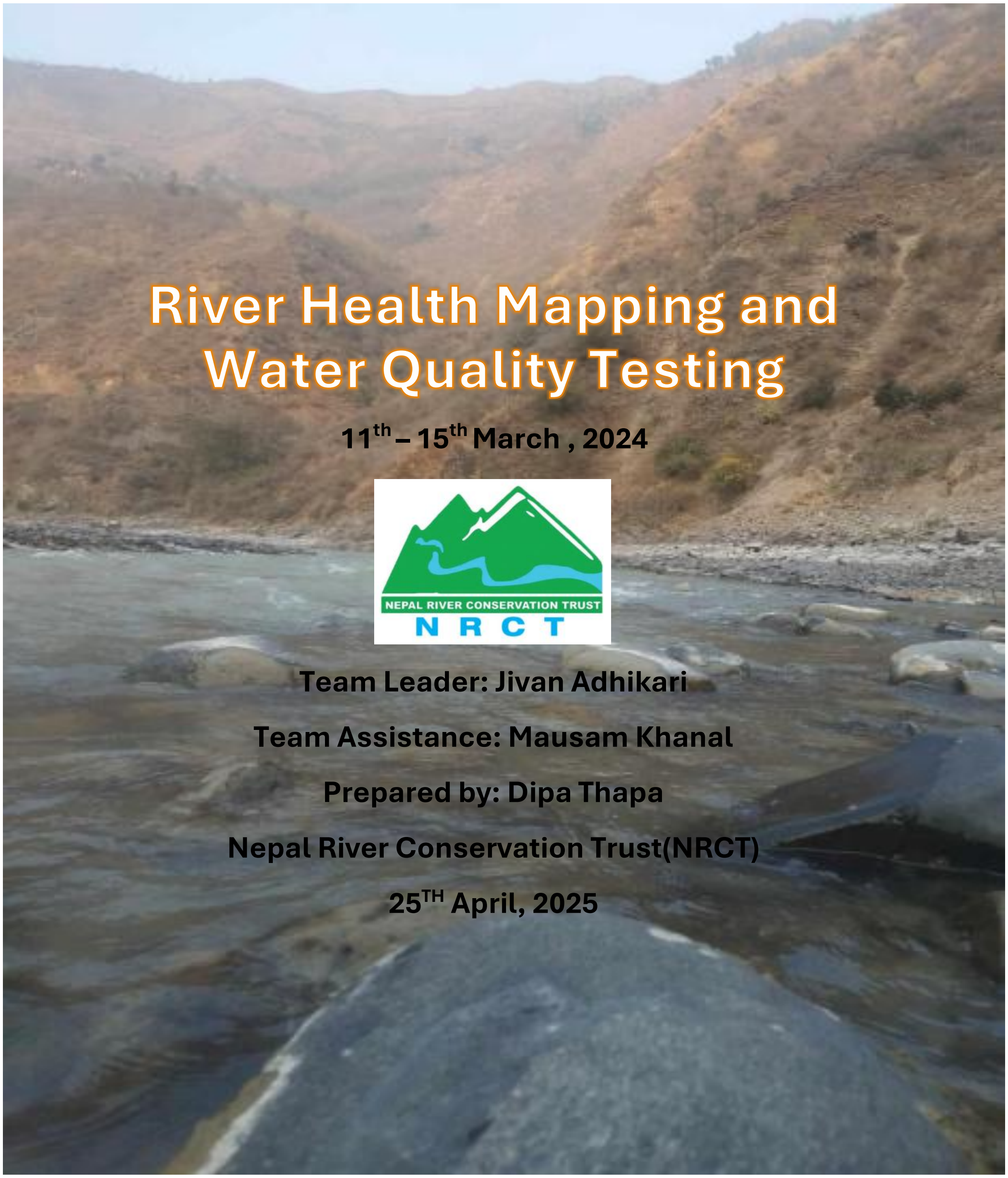

River Health Mapping and Water Quality Testing

11th – 15th March , 2024

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INTRODUCTION:

Rivers are a vital part of the natural environment. They sustain various forms of life and help maintain ecological balance. However, in recent years, many rivers have been increasingly affected by human activities (Downs et al., 2019). This issue is particularly significant in developing countries like Nepal, where the natural flow regimes of several rivers have been altered to meet human demands for transportation, water supply, flood control, and hydropower (Aryal et al., 2023). In addition, rapid urban expansion, agricultural intensification, and the unchecked discharge of untreated industrial and municipal waste have further degraded water quality in river catchments (Dahal et al., 2007).

Eutrophication is often the result of these pressures' contribution to the buildup of toxic materials in the water, such as too much organic matter and nutrients (Yang, 2008). In addition to endangered aquatic animals, this situation upsets the entire food chain. Heavy metals, pesticides, fertilizers, oil, and solid waste are among the harmful pollutants that are commonly carried by runoff into rivers in metropolitan areas (Ladislas et al., 2012). River ecosystems are seriously at risk from these pollutants, which originate from both organic and inorganic sources.

Natural factors such as the river basin's geology, land use patterns, climate, and degree of human intervention also influence the quality of river water (Anh et al., 2023). The discharge of the river can be affected by seasonal changes in rainfall, runoff, groundwater inflow, and water withdrawals. These modifications have a direct impact on pollution levels, which in turn change the water's chemical makeup and the variety of life it sustains (Qian, 2025). Increasing pollution often results in unpleasant smells, obvious deterioration, and a decrease in aquatic species (Vaghela et al., 2017). As a result of this degradation, the river's ecological health and suitability for human use decline over time.

Assessing the quality of surface water in river catchments is crucial to understanding the general state of river systems. We may evaluate the physical, chemical, and biological properties of the water and gain a better understanding of the reasons behind any changes or contamination by keeping an eye on important water quality indicators (Karr et al., 1993).

Integrated assessments that incorporate hydrology, geomorphology, water quality, aquatic ecology, and the social functions of the river are still rare, despite the importance of such assessments (Newson, 2006). Numerous analytical and mathematical tools have been developed and applied to address this issue; however, there is a significant lack of studies focused on the degradation of water ecological health.

Water quality assessment is the process of studying the physical, chemical, and biological properties of water in relation to both natural background conditions and human influences. It also considers how water is used, especially for purposes that may affect public health and aquatic ecosystem health (Rocha, 2015). Monitoring is a central part of this process, offering valuable information on the current state of the water, helping to track changes over time, and finding potential cause-effect relationships. An effective evaluation encompasses the systematic gathering and analysis of data, as well as the clear interpretation of outcomes and the formulation of meaningful recommendations for future action (Boaduo et al., 2011).

1.1 Key Physico-Chemical Parameters for Water Quality Assessment

Assessing water quality requires checking a range of physico-chemical parameters to understand its physical, chemical, and biological characteristics. The choice of parameters depends on the intended use of the water and the extent of monitoring needed (Tiwari, 2015). The following are key parameters commonly used in water quality studies:

Dissolved Oxygen (DO)

Dissolved Oxygen refers to the amount of oxygen available in water for aquatic organisms to breathe. It is one of the most critical indicators of water quality. Higher DO levels typically signify better water quality, while low DO can lead to hypoxic conditions, stressing aquatic life. DO levels are influenced by temperature, organic pollution, photosynthesis, and water flow. Reduced DO is often a sign of organic contamination and eutrophication.

pH

pH is a measure of the hydrogen ion concentration in water and shows whether the water is acidic or basic. The pH scale ranges from 0 to 14, with a neutral value of 7. Drinking water from both surface and groundwater sources should fall within the range of 6.5 to 8.5 (Islam et al., 2017). Values below 7 may result in corrosiveness and can impair the efficiency of disinfection processes such as chlorination (WHO, 2003).

Turbidity

Turbidity is caused by suspended particles in water that interfere with light transmission. It is a key indicator of water clarity and quality. Turbidity is measured using either Turbidimetry (based on light transmission) or Nephelometry (based on light scattering). High turbidity may show the presence of pathogens or pollutants.

Electrical Conductivity (EC)

EC measures the ability of water to conduct electricity, which depends on the concentration of dissolved ions such as chlorides, sulfates, nitrates, and various metal ions (Thompson et al., 2012). It is an important indicator of the salinity and overall ionic content of the water.

Temperature

Water temperature directly affects chemical reaction rates and biological activity. It influences DO levels, solubility of gases, and metabolic rates of aquatic organisms. Surface water temperature is also affected by surrounding environmental conditions.

Hardness

Water Hardness is mainly caused by calcium and magnesium ions and is typically measured as calcium carbonate. It affects soap lathering, raises boiling points, and contributes to scaling and corrosion in pipes and boilers (WHO, 2011).

Alkalinity

Alkalinity refers to the water's ability to neutralize acids and is mainly due to the presence of bicarbonates, carbonates, and hydroxides. It provides a buffering effect against sudden pH changes and is essential for keeping ecological stability.

Chlorides

Chlorides are found in all natural waters, with higher concentrations typically originating from domestic wastewater, industrial effluents, and the use of road salts. While insignificant amounts are necessary for plant and animal cell function, higher concentrations (above 250 mg/L) can impart a salty taste and damage vegetation (Maharjan, 2014).

Ammonia

Ammonia may occur naturally or be introduced through agricultural runoff, sewage, and industrial discharge. It reacts with chlorine during water treatment, increasing chlorine demand. High ammonia levels can show recent contamination and pose risks to aquatic life.

Nitrate

Nitrate (NO_3^-) is a highly soluble form of nitrogen, essential for plant growth. Its presence in water is mainly due to nitrification and is commonly associated with agricultural runoff and wastewater. Excessive nitrate in drinking water can cause health problems, especially in infants.

