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A Comprehensive Assessment of the Quality of Supplied Drinking Water in Galyang Municipality of Syangja, Nepal

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Abstract

A thorough assessment on the municipally supplied water samples from Malunga and Galyang cities; two different places in the Syangja district focused on analyzing various water quality parameters. These parameters included pH value, alkalinity, electrical conductivity, turbidity/suspended solids, chloride contents, and the presence of acid and basic radicals (heavy metal ions).

The results obtained from standard laboratory probes carried out on-site and at the chemistry laboratory of Amrit Campus, indicated that the pH value, alkalinity, electrical conductivity, chloride contents, and the presence of acid radicals (nitrate, sulfate, and chloride) and basic radicals (toxic heavy metal ions) in the water samples were all within the safe limits for potable water as suggested by both the National Drinking Water Quality Standards (NDWQS) of Nepal and the World Health Organization (WHO).

However, it was disclosed that the total suspended solids in the water samples existed in higher concentrations, leading to coagulation and the formation of thin, flat, whitish lumps during long-term storage of the samples.

Overall, while the study determined that the water samples concurred the safe limits for most parameters set by NDWQS and WHO, the higher concentration of total suspended solids during prolonged storage suggests a potential attention to be paid for the improvement of the quality.

Keywords: *Water quality, Malunga, Galyang, turbidity, suspended solids*

1. Introduction

Water, which exists as a continuous cycle in the hydrosphere, is indispensable for life in all forms. It evaporates from the surface sources, condenses in the atmosphere and eventually returns into the sources as liquid water. However, the world is facing the shortage of potable water because of uneven distribution of water sources, rapid population growth and environmental pollution among other factors. Moreover, quantity of water may be meaningless if it is devoid of quality. Hence, water quality is a critical parameter for its domestic, agricultural, recreational, and industrial use as well as aquatic lives and healthy ecosystems (Salehi, 2022).

Emphasis on the specific aspects of water quality management and the focus on the treatments of water for municipal as well as domestic usage followed by the procedures of improving effluent quality to minimize pollution risk are the basic requisites of safe water use (Garcia-Cuerva *et al*., 2016).

Potable water has been the major concern of the modern time due to the excessive need of water for different purposes in daily life. The scarcity of potable drinking water has created several problems. A number of government bodies and international organizations have been working under the common goal to protect water resources and ensure proper distribution of potable water to the human community (Salehi, 2022; Garcia-Cuerva *et al*., 2016).

Water quality refers to the overall condition or characteristics of water, including its chemical, physical, and biological properties, as measured against established standards or criteria for specific uses. (Dasgupta *et al*., 2017). There are some parameters which help us to identify the quality of water.

Different parameters that are used to measure the water quality are introduced below:

pH Value: In simple words, pH is known as the availability of hydrogen ions concentration present in water, i.e., amount of hydrogen ions (H^+) in water. pH value helps us to identify the acidic, neutral or basic characteristics of water. The values on the pH scale range from 1-14, where 7 is neutral point and within this range, water with pH value 6.5-8.5 is acceptable to drink according to the standards of WHO. The lesser the value of pH, the more acidic is water and the greater the value of pH, the more basic is the water.

Turbidity: Turbidity is the measure of the cloudiness or haziness of water caused by the presence of suspended particles, algae, and organic matters that are not dissolved (Anderson, 2005).

Electrical conductivity and salinity: Conductivity is the measure of capability of a substance to conduct electricity and heat. A solution of substance in water can conduct electricity if it contains dissolved ions. The major positively charged ions present in water are sodium, potassium, calcium and magnesium whereas those negatively charged ions are chloride, sulphate, carbonates, bicarbonates, nitrates and phosphates (Omer, 2019).

Salinity is the measure of amount of salt dissolved in water. Salts and other dissolved components affect the water's quality for drinking purpose.

Temperature: Temperature is the metric that gauges the typical energy (kinetic energy) possessed by molecules within water. It is accessed in terms of degree Celsius or degree Fahrenheit. It ranks among the paramount water quality parameters. Temperature greatly influences the water chemistry.

