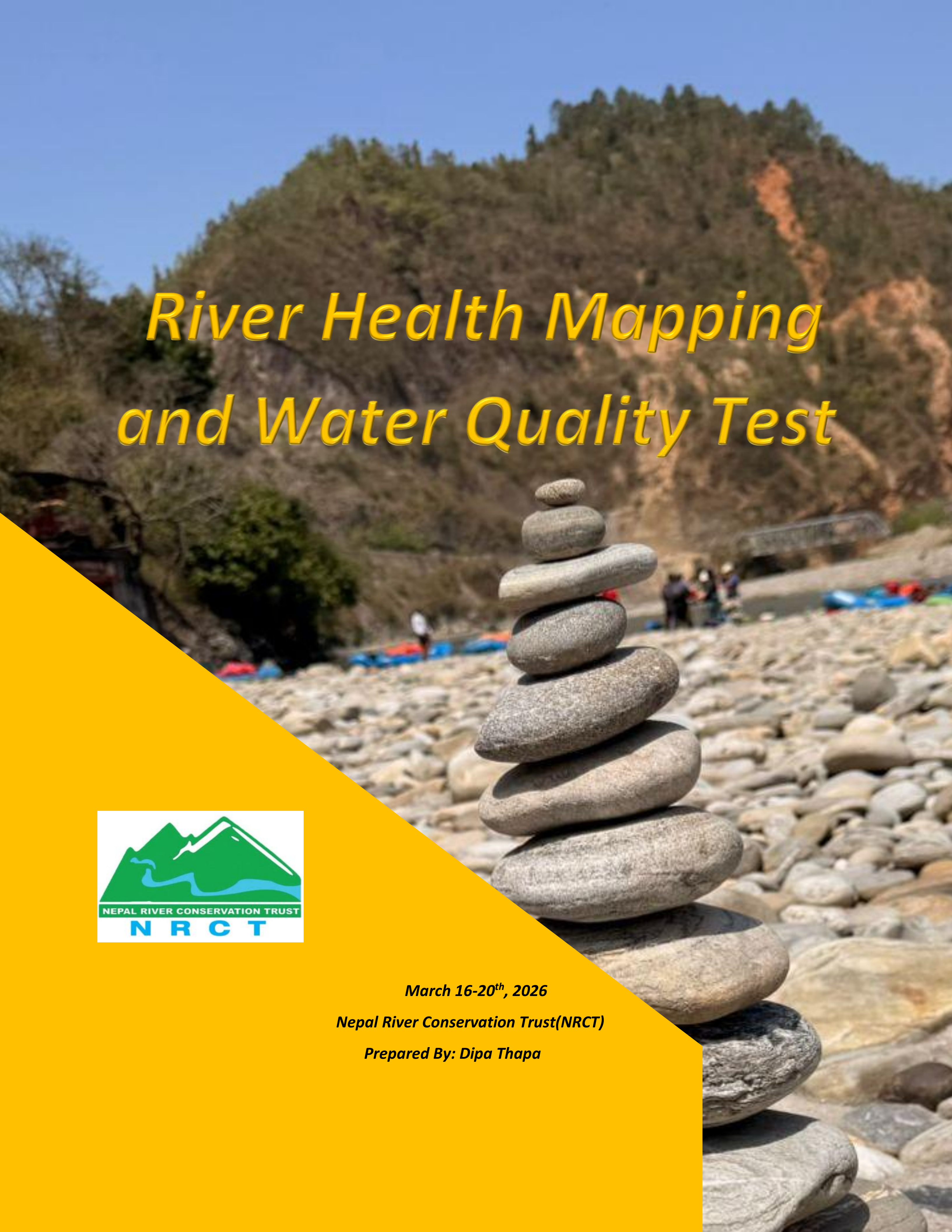

River Health Mapping and Water Quality Test

NEPAL RIVER CONSERVATION TRUST
N R C T

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Abstract

Rivers are critical components of freshwater ecosystems, providing essential ecological services including habitat support, nutrient cycling, and water supply for human use. However, increasing anthropogenic pressures and climatic variability are continuously influencing river water quality, particularly in developing regions. This study assesses the spatial variation in physico-chemical and biological water quality parameters along the Sunkoshi River, Nepal, using integrated field and laboratory-based approaches.

A total of fourteen sampling sites (SK01-SK14) were selected from upstream to downstream, including key tributary confluences such as the Indrawati and Roshi Rivers. Water samples were analyzed for major physico-chemical parameters including pH, turbidity, electrical conductivity, total hardness, alkalinity, calcium, magnesium, chloride, ammonia, iron, manganese, nitrate, and nitrite. In addition, macroinvertebrate assemblages were assessed as biological indicators of ecological condition.

Results indicated generally slightly alkaline conditions (pH 7.6-8.4) and low ionic strength, with electrical conductivity ranging from 46-316 µS/cm. Major ions (calcium and magnesium), chloride, ammonia, and nitrate remained within WHO guideline values, indicating overall acceptable water quality. However, localized exceedances were observed in turbidity (up to 40 NTU), iron (up to 2.4 mg/L), manganese (0.17 mg/L), and nitrite (0.23 mg/L), particularly in midstream and downstream reaches. Elevated turbidity was partly influenced by pre-sampling rainfall events, contributing to increased surface runoff and sediment input.

Biological assessments showed dominance of pollution-sensitive macroinvertebrates such as mayflies (Ephemeroptera) and caddisflies (Trichoptera), indicating generally good ecological conditions, with minor spatial variation in assemblage structure.

Overall, the Sunkoshi River demonstrates moderately good physico-chemical and ecological health, with localized signs of environmental stress associated with tributary inputs, sediment disturbance, and human activities. The study highlights the importance of integrated monitoring approaches and the need for seasonal assessments to distinguish between baseline conditions and event-driven variability.

Keywords: *Sunkoshi River; physico-chemical parameters; water quality assessment; turbidity; macroinvertebrates; Nepal rivers; WHO standards; river ecology; freshwater monitoring; sediment dynamics*

INTRODUCTION

Rivers are dynamic components of the Earth's hydrosphere that provide essential ecosystem services, including habitat provision, nutrient cycling, freshwater supply, and cultural benefits. They support biodiversity at multiple trophic levels and help sustain landscape connectivity, making them fundamental to both ecological integrity and human well-being (Petts & Gurnell, 2005). However, accelerating anthropogenic pressures have increasingly undermined river health globally, with pronounced impacts in rapidly developing regions such as Nepal.

In many developing countries, the regulation of river flow regimes for hydropower generation, irrigation, urban water supply, and flood mitigation has altered natural hydrological patterns, contributing to habitat fragmentation and altered sediment dynamics (Poff et al., 1997; Shrestha et al., 2018). Rapid urbanization, agricultural intensification, and the discharge of untreated municipal and industrial effluents further exacerbate the deterioration of water quality in river catchments (Gurung et al., 2017). Elevated loads of nutrients, organic matter, and toxic contaminants can trigger eutrophication and disrupt ecological processes, reducing oxygen availability and rendering habitats unsuitable for sensitive aquatic organisms (Smith et al., 1999; Paerl & Paul, 2012).

Surface runoff from urban and agricultural landscapes often carries a complex mixture of pollutants-including heavy metals, pesticides, fertilizers, hydrocarbons, and solid waste-into river systems, posing serious threats to biotic communities and overall ecosystem functioning (Allan, 2004; Dalu & Wasserman, 2016). In addition to these anthropogenic influences, natural watershed characteristics such as underlying geology, land cover, and climatic variability shape the baseline physicochemical conditions of river water (Brown et al., 2013). Seasonal fluctuations in rainfall, groundwater inflows, and water abstraction further influence discharge patterns and the assimilation capacity of rivers, with direct implications for pollutant transport and ecological stability (Ward, 1989; Datry et al., 2014).

Declines in water quality are often manifested through sensory indicators (e.g., foul odors, turbidity) and measurable losses in species richness, abundance, and functional diversity (Karr & Dudley, 1981; Dudgeon et al., 2006). These changes not *only signify degraded ecological health but also reduce the suitability of river water for domestic and agricultural uses, posing risks to public health and livelihoods.*

Comprehensive assessment of river water quality is crucial for diagnosing environmental conditions, identifying stressor sources, and informing sustainable management. Integrative approaches that combine physical, chemical, and biological indicators provide a more holistic understanding of riverine status than single-parameter evaluations (Pearce et al., 1992; Bonar et al., 2009). Systematic monitoring enables temporal trend analysis, supports causal inference, and guides the development of actionable strategies to safeguard aquatic ecosystems and human beneficiaries alike. Despite the availability of advanced analytical and statistical tools, there remains a notable gap in studies that explicitly link water quality degradation with broader ecological health outcomes, highlighting the need for multi-disciplinary assessment frameworks (Naiman & Décamps, 1997; Allan et al., 2013).

Key Physico-Chemical Parameters in River Water Quality Assessment

Evaluating river water quality involves analyzing key physico-chemical parameters that reflect the chemical, physical, and biological characteristics of water. The selection of these parameters depends on the intended water use and the objectives of the monitoring program (Tiwari, 2015). The following parameters are commonly measured in freshwater quality studies.

Parameter	***Definition***	***Importance in River Systems***	***WHO Guideline Value****
Dissolved Oxygen (DO)	*Amount of oxygen dissolved in water (mg/L)*	*Essential for survival of aquatic organisms; low DO indicates pollution and can cause stress or death of aquatic life*	*≥ 5 mg/L (good for aquatic life)*
pH	*Measure of acidity or alkalinity (0-14 scale)*	*Influences chemical reactions and biological processes; extreme pH harms aquatic life and affects water usability*	*6.5 - 8.5*
Turbidity	*Measure of water clarity due to suspended particles (NTU)*	*High turbidity reduces light penetration, affects photosynthesis, and may indicate contamination*	*≤ 5 NTU*
Electrical Conductivity (EC)	*Measure of water's ability to conduct electricity due to dissolved ions (µS/cm)*	*Indicates salinity and dissolved ions; high EC may suggest pollution or mineral enrichment*	*No fixed limit (generally < 1500 µS/cm acceptable)*
Temperature	*Degree of heat in water (°C)*	*Controls metabolic rates, oxygen solubility, and overall ecosystem health*	*No specific limit (should be ambient/natural)*

Table 1:Key Water Quality Parameters and WHO Standards

Additional Water Quality Parameters and WHO Standards

Parameter	**Short Definition**	**Importance in River Systems**	**WHO Guideline Value***
Hardness (as $CaCO_3$)	*Concentration of calcium and magnesium salts expressed as $CaCO_3$ (mg/L)*	*Affects soap efficiency, scaling, and aquatic processes; influences species composition*	*≤ 500 mg/L*
Alkalinity	*Water's capacity to neutralize acids (mainly bicarbonates and carbonates)*	*Buffers pH changes and maintains ecosystem stability*	*No specific limit*
Chloride (Cl^-)	*Naturally occurring ion in water*	*High levels indicate pollution; affects taste and can harm aquatic life and crops*	*≤ 250 mg/L*
Calcium (Ca^{2+})	*Essential dissolved mineral ion*	*Supports aquatic organisms; contributes to hardness*	*≤ 75 mg/L (desirable)*
Magnesium (Mg^{2+})	*Naturally occurring mineral ion*	*Important for biological functions; contributes to hardness*	*≤ 50 mg/L (desirable)*
Iron (Fe)	*Trace metal from natural and anthropogenic sources*	*Essential in small amounts; excess causes staining and ecological imbalance*	*≤ 0.3 mg/L*
Manganese (Mn)	*Naturally occurring trace metal*	*Important for biological processes; high levels affect water quality and health*	*≤ 0.1 mg/L*
Ammonia (NH_3/NH_4^+)	*Nitrogen compound from organic waste, sewage, and runoff*	*Indicates recent pollution; toxic at high levels and affects*	*≤ 0.5 mg/L (recommended)*

		aquatic life; increases chlorine demand	
Nitrate (NO_3^-)	*Oxidized form of nitrogen in water*	*Indicates agricultural and wastewater pollution; high levels pose health risks (especially to infants)*	*≤ 50 mg/L*
Nitrite (NO_2^-)	*Intermediate nitrogen compound in nitrification*	*Indicates recent contamination or incomplete nitrification; toxic to aquatic life and humans*	*≤ 0.2 mg/L*

Table 2:Chemical Water Quality Parameters and WHO Standards

Monitoring these parameters provides a comprehensive picture of water quality, supporting ecological assessment, pollution identification, and informed management strategies for river systems.

MATERIAL AND METHODS

2.1 Study Area

The Sunkoshi River, often called the "River of Gold," is a major hydrological artery in central Nepal, originating from the snow-covered peaks of the Tibetan Himalayas. As a principal tributary of the Koshi River system, it traverses steep valleys, dense forests, and terraced mid-hills before joining other Koshi tributaries in the lower plains (Dixit, 2017).