Nitrite

In the nitrogen cycle, nitrite (NO_2^-) is an intermediate form of nitrogen that is mostly produced by the microbial processes of nitrification and denitrification. Its presence in water may be a sign of agricultural and sewage pollution or of insufficient nitrification. Compared to nitrate, nitrite is less stable and can be hazardous to aquatic life as well as human health. High nitrite levels in drinking water can impair the blood's ability to carry oxygen, which is especially harmful for young children and babies.

Calcium

Calcium is one of the most abundant ions in freshwater and is crucial for biological processes such as shell formation in aquatic organisms. Its concentration often increases in summer due to decomposition of organic matter and may also come from surrounding geology or sewage inputs.

Magnesium

Magnesium usually occurs alongside calcium, though in lower concentrations. It is essential for photosynthesis and supports the growth of phytoplankton. It also contributes to the overall hardness of water.

Iron

Iron occurs in water in both ferrous (Fe^{2+}) and ferric (Fe^{3+}) forms. Ferrous iron is more soluble and bioavailable, while ferric iron precipitates easily. Iron is essential for aquatic organisms and plays a significant role in enzymatic and redox processes. Certain bacteria, like *Crenothrix* and *Leptothrix*, oxidize ferrous iron as an energy source.

Manganese

Rocks, soil, and water are all naturally occurring sources of manganese. It is necessary for human health in trace amounts, but high concentrations in drinking water can discolor clothing and plumbing fixtures and change the water's color and flavor. High concentrations can also pose health risks, particularly for infants and long-term exposure.

2.MATERIAL AND METHODS

2.1 Study Area

The Sunkoshi River, often referred to as the *"River of Gold"*, is a vital hydrological feature of central Nepal, originating from the snow-clad peaks of the Tibetan Himalayas. As one of the major tributaries of the Koshi River system, the Sunkoshi carves its way through deep valleys, lush forests, and terraced mid-hills before eventually converging with other Koshi tributaries in the lowlands (Dixit, 2017).

Geographically and ecologically diverse, the Sunkoshi River Basin covers a wide altitudinal range from alpine regions exceeding 4,000 meters to subtropical zones below 500 meters creating varied ecosystems that range from highland meadows to subtropical sal forests. These ecosystems support a wide variety of flora and fauna, including threatened and endemic species (Shrestha et al., 2019). Vegetation types change with elevation, transitioning from rhododendron and juniper in the higher elevations to mixed hardwood forests and agricultural land in the lower regions. The river corridor offers crucial habitat for wildlife including the red panda (*Ailurus fulgens*), Himalayan monal (*Lophophorus impejanus*), and various species of fish and macroinvertebrates.

Climatically, the basin experiences a humid subtropical to alpine climate, influenced heavily by the South Asian monsoon. The annual precipitation ranges from 1,000 mm to over 3,000 mm, with more than 75% of the rainfall concentrated between June and September. The temperature gradient across the basin is equally broad, from freezing conditions in the upper reaches during winter to over 30°C in the southern lowlands during summer. These climatic variables play a significant role in seasonal flow regimes, erosion, sediment transport, and flood events.

The basin's geology, predominantly composed of schists, quartzites, and gneisses, contributes to both its sediment load and the mineral composition of the river water. Soil in the upper catchments are shallow and rocky, while deeper alluvial soils dominate the lower sections. These features not only influence natural vegetation patterns but also shape land-use practices, including traditional agriculture, animal husbandry, and community forestry.

Socio-economically, the Sunkoshi River plays a crucial role in sustaining livelihoods through its use in irrigation, domestic water supply, sand mining, and hydropower generation. Major hydropower plants along the river include Sunkoshi Hydropower Station and others in planning or construction phases. However, the river's power during the monsoon season can be destructive, causing flash floods, landslides, and sediment deposition that disrupt transportation and displace communities.

Given these natural and human-induced pressures, understanding the river's environmental status is crucial. This study analyzed water quality at 11 different sampling sites along the river system (Figure 1). Among them, eight locations were selected directly from the main course of the Sunkoshi River, while three were taken from major confluences with its tributaries: Indrawati–Sunkoshi, Chauri Khola–Sunkoshi, and Roshi Khola–Sunkoshi. These sites were chosen to be a range of land uses, flow conditions, and pollution sources, ensuring a comprehensive understanding of spatial variation in water quality within the basin.

Such a multidisciplinary approach to understanding the hydrological, ecological, and socio-economic dynamics of the Sunkoshi River Basin provides critical insight for water resource management, disaster risk reduction, and conservation planning.

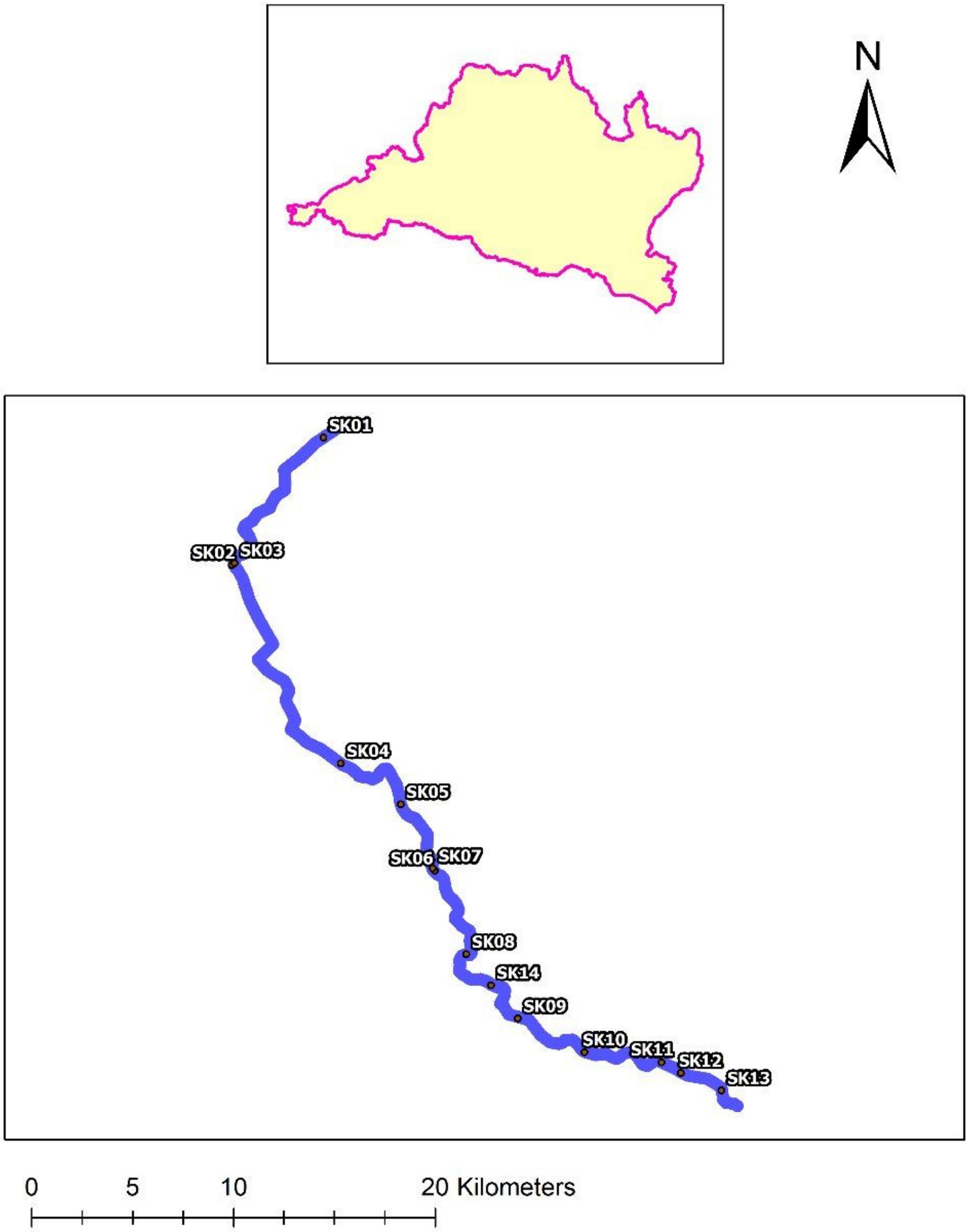

Figure 1: study area map

2.2 Data Collection

A random sampling approach was employed in this study to ensure representative data collection.

On Day 2 at Site SK01, students were divided into four groups, each assigned specific sampling tasks to ensure comprehensive data acquisition. One group used the ENPHO test kit to measure parameters such as pH, temperature, free residual chlorine, ammonia, iron, nitrate, phosphate, chloride, and hardness. A second group ran a multi-probe meter, assessing pH, temperature, turbidity, conductivity, and dissolved oxygen. These values were recorded for demonstration purposes only and were not used for analytical results. A third group conducted macroinvertebrate sampling using a tray to see the presence or absence of species. The fourth group collected water samples, using prewashed 1-liter polyethylene bottles to minimize contamination. These bottles were filled without air space, sealed, and stored in dark conditions at temperatures between 4°C and 10°C to preserve sample integrity. A total of 14 water samples were collected, labeled and coded as SK01, SK02, SK03… SK14, and were categorized based on their respective locations. Additionally, physical, chemical, biological, and social data were recorded at each site to offer a holistic view of the water quality at the sampling locations.