Total coliform: Total coliform bacteria, fecal coliforms, and *Escherichia coli* (*E. coli*) are commonly used as pinpoints of water contamination with fecal matter. Contaminated water can indeed contain a wide range of pathogens (infectious micro-organisms) that are more strenuous to identify. Monitoring the levels of these indicator bacteria provides valuable information about the overall microbiological quality of water (WHO, 2021).

E. coli: *Escherichia coli (E. coli)* is a bacterial species that commonly resides in the gastrointestinal tracts of warm-blooded animals, including humans, various other mammals, and birds. Hence, *E. coli* is prevalent in the fecal matter of all of such organisms. The presence of such bacteria in drinking water may lead several infections such as urinary tract infection, abdominal and pelvic infection, pneumonia, etc (WHO, 2021).

Chemical oxygen demand (COD): Chemical oxygen demand, COD, is indeed a crucial water quality parameter that assesses a water sample's capacity to consume oxygen during the chemical oxidation of organic matter contained within it. In other words, it represents the amount of oxygen necessary to chemically oxidize or react with the organic substances found in a specific volume of water (Geerdink *et al*., 2017). COD plays a vital role by offering valuable insights into the extent of organic contamination present in water. Through the measurement of the oxygen required to oxidize organic substances, COD enables the identification of potential risks to both human well-being and the environment.

Bio-chemical oxygen demand (BOD): Biochemical oxygen demand or biological oxygen demand (BOD) measures the amount of dissolved oxygen (DO) that aerobic microorganisms need to biologically degrade or decompose the organic substances within a water sample. BOD values are typically expressed as milligrams of oxygen per liter of water (mg/L). In aquatic ecosystems, dissolved oxygen is essential for the respiration of both microorganisms, which use it to break down organic compounds, and marine animals like fish, which extract oxygen through their gills for their metabolic processes (Jouanneau *et al.*, 2014).

Nitrogenous contents: Nitrogen is the major constituent of plants' body which is essential for growth and strength of the plant body. It is also essential for animals. However, excessive use of nitrogenous fertilizers in fields for maximum yield of crops may affect the nearby water resources. The nitrogenous fertilizers can get mixed with the water sources and contaminate it. Such a contaminated water is not be drinkable and is also harmful to aquatic lives.

Organic dyes: Industrial effluents mostly contain hazardous and non-biodegradable organic pollutants, including substances like dyes, phenols, phenoxyanilines, and their derivatives. Textile dyes, among the pollutants, are becoming increasingly detrimental because of their direct release into the water resources (Sapkota et al., 2019).

It is indeed true that scarcity of drinking water is a major issue worldwide, and the demand for water is increasing due to the factors such as population growth and its associated consequences. Contamination of water with heavy metal ions like lead, mercury, and arsenic further exacerbates the problem. To address this issue, water treatment procedures need to be implemented to purify and decontaminate water, making it safe for drinking. There are several testing procedures that should be followed to ensure the quality of drinking water.

These criteria provide guidelines and standards for determining the suitability of water for human consumption. Organizations such as the World Health Organization (WHO) and the National Drinking Water Quality Standards (NDWQS) in Nepal have developed specific standards for safe drinking water. In order to minimize the risk of global water scarcity, it is crucial to conserve existing water resources and ensure their proper utilization and distribution.

The motive of this work is to examine the physical and chemical properties of surface water collected from various parts of Galyang Municipality, specifically the water supplied for drinking purpose. The goal is to assess its suitability for drinking and other household uses based on the standards set by WHO and NDWQS-Nepal for safe and potable water for human consumption. By conducting these assessments, it is possible to identify any potential issues with the water supply and take appropriate measures to address them.

The investigation of drinking water quality and potability has been the subject of numerous studies conducted across various regions. However, there appears to be a research gap pertaining to the evaluation of supplied drinking water quality specifically within the localities of Galyang and Malunga. Addressing this gap, the present study endeavors to provide comprehensive insights into the quality of drinking water in these areas.