The Sunkoshi River Basin spans a wide altitudinal range-from alpine regions above 4,000 meters to subtropical zones below 500 meters-supporting diverse ecosystems *that include high-altitude meadows, temperate forests, and subtropical sal forests. This ecological variation sustains a rich assemblage of flora and fauna, including several endemic and threatened species (Shrestha et al., 2019). Vegetation shifts with elevation, from rhododendron and juniper at higher altitudes to mixed hardwood forests and cultivated landscapes at lower elevations. The river corridor provides critical habitat for wildlife such as the red panda (Ailurus fulgens), Himalayan monal (Lophophorus impejanus), and various fish and macroinvertebrate species.*

Climatic conditions across the basin vary from humid subtropical in the lowlands to alpine in the upper reaches, largely influenced by the South Asian monsoon. Annual precipitation ranges from approximately 1,000 mm to over 3,000 mm, with most rainfall occurring between June and September. Temperature gradients are similarly broad, from sub-zero winter conditions in high elevations to above 30°C during summer in the southern lowlands. These climatic patterns shape river discharge, sediment transport, erosion dynamics, and flood frequency.

Geologically, the basin is dominated by schists, quartzites, and gneisses, which influence both the mineral composition and sediment load of the river. Soils in the upper catchments are shallow and rocky, whereas the lower basin contains deep, fertile alluvial deposits. These factors not only dictate natural vegetation patterns but also inform local land-use practices, including traditional agriculture, livestock grazing, and community forestry initiatives.

Socio-economically, the Sunkoshi River is vital for local livelihoods, providing water for irrigation, domestic use, sand extraction, and hydropower generation. Major hydropower facilities include the Sunkoshi Hydropower Station, with additional projects in planning or under construction. Seasonal floods, landslides, and sediment deposition during the monsoon pose significant hazards, impacting settlements, infrastructure, and agricultural lands.

To assess spatial variation in water quality, this study selected 14 sampling sites along the river (Figure 1). Eight sites were located along the main river channel, while three were situated at major tributary confluences: Indrawati-Sunkoshi, Chauri Khola-Sunkoshi, and Roshi Khola-Sunkoshi. Site selection considered land-use patterns, flow regimes, and potential pollution sources, ensuring a comprehensive representation of the basin's environmental conditions.

This integrated approach, combining hydrological, ecological, and socio-economic perspectives, provides a robust framework for river management, conservation planning, and disaster risk mitigation in the Sunkoshi River Basin.

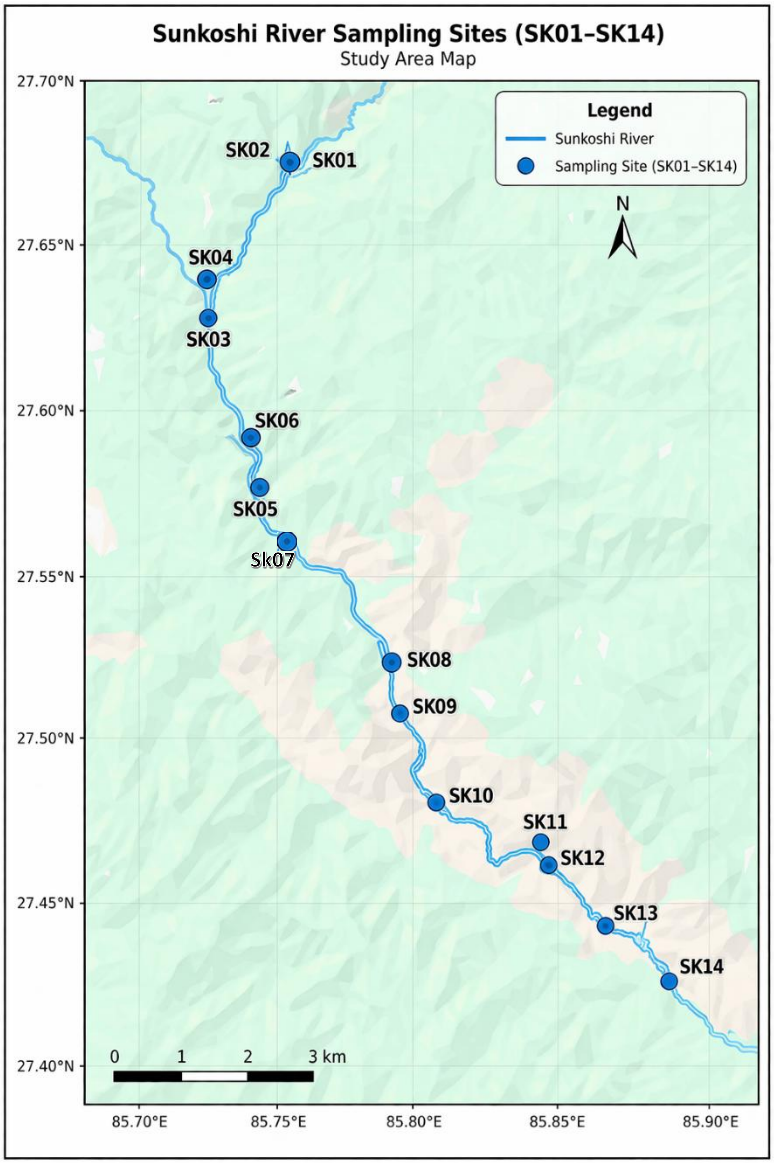
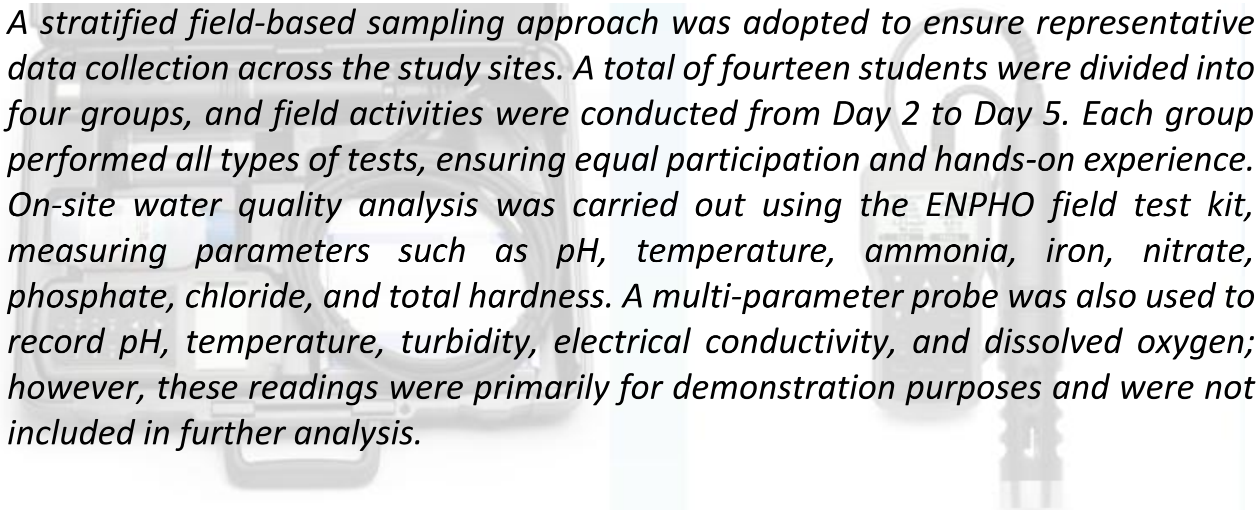


Figure 1: *Study area map showing Sunkoshi River sampling sites (SK01–SK14)*

Sampling Procedure

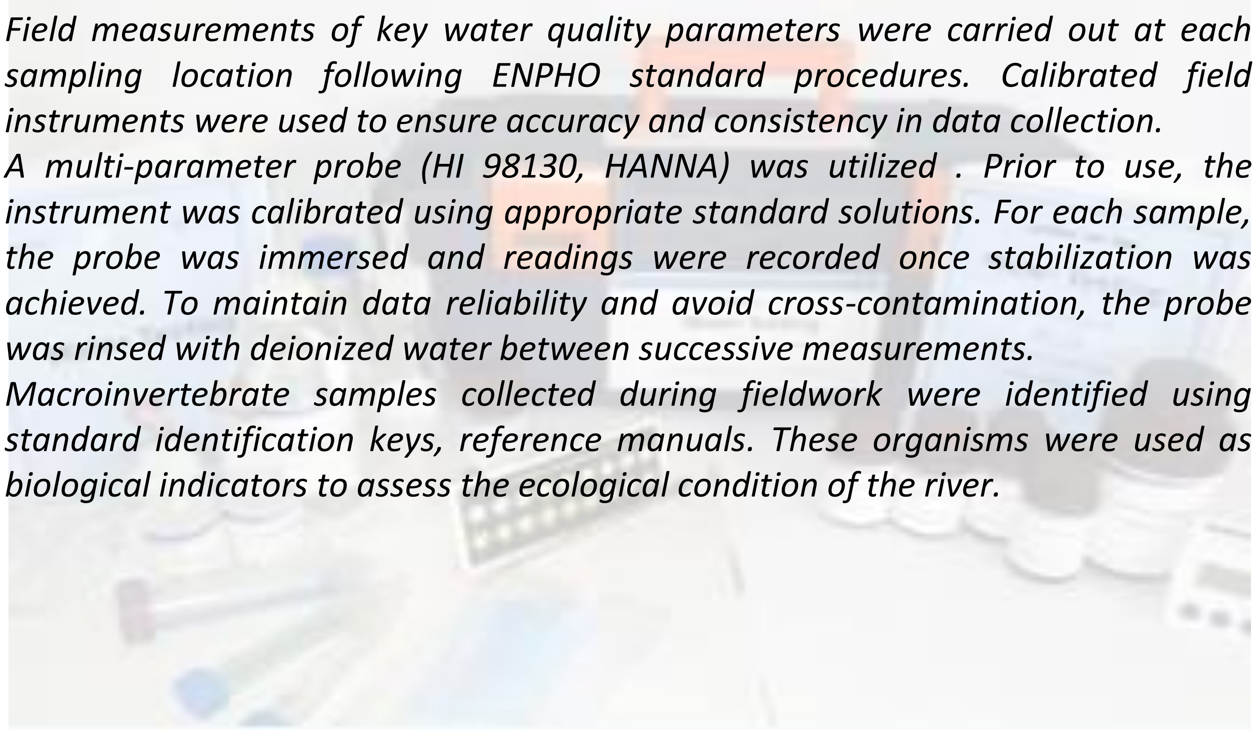


A stratified field-based sampling approach was adopted to ensure representative data collection across the study sites. A total of fourteen students were divided into four groups, and field activities were conducted from Day 2 to Day 5. Each group performed all types of tests, ensuring equal participation and hands-on experience. On-site water quality analysis was carried out using the ENPHO field test kit, measuring parameters such as pH, temperature, ammonia, iron, nitrate, phosphate, chloride, and total hardness. A multi-parameter probe was also used to record pH, temperature, turbidity, electrical conductivity, and dissolved oxygen; however, these readings were primarily for demonstration purposes and were not included in further analysis.

Biological assessment was conducted through macroinvertebrate sampling using the bedrock washing method. Samples were collected in trays, and the presence or absence of taxa was recorded and identified as bioindicators of ecological condition. Water samples were collected in pre-cleaned 1-liter polyethylene bottles, filled without air bubbles, sealed, and stored in dark conditions at 4°C-10°C to preserve sample integrity. In total, fourteen samples (SK01-SK14) were collected. Additionally, physical, chemical, biological, and socio-environmental observations were recorded at each site to support a comprehensive assessment of river water quality.

Data Analysis

1.On-Site Analysis



Field measurements of key water quality parameters were carried out at each sampling location following ENPHO standard procedures. Calibrated field instruments were used to ensure accuracy and consistency in data collection.

A multi-parameter probe (HI 98130, HANNA) was utilized . Prior to use, the instrument was calibrated using appropriate standard solutions. For each sample, the probe was immersed and readings were recorded once stabilization was achieved. To maintain data reliability and avoid cross-contamination, the probe was rinsed with deionized water between successive measurements.

Macroinvertebrate samples collected during fieldwork were identified using standard identification keys, reference manuals. These organisms were used as biological indicators to assess the ecological condition of the river.

2.Laboratory Analysis

Following field measurements, water samples collected from fourteen locations were transported to the laboratory for detailed analysis under controlled conditions. The analysis focused on selected physical and chemical parameters requiring higher precision and laboratory-based techniques.

Samples were preserved at approximately 4°C prior to analysis to prevent alteration of their chemical composition. All laboratory procedures were conducted in accordance with established protocols to ensure data quality and reliability.

The collected data were systematically compiled and organized using spreadsheet software. Subsequent analysis involved basic statistical evaluation and comparison with standard guideline values to identify trends, variations, and potential indicators of water quality degradation.

Result:

Table 3:Geographic coordinates, elevation, and description of sampling sites along the Sunkoshi River, Sindhupalchok District, Nepal.

