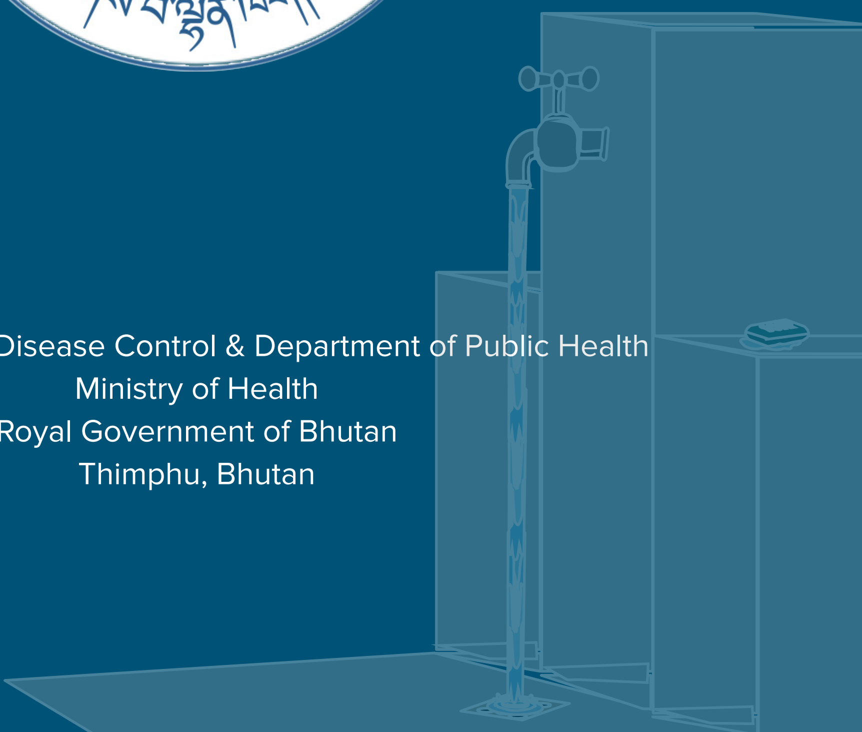
REPORT ON ASSESSMENT OF DRINKING WATER CHEMISTRY AND HEAVY METAL CONTAMINATION ACROSS BHUTAN

2026



Royal Centers for Disease Control & Department of Public Health
Ministry of Health
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Thimphu, Bhutan

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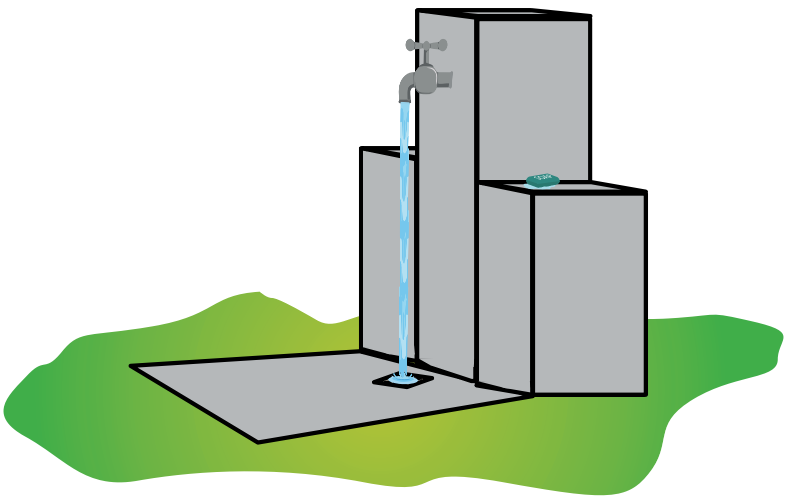

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FOREWORD

On behalf of the Ministry of Health, it is a privilege to present this comprehensive report on the Nationwide Chemical Water Quality Assessment. Access to safe and clean drinking water is a fundamental pillar of public health and remains a primary priority for the Royal Government of Bhutan. As we move toward the targets set under the Bhutan Drinking Water Quality Standards (BDWQS) 2025, understanding the complex hydrochemical landscape of our drinking water sources becomes an absolute necessity.

This report represents a significant milestone in our national surveillance efforts, representing our efforts to safeguard the population from chemical contaminants. While the assessment confirms that much of Bhutan's water remains of high geogenic quality, it also identifies localized challenges ranging from geogenic arsenic and aluminum concentrations to systemic fluoride deficiencies that demand our strategic attention.

The findings presented here are not merely data points; they serve as a critical evidence base for water safety planning, regulatory oversight, and targeted public health interventions. By identifying specific "hotspots" and understanding the natural geochemical processes at play, we are now better equipped to transition from general monitoring to high-precision, risk-based surveillance.

I am deeply grateful to our partners at the UNICEF, Ministry of Infrastructure and Trasport, Department of Water (Ministry of Energy and Natural Resources) and Thromdes and municipalities whose collaboration made this assessment possible. I would like to express my deep appreciation to the dedicated team from the Royal Center for Disease Control (RCDC) for their technical leadership in data analysis and Department of Public Health in supporting to draft this report. I particularly want to commend the tireless efforts of our district health staff, whose dedication to rigorous sampling ensures the integrity of our national data.

It is my sincere hope that this report serves as an indispensable tool for policymakers, engineers, and health professionals alike. Together, we will continue to use this evidence to refine our infrastructure, optimize our public health strategies, and ensure that every citizen of Bhutan has access to water that is not only abundant but safe.

Pemba Wangchuk
Secretary
Ministry of Health

ACKNOWLEDGEMENTS

The Roya Centers for Disease Control expresses its sincere gratitude to all the organizations and individuals whose dedication and collaboration made this nationwide drinking water quality assessment possible.

We extend our deep appreciation to the Department of Public Health (DoPH) for their continuous support in conducting drinking water quality surveillance. We also extend our gratitude to UNICEF for steadfast commitment to improving water safety in Bhutan. This initiative would not have been implemented without their technical support.

We extend special appreciation to the District Health Staff across all 20 Dzongkhags. Their hard work in the field standardizing sample collection, ensuring proper preservation, and shipping samples under strict conditions served as the backbone of this study.

We also thank Thimphu Thromde, the Department of Water (Ministry of Energy and Natural Resources), Ministry of Infrastructure and Transport (MoIT), and our various water sector partners for their continuous support. Their technical insights and collaborative spirit were invaluable during the analysis, drafting, and finalization of this report.

Finally, we acknowledge the collective efforts of the analytical team and all stakeholders who contributed to generating this evidence base report, which will serve as a vital tool for safeguarding the health of the Bhutanese population.

EXECUTIVE SUMMARY

This assessment presents a comprehensive evaluation of the chemical quality of drinking water supplied to urban and semi-urban communities across Bhutan. Through the nation's routine drinking water surveillance platform, the study analyzed 215 samples for a wide range of parameters, including major ions, nutrients, and selected trace elements, to determine compliance with the Bhutan Drinking Water Quality Standards (BDWQS) 2025 and WHO guidelines.

Key Findings:

- The chemical assessment confirms that Bhutan's drinking water is predominantly of high quality. The majority of physicochemical and heavy metal parameters remain well within the Maximum Allowable Concentrations (MACs).
- Statistical analysis identifies that the water's chemical signature is primarily shaped by natural geogenic processes, such as water-rock interaction and carbonate mineral dissolution, rather than anthropogenic pollution.
- While metal contamination is not widespread, localized exceedances were detected:
  - Aluminum (Al): Elevated levels in Chhukha (0.444 mg/L) and Dagana (0.20 mg/L) are attributed to the geochemical weathering of minerals.
  - Arsenic (As): Specific hotspots were identified in Trongsa (0.042 mg/L) and Samdrupjongkhar (0.011 mg/L).
- Fluoride levels are consistently low nationwide (typically < 1 mg/L). While this ensures compliance with safety limits, it falls below the optimal range (0.5-1.0 mg/L) required to protect against dental caries.
- Localized spikes in Iron (Fe) and Calcium (Ca) were observed, indicating potential issues with pipe corrosion or scaling in mineral-rich districts like Pemagatshel.

Strategic Recommendations:

To optimize public health and ensure long-term water safety, the following actions are proposed:

1. Strengthen monitoring programs in identified high-risk zones (e.g., Trongsa and Trashigang) for arsenic and fluoride. Confirmatory testing should precede any large-scale remedial interventions.
2. In districts with systemic fluoride deficiency, explore and evaluate alternative delivery strategies, including school-based varnish programs, fluoride supplementation, or fluoridated salt/milk.
3. Conduct assessments into localized iron spikes to differentiate between geogenic weathering and secondary contamination from aging distribution networks.
4. Integrate all hydrochemical data into a national GIS-based water quality database.

1. Introduction

Access to safe and high quality drinking water is not only a fundamental determinant of public health outcomes but also a recognized human right. The United Nations General Assembly Resolution A/RES/76/153, adopted on 16 December 2021, recognized that the human rights to safe drinking water and sanitation are derived from the right to an adequate standard of living and are inextricably linked to the right to the highest attainable standard of physical and mental health, to the right to life, and to human dignity (1). In this context, safe and reliable drinking water is also central to environmental sustainability and socio-economic development, as emphasized by the World Health Organization (WHO) and the United Nations through Sustainable Development Goal 6 (2, 3).

In Bhutan, drinking water supplies are derived from diverse sources including springs, surface water, and groundwater, which are influenced by natural geological conditions, land-use practices, infrastructure development, and climatic variability. While microbial contamination of water often receives primary attention due to its immediate health impacts, chemical contaminants pose equally significant risks, particularly through long-term exposure (4).

Chemical constituents in drinking water such as major ions, trace metals, nutrients, and other inorganic parameters may originate from both natural geochemical processes and anthropogenic activities. Prolonged exposure to certain chemical parameters above national and international standards may result in chronic health effects, affect aesthetic acceptability, and undermine public confidence in drinking water services (2). Systematic assessment of chemical water quality is therefore essential to ensure compliance with these standards, and supports evidence-based water safety management approaches such as Water Safety Plans (2).

This report presents the findings of a nationwide chemical analysis of drinking water samples collected from across Bhutan. It provides a consolidated overview of the chemical quality of drinking water supplies, identifies spatial patterns and parameter-specific concerns, and serves as a technical reference for policymakers, regulators, and water sector stakeholders.

1.1 Purpose and Objectives of the Assessment

The primary purpose of this assessment is to evaluate the chemical quality of drinking water supplied to urban and semi-urban communities across Bhutan and to determine its compliance with the Bhutan Drinking Water Quality Standards, 2025 and WHO guideline values.

The specific objectives of the assessment are to:

- Assess the concentration levels of selected chemical parameters in drinking water samples collected nationwide;
- Compare observed values against national and WHO guideline values;
- Identify chemical parameters of potential public health or operational concern, particularly those associated with long-term exposure risk;
- Examine spatial distribution patterns of key chemical parameters across districts and water supply types;
- Generate evidence to support water safety planning, regulatory oversight, and targeted remedial actions in line with WHO-recommended drinking water surveillance practices.

1.2 Scope and Coverage

The scope of this assessment covers the chemical analysis of drinking water samples collected from multiple regions of Bhutan, representing a range of geographical settings, source types, and water supply systems. To reflect the water most commonly consumed by the population, the sampling focused primarily on urban and semi-urban communities, with the majority of samples collected from thromdes, municipalities, and larger towns. These included piped supplies, point sources, and treatment outputs, providing a representative picture of the systems serving Bhutan's population centers.

The assessment focuses exclusively on chemical parameters and does not address microbiological or physical water quality, which are addressed through the drinking water surveillance and monitoring frameworks of RCDC. Parameters analyzed include major chemical indicators, nutrients, and selected trace elements, based on national monitoring priorities and available laboratory analytical capacity.

