 mortality and diarrhoea findings must be interpreted with caution given the cross-sectional design, which precludes causal inference between specific water quality parameters and health outcomes. Additionally, the exclusive reliance on field-based colorimetric test strips, while practical for community-level surveillance, has lower analytical precision than laboratory-grade spectrophotometric or inductively coupled plasma-mass spectrometry (ICP-MS) methods for heavy metals. Social desirability bias in self-reported disease outcomes is also a potential limitation.

Comparison with other studies in Indian urban slums supports the generalizability of these findings. Baranwal et al in Mumbai's Shivaji Nagar slum found a strong link between fecal water contamination and household morbidity.[9] Joshi et al in New Delhi urban slums also documented universal nominal water access but significant contamination at point-of-use.[15] Our findings add to this literature by quantifying the specific chemical contaminant profile in a Himalayan foothill peri-urban slum, which faces a distinct geo-hydrological context from urban plains settings.

The limitations of this study include its cross-sectional design, which prevents establishing a causal relationship between water quality and reported health outcomes; the use of field-based water testing methods, which may be less accurate than laboratory-based techniques; and reliance on self-reported health information, which may be subject to recall and reporting bias. Additionally, the study was conducted in a single purposively selected urban slum, limiting the generalizability of the findings to other populations.

CONCLUSION

This study provides the first systematic water quality and health assessment for Keshavpuri Basti, Doiwala, Dehradun. Multiple parameters, including mercury, sulfate, alkalinity, and hardness, exceeded WHO drinking water standards, and lead and nitrate were identified near threshold levels. Against this backdrop of chemical contamination, the community bears a high burden of waterborne illness, with diarrhoea prevalence of 34.44% and an under-5 child mortality rate of 11.11%. The near-universal absence of household water treatment, combined with limited daily water availability and river-contact practices, creates compounding vulnerabilities.

These findings carry clear implications for intervention. First, the Jal Jeevan Mission's mandate to extend piped water connections must be actively implemented in informal settlements such as Keshavpuri Basti where pipeline construction remains incomplete. Second, community health education campaigns targeting boiling and filtration as minimum-cost purification options are warranted immediately, given the zero cost of behavioral change relative to the documented disease burden. Third, the Song River requires urgent source-level pollution abatement, encompassing industrial effluent regulation, open defecation elimination, and domestic waste management. Fourth, present study's water quality data should be replicated using laboratory-grade analytical methods and linked to epidemiological surveillance to establish causation and support regulatory action.

Achieving SDG 6 in contexts like Keshavpuri Basti requires moving beyond nominal water access metrics to assess safety, reliability, and quality at the household level particularly in marginalized urban communities that fall outside formal water governance frameworks.

ACKNOWLEDGEMENTS

Authors would like to thank to Department of Community Medicine, Himalayan Institute of Medical Sciences, Swami Rama Himalayan University, Dehradun, for providing valuable guidance and institutional support. The author also extends sincere gratitude to the residents of Keshavpuri Basti for their participation and cooperation throughout the study.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. United Nations Committee on Economic, Social and Cultural Rights. General Comment No. 15: The Right to Water. UN Doc E/C.12/2002/11. Geneva: United Nations. 2002.
2. United Nations General Assembly. Transforming Our World: The 2030 Agenda for Sustainable Development. Resolution 70/1, 2026. Available at: https://www.icmc.net/2025/11/26/sustainabledevelopmentgoalsandrefugeeintegration/?gad_source=1&gad_campaignid=11827237397&gbraid=0AAAAACRvLKyAXNXV9lKVR1gbLFUkkpua9&gclid=CjwKCAjwyabTBhBFEiwAM3mNUENJ7TOiqHMbAHOT_w8klzhmYnIiLEUloWfvv7t4dtdAkHVhUGzbARoCjgkQAvD_BwE. Accessed on 20 May 2026.
3. Lloyd B, Helmer R. Surveillance of Drinking Water Quality in Rural Areas. Geneva: World Health Organization/UNEP. 1991.
4. World Health Organization; UNICEF. Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines. Geneva: WHO. 2017.
5. UNICEF. Battling Diarrhoea: Repackaging ORS and Zinc to Ensure Children Receive Adequate Treatment. New York: UNICEF. 2015.
6. UNICEF. Clean Drinking Water: Ensuring Survival and Improved Outcomes for Every Child. New York: UNICEF. Available at: https://www.unicef.org/wash. Accessed on 10 May 2026.
7. The Times of India. Doiwala Residents Facing Water Shortag, 2019. Available at: https://timesofindia.indiatimes.com/city/dehradun/doiwalaresidentsfacingwatershortage/articleshow/69348271.cms. Accessed on 20 May 2026.
8. Srivastava S, Banerjee S, Debbarma S. Rural-Urban Differentials in the Prevalence of Diarrhoea Among Older Adults in India: Evidence from Longitudinal Ageing Study in India, 2017-2018. PLoS ONE. 2022;17(3):e0265040.
9. Baranwal A, Anand A. Water Faecal Contamination and Morbidity in Slums, India. Int J Environmental Natural Sci. 2016;10:9-15.
10. Prasad G, Reshma AS, Vinodini Ramesh M. Assessment of Drinking Water Quality on Public Health at Alappuzha District, Southern Kerala, India. Materials Today: Proceedings. 2020;25:3030-6.
11. National Institute of Urban Affairs. Children and Adolescents in Urban India: Scale and Nature of Deprivation. New Delhi: NIUA. 2020.
12. WHO. Mercury and Health. Fact Sheet. Geneva: WHO. 2017.
13. Cantor KP, Lynch CF, Hildesheim M, Dosemeci M, Lubin J, Alavanja M. Drinking Water Source and Chlorination Byproducts. I: Risk of Bladder Cancer. Epidemiology. 1998;9(1):21-8.
14. Luvhimbi N, Tshitangano TG, Mabunda JT, Olaniyi FC, Edokpayi JN. Water Quality Assessment and Evaluation of Human Health Risk of Drinking Water from Source to Point of Use at Thulamela Municipality, Limpopo Province. Scientific Rep. 2022;12(1):6059.
15. Joshi A, Prasad S, Kasav JB, Segan M, Singh AK. Water and sanitation hygiene knowledge attitude practice in urban slum settings. Glob J Health Sci. 2014;6:23-34.

Cite this article as: Jakhmola A, Mamgain H, Krishali A, Sharma R. An assessment of water quality and handling technique among residents of a selected urban slum in the Doiwala block of district Dehradun. Int J Community Med Public Health 2026;13:4441-7.