Site ID	***Sampling Location***	***Description***	***Latitude (N)***	***Longitude (E)***	***Elevation (m)***
SK01	*Sukute Beach*	*Starting sampling point*	*27°41’38.8”*	*85°44’54.5”*	*639*
SK02	*Chehere River*	*Tributary confluence*	*27°40’29.3”*	*85°43’53.4”*	*631*
SK03	*Indrawati Confluence*	*Confluence with Indrawati River*	*27°38’15.6”*	*85°42’28.8”*	*613*
SK04	*Indrawati River*	*Tributary sampling site*	*27°30’01.49”*	*85°47’51.31”*	*608.31*
SK05	*Khahare Ghat*	*Riverbank site*	*27°33’43.9”*	*85°44’00.62”*	*589*
SK06	*Sunkoshi River*	*Main river sampling site*	*27°33’43.9”*	*85°44’00.62”*	*608.31*
SK07	*Chauri Ghat*	*Midstream site*	*27°33’43.99”*	*85°47’0.78”*	*608.31*
SK08	*Sunkoshi River*	*Main channel sampling*	*27°30’01.49”*	*85°47’51.31”*	*600.46*
SK09	*Lubughat*	*Local settlement reach*	*27°29’58.18”*	*85°47’54.35”*	*571.35*
SK10	*Roshi Confluence*	*Confluence with Roshi River*	*27°26’43.6”*	*85°49’44.5”*	*514*

SK11	*Roshi River*	*Tributary sampling site*	*27°25′42.95″*	*85°50′39.02″*	*521.24*
SK12	*Nepalthok*	*Near highway bridge*	*27°25′03.12″*	*85°52′34.09″*	*512.57*
SK13	*Sunkoshi River*	*Downstream reach*	*27°24′57.6″*	*85°53′46.9″*	*488*
SK14	*Mulkot*	*Final downstream sampling site*	*27°24′07.5″*	*85°55′32.1″*	*476*

Notes: Coordinates are expressed in degrees, minutes, and seconds (DMS). Elevation values represent approximate altitude above mean sea level.

The study comprised 14 systematically selected sampling sites (SK01-SK14) along the Sunkoshi River corridor and its major tributaries. The sites were strategically distributed from upstream (Sukute Beach) to downstream (Mulkot), including key confluence zones such as the Indrawati and Roshi river junctions. This spatial arrangement captures variations in hydrological, physico-chemical, and ecological conditions influenced by tributary inputs, land use patterns, and human settlements. Elevation gradually decreases from 639 m at SK01 to 476 m at SK14, reflecting the natural downstream gradient of the river system.

Table 4:Distribution of Macroinvertebrates Across Sampling Sites

Sampling Site	***Mayflies***	***Caddisflies***	***Midges***	***Snails***	***Remarks***
SK01	*10*	*0*	*1*	*0*	—
SK02	*3*	*2*	*1*	*0*	—
SK03	*10*	*1*	*6*	*0*	—
SK04					*No sample taken*

SK05	22	1	2	0	—
SK06					No sample taken
SK07	14	2	2	0	—
SK08	18	1	1	0	—
SK09	16	2	1	0	—
SK10	12	1	1	0	—
SK11	10	0	0	0	—
SK12	18	0	0	0	—
SK13	9	0	0	0	—
SK14	0	0	0	9	—

The table above presents the biological assessment results from the Sunkoshi River. The findings in(Table 4) dictate a clear dominance of mayflies (Ephemeroptera) across most sampling sites, reflecting generally good water quality and well-oxygenated conditions. The presence of caddisflies (Trichoptera) at several locations further supports this observation, as these taxa are also sensitive to pollution.

Midges (Diptera), which are comparatively more tolerant to organic pollution, were recorded in low numbers across most sites, suggesting minimal ecological stress. However, the relatively higher abundance of midges at SK03 may indicate localized disturbance or slight organic influence.

At SK14, the occurrence of both mayflies (8 individuals) and snails (9 individuals) suggests moderate water quality, characterized by a mixture of sensitive and more tolerant taxa.

Sampling was not conducted at SK04 and SK06 due to site-specific and methodological considerations. SK04 represents the confluence with the Indrawati River, where sampling was instead carried out at the confluence point to better capture the combined ecological condition. SK06 lies along the mainstream of the Sunkoshi River, where field observations by the research team indicated similar habitat characteristics and macroinvertebrate assemblages to adjacent sites (SK05 *and SK07); therefore, additional sampling was deemed redundant. Expert verification ensured that these omissions do not affect the overall reliability of the biological assessment.*

Overall, the macroinvertebrate assemblage indicates that the river maintains a generally good ecological condition, with minor spatial variations in water quality across the sampling sites.

Interpretation of Physico-Chemical Water Quality Parameters

1.Turbidity Level:

Turbidity is an important physical parameter that indicates the presence of suspended particles such as silt, clay, organic matter, and microorganisms in water. In the present study, turbidity values ranged from <1 to 40 NTU. The lowest turbidity was observed in sample SK02 (<1 NTU), indicating relatively clear water with minimal suspended particles. However, several samples such as SK09 (40 NTU), SK13 (38 NTU), SK11 (29 NTU), and SK14 (22 NTU) exhibited relatively high turbidity levels. According to drinking water guidelines recommended by the World Health Organization, turbidity in drinking water should preferably remain below 5 NTU. Elevated turbidity values may be attributed to suspended sediments, runoff during rainfall events, or disturbance of bottom sediments. High turbidity can also interfere with disinfection processes by shielding microorganisms from treatment processes.

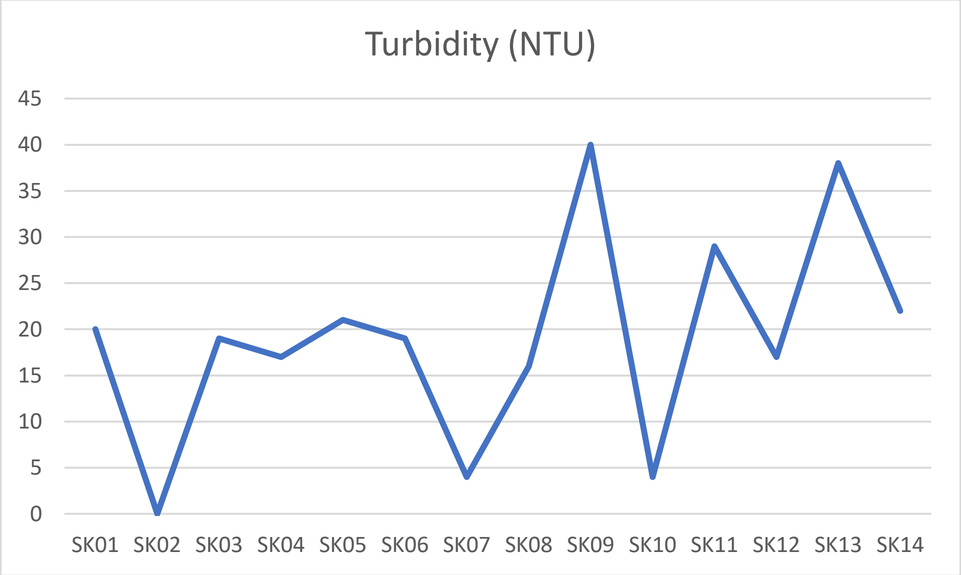


Figure 2:Total Turbidity of the Water Samples

Electrical Conductivity

Electrical conductivity (EC) reflects the ability of water to conduct electrical current and is directly related to the concentration of dissolved ions such as calcium, magnesium, sodium, chloride, and bicarbonate. The conductivity values recorded in this study ranged from 46 µS/cm to 316 µS/cm. The lowest EC value was recorded in sample SK02, indicating relatively low dissolved mineral content. Higher conductivity values were observed in SK10 (307 µS/cm) and SK11 (316 µS/cm), suggesting a greater concentration of dissolved ionic constituents in these samples. However, these values still fall within the typical range for natural freshwater systems. Variations in conductivity among the samples may reflect differences in geological formations, groundwater-rock interaction, and mineral dissolution processes.

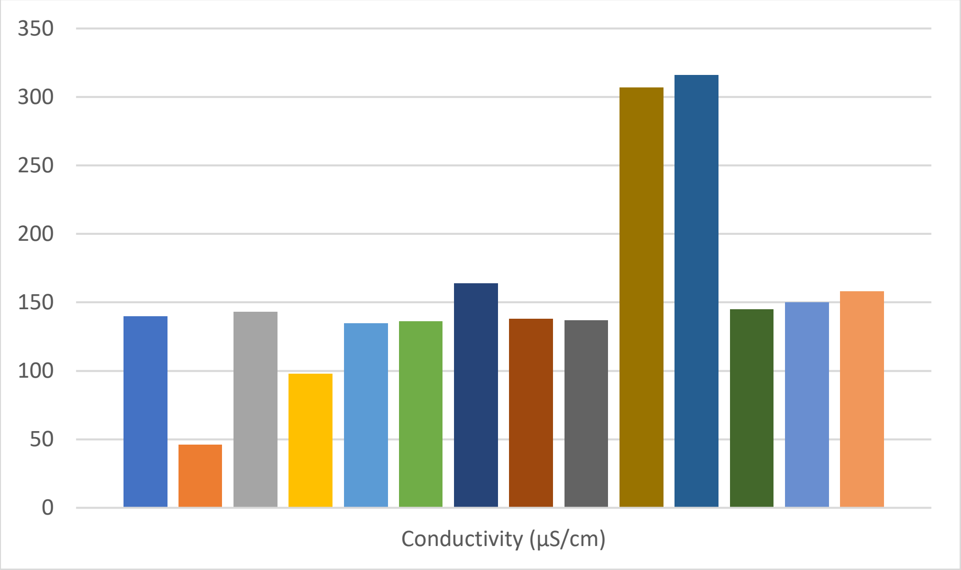


Figure 3: Total Conductivity of the Water Samples

pH

The pH of water indicates its acidity or alkalinity and plays an important role in determining water chemistry and biological processes. In this study, the pH values ranged from 7.6 to 8.4, indicating slightly alkaline conditions in all samples. These values fall within the acceptable range of 6.5-8.5 recommended by the World Health Organization for drinking water. Slightly alkaline conditions are common in groundwater systems where carbonate and bicarbonate ions are present due to the *dissolution of limestone or other carbonate minerals. Such pH levels generally do not pose any direct health risks but may influence the solubility of certain metals and minerals.*

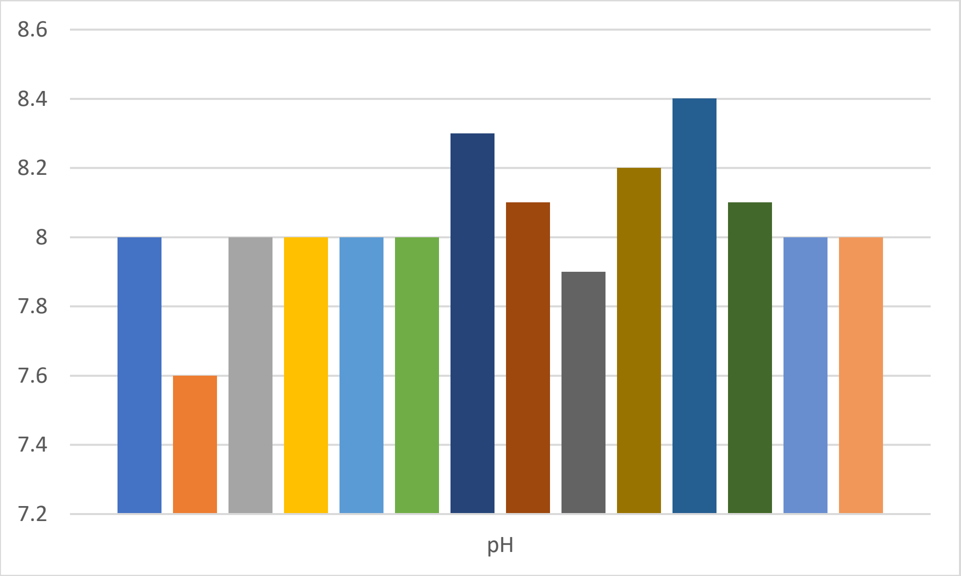


Figure 4: Total pH of the Water Samples

Total Hardness

Total hardness represents the concentration of divalent metal ions, primarily calcium and magnesium, in water. In the present analysis, total hardness values ranged from 20 mg/L to 168 mg/L as $CaCO_3$*. Sample SK02 exhibited soft water characteristics with a hardness value of 20 mg/L, while most of the samples fell within the moderately hard water category (60-120 mg/L). Samples SK10 (160 mg/L) and SK11 (168 mg/L) were classified as hard water. Although hardness does not generally pose a health risk, hard water may cause scaling in pipes, boilers, and household appliances and can reduce the effectiveness of soap and detergents.*

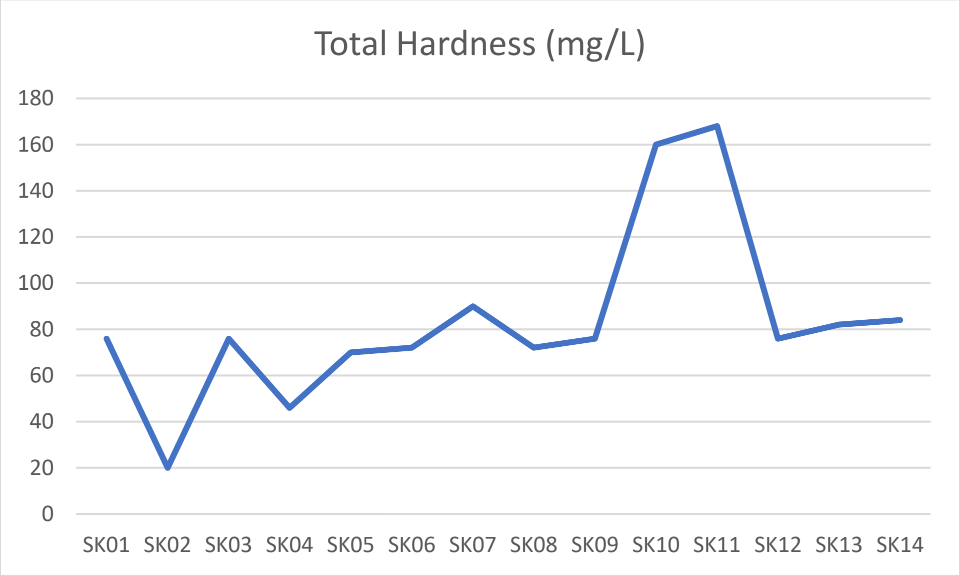


Figure 5:Total Hardness of the Water Samples

Total Alkalinity

Total alkalinity represents the capacity of water to neutralize acids and is mainly contributed by bicarbonate, carbonate, and hydroxide ions. The alkalinity values in the analyzed samples ranged from 26 mg/L to 150 mg/L. These values are within the typical range observed in natural waters. Higher alkalinity values recorded in SK10 and SK11 indicate a greater buffering capacity, which helps stabilize pH levels and resist sudden fluctuations in acidity. Such alkalinity levels are commonly associated with groundwater influenced by carbonate rock formations.