2.3 Data Analysis

2.3.1 On-Site Analysis

On-site analyses of key water quality parameters, including pH, temperature, free residual chlorine (FRC), ammonia, iron, nitrate, phosphate, chloride, and hardness, were conducted at the sample collection sites following the standard protocols and methods outlined by ENPHO. Calibrated standard instruments were used to ensure correct measurements. The pH, temperature, turbidity, conductivity, total dissolved solids (TDS), and dissolved oxygen (DO) levels of the water samples were measured using a multiprobe meter (Model HI 98130, HANNA). The multiprobe meter was calibrated using standard solutions prior to measurements. Each sample was placed in the sample holder and left for a few minutes until the readings stabilized, after which the values were recorded. To prevent cross-contamination, the probe was rinsed with deionized water after each measurement. Macroinvertebrate samples collected from the water were found using relevant articles, publications, and manuals for correct classification.

2.3.2 Laboratory Analysis

After preliminary field testing, water samples from 14 distinct locations were transported to the laboratory for more in-depth analysis under controlled conditions. The focus was on evaluating physical, chemical, and biological parameters that require specialized equipment and precise methodologies.

To preserve the integrity of the samples, they were stored at 4°C and processed according to standard laboratory protocols. All the data were organized in a spreadsheet for further interpretation and statistical analysis, helping to better understand water quality and find any unusual patterns or results.

3. RESULT

3.1 Analysis of Water Sample Turbidity

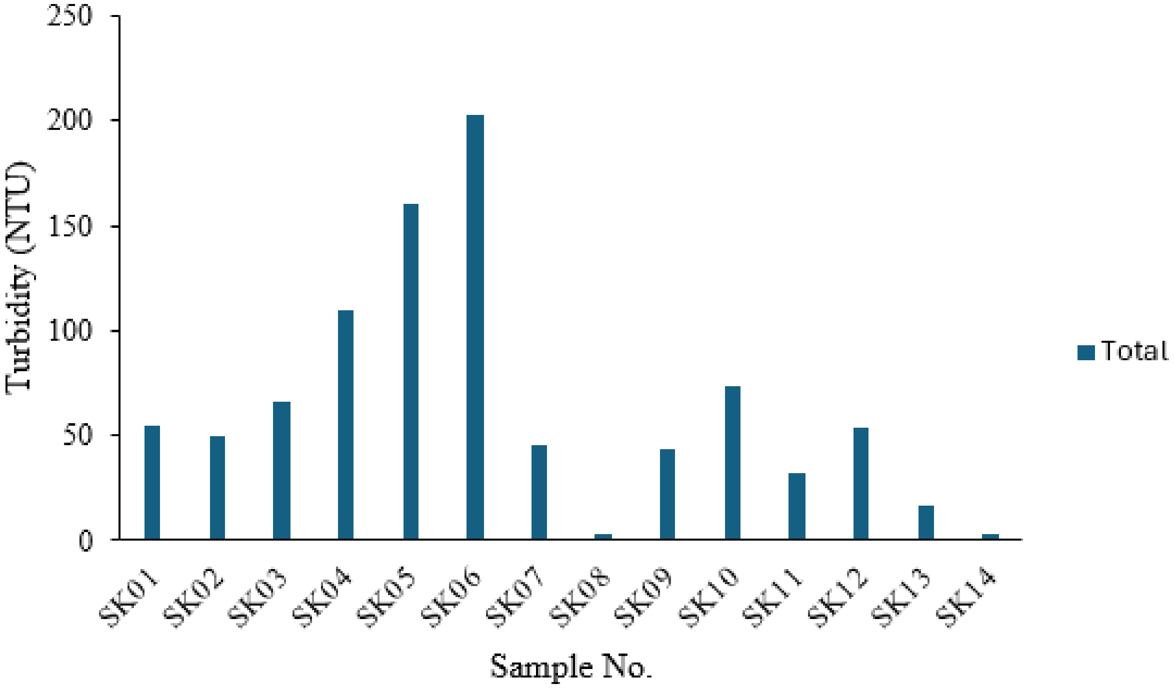

Figure 2:Turbidity level of Water Sample

The turbidity of the water samples collected from 14 separate locations (Figure 2) were examined. The turbidity levels varied significantly across the samples. Notably, Sample SK06 exhibited the highest turbidity, followed by SK05 and SK04, showing important levels of suspended particles or contaminants in these samples. In contrast, SK08 and SK14 showed the lowest turbidity, suggesting clearer water with fewer impurities.

According to the guidelines set by the World Health Organization (WHO) and the Nepal Drinking Water Quality Standards (NDWQS), the acceptable turbidity level for safe drinking water is 5 NTU. However, our findings show that most of the samples exceeded this limit, with several samples, especially SK06, far surpassing the safe threshold. This shows potential health risks if such water is consumed without proper treatment and highlights the urgent need for water purification and regular monitoring in the study area.

3.2 Analysis of water sample conductivity

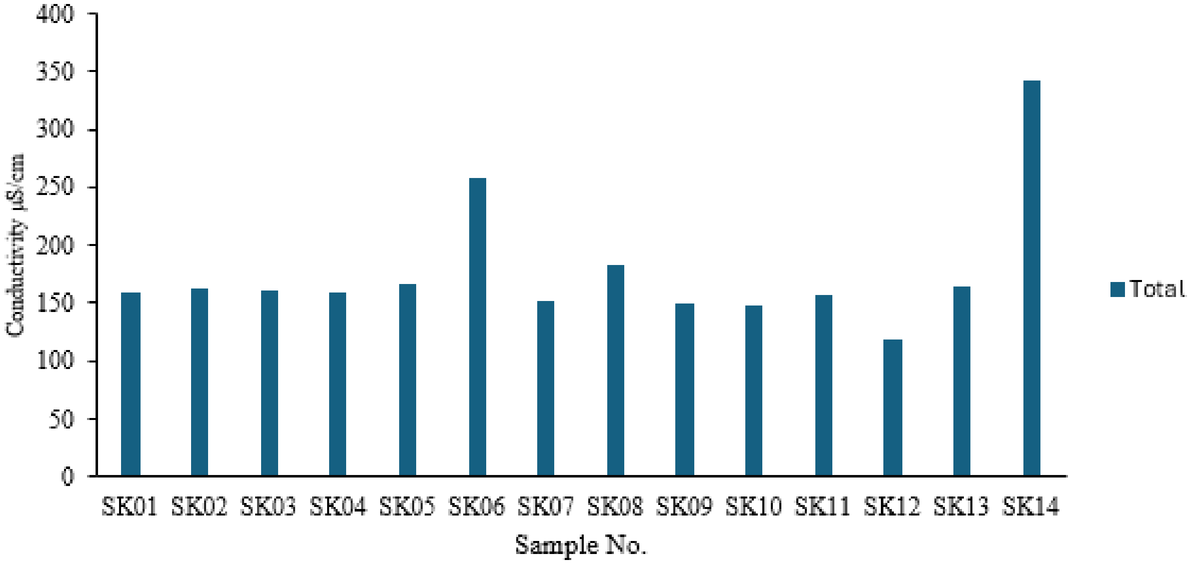

Figure 3: Conductivity of Water Samples

The conductivity of the water samples was analyzed (Figure 3). Among all the samples, SK06, SK05, and SK04 exhibited the highest conductivity values, while SK08 and SK14 showed the lowest. Overall, the conductivity levels in the samples appeared to be within the permissible limits set by the World Health Organization (WHO) and the Nepal Drinking Water Quality Standards (NDWQS).

3.3 Analysis of water sample temperature

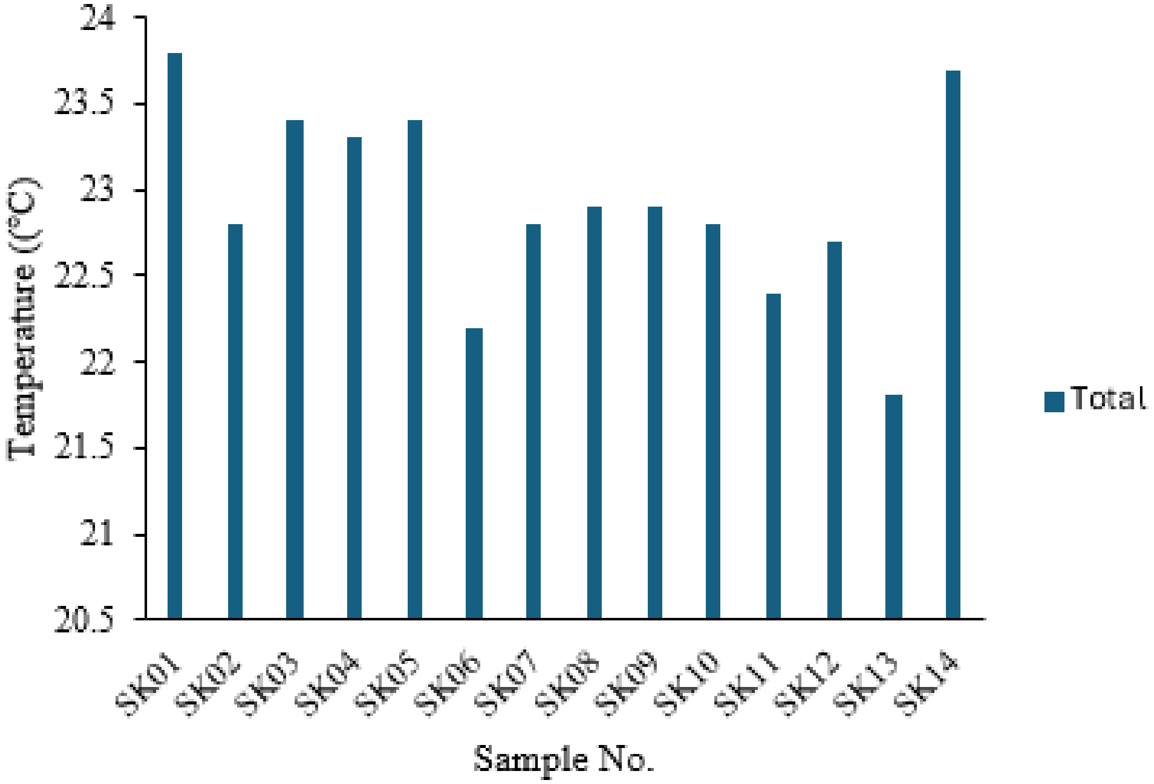

FIGURE 4: TEMPERATURE OF WATER SAMPLE

The temperature of the water samples was recorded during laboratory analysis (Figure 4). The highest temperatures were seen in samples SK01 and SK14, while SK13 showed the lowest. All recorded temperatures were found to be within the acceptable range specified by the World Health Organization (WHO) and the Nepal Drinking Water Quality Standards (NDWQS).