2. Background and Context

Bhutan's freshwater resources are overwhelmingly shaped by its Himalayan mountain environment. The country's rivers, streams, springs, and limited groundwater systems originate in high-altitude catchments and form part of the major transboundary river basins of the eastern Himalayas, including the Amo Chhu, Wang Chhu, Punatsang Chhu, Mangde Chhu, and Drangme Chhu. These mountain hydrological systems provide the primary source of drinking water for both rural and urban populations, while also supporting agriculture, hydropower generation, and downstream ecosystems within and beyond Bhutan's borders (5).

Snowpack, glaciers, and high-altitude aquifers function as natural storage reservoirs, regulating seasonal flows and sustaining baseflow during dry periods. Although Bhutan's relatively low level of industrialization and strong environmental protection policies have contributed to a general perception of pristine water resources, growing evidence from national surveillance data and targeted investigations indicates that chemical water quality cannot be assumed to be uniformly safe across all settings (6). Natural geochemical processes, combined with expanding human activities and climate-related pressures, are increasingly influencing the chemical composition of drinking water sources in different parts of the country.

Bhutan's mountainous terrain, steep slopes, and monsoon-dominated rainfall regime create highly dynamic hydrological pathways (7). Intense rainfall events during the summer monsoon, combined with fragile soils and frequent landslides, promote rapid runoff and sediment transport from catchments into surface water sources and spring systems (8). In glacier-fed catchments, seasonal snow and ice melt further influence flow variability and the timing of contaminant transport. These characteristics make drinking water sources particularly sensitive to both naturally occurring chemical constituents and contaminants introduced through human activities (9).

While Bhutan has made substantial progress in expanding access to improved drinking water sources over recent decades, ensuring consistent chemical water quality across dispersed rural settlements and rapidly growing urban centers remains a key challenge. Many supply systems continue to rely on minimally treated surface water or spring sources, and chemical monitoring has historically been less frequent than microbiological surveillance. As a result, spatial and temporal variations in chemical water quality may remain undetected without systematic and sustained assessment. This nationwide chemical water quality assessment directly supports Bhutan's commitment to Sustainable Development Goal 6 (SDG 6) by providing the evidence base needed for risk-based surveillance, targeted interventions, and policy refinement.

2.1 Chemical Contamination in Bhutan's Mountain Hydrology

Bhutan's drinking water chemistry is largely shaped by natural geological and geochemical processes within the Himalayan Mountain system. Weathering of diverse rock formations releases elements such as iron, manganese, calcium, magnesium, and fluoride into surface water and groundwater through rock-water interaction (10). Elevated concentrations of iron and manganese are commonly observed in mountainous spring and surface water sources, particularly where prolonged water-rock interaction or limited aeration promotes dissolution of Fe and Mn bearing minerals (10, 11). Fluoride may also be mobilized under specific geochemical conditions, and trace elements such as arsenic can occur naturally through oxidative weathering of arsenic-bearing minerals (12, 13), although comprehensive national-scale mapping remains limited.

Glacial and periglacial systems further influence water chemistry. Seasonal snow and ice melt release mineral-rich sediments and dissolved constituents, increasing turbidity and metal concentrations during high-flow periods, especially at the onset of the monsoon (14). Bhutan's strong hydrological seasonality governs contaminant transport: intense monsoon rainfall accelerates runoff, erosion, and landslides, mobilizing both natural and anthropogenic contaminants into water sources (15), while dry-season low flows can increase dissolved concentrations due to reduced dilution (16). Climate change, glacial retreat, and risks of glacial lake outburst floods (GLOFs) add further variability to chemical transport processes (15, 17).

Although large-scale industrial activity is limited, localized human activities contribute to contamination risks. Mining, quarrying, road construction, and hydropower development disturb soils and rock formations, while agriculture in valley and peri-urban areas may introduce nutrients and agrochemicals during monsoon runoff (18, 19). Rapid urbanization and tourism growth increase pressures from waste mismanagement, construction, and decentralized sanitation systems (19). Forest fires are an emerging concern especially in the dry season, as ash deposition and firefighting residues can alter source water chemistry and be mobilized during rainfall events (20).

2.2 Drinking water supply systems and surveillance framework

Drinking water supply systems in Bhutan rely predominantly on surface water and spring sources, with limited groundwater abstraction in selected urban and peri-urban areas (19, 21). Rural schemes are largely gravity-fed and often operate with minimal treatment (21), while urban areas depend increasingly on centralized treatment systems, though intermittent supply and operational challenges persist. Despite high reported coverage (99.7%), water safety and reliability remain variable, particularly during the monsoon when turbidity and microbial contamination risks increase (21).

The Bhutan Drinking Water Quality Standards, 2025 (BDWQS) provides strengthened health-based parameters and monitoring requirements (22). Drinking water surveillance is coordinated nationally by the Royal Centre for Disease Control (RCDC), which serves as the reference laboratory and compiles data through the Water Quality Monitoring Information System (WaQMIS). Routine monitoring by district hospitals and Primary Health Centers, combined with regulatory oversight by DOW, supports compliance assessment under the Water Act 2011 and Water Regulation, 2014 (23, 24) as shown in figure 1.

Long-term surveillance assessments indicate ongoing challenges in sustaining full compliance, particularly for microbial and selected chemical parameters (21). These findings highlight the importance of systematic chemical profiling, strengthened laboratory capacity, and risk-based monitoring. As Bhutan continues to enhance its surveillance systems and align national standards with international guidance, these efforts are critical for safeguarding public health and supporting progress toward Sustainable Development Goal 6 (clean water and sanitation).

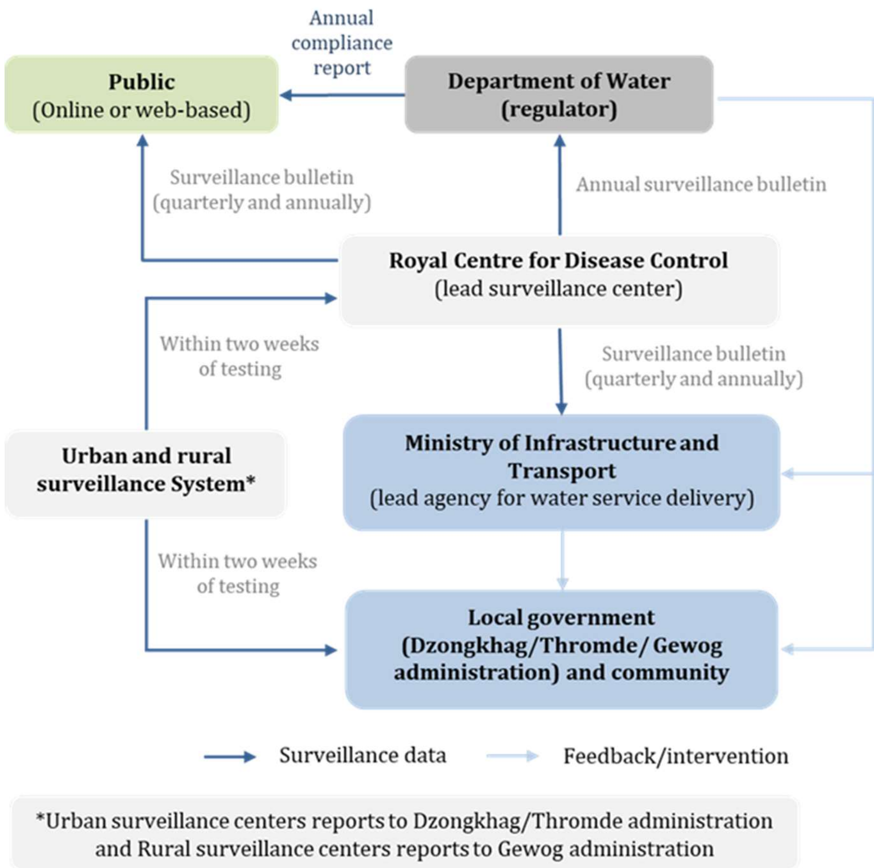

Figure 1: Surveillance data flow and feedback mechanism

3. Materials and Methods

3.1 Study Design and Sampling Framework

A nationwide cross-sectional assessment on drinking water quality was conducted using Bhutan's routine drinking water surveillance platform. Health officials from all participating Dzongkhags were trained by the RCDC on standardized procedures for water sample collection, preservation, labeling, storage, and shipment.

The training emphasized procedures outlined in the American Public Health Association (APHA) Standard Methods for the Examination of Water and Wastewater (23rd Edition). Samples for metal analysis were preserved in pre-acidified polyethylene bottles using ultrapure trace metal grade nitric acid (pH < 2), while samples for anions and general chemistry were collected in clean, non-acidified bottles. Preserved samples were packaged following standard operating procedures and shipped under cool conditions via the national courier system to RCDC, Thimphu, within a recommended window period to maintain sample integrity.

3.2 Sampling Locations and Categories

Samples were collected by health centers across the country from routine drinking water surveillance sampling points. These represented typical public exposure locations and included:

- Public water supply sources (both raw source and treated water)
- Schools
- Monastic institutes
- Health care facilities

This framework ensured representation of drinking water actually consumed by the population rather than only source water.

3.3 Chemical Parameters Analyzed

A comprehensive panel of chemical parameters was analyzed, including major ions, trace elements, and heavy metals. The analyzed parameters were: Aluminum (Al), Arsenic (As), Boron (B), Barium (Ba), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Potassium (K), Lithium (Li), Magnesium (Mg), Manganese (Mn), Molybdenum (Mo), Sodium (Na), Nickel (Ni), Lead (Pb), Antimony (Sb), Selenium (Se), Zinc (Zn), Fluoride (F-), Nitrate (NO3-), Sulfate (SO42-), Carbonate (CO32-), Bicarbonate (HCO3-), Chloride (Cl-), Total Hardness (as CaCO3), and Calcium Hardness (as CaCO3).

3.4 Analytical Methods and Instrumentation

The description of analytical methods and instruments used for the analysis is given in table 1.

Table 1: Analytical methods and instruments used for the analysis

Parameters	Method	Instrument
Aluminum (Al), Arsenic (As), Boron (B), Barium (Ba), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Potassium (K), Lithium (Li), Magnesium (Mg), Manganese (Mn), Molybdenum (Mo), Sodium (Na), Nickel (Ni), Lead (Pb), Antimony (Sb), Selenium (Se), Zinc (Zn)	Inductively Coupled Plasma - Optical Emission Spectrometry (ICP-OES)	Agilent 5110, Agilent, USA
Fluoride (F^-), nitrate (NO_3^-), sulphate (SO_4^{2-}	UV-Visible Spectrophotometric methods	HACH DR6000, USA
Carbonate (CO_3^{2-}), Bi-Carbonate (HCO_3^-)	Acid titration method	
Total Hardness, Ca Hardness	EDTA titrimetric method (APHA 23rd edition, method 2340 C)	
Chloride (Cl^-)	Argentometric titration, (APHA 23rd edition, method 4500-Cl- B)	

3.5 Quality Assurance and Quality Control (QA/QC)

A rigorous QA/QC protocol were maintained throughout the analytical process. The sampling protocol itself served as a primary quality control measure. Field staff were properly trained to follow standardized sampling procedures. Triplicate samples were collected periodically in pre-cleaned, acid-washed sampling bottles. Instrument calibration was performed using multi-element certified standard solutions (Agilent, USA). Reagent blanks and triplicate sample analyses were run to monitor for contamination and analytical precision, respectively. The method's limit of quantification (LOQ) was empirically determined for each element as ten times the standard deviation of ten replicate measurements of the blank. Recovery rates for CRMs ranged from 94.4% to 102.6% for all analyzed elements.