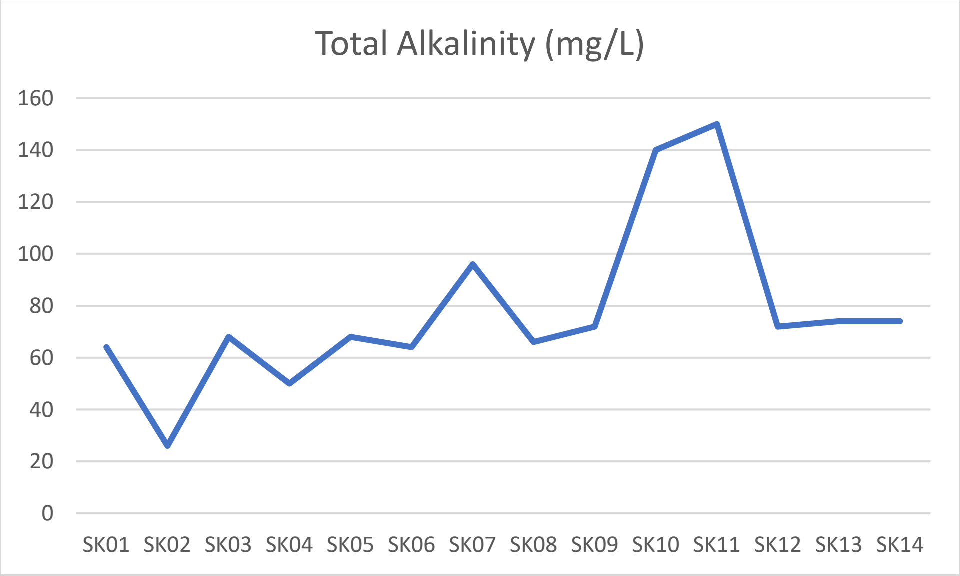


Figure 6: Total Alkalinity of the Water Samples

Calcium

Calcium is one of the major cations in natural waters and is a significant contributor to water hardness. In this study, calcium concentrations ranged from 4 mg/L to 52 mg/L. Lower concentrations were observed in sample SK02, while relatively higher concentrations were found in SK10 (51.3 mg/L) and SK11 (52 mg/L). These variations may be attributed to differences in geological formations and the dissolution of calcium-bearing minerals such as limestone and gypsum. The observed concentrations fall within the normal range typically found in groundwater systems.

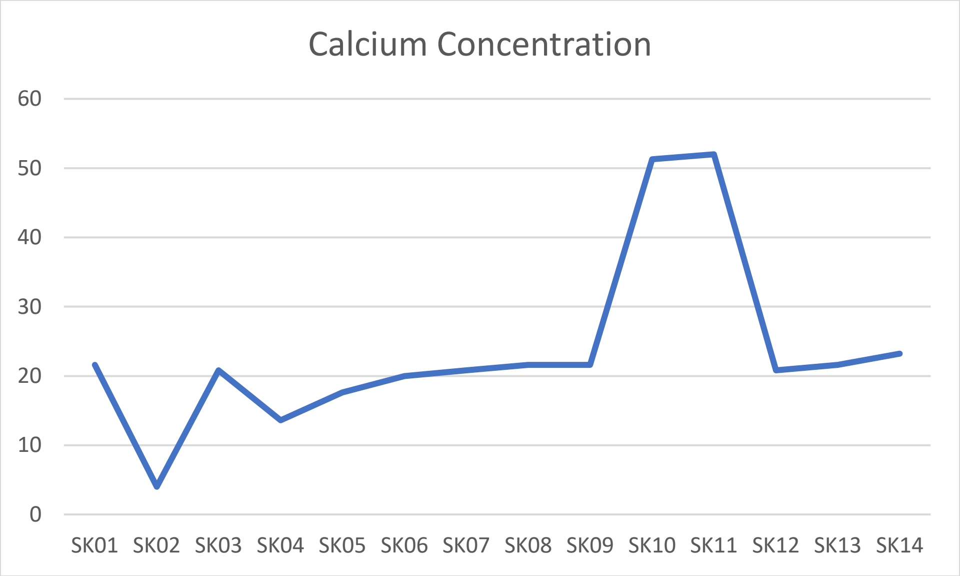


Figure 7:Total Calcium Concentration in Water Samples

Magnesium

Magnesium is another important component contributing to total hardness in water. The measured magnesium concentrations ranged from 2.4 mg/L to 9.2 mg/L across the samples. These values are relatively low and fall well within acceptable limits for drinking water. The presence of magnesium in water is usually associated with the weathering and dissolution of magnesium-rich minerals such as dolomite and magnesite.

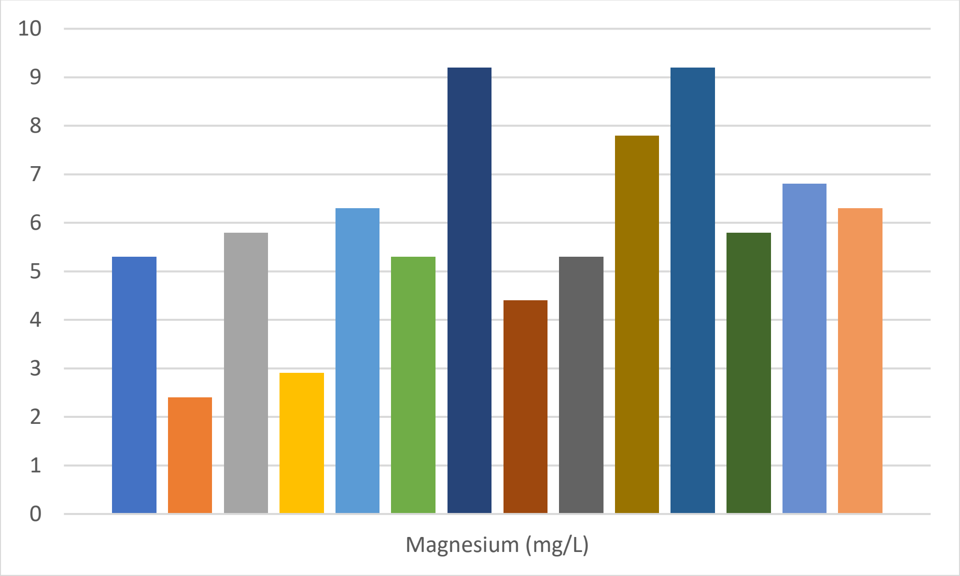


Figure 8: Total Magnesium Concentration in Water Samples

Chloride

Chloride is a common anion in natural water and can originate from geological sources, domestic wastewater, and agricultural runoff. In the present study, chloride concentrations ranged from less than 1 mg/L to 5.6 mg/L, which are significantly lower than the recommended guideline value of 250 mg/L for drinking water. Such low chloride concentrations suggest minimal influence of saline intrusion, sewage contamination, or anthropogenic activities in the sampled water sources.

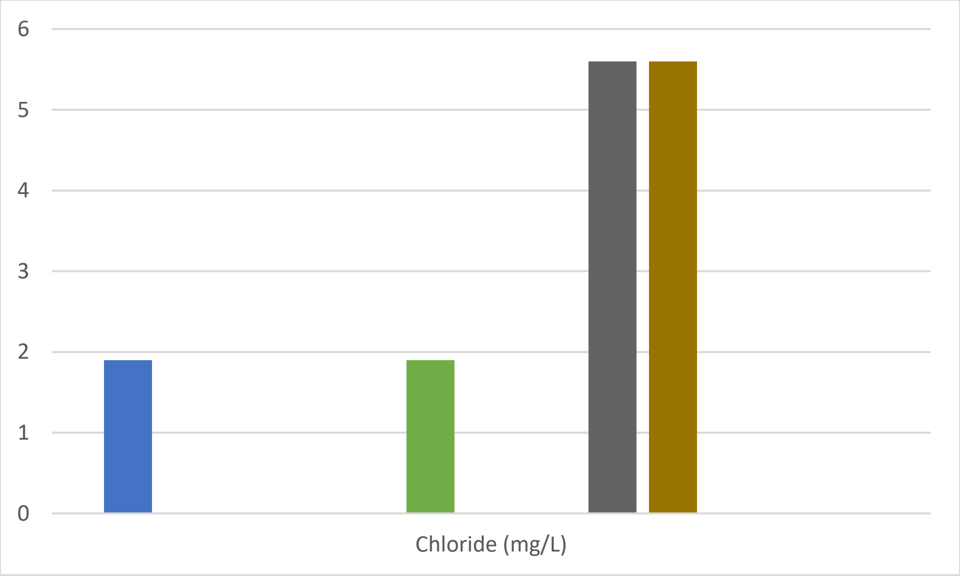


Figure 9:Total Chloride present in Water Sample

Ammonia

Ammonia in water generally indicates recent contamination from organic waste, sewage, or agricultural runoff. In all analyzed samples, ammonia concentrations were recorded as less than 0.02 mg/L, indicating negligible levels of ammonia in the water. These results suggest that water sources are not significantly affected by recent organic pollution or decomposition of nitrogenous organic matter.

Iron

Iron is a naturally occurring element commonly found in groundwater due to the dissolution of iron-bearing minerals. The iron concentrations measured in this study ranged from 0.03 mg/L to 2.4 mg/L. The highest concentration was observed in sample SK09 (2.4 mg/L). According to drinking water standards recommended by the World Health Organization, the acceptable limit for iron in drinking water is 0.3 mg/L, mainly based on aesthetic considerations. Several samples exceeded this guideline value, which may lead to undesirable taste, reddish staining of plumbing fixtures, and the formation of iron deposits in distribution systems.

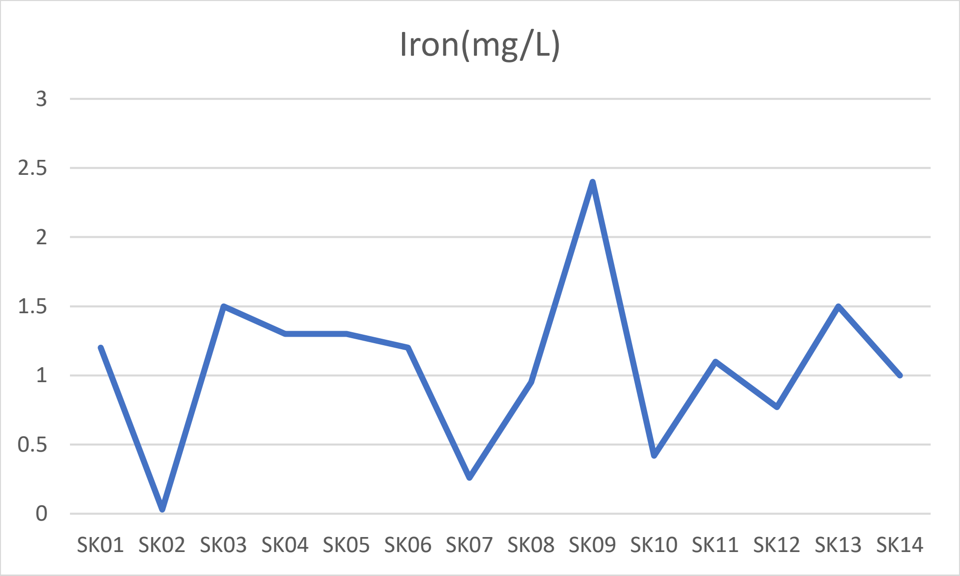


Figure 10:Total Magnesium Concentration in Water Samples

Manganese

Manganese is another trace metal commonly present in groundwater. In the analyzed samples, manganese concentrations ranged from <0.01 mg/L to 0.17 mg/L. Most samples remained within acceptable limits; however, sample SK09

(0.17 mg/L) slightly exceeded the recommended guideline value of 0.1 mg/L. Elevated manganese levels can cause discoloration of water and staining of laundry and plumbing fixtures.