3.4 Analysis of Water Sample pH

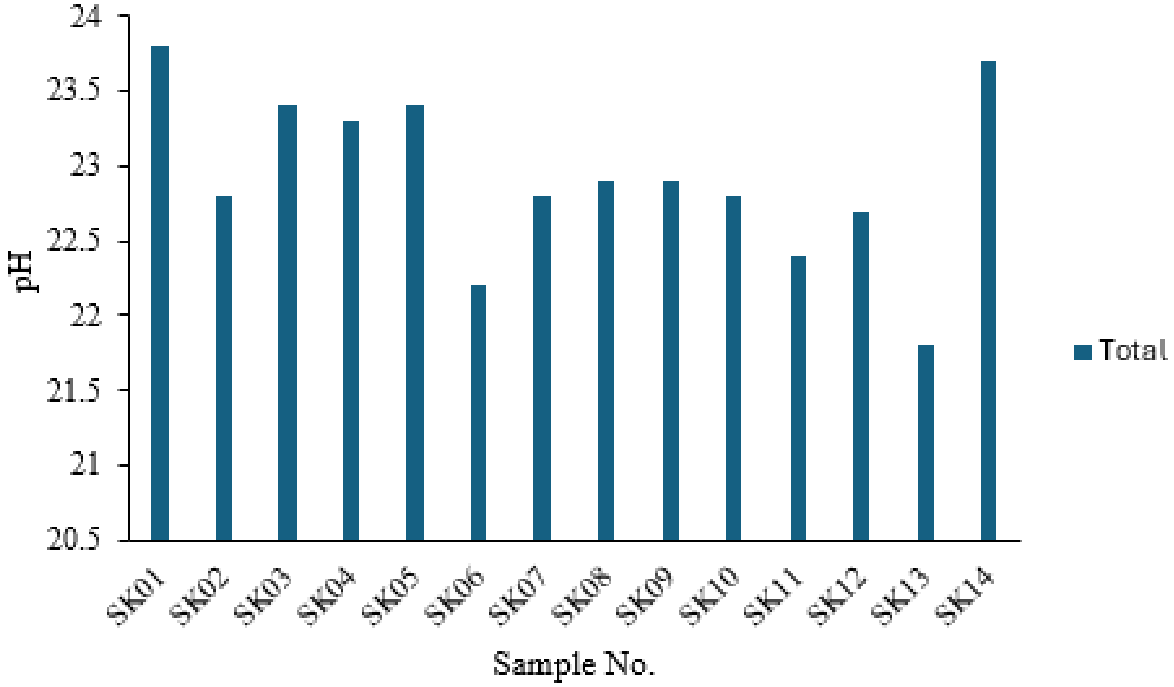

FIGURE 5: PH LEVEL OF WATER SAMPLE

The pH of the water samples was tested (Figure 5). Sample SK14 recorded the highest pH, followed by SK08, while SK06 showed the lowest. According to WHO and NDWQS guidelines, the acceptable pH range for drinking water is 6.5 to 8.5. Most of the samples fell within this range; however, SK14 slightly exceeded the upper limit, showing a marginally higher alkalinity. Although this is not at once harmful, it suggests the need for continued monitoring.

3.6 Analysis of Water Sample Hardness

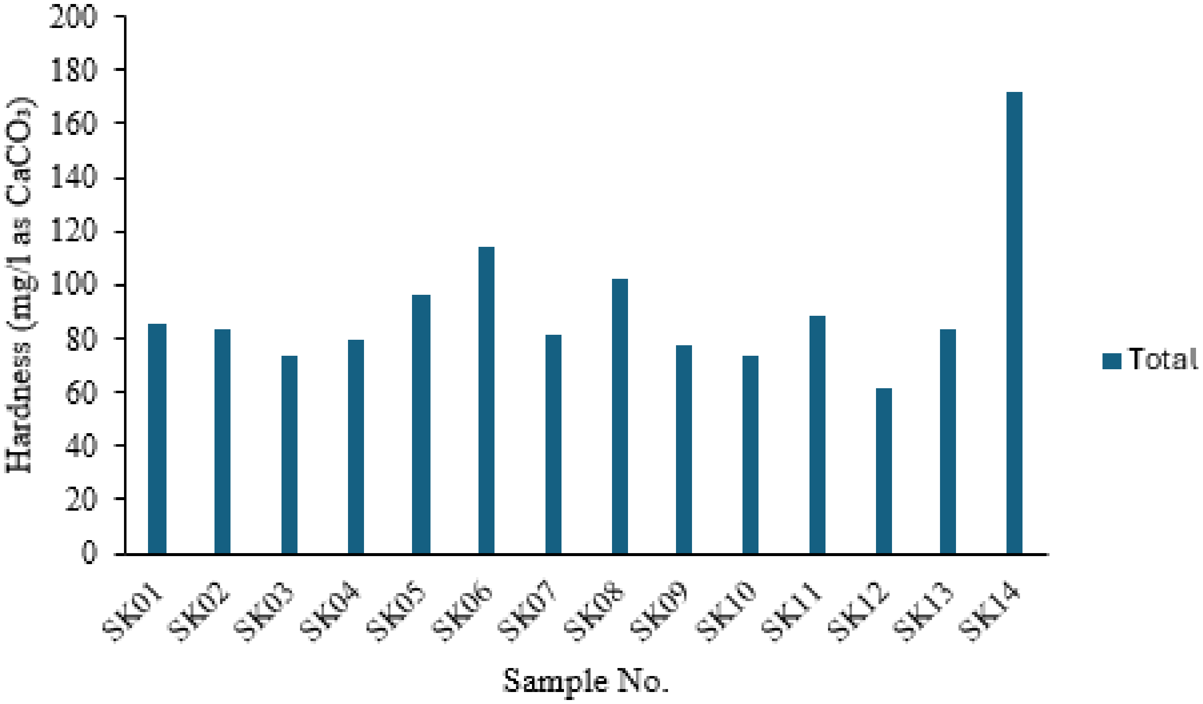

Figure 6: Total Hardness of Water Sample

The chemical parameter: total hardness was also analyzed (Figure 6). Sample SK14 exhibited the highest level of hardness, followed by SK06 and SK08. In contrast, SK12 recorded the lowest hardness value among all samples. According to the WHO and NDWQS guidelines, the acceptable limit for total hardness in drinking water is 500 mg/L as $CaCO_3$. All the tested samples were found to be within this limit, showing that the water is safe in terms of hardness.

3.7 Analysis of Water Sample Total Alkalinity

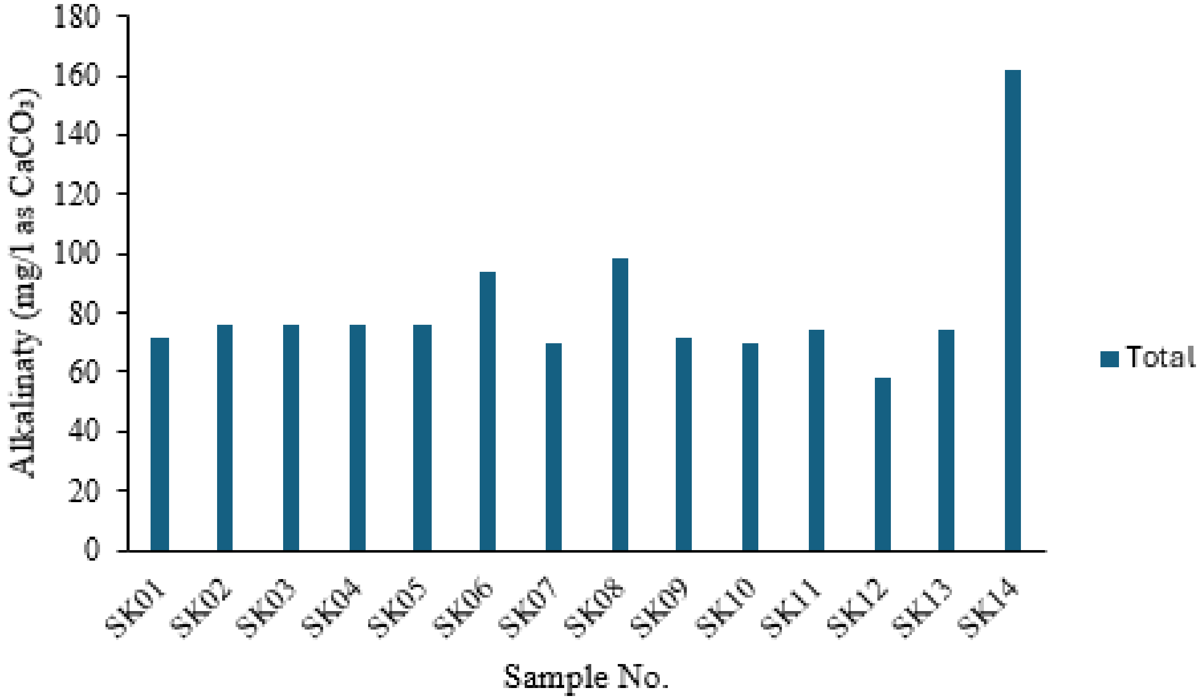

FIGURE 7: ALKALINITY OF WATER SAMPLE

Alkalinity levels of the water samples were tested (Figure 7). Sample SK14 showed the highest alkalinity, while SK12 had the lowest. According to the WHO and NDWQS guidelines, the acceptable limit for alkalinity in drinking water is 500 mg/L. The highest alkalinity recorded in our samples was 160 mg/L, which is well below the permissible limit, showing no concern related to alkalinity in the tested samples.