By focusing on physicochemical parameters relevant to water quality assessment, this study aims to ascertain whether the supplied drinking water aligns with the standards set forth by the World Health Organization (WHO) and the National Drinking Water Quality Standards for Nepal (NDWQS-Nepal). Through a thorough analysis of the physicochemical attributes of the supplied drinking water, this study endeavors to bridge the research gap in assessing water quality in the aforementioned regions.

Accordingly, various of studies and experiments have been done at different periods of time. The various of results have been obtained from a number of experiments. Some of the studies along with the results obtained correspondingly have been mentioned here below:

The study by Andrew Bittner (June, 2000) entitled 'Nepal Drinking Water Quality Assessment: Nitrates and Ammonia' has found that the nitrate contents in water was found to be more in urban areas and less in rural agricultural regions of Nepal. The study had been done under WHO guidelines (Bittner, 2000).

Another study was done by Bhoj Raj Pant in 2011. The study was performed to explore the quality of groundwater samples in the Kathmandu Valley, Nepal. The samples of groundwater were collected randomly from tube well, shallow well and deep-tube wells chosen from different locations of Kathmandu, Lalitpur, and Bhaktapur of the valley territory. The different parameters such as physical, chemical, and microbiological were evaluated in order to reveal the groundwater quality of drinking water. It was concluded that the water from groundwater sources in the valley is unsafe for drinking due to incidence of excess iron and coliform bacteria (Pant, 2011).

T. C. Shova in 2014 performed a study to understand drinking water supply quality in Metro city Kathmandu. A number of physicochemical factors such as water temperature, pH, turbidity, total alkalinity, calcium, magnesium, conductivity, total hardness, total ammonia, iron and chloride were investigated and results obtained were contrasted with the National Drinking Water Quality Standard (NDWQS) along with WHO water provisions. The results obtained associated with the above-mentioned parameters were found in normal range indicating the potability for drinking purpose (Shova, 2014).

A study was conducted by Shidiki *et al.* (2016) for comparative analysis and microbial risk assessment of different drinking water samples in Tokha, specifically in Saraswati and Chandeswari Village Development Committee. In the study, physicochemical and bacteriological analysis were done on water samples collected from various sources such as the original sources (springs), taps, wells, and stone spouts. The aim was to evaluate the quality of the water and to compare the results with the drinking water standards set by reputed institutions like the World Health Organization (WHO) and the Environmental Protection Agency (EPA).

The results of the analysis showed that the pH, total hardness, nitrate, chloride and arsenic content of the water samples were reported to be within the permissible guidelines values set by WHO and EPA for drinking and recreational water. However, the well sample exceeded the National Drinking Water Quality Standard (NDWQS) values for calcium hardness and ammonia content.

Furthermore, the total viable counts in all of the water samples were found to be higher, surpassing the limits of 1.0×10^2 colony forming units (cfu) per milliliter of water. Additionally, all the water samples tested positive for coliform bacteria and fecal organisms with numbers larger than the specified standards set by WHO and FAO for water quality. The fecal coliform colonies on the M-endo agar plate ranged from 143 to 152, and the total coliform counts ranged from 110 to 248 per 100 milliliters of water, surpassing the standard limits.

Overall, the study highlighted that the water samples collected from various sources in Tokha exhibited microbial contamination, exceeding the recommended standards for drinking water quality **(**Shidiki *et al*., 2016).