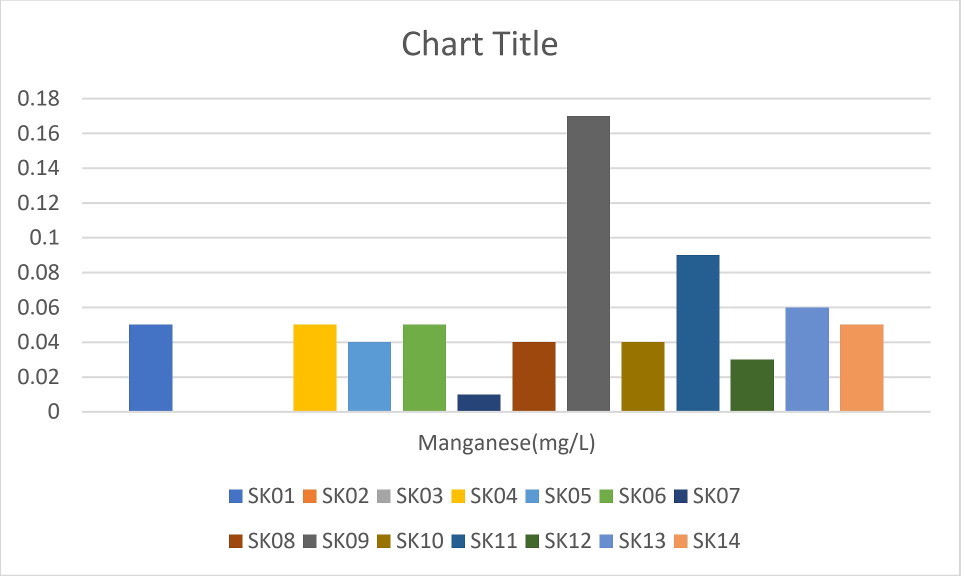


Figure 11:Total Manganese Concentration in Water Samples

Nitrate

Nitrate is an important nutrient in aquatic systems and commonly originates from agricultural fertilizers, sewage discharge, and the oxidation of nitrogenous organic matter. The nitrate concentrations in the samples studied ranged from 1.4 mg/L to 8.5 mg/L, which are well below the guideline value of 50 mg/L recommended by the World Health Organization. These results indicate that the sampled water sources are not significantly impacted by agricultural or sewage-related nitrate contamination.

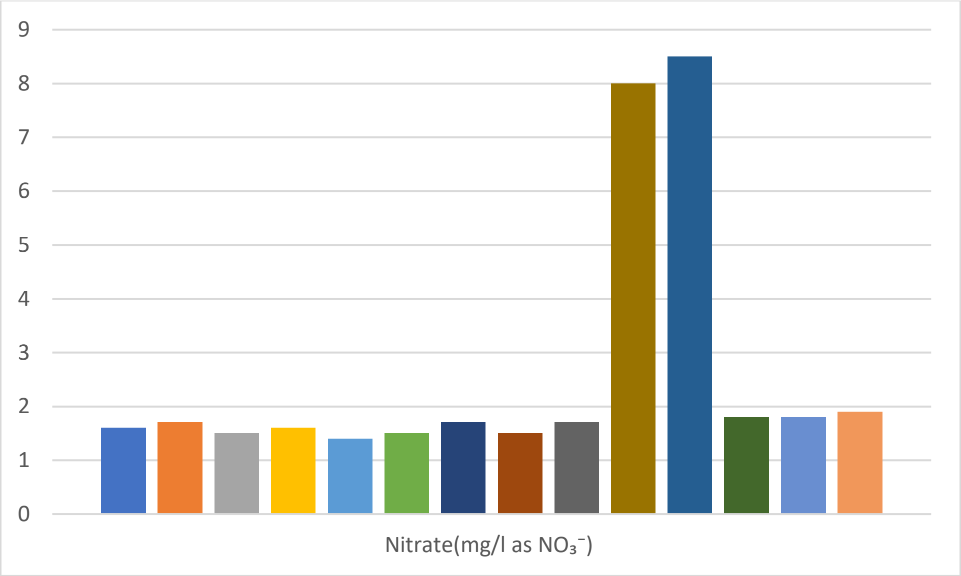


Figure 12:Total Nitrate Concentration in Water Samples

Nitrite

Nitrite is an intermediate compound in the nitrogen cycle formed during the oxidation of ammonia to nitrate. In the present study, nitrite concentrations ranged from <0.02 mg/L to 0.23 mg/L. Most samples exhibited very low concentrations, indicating minimal nitrogen transformation processes in the water. However, sample SK11 (0.23 mg/L) slightly exceeded the recommended guideline value of 0.2 mg/L, suggesting possible localized nitrogenous contamination or incomplete nitrification processes.

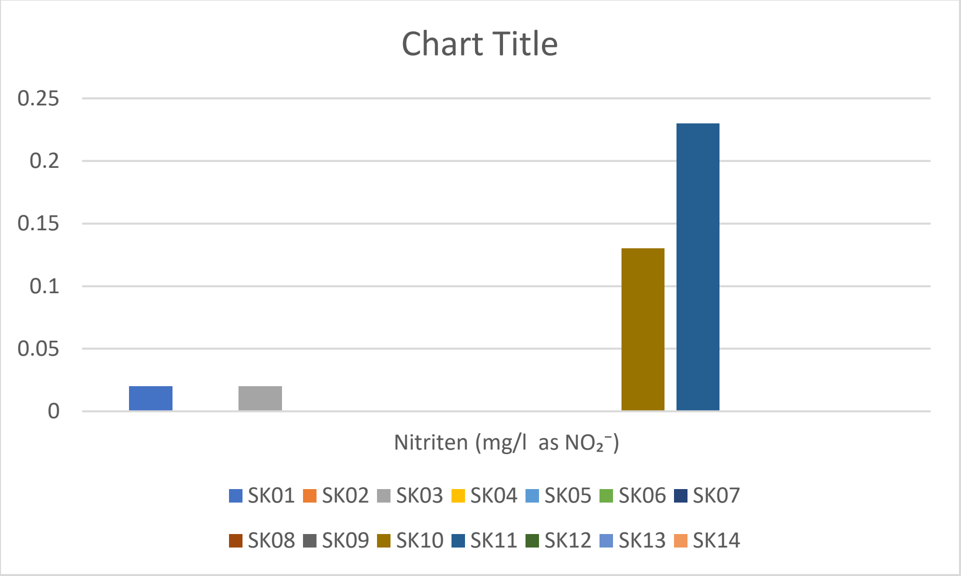


Figure 13:Total Nitrite Concentration in Water Samples

Discussion

The physico-chemical assessment of the Sunkoshi River system reveals distinct spatial variability across the upstream-downstream continuum, influenced by tributary inflows, geological conditions, land-use transitions, and localized anthropogenic activities. Riverine water quality is strongly controlled by both natural processes (e.g., lithology, hydrology, and sediment transport) and human disturbances such as agriculture, settlements, and infrastructure development (Allan & Castillo, 2007; Wetzel, 2001). In mountainous river systems such as the Sunkoshi, the interaction between hydrological dynamics and catchment characteristics often produces pronounced spatial gradients in water chemistry. In addition, short-term hydrological conditions, particularly rainfall events prior to sampling, are likely to have contributed to observed fluctuations in certain parameters, especially turbidity and suspended particulate matter. Episodic precipitation events are known to increase runoff, mobilize sediments, and transport nutrients and contaminants into river channels, thereby temporarily altering water quality parameters (Dodds & Whiles, 2020).

Turbidity exhibited the greatest variability among all measured parameters, ranging from <1 to 40 NTU. Elevated turbidity values at downstream and midstream sites (e.g., SK09, SK11, SK13, and SK14) suggest increased suspended sediment load, likely resulting from catchment runoff, bank erosion, and tributary mixing. Similar patterns have been documented in Himalayan river systems where steep slopes, intense monsoonal rainfall, and fragile geological formations promote sediment transport and turbidity fluctuations (Shrestha & Kazama, 2007). However, the occurrence of rainfall prior to sampling is an important confounding factor, as even light precipitation can enhance surface runoff and transport fine particulates into the river system. Therefore, the elevated turbidity observed at several sites may represent a combination of natural hydrological disturbance and baseline sediment dynamics rather than solely chronic pollution. Notably, turbidity values at multiple locations exceeded the World Health Organization (WHO) recommended guideline of 5 NTU for drinking water, indicating limited suitability for direct consumption without treatment and potential ecological implications such as reduced light *penetration, decreased primary productivity, and alteration of benthic habitats (WHO, 2017). Comparable turbidity ranges have been reported in other Himalayan rivers including the Bagmati and Koshi systems, where sediment loads are strongly influenced by seasonal hydrology and land-use activities (Jha et al., 2017).*

Electrical conductivity (46-316 µS/cm) remained within the typical range for freshwater systems, indicating moderate ionic strength across the river continuum. Conductivity values in natural rivers generally reflect the concentration of dissolved ions derived from mineral weathering, soil leaching, and anthropogenic inputs (Hem, 1985). Slight increases observed at downstream sites such as SK10 and SK11 suggest enhanced dissolution of minerals and potential contributions from agricultural runoff and anthropogenic inputs associated with settlements and road networks. These variations reflect the cumulative effect of catchment processes, including weathering of geological substrates and increasing land-water interaction downstream. Similar conductivity ranges have been reported for other rivers in Nepal and South Asia, where values typically fall between 50 and 500 µS/cm depending on geology and anthropogenic influence (Shrestha & Kazama, 2007; Singh et al., 2005).

The pH values (7.6-8.4) indicate consistently slightly alkaline conditions throughout the study area, remaining within the WHO acceptable range (6.5-8.5). This stability suggests a well-buffered system dominated by carbonate and bicarbonate equilibria, which help maintain chemical balance despite spatial variability in other parameters. Alkaline pH conditions are commonly observed in river systems draining carbonate-rich geological formations and regions characterized by significant mineral weathering (Wetzel, 2001). Similar pH values have been reported in Himalayan river systems including the Ganges and its tributaries, where natural buffering processes maintain relatively stable pH regimes (Singh et al., 2005). Such conditions are generally favorable for aquatic ecosystems, although slight alkalinity shifts may influence metal solubility, nutrient availability, and biological productivity.

Total hardness (20-168 mg/L) showed a clear increasing trend downstream, transitioning from soft to moderately hard and hard water conditions, particularly at SK10 and SK11. This pattern corresponds with rising calcium and magnesium concentrations, reflecting enhanced mineral weathering and possible inputs from agricultural return flows and groundwater interactions. Hardness in river water is *largely controlled by the dissolution of carbonate minerals such as calcite and dolomite (Hem, 1985). Comparable hardness values have been reported in many South Asian river systems, where values between 50 and 200 mg/L are common due to carbonate rock weathering (Singh et al., 2005). Although hardness does not pose direct health risks, elevated levels may affect domestic usability due to scaling in pipes and reduced detergent efficiency.*

Total alkalinity (26-150 mg/L) further supports the buffering capacity of the river system, with higher values in downstream reaches indicating increased carbonate input from geological weathering and prolonged water-sediment interaction. Alkalinity is a key indicator of the acid-neutralizing capacity of water and plays an important role in maintaining pH stability in aquatic ecosystems (Wetzel, 2001). Rivers draining carbonate-rich terrains often exhibit moderate to high alkalinity values due to the dissolution of bicarbonate-forming minerals. The alkalinity values observed in the Sunkoshi River are consistent with those reported for other Himalayan catchments influenced by carbonate geology and weathering processes (Shrestha & Kazama, 2007).

Calcium (4-52 mg/L) and magnesium (2.4-9.2 mg/L) distributions further confirm the geogenic control on water chemistry, with elevated concentrations downstream reflecting intensified rock-water interaction and catchment contributions. These ions are primary contributors to hardness and are essential components of natural freshwater systems. Their concentrations are comparable to those reported in other Himalayan rivers where mineral weathering plays a dominant role in determining water chemistry (Singh et al., 2005). Both calcium and magnesium remained within acceptable drinking water limits, indicating no immediate health concern while contributing beneficially to mineral content in drinking water.

Chloride concentrations (<1-5.6 mg/L) were consistently very low across all sampling sites, remaining well below the WHO guideline value of 250 mg/L. Chloride is often used as an indicator of anthropogenic contamination, particularly from sewage discharge, industrial effluents, and urban runoff (Hem, 1985). The low chloride levels observed in this study suggest minimal influence from such sources and indicate that the Sunkoshi River system remains largely unimpacted by chloride-based anthropogenic pollution. Similar low chloride concentrations have been reported in relatively pristine mountain rivers with limited urbanization (Dodds & Whiles, 2020).

Ammonia levels (<0.02 mg/L) were negligible throughout the study area, indicating an absence of recent organic pollution from sewage or livestock waste. Ammonia is typically associated with fresh organic waste inputs and is rapidly oxidized to nitrate under well-oxygenated conditions (Wetzel, 2001). The extremely low concentrations observed here suggest relatively low levels of fresh nitrogenous contamination and limited direct discharge of untreated waste into the river system.

Iron concentrations (0.03-2.4 mg/L) showed localized exceedance of WHO aesthetic guidelines (0.3 mg/L), particularly at SK09. Elevated iron concentrations in natural waters often originate from geological sources, sediment resuspension, and reductive dissolution of iron-bearing minerals under low oxygen conditions (Hem, 1985). Although iron is not generally considered a major health risk at moderate concentrations, excessive levels can cause staining, unpleasant taste, and operational problems in water supply systems (WHO, 2017). Similar iron variability has been reported in several Himalayan rivers where geochemical conditions and sediment interactions strongly influence metal concentrations (Shrestha & Kazama, 2007).