3.8 Analysis of Water Sample Calcium

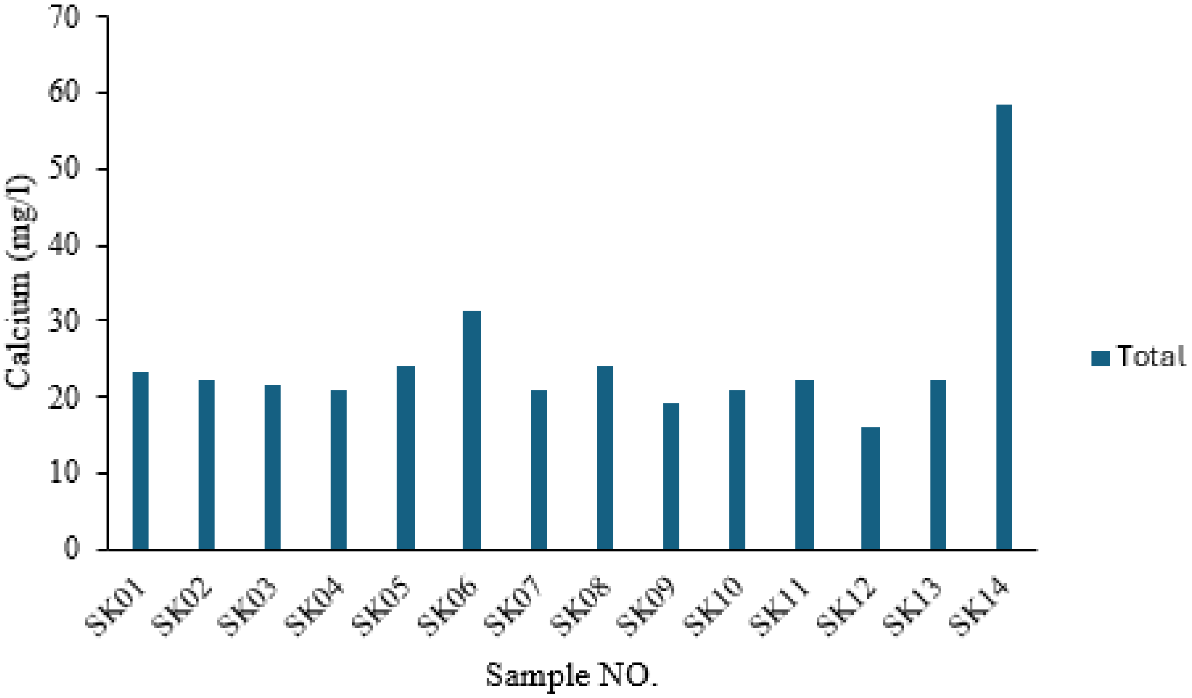

FIGURE 8: CALCIUM OF THE WATER SAMPLE

Calcium levels in the water samples were analyzed (Figure 8). Sample SK14 recorded the highest calcium concentration, while SK12 showed the lowest. All samples were found to have calcium levels below the largest permissible limit set by WHO and NDWQS, showing that the water is within acceptable standards for calcium content.

3.9 Analysis of water Sample Magnesium

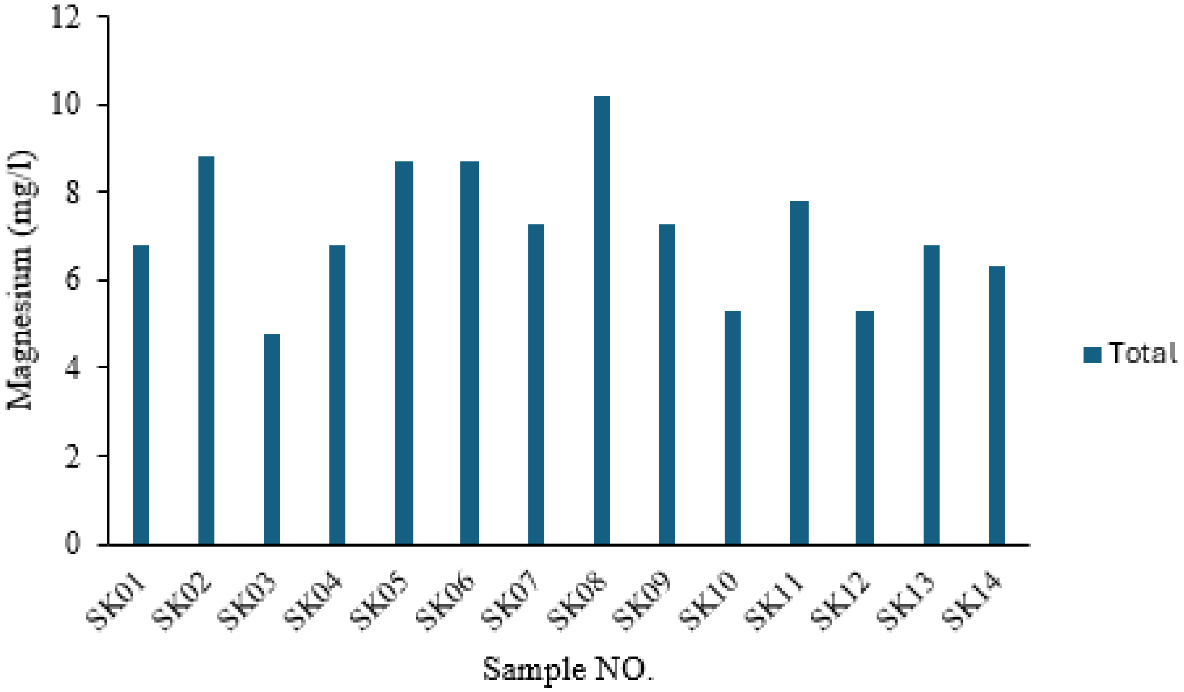

FIGURE 9: MAGNESIUM OF WATER SAMPLE

Figure 9 illustrates the total magnesium content in the water samples. Sample SK08 showed the highest concentration, followed by SK02 and SK05, while SK11 had the third highest level. On the other hand, SK02 recorded the lowest magnesium content. All samples were found to be within the acceptable limits set by WHO and NDWQS, showing that the magnesium levels pose no concern for water quality.

3.10 Analysis of Sample Chloride Water

FIGURE 10: CHLORIDE OF THE WATER SAMPLE

Figure 10 presents the chloride content in the water samples. All samples, except SK14, showed chloride levels of less than 1.0 mg/L. According to WHO and NDWQS guidelines, the acceptable limit for chloride in drinking water is 250 mg/L. Therefore, all tested samples were well within the permissible range, showing no concern related to chloride content.