The study by Shrestha *et al.* (2017) investigated the quality of drinking water, sanitation, and hygiene (WASH) conditions among a total of 708 schoolchildren and 562 households in the Dolakha and Ramechhap districts of Nepal. The study utilized a Delagua water quality testing kit to analyze 634 water samples collected from a selection of 16 specific schools, 40 community water sources, and 562 households in order to assess water quality. A flame atomic absorption spectrophotometer was employed to analyze lead and arsenic contents in the samples. In the study, it was found that 75% of the drinking water samples at schools and 76.9% of the point-of-use samples (water bottles) at schools were impaired with thermo-tolerant coliforms. Additionally, 39.5% of the water source samples in the community and 27.4% of the point-of-use samples at the household level were also found to be contaminated with thermo-tolerant coliforms. The values of water samples for pH (6.8–7.6), mean lead concentration (0.01 mg/L), free and total remnant chlorine (0.1–0.5 mg/L), and average arsenic concentration (0.05 mg/L) were found to lie within national drinking water quality standards (Shrestha *et al*., 2017)**.**

Regmi *et al.* (2017) completed a study in Kathmandu valley in order to find the quality of river water. On analyzing the water sample collected from 20 different locations by means of 10 physicochemical parameters, it has found that water quality in country areas ranged from excellent to good, while in densely populated and central urban areas, the water quality was meagre Regmi *et al*., 2017).

Maharjan *et al.* (2018) found that microbiological features of the studied water samples had a significant issue arisen from the fact that 66% of the water samples exceeded the guideline values for total coliform counts. Specifically, over 92% of the jar water samples, 77% of tanker water samples, and 69% of filtered water samples surpassed the acceptable total coliform count based on the National Drinking Water Quality Standards (NDWQS). Furthermore, 20% of the bottled water was infected with coliform bacteria. Iron and ammonia concentrations were revealed to be higher than the guideline values in 16% and 21% of the total treated water samples, respectively. The analysis of various water samples revealed that 35% of tanker water samples had elevated levels of ammonia, and 15% had higher iron content compared to the standard criteria recommended by NDWQS. Similarly, in the case of filtered water samples, 23% had increased ammonia levels, and 19% had higher iron content, both exceeding the recommended standards set by NDWQS (Maharjan *et al*., 2018).

A study done by Sara Marks and Rubika Shrestha (2020) entitled 'Improving Drinking Water Quality in Rural Communities in Mid-Western Nepal' has found that the water resources available and those used by community people were found to contain more than 75% fecal and chemical contaminants. The water treatment procedure to reduce the contamination has been applied and by the end of the analysis duration, the percentage of taps and storage containers fulfilling the WHO guidelines for microbial safety augmented from 7% to 50% and 17% to 53%, correspondingly (Marks *et al*., 2020).

The study conducted by Shrestha *et al.* (2020) in the Khageri Khola sub-watershed of the Chitwan district aimed to explore the condition of water sources, their significance, associated issues, and distribution, while suggesting suitable conservation and management strategies. The research employed several participatory tools, including household interviews, focus clusters discussions, and stakeholder consultations (Shrestha *et al*., 2020).

The study was done by Dhungel *et al.* (2022) for the quality assurance evaluation of different water sources. About 250 water samples from several sources like well water, tap water, boring water and treated water were taken, where physiochemical parameters were studied following the standard protocols. The total coliform bacterial presence in the water samples was studied by membrane filtration technique. The obtained values were compared with the upper and lower limit values suggested by the National Drinking Water Quality Standards (NDWQS, 2005) (Gaihre *et al*., 2022). Similarly, numerous reports are available in the literature on the contamination of fresh water by dyes and their removal techniques (Sapkota *et al*., 2020; Shrestha *et al*., 2022; Hanif *et al*., 2022; Sapkota *et al*., 2021a; Akter *et al*., 2021; Sapkota *et al.*, 2021b).