3.6 Data Management and Statistical Analysis

All laboratory results were compiled and curated in Microsoft Excel. The cleaned dataset was imported into R software (version 4.3.0, R Foundation for Statistical Computing) for statistical analysis. Descriptive statistics (mean, median, standard deviation, range) were calculated for all parameters. Concentrations were compared against the Bhutan Drinking Water Quality Standards (BDWQS) 2023 and WHO guidelines. Z-score normalization to evaluate dzongkhag-wise hydrochemical deviation from national averages. Spatial distribution patterns across Dzongkhags and sample categories were visualized using appropriate geospatial and multivariate statistical packages (e.g., ggplot2, FactoMineR). Correlation matrices and principal component analysis (PCA) were employed to identify potential co-occurrence patterns among chemical parameters and their possible common sources.

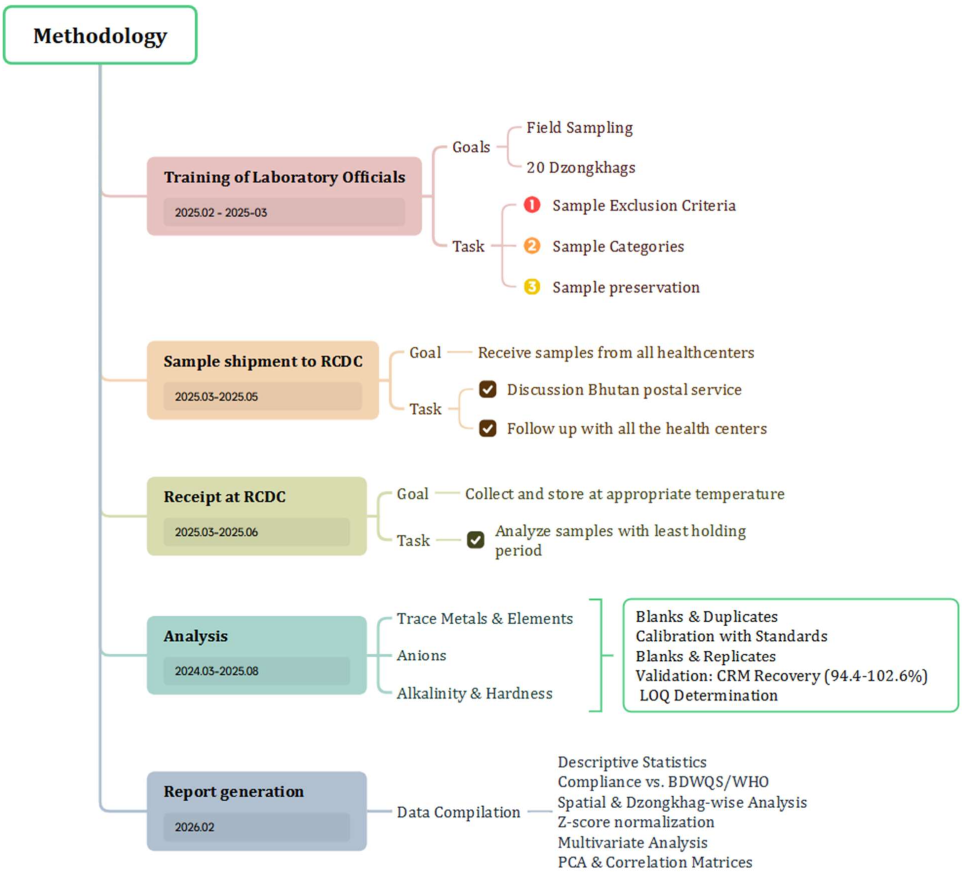

Figure 2: Methodology involved in the study

4. Results and Discussion

4.1 General Water Quality Overview

The comprehensive analysis of drinking water samples (n = 215) across Bhutan, indicates that the majority of physicochemical and heavy metal parameters remain well within the Maximum Allowable Concentrations (MACs) set by the Bhutan Drinking Water Quality Standards (BDWQS) and WHO guidelines. However, localized exceedances in parameters such as Aluminum (Al), Arsenic (As), Calcium (Ca), Fluoride (F), Iron (Fe) and Lead (Pb) highlight specific areas requiring targeted monitoring. The concentrations of analyzed potentially toxic elements (PTEs) in the drinking water samples were observed in the following order: Zn > Al > Fe > Ba > Mn > As > Cu > B > Se > Pb > Sb > Mo > Cd > Ni > Cr (Table 1). The detail of the analysis is summarized using descriptive statistics in Annex 1. A heat map indicating distribution of elements across 20 Dzongkhags is given in figure 3.

Table 2: Detail of samples exceeding the BDWQS and WHO drinking water guidelines.

Parameter	No of samples (n)	Mean	SEM	Min	Max	Median	WHO	No. of times exceeded WHO	BDWQS	No. of times exceeded BDWQS
Aluminum (Al)	215	0.03	0.004	ND	0.444	0.013	0.2	2	0.2	2
Arsenic (As)	215	0.003	0	ND	0.042	0.002	0.01	2	0.01	2
Boron (B)	215	0	0	ND	0.034	0	2.4	0	0.5	0
Barium (Ba)	215	0.012	0.002	ND	0.121	0.002	0.7	0	0.7	0
Cadmium (Cd)	215	0	0	ND	0.001	0	0.003	0	0.003	0
Chromium (Cr)	215	0	0	ND	0.001	0	0.05	0	NA	NA
Copper (Cu)	215	0.002	0	ND	0.035	0	2	0	NA	NA
Iron (Fe)	215	0.032	0.005	ND	0.726	0.009	0.3	3	0.3	3
Potassium (K)	215	0.44	0.044	ND	6.021	0.363	NA	NA	NA	NA
Magnesium (Mg)	215	0.42	0.068	ND	10.025	0.001	NA	NA	100	0
Manganese (Mn)	215	0.007	0.003	ND	0.615	0.001	0.4	1	0.4	1
Molybdenum (Mo)	215	0	0	ND	0.002	0	0.1	0	0.4	0
Sodium (Na)	215	0.397	0.195	ND	33.908	0	200	0	NA	NA
Nickel (Ni)	215	0	0	ND	0.007	0	0.07	0	NA	NA
Lead (Pb)	215	0	0	ND	0.011	0	0.01	1	0.01	1

Antimony (Sb)	215	0	0	ND	0.004	0	0.02	0	NA	NA
Selenium (Se)	215	0	0	ND	0.007	0	0.04	0	NA	NA
Zinc (Zn)	215	0.133	0.012	ND	1.075	0.067	3	0	3	0
Fluoride (F)	181	0.213	0.045	ND	6.393	0.137	1.5	2	1.5	2
Nitrate (NO3)	181	0.381	0.035	0.01	5.33	0.3	50	0	50	0
Sulfate (SO4)	181	8.993	1.286	ND	97.67	1.6	250	0	250	0
Carbonate (CO3)	126	0.023	0.023	ND	2.86	0	NA	NA	NA	NA
Bicarbonate (HCO3)	126	4.799	0.334	0.16	22.31	3.64	NA	NA	NA	NA
Chloride (Cl)	121	32.41	1.918	1.47	163.8	28.8	250	0	NA	NA
Total Hardness (TH)	126	55.033	5.163	6	295.2	27.75	500	0	NA	NA
Calcium (Ca)	120	48.812	4.981	5.8	242.8	24.42	100	17	NA	NA

ND: Not detected

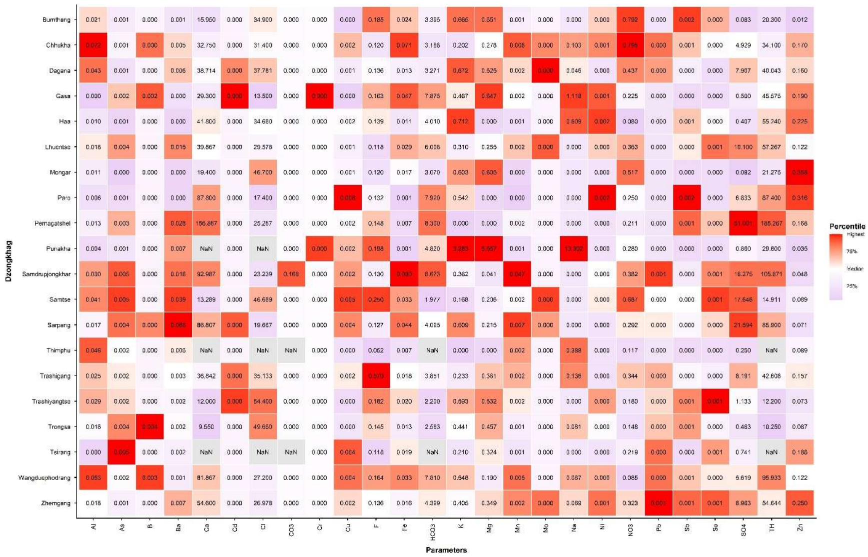

Figure 3: Heat map showing distribution of elements across all Dzongkhags

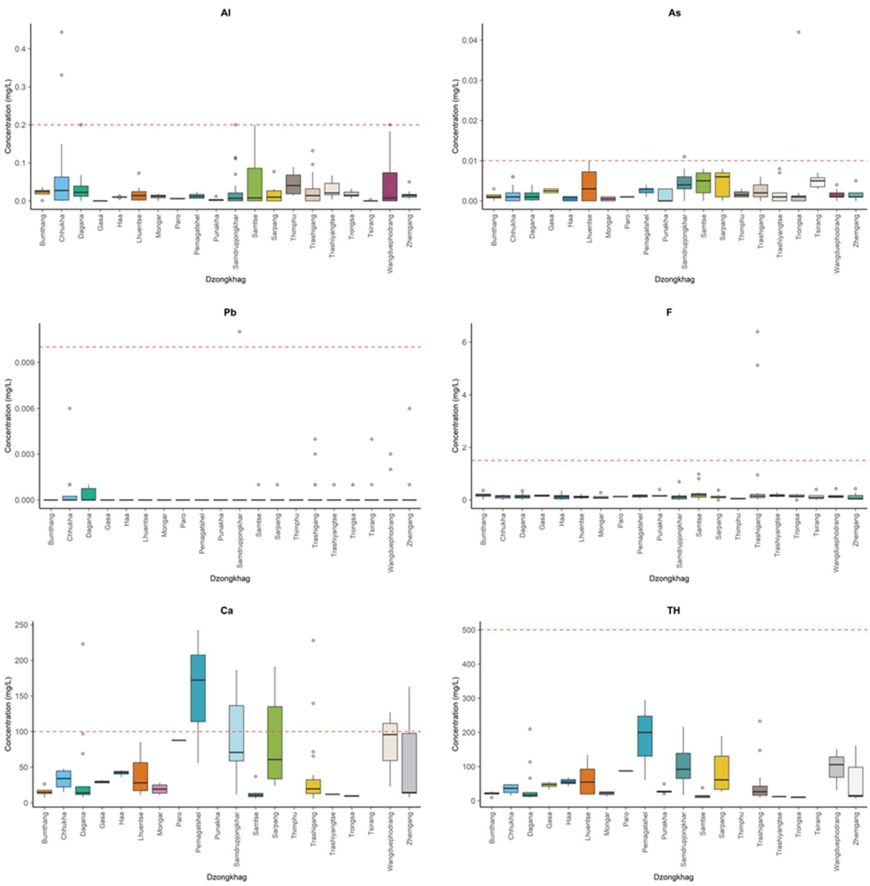

Figure 4: Distribution of selected elements across 20 Dzongkhags

4.2 Trace Elements and Heavy Metals

4.2.1 Arsenic, Lead, Cadmium, and Antimony

As is a well-established carcinogen and a major cause of chronic toxicity (arsenicosis), commonly associated with dermatological manifestations such as skin lesions and pigmentation, as well as cancers of the skin, bladder, and lungs (25). The national mean concentration (0.003 mg/L) is safely below the limit of 0.01 mg/L. However, two samples exceeded the limit, with the highest concentration recorded in Yudrung Central School at Trongsa (0.042 mg/L) and Karmaling Higher Secondary School in Samdrupjongkhar (0.011mg/L). Higher concentration of As is also observed in the neighboring countries including Bangladesh and Nepal, where As concentrations frequently exceed WHO limits due to geogenic mobilization in alluvial aquifer systems (26, 27).