Manganese concentrations (0.01-0.17 mg/L) remained within acceptable limits in most samples, with slight exceedance at SK09. Like iron, manganese behavior is closely associated with redox conditions, sediment interactions, and mineral dissolution processes (Wetzel, 2001). Elevated manganese concentrations are commonly observed in river systems where reducing microenvironments occur in sediments or groundwater inflows. Although the concentrations observed in the Sunkoshi River are generally low, localized increases may reflect natural geochemical processes rather than direct anthropogenic contamination.

Nitrate (1.4-8.5 mg/L) and nitrite (<0.02-0.23 mg/L) concentrations indicate generally low nutrient pollution across the basin. Nitrate values were well below the WHO guideline of 50 mg/L, suggesting minimal agricultural fertilizer impact or effective dilution within the river system. In many river systems, elevated nitrate concentrations are associated with intensive agricultural activities and urban wastewater discharge (Dodds & Whiles, 2020). The relatively low nitrate concentrations observed in this study therefore indicate limited nutrient enrichment within the catchment. However, the slight exceedance of nitrite at SK11 may *indicate localized nitrogen transformation processes or minor organic contamination, potentially associated with settlement influence or reduced oxygen conditions. Nitrite is typically an intermediate product in the nitrogen cycle and is usually present at low concentrations in well-oxygenated river systems.*

Overall Synthesis

Overall, the Sunkoshi River exhibits relatively good physico-chemical water quality conditions across most measured parameters, with general compliance to WHO drinking water guidelines for major ions, nutrients, and pH. However, localized exceedances in turbidity, iron, manganese, and nitrite highlight site-specific environmental stressors, particularly in midstream and downstream sections influenced by tributary mixing, sediment disturbance, and human activity.

Importantly, rainfall prior to sampling likely contributed to elevated turbidity values, emphasizing the need to interpret sediment-related parameters in the context of short-term hydrological variability. River systems in mountainous regions are particularly sensitive to precipitation events that can rapidly mobilize sediments and nutrients (Shrestha & Kazama, 2007). Consequently, while the river system remains largely within acceptable water quality standards, the presence of localized hotspots and event-driven variability underscores the importance of continuous monitoring across seasons to distinguish between baseline conditions and episodic disturbances.

These findings collectively indicate that the Sunkoshi River is generally in a moderately healthy ecological state but remains vulnerable to localized degradation, particularly under conditions of increased rainfall, land-use change, and expanding anthropogenic pressures within the catchment. Long-term monitoring and integrated watershed management strategies are therefore essential to preserve the water quality and ecological integrity of this important Himalayan river system.

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Annex:

Annex I: Sampling Location Details

The geographic location of the sampling site is provided below for verification and reproducibility purposes:

Google Maps Link: https://maps.app.goo.gl/HuivM5jWXGmTstM58

Annex II: Laboratory Analysis Report

Laboratory Analysis Report:

The detailed laboratory test results for the collected water samples are provided below :

Sunkoshi River Water Quality Test(Mar 16th -Mar 20th)

VAT/PAN No.: 300124309
Regd. No. 104177/052/053
"Training For Success"
SAVE WATER
Water
Engineering & Training Centre (P.) Ltd.
Testing Laboratory
Test Report/Certificate

Name of Sender: Nepal River Conservation Trust
Sample No: 3230-1/082/083
Date of Receipt: 22/03/2026
Report Release Date: 27/03/2026
Sampled by: Client
Source: SK 01
Analyzed Date: 22/03/2026-26/03/2026
Sample Details: 1 Liter Bottle
No. of Samples: 01
Location: Gandaki

Parameters	Units	WHO GV	NDWQS	Result	Methods used
PHYSICAL					
Turbidity	NTU	5	5 (Max)	**20.0**	2130 B., APHA, 24th EDITION
Conductivity	µS/cm	-	1500	140.0	2510 B., APHA, 24th EDITION
Lab Temperature	°C	-	-	21.7	2550 B., APHA, 24th EDITION
pH	-	6.5 - 8.5	6.5-8.5	8.0	4500-H^+ B., APHA, 24th EDITION
CHEMICAL					
Total Hardness	mg/l as $CaCO_3$	500	500	76.0	2340 C., APHA, 24th EDITION
Total Alkalinity	mg/l as $CaCO_3$	500	-	64.0	2320 B., APHA, 24th EDITION
Calcium	mg/l	-	200	21.6	3500 - Ca B. APHA, 24th EDITION
Magnesium	mg/l	-	-	5.3	3500-Mg B. APHA, 24th EDITION
Chloride	mg/l	250	250	<1.0	4500-Cl^- B, APHA, 24th EDITION
Ammonia	mg/l	1.5	1.5	<0.02	4500-NH_3 F., APHA, 24th EDITION
Iron	mg/l	0.3	0.3 (3)	**1.2**	3111 B., APHA, 24th EDITION
Manganese	mg/l	0.08	0.2 (Max)	0.05	3111 B. APHA, 24th EDITION
Nitrate	mg/l as NO_3	50	50	1.6	4500-NO_3^- B., APHA, 24th EDITION
Nitrite	mg/l as NO_2	3	3	0.02	4500-NO_2^- B., APHA, 24th EDITION

APHA: American Public Health Association, Standard Methods for the Examination of Water & Waste Water.
WHO GV: World Health Organization Guideline Value, 2024 Update, NDWQS: National Drinking Water Quality Standard, 2062 (Nepal).
* These values show lower and upper limits, () Values in the parenthesis refers the acceptable values only when alternative is not available.

Comments: Turbidity and Iron are high as per WHO Guideline Value. Value of Iron seems high due to the turbid (associated suspended) matter.

Analyzed by
Checked by
Authorized Signature
Bhola Nath Paudyal

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VAT/PAN No.: 300124309
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Testing Laboratory
Test Report/Certificate

Name of Sender: Nepal River Conservation Trust
Sample No: 3230-2/082/083
Date of Receipt: 22/03/2026
Report Release Date: 27/03/2026
Sampled by: Client
Source: SK 02
Analyzed Date: 22/03/2026-26/03/2026
Sample Details: 1 Liter Bottle
No. of Samples: 01
Location: Gandaki

Parameters	Units	WHO GV	NDWQS	Result	Methods used
PHYSICAL					
Turbidity	NTU	5	5 (Max)	<1.0	2130 B., APHA, 24th EDITION
Conductivity	µS/cm	-	1500	46.0	2510 B., APHA, 24th EDITION
Lab Temperature	°C	-	-	21.9	2550 B., APHA, 24th EDITION
pH	-	6.5 - 8.5	6.5-8.5	7.6	4500-H^+ B., APHA, 24th EDITION
CHEMICAL					
Total Hardness	mg/l as $CaCO_3$	500	500	20.0	2340 C., APHA, 24th EDITION
Total Alkalinity	mg/l as $CaCO_3$	500	-	26.0	2320 B., APHA, 24th EDITION
Calcium	mg/l	-	200	4.0	3500 - Ca B. APHA, 24th EDITION
Magnesium	mg/l	-	-	2.4	3500-Mg B. APHA, 24th EDITION
Chloride	mg/l	250	250	1.9	4500-Cl^- B, APHA, 24th EDITION
Ammonia	mg/l	1.5	1.5	<0.02	4500-NH_3 F., APHA, 24th EDITION
Iron	mg/l	0.3	0.3 (3)	0.03	3111 B., APHA, 24th EDITION
Manganese	mg/l	0.08	0.2 (Max)	<0.01	3111 B. APHA, 24th EDITION
Nitrate	mg/l as NO_3	50	50	1.7	4500-NO_3^- B., APHA, 24th EDITION
Nitrite	mg/l as NO_2	3	3	<0.02	4500-NO_2^- B., APHA, 24th EDITION

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WHO GV: World Health Organization Guideline Value, 2024 Update, NDWQS: National Drinking Water Quality Standard, 2062 (Nepal).
* These values show lower and upper limits, () Values in the parenthesis refers the acceptable values only when alternative is not available.

Comment: The tested Physical and Chemical parameters are within WHO Guideline Value.

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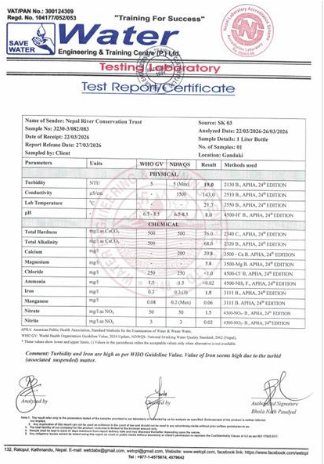

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Regd. No. 104177/052/053
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Name of Sender: Nepal River Conservation Trust
Sample No: 3230-3/082/083
Date of Receipt: 22/03/2026
Report Release Date: 27/03/2026
Sampled by: Client
Source: SK 03
Analyzed Date: 22/03/2026-26/03/2026
Sample Details: 1 Liter Bottle
No. of Samples: 01
Location: Gandaki

Parameters	Units	WHO GV	NDWQS	Result	Methods used
PHYSICAL					
Turbidity	NTU	5	5 (Max)	**19.0**	2130 B., APHA, 24th EDITION
Conductivity	µS/cm	-	1500	143.0	2510 B., APHA, 24th EDITION
Lab Temperature	°C	-	-	21.7	2550 B., APHA, 24th EDITION
pH	-	6.5 - 8.5	6.5-8.5	8.0	4500-H^+ B., APHA, 24th EDITION
CHEMICAL					
Total Hardness	mg/l as $CaCO_3$	500	500	76.0	2340 C., APHA, 24th EDITION
Total Alkalinity	mg/l as $CaCO_3$	500	-	68.0	2320 B., APHA, 24th EDITION
Calcium	mg/l	-	200	20.8	3500 - Ca B. APHA, 24th EDITION
Magnesium	mg/l	-	-	5.8	3500-Mg B. APHA, 24th EDITION
Chloride	mg/l	250	250	<1.0	4500-Cl^- B, APHA, 24th EDITION
Ammonia	mg/l	1.5	1.5	<0.02	4500-NH_3 F., APHA, 24th EDITION
Iron	mg/l	0.3	0.3 (3)	**1.5**	3111 B., APHA, 24th EDITION
Manganese	mg/l	0.08	0.2 (Max)	0.06	3111 B. APHA, 24th EDITION
Nitrate	mg/l as NO_3	50	50	1.5	4500-NO_3^- B., APHA, 24th EDITION
Nitrite	mg/l as NO_2	3	3	0.02	4500-NO_2^- B., APHA, 24th EDITION

APHA: American Public Health Association, Standard Methods for the Examination of Water & Waste Water.
WHO GV: World Health Organization Guideline Value, 2024 Update, NDWQS: National Drinking Water Quality Standard, 2062 (Nepal).
* These values show lower and upper limits, () Values in the parenthesis refers the acceptable values only when alternative is not available.

Comment: Turbidity and Iron are high as per WHO Guideline Value. Value of Iron seems high due to the turbid (associated suspended) matter.

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Name of Sender: Nepal River Conservation Trust
Sample No: 3230-4/082/083
Date of Receipt: 22/03/2026
Report Release Date: 27/03/2026
Sampled by: Client
Source: SK 04
Analyzed Date: 22/03/2026-26/03/2026
Sample Details: 1 Liter Bottle
No. of Samples: 01
Location: Gandaki

Parameters	Units	WHO GV	NDWQS	Result	Methods used
PHYSICAL					
Turbidity	NTU	5	5 (Max)	**17.0**	2130 B., APHA, 24th EDITION
Conductivity	µS/cm	-	1500	98.0	2510 B., APHA, 24th EDITION
Lab Temperature	°C	-	-	21.7	2550 B., APHA, 24th EDITION
pH	-	6.5 - 8.5	6.5-8.5	8.0	4500-H^+ B., APHA, 24th EDITION
CHEMICAL					
Total Hardness	mg/l as $CaCO_3$	500	500	46.0	2340 C., APHA, 24th EDITION
Total Alkalinity	mg/l as $CaCO_3$	500	-	30.0	2320 B., APHA, 24th EDITION
Calcium	mg/l	-	200	17.6	3500 - Ca B. APHA, 24th EDITION
Magnesium	mg/l	-	-	2.9	3500-Mg B. APHA, 24th EDITION
Chloride	mg/l	250	250	<1.0	4500-Cl^- B, APHA, 24th EDITION
Ammonia	mg/l	1.5	1.5	<0.02	4500-NH_3 F., APHA, 24th EDITION
Iron	mg/l	0.3	0.3 (3)	**1.3**	3111 B., APHA, 24th EDITION
Manganese	mg/l	0.08	0.2 (Max)	0.05	3111 B. APHA, 24th EDITION
Nitrate	mg/l as NO_3	50	50	1.6	4500-NO_3^- B., APHA, 24th EDITION
Nitrite	mg/l as NO_2	3	3	<0.02	4500-NO_2^- B., APHA, 24th EDITION

APHA: American Public Health Association, Standard Methods for the Examination of Water & Waste Water.
WHO GV: World Health Organization Guideline Value, 2024 Update, NDWQS: National Drinking Water Quality Standard, 2062 (Nepal).
* These values show lower and upper limits, () Values in the parenthesis refers the acceptable values only when alternative is not available.

Comment: Turbidity and Iron are high as per WHO Guideline Value. Value of Iron seems high due to the turbid (associated suspended) matter.