2. Materials and methods

2.1 Materials used

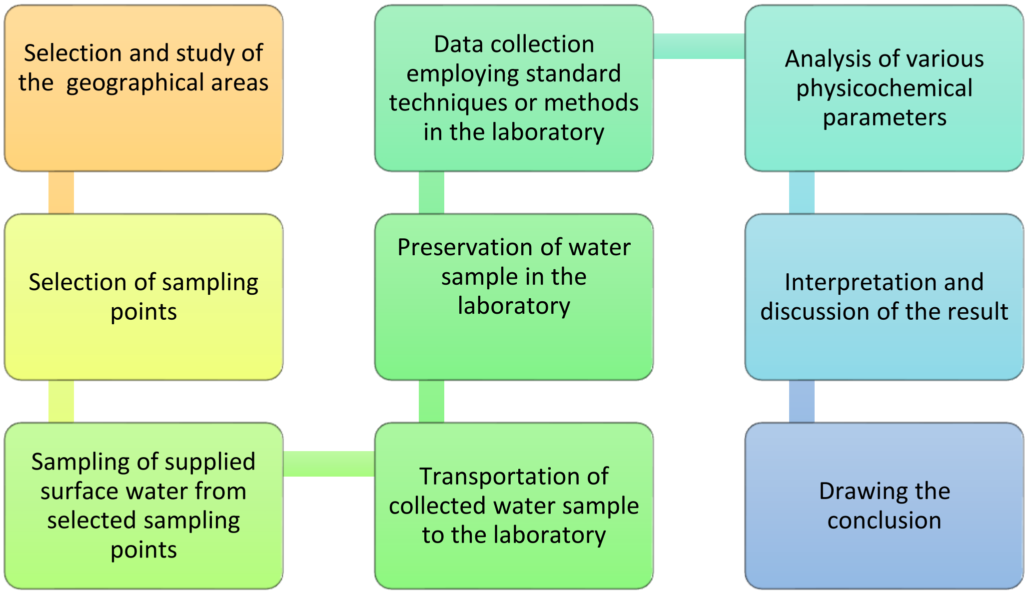
During the experiments, various of materials were used according to the specifications and requirements of the respective work. Some of the major materials that were used during the research work are: Water samples, EDTA solution, Standardize $AgNO_3$ solution, pH meter (HANNA instrument, USA), Conductivity meter (Labtronics), Ice box, etc.

2.2 Study design

This proposed experiment was carried out fully under the supervision of the supervisor in the laboratory, Dept. of Chemistry, Amrit Campus. The test procedure/study design followed to examine the water quality includes the selection and study of the geographical area, selection of sampling points, sampling of supplied surface water from selected sampling points, transportation of collected water sample to the laboratory, preservation of water samples in the laboratory, data collection employing standard techniques or methods in the laboratory, analysis of various physicochemical properties of water, interpretation and discussion of the results and drawing the conclusion. The flow diagram of research work is shown in the Scheme **1**.

2.3 Study population/participants

Some of the population inside the research territory were used for the study purpose.



Scheme 1. Study design of the work

2.4 Sampling

The major task of the project is to do proper sampling for the better output of the work done. For this reason, the sampling was done in a such way that it could help to bring out the precise information of the quality of supplied drinking water in the selected area of study.

2.4.1 Sample collection and preservation

The required samples were collected from the definite territory of those areas where the maximum number of people is depended upon the single source of drinking water.

The manual collection of samples was done and the samples were collected in a plastic container in compliance with established standard norms and guidelines adapted. The drinking water samples from Malunga and Galyang were collected within a same day and were collected on 24th December, 2022. The proper labeling of the samples was done for the proper identification of samples collected. Sample preservation was done in tune with Surface Water Guidelines with minimum time lapse between sample collection and analysis.

2.4.2 Sampling procedure

Random sampling method of sampling was used for the study.

2.5 Area of study

Water samples for the study purpose were collected from Malunga and Galyang city located in Galyang Municipality, Syangja, Nepal. The water samples of Malunga were from Bhakbhake Khanepani Project and that of Galyang were from Chideypani Khaneypani Project. Malunga water samples were denoted by the symbol M and 7 different samples of water were collected from Dhangling, Phaata, Gaihraa, Chaura, Newar Thumka and Tunibot. The water samples of Galyang were denoted by G and 7 different samples of water were collected from 7 different houses located in the Siddhartha Highway catchment of Galyang. Galyang is also the only one city of Galyang Municipality and has highly dense population. Drinking water has been the major concern of citizens all over the municipality; however, the demand has fulfilled on periodical supply of drinking water. Bhakbhake Khaneypani is the newly constructed project and hasn't completed fully; however, drinking water has been supplied to almost 70% population in the project area.