Pb is a highly toxic heavy metal that poses serious health risks even at low concentrations, particularly due to its tendency to accumulate in the human body that can harm the brain, nervous system, kidneys, and blood, with children being especially vulnerable to developmental effects (28). Low Pb levels have been reported in rural areas of neighboring countries like Nepal with limited industrial activity, while much higher concentrations are typically found in urban and mining-affected regions of China and Pakistan (29-31). Cadmium is a highly toxic heavy metal associated with chronic health effects, particularly kidney damage, bone demineralization (Itai-itai disease), and increased risks of cancer following long-term exposure (32). However, in the current assessment, both Pb and cadmium metals were largely non-detectable or present at negligible levels. Only one sample from Samdrupjongkhar (Gomadar Central School) exceeded the recommended level of 0.01 mg/L reaching 0.011 mg/L. Cadmium remained consistently low (Max: 0.001 mg/L), confirming that industrial heavy metal contamination is not a widespread issue in the sampled districts.

Antimony (WHO MAC: 0.02 mg/L)and Molybdenum (WHO MAC: 0.1 mg/L) are trace elements whose presence in drinking water is primarily governed by local lithology and geogenic leaching. Antimony is an element of emerging concern; while it has no known biological function, chronic ingestion of elevated levels is linked to gastrointestinal distress and adverse cardiovascular effects, including hypertension. Conversely, Molybdenum is an essential micronutrient for enzyme catalysis, yet excessive intake can disrupt copper metabolism, leading to “molybdenosis” and gout-like symptoms (2). As per the report, Antimony and Molybdenum are also within safe ranges across all 20 Dzongkhags. The maximum recorded Antimony was 0.004 mg/L, and Molybdenum was 0.002 mg/L, indicating no immediate health risks from these elements.

4.2.2 Aluminum, Chromium, Nickel, and Copper

Al was detected in several sampling sites, with mean values of 0.03 mg/L that ranged from 0.000 to 0.440 mg/L. Overall, the mean concentrations remain below the national and WHO guideline value of 0.2 mg/L. While most sites comply with the 0.2 mg/L threshold, two samples from Chhukha exceeded the limit, notably in Chukha Central School (0.444 mg/L) in Tsimalakha and Chhukha Dzongsite armycamp (0.333 mg/L). These elevated levels are typically attributed to natural geochemical weathering of aluminosilicate minerals in mountainous catchments. Comparable Al concentrations have been reported in drinking-water studies from other mountainous regions, where geogenic inputs are dominant and concentrations are within guideline limits (33).

Cr concentrations were generally low across the sampling sites, with a mean value of 0.001 mg/L and a range from 0.000 to 0.0320 mg/L. Overall, all observed Cr concentrations remained below the WHO guideline limit of 0.050 mg/L. Comparatively higher Cr concentrations were observed in Samtse (0.0320 mg/L) and Samdrupjongkhar (0.029 mg/L) relative to other Dzongkhags. Concentrations within this range are not expected to pose adverse health effects and indicate negligible to low health risk (2). Ni, and Cu showed excellent compliance, posing negligible risk to consumers. Ni concentrations ranged from 0.000 to a maximum of 0.007 mg/L. Cu reached a maximum of 0.035 mg/L, which is far below the aesthetic and health limit of 2.0 mg/L.

The absence of significant metal contamination suggests that natural geochemical weathering rather than anthropogenic pollution is the dominant control on trace metal concentrations in Bhutan’s drinking water.

4.3 Major Ions, Nutrients, and Other Chemical Parameters

4.3.1 Nitrate, Fluoride, Sulfate and Chloride

Nitrate primarily originates from agricultural runoff, high intake of nitrate is linked to “blue baby syndrome” (methemoglobinemia) in infants. It is also classified as a “probable human carcinogen” (Group 2A), associated with increased risk of stomach, colorectal, and thyroid cancers. According to the report, Nitrate concentrations across all districts were substantially below the WHO guideline of 50 mg/L with mean concentration of 0.381 mg/L. Contrast findings are observed with elevated nitrate levels reported in intensively farmed regions of Southeast Asia (34).

The report indicates that Fluoride concentrations in most of the water samples were consistently low (generally < 1 mg/L). While this ensures compliance with the BDWQS and WHO guideline value of 1.5 mg/L, it situates population-level exposure below the optimal range (0.5-1.0 mg/L) recommended for conferring protective benefits against dental caries (tooth decay)(2). Epidemiological evidence consistently shows an inverse relationship between fluoride concentrations in drinking water and dental caries prevalence, even modest increases toward optimal levels are associated with significant reductions in caries risk among children and adolescents, whereas fluoride concentrations well below recommended targets do not confer these protective effects (35, 36). These low fluoride levels are unlikely to confer significant systemic protection against dental caries, which may partly explain the persistently high prevalence of tooth decay reported in national health surveillance (37). In contrary, two samples in Trashigang, Jampeling Central School (6.393 mg/L) and Khaling Hospital (5.123 mg/L) significantly exceeded the recommended limit, posing a localized risk for dental fluorosis.

To mitigate low fluoride exposure and its contribution to high caries burden, many countries have adopted public health strategies such as community water fluoridation that maintains target fluoride levels in public supplies and has been linked to substantial declines in dental decay. Where water fluoridation is not feasible, alternative measures including fluoride supplementation (tablets or drops), salt or milk fluoridation, and promotion of fluoridated toothpaste and professional varnish applications have been successfully used to enhance fluoride exposure and improve oral health outcomes (38).

Both sulfate and chloride concentrations in drinking water were below the recommended limits. The mean sulfate concentration was 8.99 mg/L, with values ranging from 0.00 to 97.6 mg/L, while chloride had a mean concentration of 32.41 mg/L, ranging from 1.47 to 63.8 mg/L.

4.3.2 Iron and Manganese

Iron in drinking water can be both beneficial and harmful depending on its concentration. Trace amounts are nutritionally beneficial, as iron is an essential element required for hemoglobin formation and oxygen transport. However, excessive iron in drinking water reduces water acceptability due to unpleasant taste, discoloration, and staining, which may discourage consumption of safe water and increase reliance on unsafe sources.

As per the report, Fe concentration ranged from a 0.00 mg/L to 0.726 mg/L, with a mean concentration of 0.032 mg/L. Three samples exceeded the 0.3 mg/L limit, with two samples from Samdrupjongkhar (Housing colony = 0.726 and Dug well = 0.378 mg/L) and one sample from Chhukha Central School having 0.690 mg/L. These suggests that a few sources may have elevated iron concentrations, possibly due to natural geochemical processes, corrosion of pipelines, or anthropogenic contamination.

Manganese is an essential trace element required for normal metabolic and neurological functions, and low levels in drinking water generally do not pose health concerns. However, long term exposure to high manganese can affect cognitive and motor development, especially in infants and young children (2). The mean concentration of Mn was 0.007 mg/L. Only one sample in Samdrupjongkhar from Housing colony (0.615 mg/L) exceeded the WHO limit of 0.4 mg/L

4.4 Total Hardness and Carbonate Chemistry

Total hardness, caused mainly by calcium and magnesium ions, varied widely across Dzongkhags, reflecting differences in local geology. As per the report, Bhutan's drinking water is generally categorized as "soft" to "moderately hard" with a national mean of 55.03 mg/L that ranged from 6.00 to 295.20 mg/L. Pemagatshel recorded the highest hardness, with a median of 174.1 mg/L and a maximum of 295.2 mg/L. Overall, the concentration remaining below the national and WHO guideline value of 500 mg/L.

Calcium hardness shows the highest frequency of exceedance in the current dataset. 17 samples exceeded the recommended threshold, with a maximum of 242.8 mg/L. High calcium levels contribute to scaling in distribution pipes and household appliances and are likely linked to carbonate dissolution in districts with limestone-rich geology.

Carbonate and Bicarbonate represent the primary buffering capacity of water, derived largely from the geogenic weathering of carbonate rocks. In the current dataset, bicarbonate is the dominant alkalinity species with a mean of 4.79 mg/L (range: 0.16-22.31 mg/L), providing essential pH stability. Carbonate remains negligible with mean value of 0.023 mg/L. Comparatively, these levels remain remarkably stable relative to the previous whole-Dzongkhag dataset, confirming a consistent hydrochemical signature across the country.

4.5 Principal Component Analysis (PCA)

PCA was performed to identify the major factors controlling the chemical composition of drinking water samples. The PCA results showed that several parameters contributed strongly to the first two principal components, indicating their importance in explaining the variability in water chemistry (Figure 5).

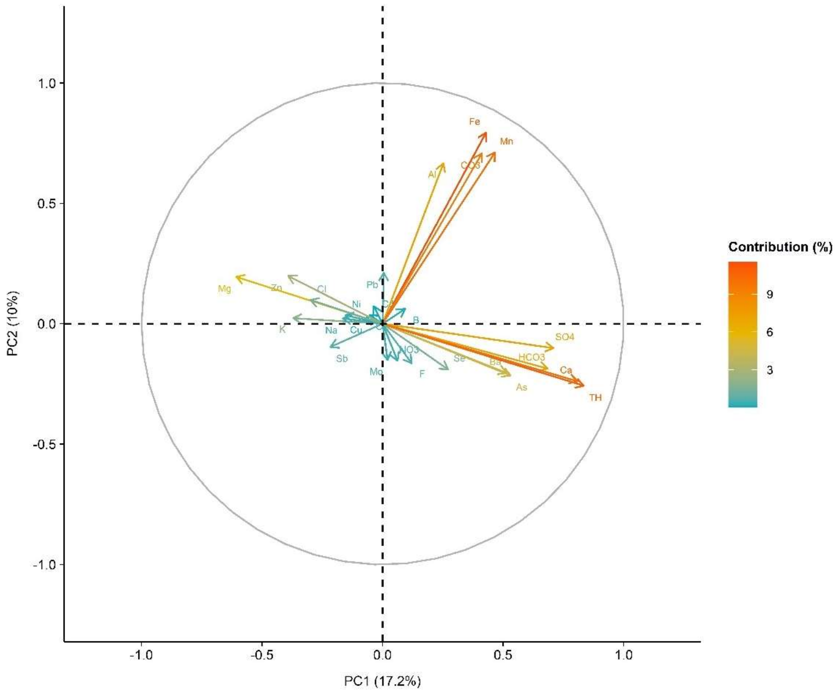

Figure 5: Principal Component Analysis (PCA) of water quality parameters

Table 3: PCA loadings, contributions, and representation quality (cos^2) of drinking water quality parameters.