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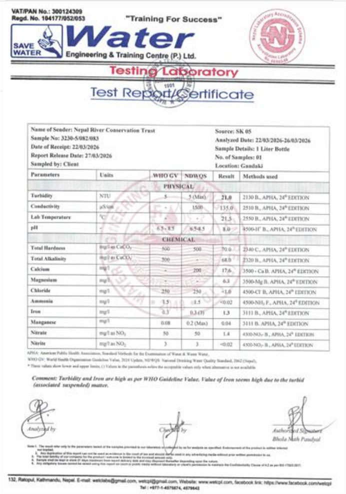
Tel : +977-1-4575874, 4579642



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Name of Sender: Nepal River Conservation Trust
Sample No: 3230-5/082/083
Date of Receipt: 22/03/2026
Report Release Date: 27/03/2026
Sampled by: Client
Source: SK 05
Analyzed Date: 22/03/2026-26/03/2026
Sample Details: 1 Liter Bottle
No. of Samples: 01
Location: Gandaki

Parameters	Units	WHO GV	NDWQS	Result	Methods used
PHYSICAL					
Turbidity	NTU	5	5 (Max)	**21.0**	2130 B., APHA, 24th EDITION
Conductivity	µS/cm	-	1500	135.0	2510 B., APHA, 24th EDITION
Lab Temperature	°C	-	-	21.5	2550 B., APHA, 24th EDITION
pH	-	6.5 - 8.5	6.5-8.5	8.0	4500-H^+ B., APHA, 24th EDITION
CHEMICAL					
Total Hardness	mg/l as $CaCO_3$	500	500	70.0	2340 C., APHA, 24th EDITION
Total Alkalinity	mg/l as $CaCO_3$	500	-	68.0	2320 B., APHA, 24th EDITION
Calcium	mg/l	-	200	17.6	3500 - Ca B. APHA, 24th EDITION
Magnesium	mg/l	-	-	6.3	3500-Mg B. APHA, 24th EDITION
Chloride	mg/l	250	250	<1.0	4500-Cl^- B, APHA, 24th EDITION
Ammonia	mg/l	1.5	1.5	<0.02	4500-NH_3 F., APHA, 24th EDITION
Iron	mg/l	0.3	0.3 (3)	**1.3**	3111 B., APHA, 24th EDITION
Manganese	mg/l	0.08	0.2 (Max)	0.04	3111 B. APHA, 24th EDITION
Nitrate	mg/l as NO_3	50	50	1.4	4500-NO_3^- B., APHA, 24th EDITION
Nitrite	mg/l as NO_2	3	3	<0.02	4500-NO_2^- B., APHA, 24th EDITION

APHA: American Public Health Association, Standard Methods for the Examination of Water & Waste Water.
WHO GV: World Health Organization Guideline Value, 2024 Update, NDWQS: National Drinking Water Quality Standard, 2062 (Nepal).
* These values show lower and upper limits, () Values in the parenthesis refers the acceptable values only when alternative is not available.

Comment: Turbidity and Iron are high as per WHO Guideline Value. Value of Iron seems high due to the turbid (associated suspended) matter.

Analyzed by
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Bhola Nath Paudyal

132, Ratopul, Kathmandu, Nepal. E-mail: wetclabs@gmail.com, wetcpl@gmail.com, Website: www.wetcpl.com, facebook link: https://www.facebook.com/wetcpl
Tel : +977-1-4575874, 4579642

VAT/PAN No.: 300124309
Regd. No. 104177/052/053
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Testing Laboratory
Test Report/Certificate

Name of Sender: Nepal River Conservation Trust
Sample No: 3230-6/082/083
Date of Receipt: 22/03/2026
Report Release Date: 27/03/2026
Sampled by: Client
Source: SK 06
Analyzed Date: 22/03/2026-26/03/2026
Sample Details: 1 Liter Bottle
No. of Samples: 01
Location: Gandaki

Parameters	Units	WHO GV	NDWQS	Result	Methods used
PHYSICAL					
Turbidity	NTU	5	5 (Max)	**19.0**	2130 B., APHA, 24th EDITION
Conductivity	µS/cm	-	1500	136.0	2510 B., APHA, 24th EDITION
Lab Temperature	°C	-	-	21.7	2550 B., APHA, 24th EDITION
pH	-	6.5 - 8.5	6.5-8.5	8.0	4500-H^+ B., APHA, 24th EDITION
CHEMICAL					
Total Hardness	mg/l as $CaCO_3$	500	500	72.0	2340 C., APHA, 24th EDITION
Total Alkalinity	mg/l as $CaCO_3$	500	-	64.0	2320 B., APHA, 24th EDITION
Calcium	mg/l	-	200	20.0	3500 - Ca B. APHA, 24th EDITION
Magnesium	mg/l	-	-	5.3	3500-Mg B. APHA, 24th EDITION
Chloride	mg/l	250	250	<1.0	4500-Cl^- B, APHA, 24th EDITION
Ammonia	mg/l	1.5	1.5	<0.02	4500-NH_3 F., APHA, 24th EDITION
Iron	mg/l	0.3	0.3 (3)	**1.2**	3111 B., APHA, 24th EDITION
Manganese	mg/l	0.08	0.2 (Max)	0.05	3111 B. APHA, 24th EDITION
Nitrate	mg/l as NO_3	50	50	1.5	4500-NO_3^- B., APHA, 24th EDITION
Nitrite	mg/l as NO_2	3	3	<0.02	4500-NO_2^- B., APHA, 24th EDITION

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WHO GV: World Health Organization Guideline Value, 2024 Update, NDWQS: National Drinking Water Quality Standard, 2062 (Nepal).
* These values show lower and upper limits, () Values in the parenthesis refers the acceptable values only when alternative is not available.

Comment: Turbidity and Iron are high as per WHO Guideline Value. Value of Iron seems high due to the turbid (associated suspended) matter.

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Name of Sender: Nepal River Conservation Trust
Sample No: 3230-7/082/083
Date of Receipt: 22/03/2026
Report Release Date: 27/03/2026
Sampled by: Client
Source: SK 07
Analyzed Date: 22/03/2026-26/03/2026
Sample Details: 1 Liter Bottle
No. of Samples: 01
Location: Gandaki

Parameters	Units	WHO GV	NDWQS	Result	Methods used
PHYSICAL					
Turbidity	NTU	5	5 (Max)	4.0	2130 B., APHA, 24th EDITION
Conductivity	µS/cm	-	1500	164.0	2510 B., APHA, 24th EDITION
Lab Temperature	°C	-	-	21.6	2550 B., APHA, 24th EDITION
pH	-	6.5 - 8.5	6.5-8.5	8.3	4500-H^+ B., APHA, 24th EDITION
CHEMICAL					
Total Hardness	mg/l as $CaCO_3$	500	500	90.0	2340 C., APHA, 24th EDITION
Total Alkalinity	mg/l as $CaCO_3$	500	-	96.0	2320 B., APHA, 24th EDITION
Calcium	mg/l	-	200	20.8	3500 - Ca B. APHA, 24th EDITION
Magnesium	mg/l	-	-	9.2	3500-Mg B. APHA, 24th EDITION
Chloride	mg/l	250	250	1.9	4500-Cl^- B, APHA, 24th EDITION
Ammonia	mg/l	1.5	1.5	<0.02	4500-NH_3 F., APHA, 24th EDITION
Iron	mg/l	0.3	0.3 (3)	0.26	3111 B., APHA, 24th EDITION
Manganese	mg/l	0.08	0.2 (Max)	0.01	3111 B. APHA, 24th EDITION
Nitrate	mg/l as NO_3	50	50	1.7	4500-NO_3^- B., APHA, 24th EDITION
Nitrite	mg/l as NO_2	3	3	<0.02	4500-NO_2^- B., APHA, 24th EDITION

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WHO GV: World Health Organization Guideline Value, 2024 Update, NDWQS: National Drinking Water Quality Standard, 2062 (Nepal).
* These values show lower and upper limits, () Values in the parenthesis refers the acceptable values only when alternative is not available.

Comment: The tested Physical and Chemical parameters are within WHO Guideline Value.

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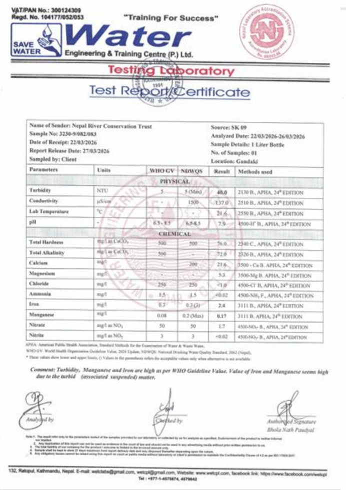
Tel : +977-1-4575874, 4579642



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Name of Sender: Nepal River Conservation Trust
Sample No: 3230-9/082/083
Date of Receipt: 22/03/2026
Report Release Date: 27/03/2026
Sampled by: Client
Source: SK 09
Analyzed Date: 22/03/2026-26/03/2026
Sample Details: 1 Liter Bottle
No. of Samples: 01
Location: Gandaki

Parameters	Units	WHO GV	NDWQS	Result	Methods used
PHYSICAL					
Turbidity	NTU	5	5 (Max)	**40.0**	2130 B., APHA, 24th EDITION
Conductivity	µS/cm	-	1500	137.0	2510 B., APHA, 24th EDITION
Lab Temperature	°C	-	-	21.6	2550 B., APHA, 24th EDITION
pH	-	6.5 - 8.5	6.5-8.5	7.9	4500-H^+ B., APHA, 24th EDITION
CHEMICAL					
Total Hardness	mg/l as $CaCO_3$	500	500	76.0	2340 C., APHA, 24th EDITION
Total Alkalinity	mg/l as $CaCO_3$	500	-	72.0	2320 B., APHA, 24th EDITION
Calcium	mg/l	-	200	21.6	3500 - Ca B. APHA, 24th EDITION
Magnesium	mg/l	-	-	5.3	3500-Mg B. APHA, 24th EDITION
Chloride	mg/l	250	250	<1.0	4500-Cl^- B, APHA, 24th EDITION
Ammonia	mg/l	1.5	1.5	<0.02	4500-NH_3 F., APHA, 24th EDITION
Iron	mg/l	0.3	0.3 (3)	**2.4**	3111 B., APHA, 24th EDITION
Manganese	mg/l	0.08	0.2 (Max)	**0.17**	3111 B. APHA, 24th EDITION
Nitrate	mg/l as NO_3	50	50	1.7	4500-NO_3^- B., APHA, 24th EDITION
Nitrite	mg/l as NO_2	3	3	<0.02	4500-NO_2^- B., APHA, 24th EDITION

APHA: American Public Health Association, Standard Methods for the Examination of Water & Waste Water.
WHO GV: World Health Organization Guideline Value, 2024 Update, NDWQS: National Drinking Water Quality Standard, 2062 (Nepal).
* These values show lower and upper limits, () Values in the parenthesis refers the acceptable values only when alternative is not available.

Comment: Turbidity, Manganese and Iron are high as per WHO Guideline Value. Value of Iron and Manganese seems high due to the turbid (associated suspended) matter.

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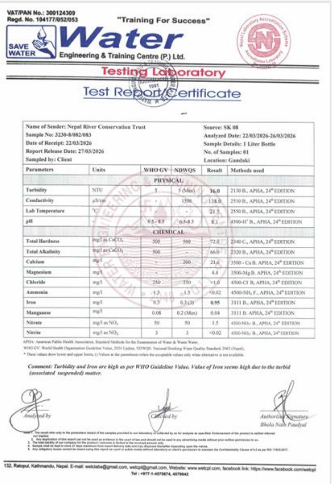

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Name of Sender: Nepal River Conservation Trust
Sample No: 3230-8/082/083
Date of Receipt: 22/03/2026
Report Release Date: 27/03/2026
Sampled by: Client
Source: SK 08
Analyzed Date: 22/03/2026-26/03/2026
Sample Details: 1 Liter Bottle
No. of Samples: 01
Location: Gandaki

Parameters	Units	WHO GV	NDWQS	Result	Methods used
PHYSICAL					
Turbidity	NTU	5	5 (Max)	**16.0**	2130 B., APHA, 24th EDITION
Conductivity	µS/cm	-	1500	138.0	2510 B., APHA, 24th EDITION
Lab Temperature	°C	-	-	21.5	2550 B., APHA, 24th EDITION
pH	-	6.5 - 8.5	6.5-8.5	8.1	4500-H^+ B., APHA, 24th EDITION
CHEMICAL					
Total Hardness	mg/l as $CaCO_3$	500	500	72.0	2340 C., APHA, 24th EDITION
Total Alkalinity	mg/l as $CaCO_3$	500	-	66.0	2320 B., APHA, 24th EDITION
Calcium	mg/l	-	200	21.6	3500 - Ca B. APHA, 24th EDITION
Magnesium	mg/l	-	-	4.4	3500-Mg B. APHA, 24th EDITION
Chloride	mg/l	250	250	<1.0	4500-Cl^- B, APHA, 24th EDITION
Ammonia	mg/l	1.5	1.5	<0.02	4500-NH_3 F., APHA, 24th EDITION
Iron	mg/l	0.3	0.3 (3)	**0.95**	3111 B., APHA, 24th EDITION
Manganese	mg/l	0.08	0.2 (Max)	0.04	3111 B. APHA, 24th EDITION
Nitrate	mg/l as NO_3	50	50	1.5	4500-NO_3^- B., APHA, 24th EDITION
Nitrite	mg/l as NO_2	3	3	<0.02	4500-NO_2^- B., APHA, 24th EDITION

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WHO GV: World Health Organization Guideline Value, 2024 Update, NDWQS: National Drinking Water Quality Standard, 2062 (Nepal).
* These values show lower and upper limits, () Values in the parenthesis refers the acceptable values only when alternative is not available.