3.11 Analysis of water Sample Ammonia

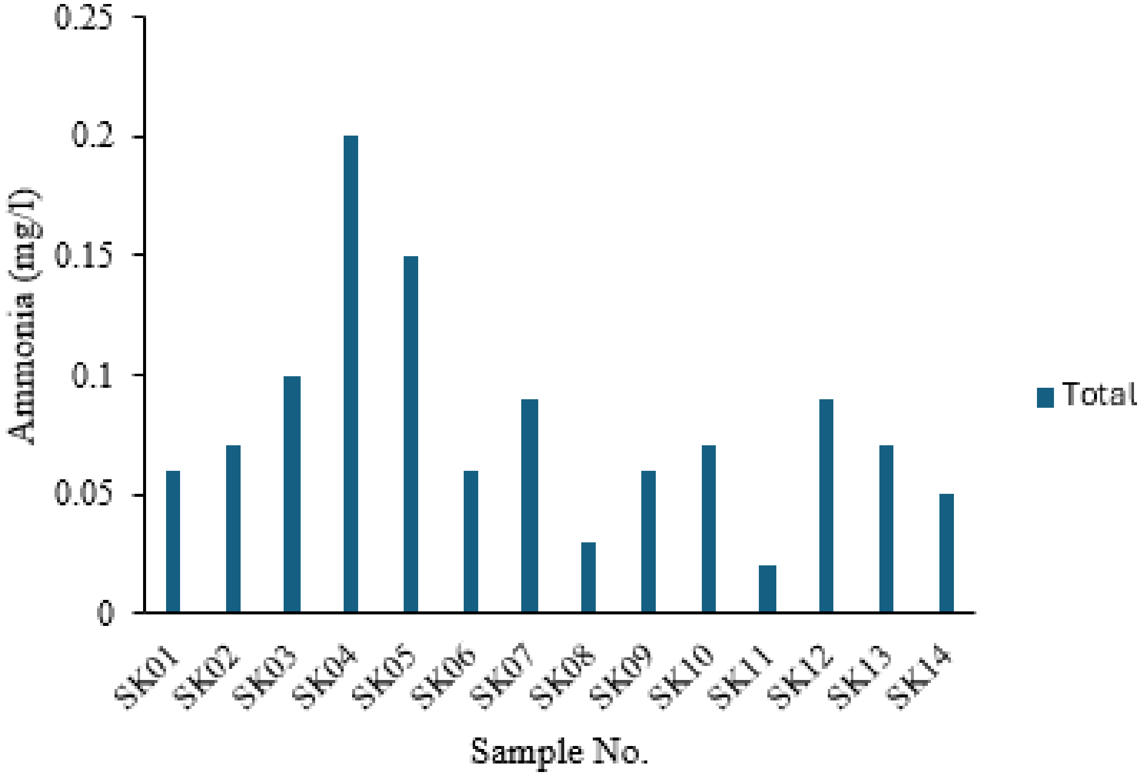

FIGURE 11: AMMONIA OF WATER SAMPLE

Figure 11 shows the ammonia content in the water samples. Sample SK04 recorded the highest level at 0.2 mg/L, followed by SK05 with 0.15 mg/L. The lowest ammonia concentration was seen in sample SK11. According to WHO and NDWQS guidelines, the acceptable limit for ammonia in drinking water is 1.5 mg/L. All samples were well within this limit, showing no significant concern about ammonia levels.

3.12 Analysis of Water Sample Iron

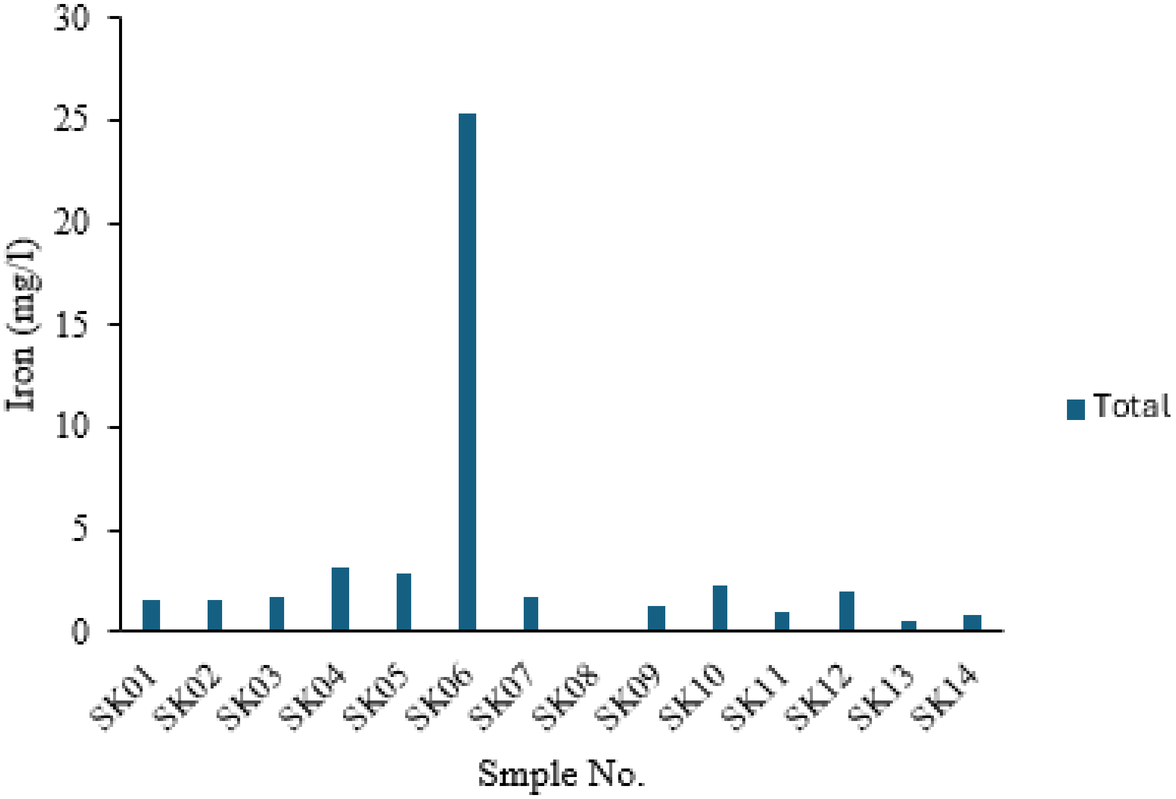

FIGURE 12: IRON OF WATER SAMPLE

Iron concentration in the water samples was analyzed (Figure 12). Sample SK06 exhibited the highest concentration at approximately 25 mg/L, which significantly exceeds the acceptable limit. In contrast, no detectable iron was found in sample SK08, while SK13 recorded the lowest measurable concentration. According to WHO and NDWQS guidelines, the permissible limit for iron in drinking water is 0.3 mg/L. Therefore, sample SK06 poses a concern and shows possible contamination requiring further investigation.

3.13 Analysis of water Sample Manganese

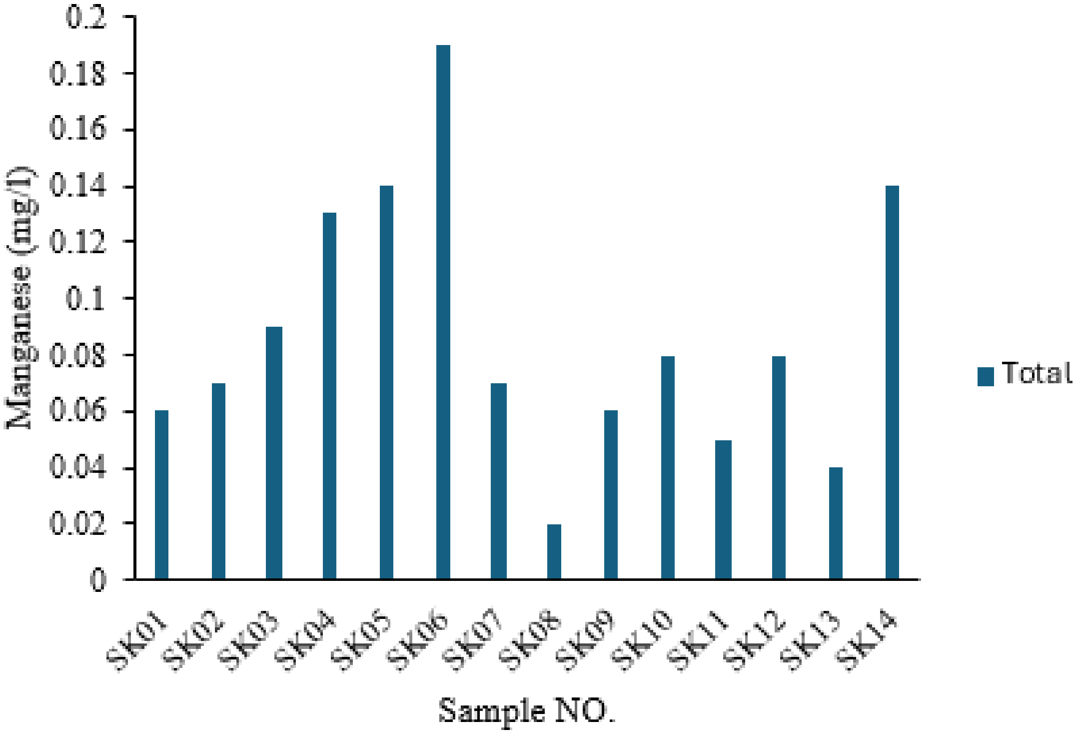

FIGURE 13: MANGANESE OF WATER SAMPLE

Manganese levels in the water samples were analyzed (Figure 13). The highest concentration was seen in sample SK08 at 0.19 mg/L, while the lowest was found in sample SK04 at 0.02 mg/L. According to the WHO guideline, the acceptable limit for manganese in drinking water is 0.5 mg/L, while the NDWQS sets a stricter limit of 0.2 mg/L. All samples were within both guidelines, showing no immediate concern about manganese content.