Parameter	PC1 Loading	PC2 Loading	PC1 Contribution	PC2 Contribution	Representation Quality
TH	0.835	-0.258	15.6	2.6	0.763
Ca	0.808	-0.239	14.6	2.2	0.71
SO4	0.709	-0.101	11.3	0.4	0.513
HCO3	0.685	-0.186	10.5	1.3	0.503
Mg	-0.608	0.195	8.3	1.5	0.407
As	0.531	-0.215	6.3	1.8	0.328
Ba	0.514	-0.204	5.9	1.6	0.306
Mn	0.467	0.711	4.9	19.5	0.724
Fe	0.429	0.793	4.1	24.2	0.814
CO3	0.412	0.707	3.8	19.2	0.67
Zn	-0.392	0.198	3.4	1.5	0.193
K	-0.371	0.023	3.1	0	0.138
Cl	-0.299	0.099	2	0.4	0.099

Parameter	PC1 Loading	PC2 Loading	PC1 Contribution	PC2 Contribution	Representation Quality
Se	0.272	-0.19	1.7	1.4	0.11
Al	0.253	0.666	1.4	17.1	0.508
Sb	-0.216	-0.096	1.1	0.4	0.056
Na	-0.164	0.022	0.6	0	0.028
Ni	-0.155	0.035	0.5	0	0.025
F	0.121	-0.164	0.3	1	0.042
B	0.094	0.062	0.2	0.1	0.013
Cr	-0.054	0.036	0.1	0.1	0.004
Cu	-0.073	0.024	0.1	0	0.006
NO3	0.062	-0.154	0.1	0.9	0.028
Cd	-0.037	0.073	0	0.2	0.007
Mo	0.021	-0.151	0	0.9	0.023
Pb	0.005	0.212	0	1.7	0.045

The first principal component (PC1) was mainly dominated by total hardness (TH), calcium (Ca), sulfate (SO_4^{2-}), and bicarbonate (HCO_3^-), which showed strong positive loadings (0.685-0.835) and the highest contributions to PC1 (Figure 4 and Table 2). TH and Ca contributed 15.6% and 14.6%, respectively, followed by SO_4^{2-} (11.3%) and HCO_3^- (10.5%). These parameters are typically associated with water-rock interactions and carbonate mineral dissolution, suggesting that the natural geochemical characteristics of the aquifer or source rocks are a major control on the chemical composition of drinking water. Magnesium (Mg) showed a relatively strong negative loading on PC1 (-0.608), indicating an inverse relationship with the dominant Ca-HCO_3-SO_4 hydrochemical signature.
Trace elements such as arsenic (As) and barium (Ba) also showed moderate positive loadings on PC1, with contributions of 6.3% and 5.9%, respectively. This suggests that their presence may also be influenced by natural geological sources rather than widespread anthropogenic contamination.

The second principal component (PC2) was primarily associated with iron (Fe), manganese (Mn), carbonate (CO_3^{2-}), and aluminum (Al), which exhibited strong positive loadings and high contributions to PC2. Fe showed the highest contribution (24.2%), followed by Mn (19.5%), CO_3^{2-}

(19.2%), and Al (17.1%). These elements are commonly linked to redox conditions, mineral weathering, and geochemical mobilization processes, indicating that local hydrogeochemical conditions may influence their variability in drinking water sources.

The quality of representation (cos^2) values indicated that TH (0.763), Ca (0.71), Fe (0.814), Mn (0.724), and CO_3 (0.67) were well represented by the first two principal components, suggesting that these variables play a significant role in explaining the overall variability in the dataset.

Overall, the PCA results suggest that the chemical composition of drinking water is primarily controlled by natural geochemical processes, particularly mineral dissolution and water-rock interactions, with limited evidence of widespread anthropogenic contamination. The clustering of hardness-related parameters in PC1 further highlights the influence of carbonate geology on water chemistry, while the association of Fe, Mn, and Al in PC2 reflects localized geochemical conditions affecting metal mobility.

5. Limitations of the Report

This chemical water quality assessment across Bhutan has several specific limitations that affect the interpretation of results:

1. Sampling coverage was uneven across the 20 Dzongkhags. Most samples were collected from major towns and routine surveillance sites, potentially overlooking other distribution points across all Dzongkhags. Remote and rural areas were excluded as per BDWQS 2025 requirements and logistical challenges.

2. Analysis focused on major ions and selected trace metals; emerging contaminants such as microplastics, pharmaceuticals, and endocrine disruptors were not included.

3. Data collection occurred during a single monitoring period, missing seasonal variations in water chemistry, particularly during monsoon runoff and dilution.

4. Minor uncertainties may arise from sample handling, transport, and instrument calibration, especially for trace elements near detection limits.

5. Limited integration of geological and hydrological data restricts understanding of natural sources and groundwater flow effects on water chemistry.

6. Microbiological and physical water quality parameters (e.g., turbidity, residual chlorine) were monitored separately and are not part of this report.

7. Laboratory and field logistical constraints occasionally delayed sample processing and limited replication, impacting statistical reliability for some measurements.

6. Conclusion and Recommendation

This nationwide assessment of drinking water quality across all 20 Dzongkhags confirms that Bhutan's water supply is largely of good quality, with most physicochemical and trace element parameters meeting WHO and BDWQS standards. The Principal Component Analysis (PCA) further indicates that the chemical profile of the water is shaped mainly by natural geogenic processes-particularly water-rock interactions and the dissolution of carbonate minerals-rather than by human-induced pollution. While trace metal contamination is not a widespread issue, aluminum was detected across several sampling sites. Although the national mean remains well within the 0.2 mg/L guideline, localized exceedances in Chhukha (0.444 mg/L) and Dagana (0.20 mg/L) highlight the influence of natural geochemical weathering of minerals in mountainous catchments. Furthermore, localized exceedances of arsenic in Trongsa and Samdrupjongkhar indicate specific hotspots that require targeted investigation and intervention. Conversely, there were consistently low levels of fluoride across the majority of drinking water sources. While these low concentrations ensure compliance with the maximum allowable limit, they sit well below the optimal range required to confer protective benefits against dental caries, representing a significant public health trade-off.

To ensure long-term water safety and the optimization of public health, it is recommended that the chemical profiles of all drinking water sources be continuously monitored. For parameters found to exceed established limits particularly those with significant health implications, additional confirmatory testing should be conducted. Following such verification, targeted monitoring programs must be established in identified high-risk zones, with a specific focus on areas exhibiting elevated levels of parameters of concern. In districts where fluoride levels remain significantly below the optimal threshold for oral health, the implementation of alternative fluoride delivery strategies, such as fluoride supplementation, salt or milk fluoridation, and the promotion of fluoridated toothpaste or professional varnish applications, maybe be evaluated.

Additionally, investigating the source of localized iron spikes is necessary to differentiate between natural mineral weathering and secondary contamination caused by the corrosion of aging distribution infrastructure. Finally, integrating these hydrochemical findings into a national GIS-based water quality database will provide an indispensable tool for evidence-based policymaking. Such a system would facilitate the strategic allocation of water treatment resources and allow for more efficient infrastructure interventions across the country.

7. References

1. United Nations General Assembly. The human rights to safe drinking water and sanitation. New York: United Nations; 2022.

2. World Health Organization. Guidelines for drinking-water quality: fourth edition incorporating the first addendum. Geneva: World Health Organization; 2017.

3. United Nations. Goal 6: Ensure availability and sustainable management of water and sanitation for all. New York: United Nations; 2015.

4. Villanueva CM, Kogevinas M, Cordier S, Templeton MR, Vermeulen R, Nuckols JR, et al. Assessing exposure and health consequences of chemicals in drinking water: current state of knowledge and research needs. Environ Health Perspect. 2014;122(3):213-21.

5. Department of Environment and Climate Change. Bhutan's Long-Term Low Greenhouse Gas Emission and Climate Resilient Development Strategy (LTS). Thimphu: Ministry of Energy and Natural Resources, Royal Government of Bhutan; 2023.

6. Chimmi D, Chophel P. Determination of Water Quality Indices and Assessment of Heavy Metal Pollution of Drinking Water Sources in Thimphu. Bhutan Health Journal. 2023;9(2):16-21.

7. National Center for Hydrology and Meteorology. River System of Bhutan Thimphu, Bhutan: National Center for Hydrology and Meteorology; [cited 2026 Mar 4]. Available from: https://www.nchm.gov.bt/home/pageMenu/134.

8. Dendup T, Tshering D, Tobgay S, Liu F. Sources and pathways of spring flow and climate change effects in the Dungju Ri & Yude Ri catchments, Bhutan Himalaya. Heliyon. 2024;10(16):e36211.

9. Yapiyev V, Wade AJ, Shahgedanova M, Saidaliyeva Z, Madibekov A, Severskiy I. The hydrochemistry and water quality of glacierized catchments in Central Asia: A review of the current status and anticipated change. Journal of Hydrology: Regional Studies. 2021;38:100960.

10. Tsering T, Abdel Wahed MSM, Iftekhar S, Sillanpää M. Major ion chemistry of the Teesta River in Sikkim Himalaya, India: Chemical weathering and assessment of water quality. Journal of Hydrology: Regional Studies. 2019;24:100612.

11. Azam MM, Tripathi JK. Health and ecological risk assessment of metals in surface water from the Himalayan tributaries of the Ganga river, India. Geochemical Transactions. 2025;26(1):3.

12. Zhang J-W, Yan Y-N, Zhao Z-Q, Li X-D, Guo J-Y, Ding H, et al. Spatial and seasonal variations of dissolved arsenic in the Yarlung Tsangpo River, southern Tibetan Plateau. Science of The Total Environment. 2021;760:143416.

13. Zheng T, Lin H, Deng Y, Xie Y, Yuan J, Du X, et al. Hydrogeochemical processes regulating the enrichment and migration of As and B from the river sediments in the Singe Tsangpo River Bain, Western Tibetan plateau. Applied Geochemistry. 2023;148:105549.

14. Milner AM, Khamis K, Battin TJ, Brittain JE, Barrand NE, Füreder L, et al. Glacier shrinkage driving global changes in downstream systems. Proceedings of the National Academy of Sciences. 2017;114(37):9770-8.

15. Syldon P, Shrestha BB, Miyamoto M, Tamakawa K, Nakamura S. Assessing the impact of climate change on flood inundation and agriculture in the Himalayan Mountainous Region of Bhutan. Journal of Hydrology: Regional Studies. 2024;52:101687.

16. Hill AF, Rittger K, Dendup T, Tshering D, Painter TH. How Important Is Meltwater to the Chamkhar Chhu Headwaters of the Brahmaputra River? Frontiers in Earth Science. 2020;Volume 8 - 2020.

17. Shah S, Ishtiaque A. Adaptation to Glacial Lake Outburst Floods (GLOFs) in the Hindukush-Himalaya: A Review. Climate. 2025;13(3):60.

18. Rai R. Contamination of surface water resources by wastewater in Bhutan: A review. 2022.

19. Chathuranika IM, Sachinthanie E, Zam P, Gunathilake MB, Denkar D, Muttil N, et al. Assessing the water quality and status of water

resources in urban and rural areas of Bhutan. Journal of Hazardous Materials Advances. 2023;12:100377.

20. Ministry of Infrastructure and Transport. The project for formulation of comprehensive development plan for Bhutan 2030. Thimphu: Ministry of Infrastructure and Transport, Royal Government of Bhutan; 2019.

21. Chophel P, Tashi AN, Wangdi R, Dorji C. Drinking water quality surveillance in Bhutan: trend and compliance (2017-2024). Journal of Water and Health. 2025;23(9):1109-22.

22. Department of Water. Bhutan Drinking Water Quality Standards 2025. In: Department of Water MoEaNR, editor. Thimphu: Ministry of Energy and Natural Resources; 2025.

23. Parliament of the Kingdom of Bhutan. The Water Act of Bhutan, 2011. In: Bhutan PotKo, editor. Thimphu, Bhutan: Parliament of the Kingdom of Bhutan; 2011.

24. National Environment Commission. The Water Regulation of Bhutan 2014. In: National Environment Commission, editor. Thimphu: Royal Government of Bhutan; 2014.

25. Speer RM, Zhou X, Volk LB, Liu KJ, Hudson LG. Arsenic and cancer: Evidence and mechanisms. Adv Pharmacol. 2023;96:151-202.