Comment: Turbidity and Iron are high as per WHO Guideline Value. Value of Iron seems high due to the turbid (associated suspended) matter.

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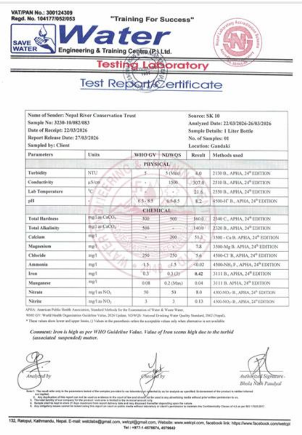

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Name of Sender: Nepal River Conservation Trust
Sample No: 3230-10/082/083
Date of Receipt: 22/03/2026
Report Release Date: 27/03/2026
Sampled by: Client
Source: SK 10
Analyzed Date: 22/03/2026-26/03/2026
Sample Details: 1 Liter Bottle
No. of Samples: 01
Location: Gandaki

Parameters	Units	WHO GV	NDWQS	Result	Methods used
PHYSICAL					
Turbidity	NTU	5	5 (Max)	4.0	2130 B., APHA, 24th EDITION
Conductivity	µS/cm	-	1500	307.0	2510 B., APHA, 24th EDITION
Lab Temperature	°C	-	-	21.6	2550 B., APHA, 24th EDITION
pH	-	6.5 - 8.5	6.5-8.5	8.2	4500-H^+ B., APHA, 24th EDITION
CHEMICAL					
Total Hardness	mg/l as $CaCO_3$	500	500	160.0	2340 C., APHA, 24th EDITION
Total Alkalinity	mg/l as $CaCO_3$	500	-	140.0	2320 B., APHA, 24th EDITION
Calcium	mg/l	-	200	51.3	3500 - Ca B. APHA, 24th EDITION
Magnesium	mg/l	-	-	7.8	3500-Mg B. APHA, 24th EDITION
Chloride	mg/l	250	250	5.6	4500-Cl^- B, APHA, 24th EDITION
Ammonia	mg/l	1.5	1.5	<0.02	4500-NH_3 F., APHA, 24th EDITION
Iron	mg/l	0.3	0.3 (3)	**0.42**	3111 B., APHA, 24th EDITION
Manganese	mg/l	0.08	0.2 (Max)	0.04	3111 B. APHA, 24th EDITION
Nitrate	mg/l as NO_3	50	50	8.0	4500-NO_3^- B., APHA, 24th EDITION
Nitrite	mg/l as NO_2	3	3	0.13	4500-NO_2^- B., APHA, 24th EDITION

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WHO GV: World Health Organization Guideline Value, 2024 Update, NDWQS: National Drinking Water Quality Standard, 2062 (Nepal).
* These values show lower and upper limits, () Values in the parenthesis reflex the acceptable values only when alternative is not available.

Comment: Iron is high as per WHO Guideline Value. Value of Iron seems high due to the turbid (associated suspended) matter.

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Bhola Nath Paudyal

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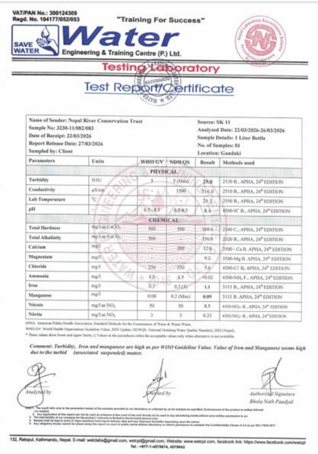
Tel : +977-1-4579874, 4579642



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Name of Sender: Nepal River Conservation Trust
Sample No: 3230-11/082/083
Date of Receipt: 22/03/2026
Report Release Date: 27/03/2026
Sampled by: Client
Source: SK 11
Analyzed Date: 22/03/2026-26/03/2026
Sample Details: 1 Liter Bottle
No. of Samples: 01
Location: Gandaki

Parameters	Units	WHO GV	NDWQS	Result	Methods used
PHYSICAL					
Turbidity	NTU	5	5 (Max)	**29.0**	2130 B., APHA, 24th EDITION
Conductivity	µS/cm	-	1500	316.0	2510 B., APHA, 24th EDITION
Lab Temperature	°C	-	-	21.5	2550 B., APHA, 24th EDITION
pH	-	6.5 - 8.5	6.5-8.5	8.4	4500-H^+ B., APHA, 24th EDITION
CHEMICAL					
Total Hardness	mg/l as $CaCO_3$	500	500	168.0	2340 C., APHA, 24th EDITION
Total Alkalinity	mg/l as $CaCO_3$	500	-	150.0	2320 B., APHA, 24th EDITION
Calcium	mg/l	-	200	52.0	3500 - Ca B. APHA, 24th EDITION
Magnesium	mg/l	-	-	9.2	3500-Mg B. APHA, 24th EDITION
Chloride	mg/l	250	250	5.6	4500-Cl^- B, APHA, 24th EDITION
Ammonia	mg/l	1.5	1.5	<0.02	4500-NH_3 F., APHA, 24th EDITION
Iron	mg/l	0.3	0.3 (3)	**1.1**	3111 B., APHA, 24th EDITION
Manganese	mg/l	0.08	0.2 (Max)	**0.09**	3111 B. APHA, 24th EDITION
Nitrate	mg/l as NO_3	50	50	8.5	4500-NO_3^- B., APHA, 24th EDITION
Nitrite	mg/l as NO_2	3	3	0.23	4500-NO_2^- B., APHA, 24th EDITION

APHA: American Public Health Association, Standard Methods for the Examination of Water & Waste Water.
WHO GV: World Health Organization Guideline Value, 2024 Update, NDWQS: National Drinking Water Quality Standard, 2062 (Nepal).
* These values show lower and upper limits, () Values in the parenthesis reflex the acceptable values only when alternative is not available.

Comment: Turbidity, Iron and manganese are high as per WHO Guideline Value. Value of Iron and Manganese seems high due to the turbid (associated suspended) matter.

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Name of Sender: Nepal River Conservation Trust
Sample No: 3230-12/082/083
Date of Receipt: 22/03/2026
Report Release Date: 27/03/2026
Sampled by: Client
Source: SK 12
Analyzed Date: 22/03/2026-26/03/2026
Sample Details: 1 Liter Bottle
No. of Samples: 01
Location: Gandaki

Parameters	Units	WHO GV	NDWQS	Result	Methods used
PHYSICAL					
Turbidity	NTU	5	5 (Max)	**17.0**	2130 B., APHA, 24th EDITION
Conductivity	µS/cm	-	1500	145.0	2510 B., APHA, 24th EDITION
Lab Temperature	°C	-	-	21.7	2550 B., APHA, 24th EDITION
pH	-	6.5 - 8.5	6.5-8.5	8.1	4500-H^+ B., APHA, 24th EDITION
CHEMICAL					
Total Hardness	mg/l as $CaCO_3$	500	500	76.0	2340 C., APHA, 24th EDITION
Total Alkalinity	mg/l as $CaCO_3$	500	-	72.0	2320 B., APHA, 24th EDITION
Calcium	mg/l	-	200	20.8	3500 - Ca B. APHA, 24th EDITION
Magnesium	mg/l	-	-	5.8	3500-Mg B. APHA, 24th EDITION
Chloride	mg/l	250	250	<1.0	4500-Cl^- B, APHA, 24th EDITION
Ammonia	mg/l	1.5	1.5	<0.02	4500-NH_3 F., APHA, 24th EDITION
Iron	mg/l	0.3	0.3 (3)	**0.77**	3111 B., APHA, 24th EDITION
Manganese	mg/l	0.08	0.2 (Max)	0.03	3111 B. APHA, 24th EDITION
Nitrate	mg/l as NO_3	50	50	1.8	4500-NO_3^- B., APHA, 24th EDITION
Nitrite	mg/l as NO_2	3	3	<0.02	4500-NO_2^- B., APHA, 24th EDITION

APHA: American Public Health Association, Standard Methods for the Examination of Water & Waste Water.
WHO GV: World Health Organization Guideline Value, 2024 Update, NDWQS: National Drinking Water Quality Standard, 2062 (Nepal).
* These values show lower and upper limits, () Values in the parenthesis reflex the acceptable values only when alternative is not available.

Comment: Turbidity and Iron are high as per WHO Guideline Value. Value of Iron seems high due to the turbid (associated suspended) matter.

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Name of Sender: Nepal River Conservation Trust
Sample No: 3230-13/082/083
Date of Receipt: 22/03/2026
Report Release Date: 27/03/2026
Sampled by: Client
Source: SK 13
Analyzed Date: 22/03/2026-26/03/2026
Sample Details: 1 Liter Bottle
No. of Samples: 01
Location: Gandaki

Parameters	Units	WHO GV	NDWQS	Result	Methods used
PHYSICAL					
Turbidity	NTU	5	5 (Max)	**38.0**	2130 B., APHA, 24th EDITION
Conductivity	µS/cm	-	1500	150.0	2510 B., APHA, 24th EDITION
Lab Temperature	°C	-	-	21.8	2550 B., APHA, 24th EDITION
pH	-	6.5 - 8.5	6.5-8.5	8.0	4500-H^+ B., APHA, 24th EDITION
CHEMICAL					
Total Hardness	mg/l as $CaCO_3$	500	500	82.0	2340 C., APHA, 24th EDITION
Total Alkalinity	mg/l as $CaCO_3$	500	-	74.0	2320 B., APHA, 24th EDITION
Calcium	mg/l	-	200	21.6	3500 - Ca B. APHA, 24th EDITION
Magnesium	mg/l	-	-	6.8	3500-Mg B. APHA, 24th EDITION
Chloride	mg/l	250	250	<1.0	4500-Cl^- B, APHA, 24th EDITION
Ammonia	mg/l	1.5	1.5	<0.02	4500-NH_3 F., APHA, 24th EDITION
Iron	mg/l	0.3	0.3 (3)	**1.5**	3111 B., APHA, 24th EDITION
Manganese	mg/l	0.08	0.2 (Max)	0.06	3111 B. APHA, 24th EDITION
Nitrate	mg/l as NO_3	50	50	1.8	4500-NO_3^- B., APHA, 24th EDITION
Nitrite	mg/l as NO_2	3	3	<0.02	4500-NO_2^- B., APHA, 24th EDITION

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WHO GV: World Health Organization Guideline Value, 2024 Update, NDWQS: National Drinking Water Quality Standard, 2062 (Nepal).
* These values show lower and upper limits, () Values in the parenthesis reflex the acceptable values only when alternative is not available.

Comment: Turbidity and Iron are high as per WHO Guideline Value. Value of Iron seems high due to the turbid (associated suspended) matter.

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Bhola Nath Paudyal

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VAT/PAN No.: 300124309
Regd. No. 104177/052/053
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Name of Sender: Nepal River Conservation Trust
Sample No: 3230-14/082/083
Date of Receipt: 22/03/2026
Report Release Date: 27/03/2026
Sampled by: Client
Source: SK 14
Analyzed Date: 22/03/2026-26/03/2026
Sample Details: 1 Liter Bottle
No. of Samples: 01
Location: Gandaki

Parameters	Units	WHO GV	NDWQS	Result	Methods used
PHYSICAL					
Turbidity	NTU	5	5 (Max)	**22.0**	2130 B., APHA, 24th EDITION
Conductivity	µS/cm	-	1500	158.0	2510 B., APHA, 24th EDITION
Lab Temperature	°C	-	-	21.7	2550 B., APHA, 24th EDITION
pH	-	6.5 - 8.5	6.5-8.5	8.0	4500-H^+ B., APHA, 24th EDITION
CHEMICAL					
Total Hardness	mg/l as $CaCO_3$	500	500	84.0	2340 C., APHA, 24th EDITION
Total Alkalinity	mg/l as $CaCO_3$	500	-	74.0	2320 B., APHA, 24th EDITION
Calcium	mg/l	-	200	23.2	3500 - Ca B. APHA, 24th EDITION
Magnesium	mg/l	-	-	6.3	3500-Mg B. APHA, 24th EDITION
Chloride	mg/l	250	250	<1.0	4500-Cl^- B, APHA, 24th EDITION
Ammonia	mg/l	1.5	1.5	<0.02	4500-NH_3 F., APHA, 24th EDITION
Iron	mg/l	0.3	0.3 (3)	**1.0**	3111 B., APHA, 24th EDITION
Manganese	mg/l	0.08	0.2 (Max)	0.05	3111 B. APHA, 24th EDITION
Nitrate	mg/l as NO_3	50	50	1.9	4500-NO_3^- B., APHA, 24th EDITION
Nitrite	mg/l as NO_2	3	3	<0.02	4500-NO_2^- B., APHA, 24th EDITION

APHA: American Public Health Association, Standard Methods for the Examination of Water & Waste Water.
WHO GV: World Health Organization Guideline Value, 2024 Update, NDWQS: National Drinking Water Quality Standard, 2062 (Nepal).
* These values show lower and upper limits, () Values in the parenthesis reflex the acceptable values only when alternative is not available.

Comment: Turbidity and Iron are high as per WHO Guideline Value. Value of Iron seems high due to the turbid (associated suspended) matter.

Analyzed by
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