3.14 Analysis of water Sample Nitrate

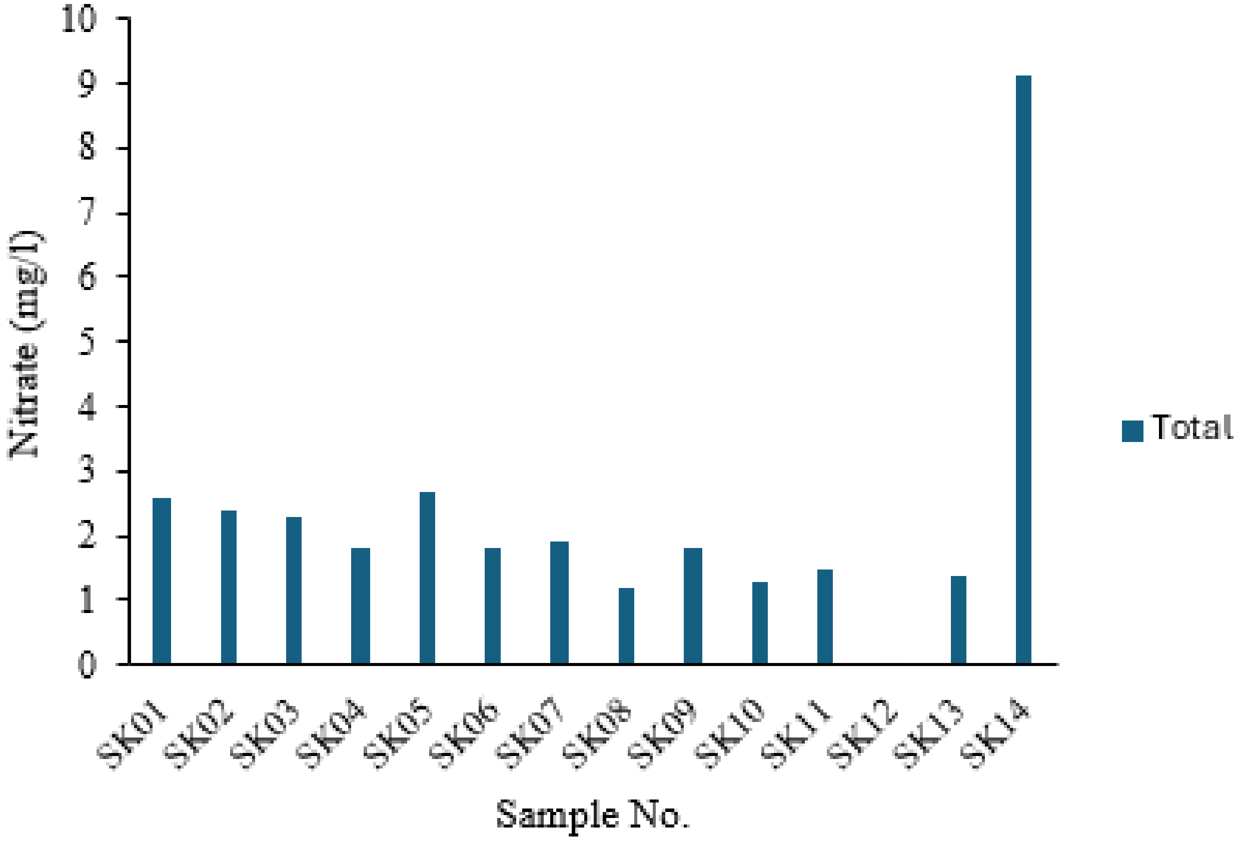

FIGURE 14: NITRATE OF WATER SAMPLE

Nitrate levels in the water samples were assessed (Figure 14). The highest concentration was recorded in sample SK14 at 9.1 mg/L, while the lowest was seen in sample SK12, with levels below 0.02 mg/L. According to WHO and NDWQS guidelines, the permissible limit for nitrate in drinking water is 50 mg/L. All samples were well within this limit, showing no concern about nitrate contamination.

3.15 Analysis of water Sample Nitrite

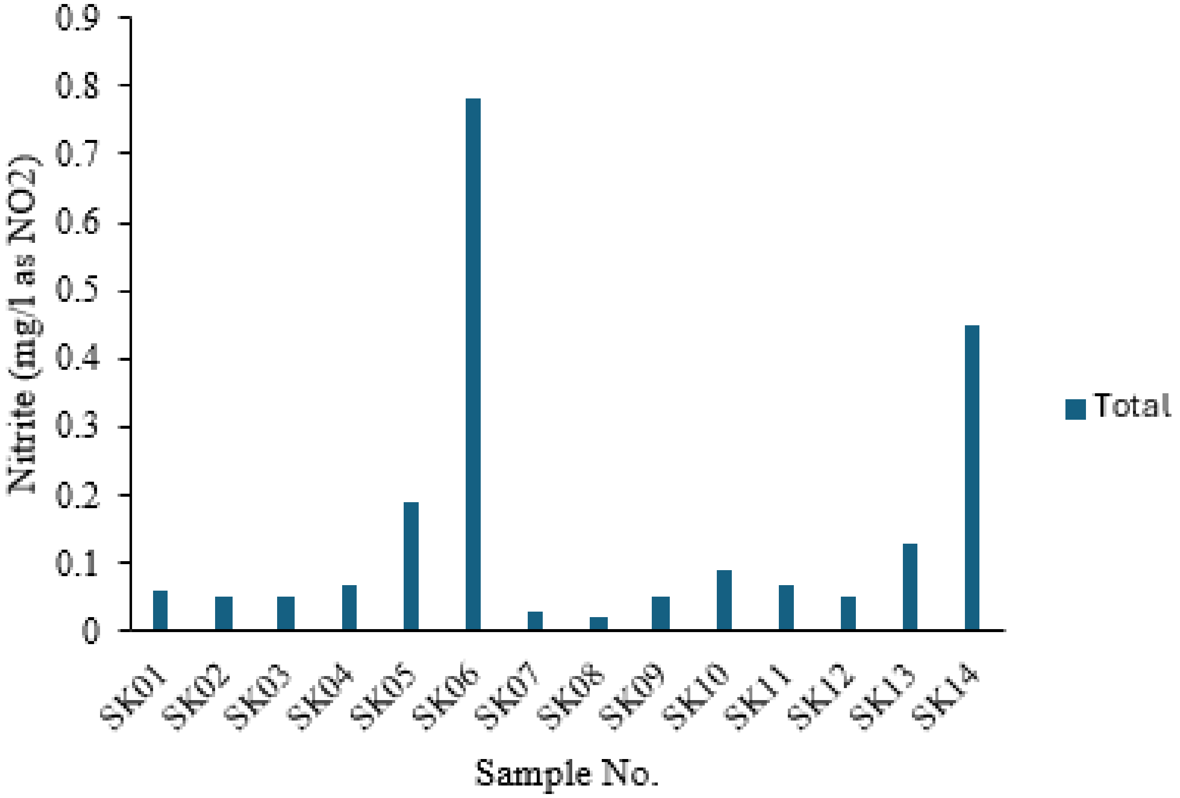

FIGURE 15: NITRITE OF WATER SAMPLE

Nitrite levels in the water samples were decided (Figure 15). The highest concentration was seen in the sample SK06 at 0.78 mg/L, followed by SK14 at 0.45 mg/L, while the lowest concentration was found in SK08 at 0.02 mg/L. The permissible limit for nitrite according to WHO and NDWQS guidelines is 3 mg/L. Therefore, all samples were within the acceptable range, showing that nitrite levels do not pose a significant risk.

3.16 Descriptive Analysis of Physico-Chemical Parameters

Parameter	Mean	Standard Deviation	Sample Variance	Minimum	Maximum
Turbidity (NTU)	66.08	59.52	3542.74	3	203
Conductivity (µS/cm)	178.62	58.53	3425.76	118	342
Temperature (°C)	22.85	0.52	0.27	21.8	23.7
pH	8.21	0.20	0.04	7.8	8.6
Total Hardness (mg/l as $CaCO_3$)	91.54	27.58	760.77	62	172
Total Alkalinity (mg/l as $CaCO_3$)	82.77	25.87	669.03	58	162
Calcium (mg/l)	24.92	10.63	112.94	16	58.4
Magnesium (mg/l)	7.24	1.60	2.54	4.8	10.2
Ammonia (mg/l)	0.08	0.05	0.00	0.02	0.2
Iron (mg/l)	3.41	6.63	43.99	0.09	25.3
Manganese (mg/l)	0.09	0.05	0.00	0.02	0.19
Nitrate (mg/l as NO_3)	2.25	2.16	4.68	0.01	9.1
Nitrite (mg/l as NO_2)	0.16	0.22	0.05	0.02	0.78

TABLE 1: DESCRIPTIVE ANALYSIS OF WATER PARAMETER

Descriptive statistical analysis of the water quality data revealed notable variations across the sampling sites (Table16). The mean turbidity was 65.29 NTU, with a wide range from 3 to 203 NTU, showing significant spatial water differences in clarity. Electrical conductivity had an average of 177.21 µS/cm, reflecting moderate ionic content, and displayed considerable variability (SD = 56.48). The temperature of the water samples was relatively consistent, averaging 22.92°C. The pH values were slightly alkaline, ranging from 7.8 to 8.6, with a mean of 8.21, suggesting stable hydrogen ion concentrations. Total hardness and alkalinity averaged 91.14 mg/L and 82 mg/L as $CaCO_3$, respectively, showing that the water is moderately hard and well-buffered. Calcium and magnesium levels were 24.8 mg/L and 7.21 mg/L on average, with minimal variation in magnesium across sites. Ammonia values remained constant at 7.9 mg/L, which may suggest a data recording error or uniform pollution source and should be rechecked. Iron concentrations averaged 0.08 mg/L, while manganese levels were highly variable, with a mean of 3.27 mg/L and a high standard deviation of 6.39 mg/L, pointing to possible localized contamination. Nitrate and nitrite concentrations averaged 2.45 mg/L and 0.15 mg/L, respectively, with some variability, showing possible inputs from agricultural runoff or organic waste. These findings reflect a diverse range of water quality conditions that may influence aquatic health and signal areas of concern requiring targeted intervention.

4. DISCUSSION

This study looked at the overall water quality at separate locations by testing physical, chemical, biological, and microbial factors. The results showed that while some samples met the standards set by WHO and Nepal Drinking Water Quality Standards (NDWQS), others did not. This means better water management is needed in some areas.

One of the main problems found was the exceedingly high turbidity levels in samples SK06, SK05, and SK04. These were much higher than the WHO limit of 5 NTU (WHO, 2017). High turbidity usually means the water has a lot of dirt, organic waste, or microbes, which can make it unsafe and harder to treat (Said et al., 2004). This may be caused by runoff from farms or towns and should be studied further.