26. Chakraborti D, Rahman MM, Mukherjee A, Alauddin M, Hassan M, Dutta RN, et al. Groundwater arsenic contamination in Bangladesh—21 Years of research. Journal of Trace Elements in Medicine and Biology. 2015;31:237-48.

27. Thakur JK, Thakur RK, Ramanathan A, Kumar M, Singh SK. Arsenic Contamination of Groundwater in Nepal—An Overview. Water. 2011;3(1):1-20.

28. World Health Organization. Lead poisoning. Geneva: World Health Organization; 2024.

29. Rupakheti D, Tripathee L, Kang S, Sharma CM, Paudyal R, Sillanpää M. Assessment of water quality and health risks for toxic trace

elements in urban Phewa and remote Gosainkunda lakes, Nepal. Human and Ecological Risk Assessment: An International Journal. 2017;23(5):959-73.

30. Afzal I, Begum S, Iram S, Shabbir R, Shahat AA, Javed T. Comparative analysis of heavy metals toxicity in drinking water of selected industrial zones in Gujranwala, Pakistan. Scientific Reports. 2024;14(1):30639.

31. Wang G, Shen J, Wei S, Cai D, Liu J. Identification of Heavy Metals and Organic Micropollutants in Drinking Water Sources in Typical Villages and Towns in Northeast China. Molecules. 2022;27(22):8033.

32. Satarug S, Garrett SH, Sens MA, Sens DA. Cadmium, environmental exposure, and health outcomes. Environ Health Perspect. 2010;118(2):182-90.

33. Aswal RS, Prasad M, Patel NK, Srivastav AL, Egbueri JC, Kumar GA, et al. Occurrences, sources and health hazard estimation of potentially toxic elements in the groundwater of Garhwal Himalaya, India. Scientific Reports. 2023;13(1):13069.

34. Brindha K, Pavelic P, Sotoukee T. Environmental assessment of water and soil quality in the Vientiane Plain, Lao PDR. Groundwater for Sustainable Development. 2019;8:24-30.

35. Kirkeskov L, Kristiansen E, Bøggild H, von Platen-Hallermund F, Sckerl H, Carlsen A, et al. The association between fluoride in drinking water and dental caries in Danish children. Linking data from health registers, environmental registers and administrative registers. Community Dent Oral Epidemiol. 2010;38(3):206-12.

36. Blufstein A, Salzmann E, Lilaj B, Dauti R, Andrukhov O, Nell A. Fluoride Levels in Austrian Drinking Water Are Insufficient for Effective Caries Prevention. Dentistry Journal. 2025;13(10):446.

37. Ministry of Health. Annual Health Bulletin 2024. Thimphu: Ministry of Health,; 2024.

38. Umer MF. A Systematic Review on Water Fluoride Levels Causing Dental Fluorosis. Sustainability. 2023;15(16):12227.

Annex 1

Summary of concentrations for all water samples across 20 Dzongkhags and Maximum Allowable Concentrations (MAC) for Bhutan Drinking Water Quality Standard 2025 and WHO guideline values.

Dzongkhag	Statistic	Al	As	B	Ba	Cd	Cr	Cu	Fe	K	Mg	Mn	Mo
BDWQS (MAC)		0.2	0.01	0.5	0.7	0.003			0.3		30-100	0.4	
WHO (MAC)		0.2	0.01	2.4	0.7	0.003	0.05	2	0.3			0.1	0.07
Bumthang	Mean	0.021	0.001	0	0.001	0	0	0	0.024	0.665	0.551	0.001	0
	Min	0.001	0	0	0	0	0	0	0.003	0.523	0.365	0	0
	Q25	0.018	0.001	0	0	0	0	0	0.011	0.568	0.39	0.001	0
	Median	0.024	0.001	0	0.001	0	0	0	0.018	0.619	0.448	0.002	0
	SEM	0.007	0.001	0	0.001	0	0	0	0.011	0.083	0.134	0	0
	Q75	0.028	0.002	0	0.002	0	0	0	0.031	0.716	0.609	0.002	0
	Max	0.036	0.003	0	0.002	0	0	0	0.055	0.901	0.945	0.002	0
Chhukha	Mean	0.072	0.001	0	0.005	0	0	0.002	0.071	0.202	0.278	0.006	0
	Min	0	0	0	0	0	0	0	0	0	0	0	0
	Q25	0.002	0	0	0	0	0	0	0.005	0	0	0.001	0
	Median	0.028	0.001	0	0	0	0	0	0.034	0	0	0.003	0
	SEM	0.026	0	0	0.002	0	0	0.001	0.034	0.059	0.089	0.003	0
	Q75	0.063	0.002	0	0.007	0	0	0.001	0.056	0.484	0.536	0.007	0
	Max	0.444	0.006	0.008	0.049	0	0	0.026	0.69	0.691	1.015	0.057	0.001
Dagana	Mean	0.043	0.001	0	0.006	0	0	0.001	0.013	0.672	0.525	0.002	0
	Min	0	0	0	0.001	0	0	0	0	0	0	0	0
	Q25	0.012	0	0	0.002	0	0	0	0	0.631	0.41	0.001	0
	Median	0.022	0.001	0	0.004	0	0	0	0.006	0.78	0.617	0.001	0
	SEM	0.014	0	0	0.001	0	0	0.001	0.004	0.085	0.073	0.001	0
	Q75	0.039	0.002	0	0.008	0	0	0	0.018	0.919	0.727	0.003	0
	Max	0.2	0.004	0	0.022	0.001	0	0.009	0.052	1.058	0.869	0.009	0.002
Gasa	Mean	0	0.002	0.002	0	0	0	0	0.047	0.467	0.647	0.002	0
	Min	0	0.002	0.002	0	0	0	0	0.03	0.444	0.622	0.001	0
	Q25	0	0.002	0.002	0	0	0	0	0.04	0.453	0.638	0.002	0
	Median	0	0.002	0.002	0	0	0	0	0.046	0.466	0.648	0.002	0
	SEM	0	0	0	0	0	0	0	0.007	0.011	0.01	0	0
	Q75	0	0.003	0.002	0.001	0	0	0	0.054	0.48	0.657	0.002	0
	Max	0	0.003	0.003	0.001	0.001	0.001	0	0.064	0.493	0.672	0.002	0
Haa	Mean	0.01	0.001	0	0	0	0	0.002	0.011	0.712	0	0.001	0
	Min	0.007	0	0	0	0	0	0	0	0.692	0	0	0
	Q25	0.01	0	0	0	0	0	0	0.002	0.703	0	0.001	0
	Median	0.01	0.001	0	0	0	0	0.001	0.004	0.708	0	0.001	0
	SEM	0.001	0	0	0	0	0	0.001	0.009	0.009	0	0	0
	Q75	0.011	0.001	0	0	0	0	0.003	0.005	0.71	0	0.001	0
	Max	0.013	0.001	0	0	0	0	0.004	0.046	0.747	0	0.001	0

Na	Ni	Pb	Sb	Se	Zn	F	NO3	SO4	CO3	HCO3	Cl	TH	Ca
		0.01			3	1.5	50	250			0.2-0.5		75
20	0.07	0.01	0.02	0.04	3	1.5	50	250			250	500	100-300
0	0	0	0.002	0	0.012	0.186	0.792	0.083	0	3.395	34.9	20.3	15.95
0	0	0	0	0	0	0.013	0.5	0	0	2.59	24.8	9.8	7.8
0	0	0	0.001	0	0	0.14	0.525	0	0	2.83	24.8	19.25	13.05
0	0	0	0.002	0	0.002	0.183	0.8	0	0	2.91	33.8	22.4	14.8
0	0	0	0.001	0	0.011	0.071	0.159	0.083	0	0.596	5.9	3.637	3.854
0	0	0	0.003	0.001	0.013	0.228	1.067	0.083	0	3.475	43.9	23.45	17.7
0	0.001	0	0.003	0.001	0.044	0.363	1.067	0.333	0	5.17	47.2	26.6	26.4
0.103	0.001	0	0.001	0	0.17	0.12	0.795	4.929	0	3.188	31.4	34.1	32.75
0	0	0	0	0	0	0	0.3	0	0	1.77	29	14.8	15
0	0	0	0	0	0.051	0.068	0.392	1.333	0	2.745	31.1	23.65	22.2
0	0	0	0	0	0.167	0.135	0.6	5.666	0	3.31	31.9	36.4	34.1
0.071	0	0	0	0	0.031	0.018	0.135	1.219	0	0.542	0.829	8.12	7.777
0	0.001	0	0.001	0	0.222	0.169	1.025	7.417	0	3.752	32.2	46.85	44.65
1.038	0.003	0.006	0.002	0.001	0.511	0.203	2	16.667	0	4.36	32.8	48.8	47.8
0.046	0	0	0	0	0.16	0.136	0.437	7.907	0	3.271	37.781	40.043	38.714
0	0	0	0	0	0.013	0	0.167	0	0	0.16	2.54	9	7.4
0	0	0	0	0	0.07	0.07	0.333	0.666	0	1.78	24.15	12.7	11.6
0	0	0	0	0	0.123	0.13	0.4	1.333	0	2.1	30.8	16.1	13.9
0.029	0	0	0	0	0.029	0.026	0.042	4.467	0	1.031	8.393	15.131	15.762
0	0	0.001	0	0	0.218	0.18	0.567	3.333	0	3.678	40.75	23.75	22.65
0.484	0	0.001	0.001	0	0.425	0.347	0.7	62	0	15.85	137	209.8	222.8
1.118	0.001	0	0	0	0.19	0.162	0.225	0.5	0	7.875	13.5	45.575	29.3
1.092	0	0	0	0	0.113	0.13	0.1	0	0	6.4	9	33.3	27.2
1.092	0	0	0	0	0.115	0.138	0.175	0	0	7	12	41.4	27.95
1.112	0	0	0	0	0.175	0.165	0.25	0.5	0	7.85	13.45	46.75	29.1
0.016	0.001	0	0	0	0.046	0.016	0.048	0.289	0	0.668	1.867	4.708	1.015
1.138	0.002	0	0	0	0.25	0.19	0.3	1	0	8.725	14.95	50.925	30.45
1.155	0.003	0	0	0	0.299	0.19	0.3	1	0	9.4	13.5	55.5	31.8
0.609	0.002	0	0.001	0	0.225	0.139	0.08	0.407	0	4.01	34.68	55.24	41.8
0.599	0	0	0	0	0.062	0	0.033	0	0	3.72	30.4	42.6	36
0.609	0	0	0	0	0.069	0.043	0.067	0.033	0	3.88	34.2	50	40.4
0.609	0	0	0.001	0	0.176	0.13	0.1	0.667	0	3.88	35.2	53.6	42.6
0.003	0.001	0	0	0	0.089	0.061	0.013	0.159	0	0.139	1.194	4.477	1.703
0.614	0.001	0	0.001	0	0.268	0.173	0.1	0.667	0	4.04	36.2	61.8	44.2
0.615	0.007	0	0.001	0.001	0.548	0.35	0.1	0.667	0	4.53	37.4	68.2	45.8

Dzongkhag	Statistic	Al	As	B	Ba	Cd	Cr	Cu	Fe	K	Mg	Mn	Mo
BDWQS (MAC)		**0.2**	**0.01**	**0.5**	**0.7**	**0.003**			**0.3**		**30-100**	**0.4**	
WHO (MAC)		**0.2**	**0.01**	**2.4**	**0.7**	**0.003**	**0.05**	**2**	**0.3**			**0.1**	**0.07**
Lhuentse	Mean	0.018	0.004	0	0.015	0	0	0.001	0.029	0.31	0.255	0.002	0
	Min	0	0	0	0	0	0	0	0	0	0	0	0
	Q25	0.002	0	0	0	0	0	0	0.009	0	0	0.001	0
	Median	0.014	0.003	0	0.008	0	0	0	0.012	0	0	0.002	0
	SEM	0.006	0.001	0	0.007	0	0	0	0.009	0.134	0.112	0	0
	Q75	0.024	0.007	0	0.017	0	0	0.001	0.042	0.798	0.618	0.003	0
	Max	0.073	0.01	0	0.081	0	0	0.004	0.095	1.067	0.918	0.005	0.001
Mongar	Mean	0.011	0	0	0	0	0	0.001	0.017	0.603	0.605	0	0
	Min	0	0	0	0	0	0	0	0.003	0	0	0	0
	Q25	0.008	0	0	0	0	0	0.001	0.014	0.575	0.5	0	0
	Median	0.013	0	0	0	0	0	0.001	0.018	0.79	0.67	0	0
	SEM	0.004	0	0	0	0	0	0	0.006	0.201	0.223	0	0
	Q75	0.015	0.001	0	0	0	0	0.001	0.021	0.818	0.775	0.001	0
	Max	0.019	0.001	0	0	0	0	0.002	0.031	0.831	1.078	0.001	0
Paro	Mean	0.006	0.001	0	0	0	0	0.009	0.001	0.542	0	0	0
	Min	0.004	0.001	0	0	0	0	0.004	0	0	0	0	0
	Q25	0.005	0.001	0	0	0	0	0.006	0	0.271	0	0	0
	Median	0.006	0.001	0	0	0	0	0.009	0.001	0.542	0	0	0
	SEM	0.002	0	0	0	0	0	0.004	0.001	0.542	0	0	0
	Q75	0.007	0.001	0	0	0	0	0.011	0.002	0.814	0	0	0
	Max	0.008	0.001	0	0	0	0	0.013	0.002	1.085	0	0	0
Pemagatshel	Mean	0.013	0.003	0	0.028	0	0	0.002	0.007	0	0	0.002	0
	Min	0.007	0.001	0	0.022	0	0	0	0	0	0	0.001	0
	Q25	0.007	0.002	0	0.025	0	0	0	0.001	0	0	0.001	0
	Median	0.012	0.003	0	0.025	0	0	0	0.003	0	0	0.001	0
	SEM	0.003	0.001	0	0.003	0	0	0.001	0.004	0	0	0.001	0
	Q75	0.017	0.003	0	0.033	0	0	0.001	0.009	0	0	0.001	0
	Max	0.024	0.004	0	0.035	0	0	0.007	0.022	0	0	0.004	0
Punakha	Mean	0.004	0.001	0	0.007	0	0	0.002	0.001	3.283	5.557	0.001	0
	Min	0	0	0	0.004	0	0	0	0	0.612	0.579	0	0
	Q25	0.001	0	0	0.004	0	0	0	0	2.109	3.432	0.001	0
	Median	0.003	0	0	0.007	0	0	0	0.001	3.109	6.51	0.001	0
	SEM	0.002	0.001	0	0.001	0	0	0.002	0	0.94	1.628	0	0
	Q75	0.003	0.003	0	0.01	0	0	0.002	0.002	4.564	7.238	0.001	0
	Max	0.012	0.003	0	0.01	0	0.001	0.008	0.002	6.021	10.025	0.001	0
Samdrup Jongkhar	Mean	0.03	0.005	0	0.016	0	0	0.002	0.08	0.362	0.041	0.047	0
	Min	0	0	0	0	0	0	0	0	0	0	0	0
	Q25	0	0.003	0	0.003	0	0	0	0	0	0	0	0
	Median	0.007	0.004	0	0.009	0	0	0	0.006	0	0	0.002	0
	SEM	0.011	0.001	0	0.004	0	0	0.001	0.039	0.095	0.041	0.031	0
	Q75	0.021	0.006	0	0.026	0	0	0.001	0.023	0.813	0	0.007	0
	Max	0.2	0.011	0	0.062	0	0	0.029	0.726	1.016	0.851	0.615	0

Na	Ni	Pb	Sb	Se	Zn	F	NO3	SO4	CO3	HCO3	Cl	TH	Ca
		0.01			3	1.5	50	250			0.2-0.5		75
20	0.07	0.01	0.02	0.04	3	1.5	50	250			250	500	100-300
0	0	0	0	0.001	0.122	0.118	0.363	10.1	0	6.008	29.578	57.267	39.867
0	0	0	0	0	0.005	0.027	0.133	3	0	0.26	9.6	17.6	11.2
0	0	0	0	0	0.01	0.082	0.208	5.084	0	2.1	15.4	19.4	17
0	0	0	0	0.001	0.026	0.116	0.35	7.834	0	3.55	31.2	54.6	28
0	0	0	0	0	0.06	0.019	0.057	1.917	0	2.214	4.838	13.87	9.004
0	0	0	0.001	0.001	0.108	0.148	0.517	15.667	0	7.43	42.6	92.4	56.4
0	0.001	0	0.001	0.002	0.708	0.243	0.6	19.667	0	22.31	48.8	133.6	85.4
0	0	0	0	0	0.358	0.12	0.517	0.082	0	3.07	46.7	21.275	19.4
0	0	0	0	0	0	0.05	0.37	0	0	2.26	32.4	12.2	11
0	0	0	0	0	0	0.065	0.415	0	0	2.388	35.55	17.9	13.55
0	0	0	0	0	0.21	0.075	0.465	0	0	2.91	43.1	22.7	19.2
0	0	0	0	0	0.239	0.054	0.088	0.082	0	0.451	8.048	3.44	4.022
0	0	0	0	0	0.568	0.13	0.568	0.082	0	3.593	54.25	26.075	25.05
0	0	0	0	0	1.01	0.28	0.77	0.33	0	4.2	68.2	27.5	28.2
0	0.002	0	0.002	0	0.316	0.132	0.25	6.834	0	7.92	17.4	87.4	87.8
0	0	0	0.002	0	0	0.123	0.133	3	0	7.92	17.4	87.4	87.8
0	0.001	0	0.002	0	0.158	0.127	0.192	4.917	0	7.92	17.4	87.4	87.8
0	0.002	0	0.002	0	0.316	0.132	0.25	6.834	0	7.92	17.4	87.4	87.8
0	0.002	0	0	0	0.316	0.009	0.117	3.833	NA	NA	NA	NA	NA
0	0.004	0	0.003	0	0.474	0.136	0.308	8.75	0	7.92	17.4	87.4	87.8
0	0.005	0	0.003	0	0.632	0.14	0.367	10.667	0	7.92	17.4	87.4	87.8
0	0	0	0.001	0	0.168	0.148	0.211	51.001	0	8.3	25.267	185.267	156.867
0	0	0	0	0	0.084	0.063	0.167	3	0	4.37	23.4	60.6	55.6
0	0	0	0	0	0.09	0.112	0.167	27.666	0	7.035	23.9	130.3	113.9
0	0	0	0.001	0	0.101	0.16	0.167	52.333	0	9.7	24.4	200	172.2
0	0	0	0.001	0	0.064	0.046	0.044	27.337	0	1.992	1.397	68.123	54.581
0	0	0	0.001	0	0.144	0.19	0.233	75.001	0	10.265	26.2	247.6	207.5
0	0	0	0.003	0.002	0.419	0.22	0.3	97.67	0	10.83	28	295.2	242.8
13.302	0	0	0	0	0.035	0.198	0.28	0.86	0	4.82	NA	29.8	NA
2.001	0	0	0	0	0.014	0.12	0.1	0.7	0	0.4	Inf	20.1	Inf
2.091	0	0	0	0	0.031	0.14	0.1	0.8	0	4.6	NA	25.6	NA
4.143	0	0	0	0	0.039	0.16	0.4	0.8	0	4.7	NA	25.7	NA
6.649	0	0	0	0	0.006	0.051	0.073	0.06	0	1.3	NA	4.993	NA
24.366	0	0	0	0	0.041	0.17	0.4	1	0	6	NA	28.6	NA
33.908	0	0	0	0	0.048	0.4	0.4	1	0	8.4	NA	49	NA
0	0	0.001	0	0.001	0.048	0.13	0.382	16.275	0.168	8.673	23.239	105.871	92.988
0	0	0	0	0	0.007	0	0.01	0	0	2.1	1.47	16.4	11.8
0	0	0	0	0	0.014	0.037	0.017	1	0	5.17	17.8	65	58.8
0	0	0	0	0.001	0.022	0.113	0.47	10.667	0	9.86	25	92	70.7
0	0	0.001	0	0	0.011	0.04	0.063	5.259	0.168	0.898	1.916	14.819	14.077
0	0	0	0	0.001	0.077	0.157	0.567	17.333	0	10.8	27.2	139	136.4
0	0.001	0.011	0.001	0.004	0.166	0.693	0.7	68.667	2.86	14.88	33.8	215.8	186.4

Dzongkhag	Statistic	Al	As	B	Ba	Cd	Cr	Cu	Fe	K	Mg	Mn	Mo
BDWQS (MAC)		**0.2**	**0.01**	**0.5**	**0.7**	**0.003**			**0.3**		**30-100**	**0.4**	
WHO (MAC)		**0.2**	**0.01**	**2.4**	**0.7**	**0.003**	**0.05**	**2**	**0.3**			**0.1**	**0.07**
Samtse	Mean	0.041	0.005	0	0.039	0	0	0.005	0.033	0.168	0.206	0.002	0
	Min	0	0	0	0	0	0	0	0	0	0	0	0
	Q25	0	0.002	0	0	0	0	0	0	0	0	0	0
	Median	0.008	0.005	0	0.005	0	0	0.001	0.011	0	0	0	0
	SEM	0.014	0.001	0	0.011	0	0	0.002	0.013	0.076	0.076	0.001	0
	Q75	0.086	0.007	0	0.092	0	0	0.007	0.041	0	0.472	0.003	0.001
	Max	0.2	0.008	0	0.121	0	0	0.032	0.221	0.811	0.978	0.009	0.001
Sarpang	Mean	0.017	0.004	0	0.066	0	0	0.004	0.044	0.609	0.215	0.007	0
	Min	0	0	0	0.004	0	0	0	0	0	0	0	0
	Q25	0	0.001	0	0.028	0	0	0	0.005	0.332	0	0	0
	Median	0.01	0.006	0	0.075	0	0	0	0.012	0.844	0	0.002	0
	SEM	0.007	0.001	0	0.013	0	0	0.003	0.021	0.111	0.111	0.004	0
	Q75	0.027	0.007	0	0.104	0	0	0.002	0.05	0.851	0.376	0.007	0
	Max	0.077	0.008	0.002	0.121	0.001	0	0.028	0.24	0.916	0.849	0.044	0.001
Thimphu	Mean	0.046	0.002	0	0.005	0	0	0	0.007	0	0	0.002	0
	Min	0.014	0.001	0	0	0	0	0	0	0	0	0	0
	Q25	0.018	0.001	0	0.002	0	0	0	0	0	0	0.002	0
	Median	0.04	0.002	0	0.005	0	0	0	0.001	0	0	0.002	0
	SEM	0.018	0	0	0.002	0	0	0	0.007	0	0	0.001	0
	Q75	0.068	0.002	0	0.009	0	0	0	0.009	0	0	0.003	0
	Max	0.089	0.003	0	0.01	0	0	0.001	0.028	0	0	0.004	0
Trashigang	Mean	0.025	0.002	0	0.003	0	0	0.002	0.018	0.233	0.361	0.002	0
	Min	0	0	0	0	0	0	0	0	0	0	0	0
	Q25	0	0.001	0	0	0	0	0	0	0	0	0	0
	Median	0.014	0.002	0	0.001	0	0	0	0.007	0	0.354	0.001	0
	SEM	0.006	0	0	0.001	0	0	0.001	0.005	0.053	0.069	0.001	0
	Q75	0.032	0.004	0	0.003	0	0	0	0.023	0.533	0.597	0.002	0
	Max	0.132	0.006	0	0.028	0.001	0	0.035	0.132	0.941	1.073	0.025	0
Trashi Yangtse	Mean	0.029	0.002	0	0.002	0	0	0	0.02	0.593	0.532	0.002	0
	Min	0.004	0	0	0	0	0	0	0	0	0.365	0	0
	Q25	0.016	0	0	0	0	0	0	0	0.615	0.417	0.001	0
	Median	0.021	0.001	0	0	0	0	0	0.009	0.654	0.443	0.001	0
	SEM	0.008	0.001	0	0.001	0	0	0	0.009	0.124	0.052	0.001	0
	Q75	0.046	0.002	0	0.002	0	0	0	0.032	0.703	0.655	0.003	0
	Max	0.067	0.008	0	0.007	0.001	0	0.001	0.083	1.061	0.81	0.005	0
Trongsa	Mean	0.018	0.004	0.004	0.002	0	0	0	0.013	0.441	0.457	0.001	0
	Min	0.006	0	0	0	0	0	0	0	0	0	0	0
	Q25	0.013	0	0	0	0	0	0	0.006	0	0.34	0.001	0
	Median	0.014	0.001	0	0.002	0	0	0	0.01	0.637	0.498	0.001	0
	SEM	0.003	0.003	0.002	0.001	0	0	0	0.003	0.095	0.082	0	0
	Q75	0.023	0.001	0.003	0.002	0	0	0.001	0.016	0.702	0.537	0.002	0
	Max	0.032	0.042	0.025	0.01	0	0	0.001	0.035	0.714	1.017	0.002	0