Another grave issue was the high iron level in sample SK06, which was about 25 mg/L. This is far above the safe limit of 0.3 mg/L given by WHO and NDWQS (WHO, 2017; NDWQS, 2020). Too much iron in drinking water may not be dangerous to health, but it can make the water taste bad, stain clothes, and help iron bacteria grow, which can block water pipes and carry germs (Katsoyiannis & Zouboulis, 2006). This could be due to natural soil and rock or rusting iron pipes.

On the other hand, most other parameters like pH, temperature, conductivity, hardness, alkalinity, nitrate, nitrite, chloride, calcium, magnesium, and manganese were within safe limits. The average pH was 8.21, which is slightly alkaline and normal for groundwater in areas with sedimentary rocks (EPA, 2003). However, sample SK14 had a pH slightly above the limit of 8.5, which could be from extra carbonate or bicarbonate in the water. It’s not dangerous, but it should be watched.

Ammonia levels were also within limits but showed differences between locations. Higher levels could come from farm runoff, sewage, or rotting organic waste (UNESCO/WHO/UNEP, 1996). Manganese was also close to the NDWQS limit in some samples, possibly due to natural sources or maybe pollution.

Although detailed data weren't shown here, biological testing using macroinvertebrates helped provide more information. The types of insects and other small animals in the water can tell us a lot about how clean or polluted it is, and how healthy the ecosystem is overall (Rosenberg & Resh, 1993). This method supports the chemical results and adds another layer of understanding.

From the statistical analysis, turbidity and manganese had high variability between sites. For example, turbidity ranged up to 203 NTU, with an average of 65.29 NTU. This shows that pollution sources are not the same everywhere, and each site may need its own approach.

The study also included information from the local community, which gave a better understanding of the environmental and social situation. This is especially important in rural and semi-urban parts of Nepal, where water is often shared, and infrastructure is limited.

The findings agree with earlier research. For example, Govorushko (2007) also warned about human activities harming water sources. Similarly, Shrestha and Kazama (2007) found that land use and uncontrolled waste disposal in the Bagmati River area affected water quality. This supports the idea that local behavior and land practices have a substantial impact.

In conclusion, this study shows the importance of regular water testing, public awareness, and investing in small-scale water treatment systems. Places with high turbidity and iron should be the focus for improvement. Even if other measures are currently within a safe level, they still need to be checked, as they can change quickly due to weather or development.

5. CONCLUSION

Water samples from several locations were analyzed, and the results show a mix of acceptable and concerning values. Most physical characteristics such as conductivity, temperature, and alkalinity met the WHO and NDWQS guidelines, although one sample (SK14) showed a slightly high pH that should be checked.

Chemically, levels of ammonia, nitrate, nitrite, calcium, magnesium, hardness, and chloride were within acceptable limits. Manganese levels were also within the guidelines, although a few samples were near the NDWQS limits. However, two issues stand out. First, the turbidity in samples SK06, SK05, and SK04 was above the recommended 5 NTU, suggesting the presence of suspended particles that could affect water clarity and safety. Second, the iron concentration was much higher than acceptable; for example, sample SK06 had about 25 mg/L of iron, far exceeding the allowable limit of 0.3 mg/L. This elevated level of iron shows possible contamination that needs immediate attention.

While most parameters are within safe limits, the elevated turbidity and iron levels show that continuous monitoring and corrective measures are necessary to keep the long-term quality and safety of the water supply.

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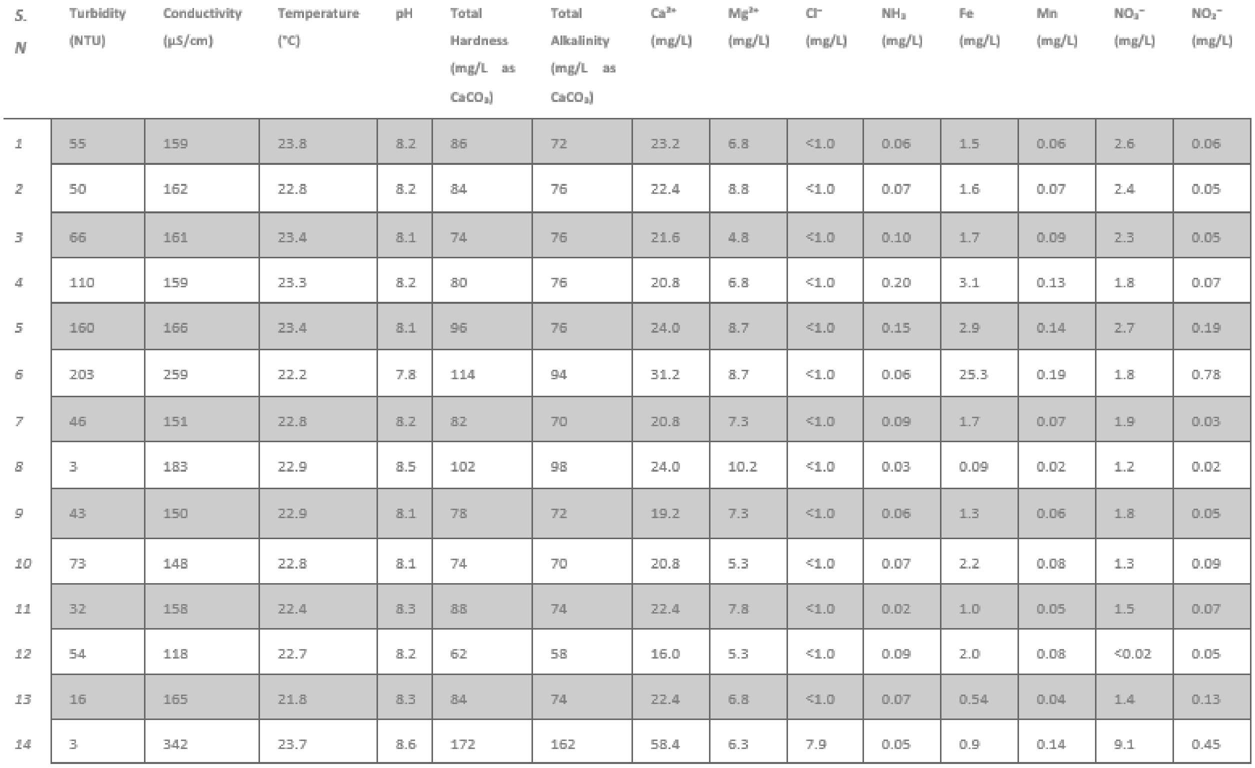
Annex:

Physico-Chemical Parameters of Water Samples Collected from Study Area



S. N	Turbidity (NTU)	Conductivity (µS/cm)	Temperature (°C)	pH	Total Hardness (mg/L as $CaCO_3$)	Total Alkalinity (mg/L as $CaCO_3$)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Cl^- (mg/L)	NH_3 (mg/L)	Fe (mg/L)	Mn (mg/L)	NO_3^- (mg/L)	NO_2^- (mg/L)
1	55	159	23.8	8.2	86	72	23.2	6.8	<1.0	0.06	1.5	0.06	2.6	0.06
2	50	162	22.8	8.2	84	76	22.4	8.8	<1.0	0.07	1.6	0.07	2.4	0.05
3	66	161	23.4	8.1	74	76	21.6	4.8	<1.0	0.10	1.7	0.09	2.3	0.05
4	110	159	23.3	8.2	80	76	20.8	6.8	<1.0	0.20	3.1	0.13	1.8	0.07
5	160	166	23.4	8.1	96	76	24.0	8.7	<1.0	0.15	2.9	0.14	2.7	0.19
6	203	259	22.2	7.8	114	94	31.2	8.7	<1.0	0.06	25.3	0.19	1.8	0.78
7	46	151	22.8	8.2	82	70	20.8	7.3	<1.0	0.09	1.7	0.07	1.9	0.03
8	3	183	22.9	8.5	102	98	24.0	10.2	<1.0	0.03	0.09	0.02	1.2	0.02
9	43	150	22.9	8.1	78	72	19.2	7.3	<1.0	0.06	1.3	0.06	1.8	0.05
10	73	148	22.8	8.1	74	70	20.8	5.3	<1.0	0.07	2.2	0.08	1.3	0.09
11	32	158	22.4	8.3	88	74	22.4	7.8	<1.0	0.02	1.0	0.05	1.5	0.07
12	54	118	22.7	8.2	62	58	16.0	5.3	<1.0	0.09	2.0	0.08	<0.02	0.05
13	16	165	21.8	8.3	84	74	22.4	6.8	<1.0	0.07	0.54	0.04	1.4	0.13
14	3	342	23.7	8.6	172	162	58.4	6.3	7.9	0.05	0.9	0.14	9.1	0.45

Table 2: Physico-chemical parameter of water samples

WHO & NDWQS Water Quality Standards Table

Parameter	Unit	WHO	NDWQS
Turbidity	NTU	5	5 (Max)
Conductivity	µS/cm	—	1500
Temperature	°C	—	—
pH	—	6.5–8.5	6.5–8.5
Total Hardness	mg/l ($CaCO_3$)	500	500
Alkalinity	mg/l ($CaCO_3$)	500	500
Calcium	mg/l	—	200
Magnesium	mg/l	—	—
Chloride	mg/l	250	250
Ammonia	mg/l	1.5	1.5
Iron	mg/l	0.3	0.3 (3)
Manganese	mg/l	0.5	0.2 (Max)
Nitrate	mg/l (NO_3^-)	50	50
Nitrite	mg/l (NO_2^-)	3	3

TABLE 3: WATER QUALITY REFERENCE FROM WHO & NDWQS