Na	Ni	Pb	Sb	Se	Zn	F	NO3	SO4	CO3	HCO3	Cl	TH	Ca
		0.01			3	1.5	50	250			0.2-0.5		75
20	0.07	0.01	0.02	0.04	3	1.5	50	250			250	500	100-300
0	0	0	0	0.001	0.089	0.25	0.687	17.646	0	1.977	46.689	14.911	13.289
0	0	0	0	0	0	0	0.167	0	0	0.32	24.4	8.2	5.8
0	0	0	0	0	0.021	0.108	0.2	2.5	0	1.3	32.8	8.8	8.6
0	0	0	0	0.001	0.064	0.196	0.334	10	0	1.61	37.2	13.4	10.8
0	0	0	0	0	0.023	0.067	0.313	4.274	0	0.385	8.447	3.062	3.098
0	0	0	0	0.002	0.113	0.243	0.607	36.333	0	2.42	45.2	15	13.2
0	0.002	0.001	0.003	0.004	0.325	0.98	5.33	43.333	0	4.37	91.4	38.2	37
0	0	0	0	0	0.071	0.127	0.292	21.594	0	4.095	19.667	85.9	86.807
0	0	0	0	0	0	0	0.033	0	0	2.42	12.4	26.4	24.24
0	0	0	0	0	0.012	0.09	0.125	2.333	0	2.63	15.35	33.1	33.55
0	0	0	0	0	0.014	0.097	0.333	8.333	0	3.315	19	61.2	60.7
0	0	0	0	0	0.055	0.029	0.057	8.549	0	0.788	2.43	27.785	28.588
0	0	0	0	0	0.019	0.142	0.467	23.666	0	5.455	24.9	130.4	134.95
0	0	0.001	0.001	0.002	0.624	0.373	0.567	81	0	6.95	26.6	189.4	191
0.388	0	0	0	0	0.089	0.052	0.116	0.25	NA	NA	NA	NA	NA
0	0	0	0	0	0.009	0.03	0.07	0	Inf	Inf	Inf	Inf	Inf
0.232	0	0	0	0	0.068	0.038	0.115	0	NA	NA	NA	NA	NA
0.423	0	0	0	0	0.09	0.054	0.132	0	NA	NA	NA	NA	NA
0.153	0	0	0	0	0.032	0.01	0.016	0.25	NA	NA	NA	NA	NA
0.579	0	0	0	0	0.111	0.068	0.133	0.25	NA	NA	NA	NA	NA
0.705	0	0	0	0	0.167	0.07	0.133	1	NA	NA	NA	NA	NA
0.136	0	0	0	0	0.157	0.57	0.344	8.191	0	3.851	35.133	42.608	36.842
0	0	0	0	0	0	0.02	0.04	0	0	0.81	3.4	9	6.2
0	0	0	0	0	0.045	0.09	0.223	0.248	0	2.02	20.85	15.7	13.05
0	0	0	0	0	0.099	0.15	0.3	2.83	0	3.23	27.4	26.3	19.6
0.049	0	0	0	0	0.033	0.281	0.041	3.542	0	0.478	6.121	10.203	10.172
0	0	0	0	0	0.17	0.217	0.377	4.667	0	4.65	38.85	42.65	32.4
0.795	0	0.004	0.001	0.001	0.958	6.393	1	86.67	0	9.38	163.8	233	228
0	0	0	0.001	0.001	0.073	0.182	0.18	1.133	0	2.2	54.4	12.2	12
0	0	0	0	0	0.029	0.107	0.067	0	0	2.2	54.4	12.2	12
0	0	0	0	0	0.044	0.137	0.1	0	0	2.2	54.4	12.2	12
0	0	0	0.001	0	0.048	0.167	0.1	0	0	2.2	54.4	12.2	12
0	0	0	0	0.001	0.015	0.033	0.056	0.975	NA	NA	NA	NA	NA
0	0.001	0	0.001	0.002	0.103	0.203	0.3	0.667	0	2.2	54.4	12.2	12
0	0.001	0.001	0.002	0.007	0.153	0.297	0.333	5	0	2.2	54.4	12.2	12
0.081	0	0	0.001	0	0.087	0.145	0.148	0.463	0	2.582	49.65	10.25	9.55
0	0	0	0	0	0	0	0.067	0	0	1.62	42.2	8.8	8.6
0	0	0	0	0	0.011	0.117	0.1	0	0	1.98	46.25	8.95	8.9
0	0	0	0	0	0.053	0.14	0.167	0	0	2.42	49.6	10.2	9.5
0.081	0	0	0	0	0.034	0.024	0.019	0.209	0	0.487	3.169	0.785	0.457
0	0	0	0	0	0.095	0.193	0.2	0.667	0	3.022	53	11.5	10.15
0.972	0.001	0.001	0.004	0.002	0.4	0.24	0.233	1.5	0	3.87	57.2	11.8	10.6

Dzongkhag	Statistic	Al	As	B	Ba	Cd	Cr	Cu	Fe	K	Mg	Mn	Mo
BDWQS (MAC)		0.2	0.01	0.5	0.7	0.003			0.3		30-100	0.4	
WHO (MAC)		0.2	0.01	2.4	0.7	0.003	0.05	2	0.3			0.1	0.07
Tsirang	Mean	0	0.005	0	0.002	0	0	0.004	0.019	0.21	0.324	0.001	0
	Min	0	0.003	0	0	0	0	0.001	0.001	0	0	0	0
	Q25	0	0.004	0	0	0	0	0.002	0.004	0	0.15	0	0
	Median	0	0.005	0	0.001	0	0	0.002	0.01	0.32	0.161	0.001	0
	SEM	0	0	0	0.001	0	0	0.002	0.008	0.058	0.114	0	0
	Q75	0	0.006	0	0.003	0	0	0.004	0.015	0.325	0.422	0.001	0
	Max	0.003	0.007	0	0.005	0	0	0.022	0.068	0.448	1.061	0.003	0
Wangdue Phodrang	Mean	0.053	0.002	0.003	0.001	0	0	0.004	0.033	0.548	0.19	0.005	0
	Min	0	0	0	0	0	0	0	0	0	0	0	0
	Q25	0	0.001	0	0	0	0	0	0	0.273	0	0	0
	Median	0.008	0.001	0	0	0	0	0	0	0.544	0.11	0	0
	SEM	0.025	0	0.003	0.001	0	0	0.002	0.019	0.126	0.074	0.003	0
	Q75	0.074	0.002	0	0.002	0	0	0.005	0.049	0.936	0.272	0.006	0
	Max	0.2	0.004	0.034	0.008	0	0	0.025	0.18	1.014	0.631	0.025	0
Zhemgang	Mean	0.018	0.001	0	0.007	0	0	0.002	0.016	0.405	0.349	0.002	0
	Min	0.006	0	0	0	0	0	0	0	0	0	0	0
	Q25	0.01	0.001	0	0	0	0	0.001	0.003	0.155	0	0.001	0
	Median	0.015	0.001	0	0	0	0	0.002	0.004	0.363	0.342	0.001	0
	SEM	0.004	0.001	0	0.007	0	0	0.001	0.007	0.117	0.117	0.001	0
	Q75	0.017	0.002	0	0	0	0	0.003	0.027	0.47	0.651	0.005	0
	Max	0.05	0.005	0	0.06	0	0	0.004	0.06	1.065	0.768	0.006	0.001

Na	Ni	Pb	Sb	Se	Zn	F	NO3	SO4	CO3	HCO3	Cl	TH	Ca
		0.01			3	1.5	50	250			0.2-0.5		75
20	0.07	0.01	0.02	0.04	3	1.5	50	250			250	500	100-300
0	0	0	0	0.001	0.188	0.118	0.219	0.741	NA	NA	NA	NA	NA
0	0	0	0	0	0.03	0	0.1	0	Inf	Inf	Inf	Inf	Inf
0	0	0	0	0.001	0.07	0.05	0.133	0	NA	NA	NA	NA	NA
0	0	0	0	0.001	0.15	0.097	0.233	0	NA	NA	NA	NA	NA
0	0	0	0	0	0.044	0.041	0.032	0.493	NA	NA	NA	NA	NA
0	0	0	0	0.001	0.322	0.173	0.267	0	NA	NA	NA	NA	NA
0	0	0.004	0	0.001	0.402	0.4	0.4	3.667	NA	NA	NA	NA	NA
0.087	0	0	0.001	0	0.122	0.164	0.085	5.619	0	7.81	27.2	95.933	81.867
0	0	0	0	0	0	0.07	0.037	0	0	2.1	22.2	31.4	22.8
0	0	0	0	0	0	0.098	0.068	0.166	0	6.3	25.6	68.5	59.3
0	0	0	0	0	0.07	0.117	0.07	1	0	10.5	29	105.6	95.8
0.056	0	0	0	0	0.051	0.046	0.014	4.282	0	2.857	2.532	34.805	30.876
0.027	0.001	0	0.001	0.001	0.154	0.167	0.1	3.5	0	10.665	29.7	128.2	111.4
0.469	0.001	0.003	0.002	0.001	0.484	0.43	0.15	31	0	10.83	30.4	150.8	127
0.069	0.001	0.001	0.001	0.001	0.25	0.136	0.323	8.963	0	4.399	26.978	54.644	54.6
0	0	0	0	0	0	0.023	0.067	0	0	0.48	13	6	7.6
0	0	0	0	0	0.022	0.03	0.1	0.333	0	1.46	20	12	13.4
0	0.001	0	0.001	0.001	0.051	0.053	0.2	2.667	0	2.75	28.6	15	14.4
0.058	0	0.001	0	0	0.122	0.047	0.089	4.284	0	1.378	3.48	21.521	21.584
0	0.001	0	0.002	0.002	0.332	0.17	0.6	10	0	7.61	31.4	98	97.4
0.522	0.002	0.006	0.002	0.002	1.075	0.43	0.7	33.667	0	11.5	45	161.2	163