Fig. 1: Galyang Bazaar (source: Google Earth)

Fig. 2: Malunga (source: Google Earth)

The samples code of different water samples collected from Malunga are displayed in the Table 1.

Table 1: Sample codes of different samples

Sample Codes	Sample Collection Point (Malunga)
S-1	Dhangling-Pandit Tole
S-2	Dhangling-Chaura
S-3	Phaata
S-4	Gaihraa
S-5	Chaura
S-6	Newar Thumka
S-7	Tunibot

The drinking water samples (7 different samples) of Galyang Bazaar were collected from the 7 different houses located in the Siddhartha Highway of Galyang Bazaar and were named as S-1, S-2, S-3, S-4, S-5, S-6 and S-7.

2.6 Water sample collection

Water samples were collected in plastic bottles, which were freshly manufactured and sterilized by the Bluelight Drinking Water Company located in Tallo Galyang Bazaar. All of the water samples were collected within a day on 24th December, 2022 and were brought to Amrit

Campus next morning (the next day after collection). Water samples were stored in Chemistry Department laboratory where different tests were done at different times. However, pH of the water samples was tested later by re-visiting the same sample collected location by the help of handy pH meter rented from the laboratory of Chemistry, Amrit Campus. Different physicochemical parameters' tests were done in different interval of time period. It took about 3 months for the completion of the task.

2.7 Preparation of chemical reagents

2.7.1 Preparation of standard N/50 Na_2CO_3 solution

0.106 g of anhydrous sodium carbonate (Na_2CO_3) was added in a 100 mL volumetric flask where distilled water was added up to the mark and the solution was prepared.

2.7.2 Preparation of approximately N/50 HCl solution

5 mL of 2N strength of known concentration available in the laboratory was taken in a 500 mL volumetric flask and the solution was diluted up to the mark to make the strength N/50, later the HCl solution prepared was standardized with N/50 standard Na_2CO_3 solution.

2.7.3 Preparation of standard N/50 NaCl solution

Accurately weighed 0.585 g of NaCl salt powder was taken in a 500 mL volumetric flask and dissolved in distilled water. The volume was made up to the mark using distilled water.

2.7.4 Preparation of approximately N/50 $AgNO_3$ solution

1.70 g of $AgNO_3$ salt was taken in a 500 mL volumetric flask and was dissolved using distilled water. The volume was made up to the mark. Later on, the prepared solution of silver nitrate was standardized with the help of standard N/50 NaCl solution.

2.7.5 Preparation of 2% K_2CrO_4 solution

0.196 g of K_2CrO_4 crystals was taken in a 100 mL volumetric flask and dissolved in distilled water. The volume was made up to the mark.

2.7.6 Preparation of 0.01M EDTA solution

29.8 g of EDTA was taken in a 1000 mL volumetric flask and was dissolved in distilled water. The distilled water was filled up to mark to make the strength of 0.01M concentration.

2.7.7 Preparation of Solochrome black indicator

0.6 g of solochrome black powder was weighed and was put into 100 mL volumetric flask. About 50 mL of ethanol was added to make the powder dissolved. 5 g of hydroxylamine hydrochloride was also added to the flask containing solochrome black powder and ethanol. Again, the ethyl alcohol was added up to the mark.

2.7.8 Preparation of pH 10 NH_4OH-NH_4Cl buffer solution

56.8 mL of conc.NH_3 was added to the solution of 7 g of NH_4Cl dissolved in 100 mL of water in volumetric flask.

2.7.9 Preparation of 0.2M $MgSO_4$ solution

4.93 g of anhydrous $MgSO_4$ was weighed and transferred into 100 mL volumetric flask and distilled water was used to dissolve the solute and distilled water was filled up to the mark to make its concentration 0.2M.

2.8 Method of analysis

2.8.1 pH analysis

The pH meter of HANNA instruments made in Romania was used for the measurement of pH of water during the sample collection. The pH meter was calibrated using the buffer solution of pH 4 and 7 before using it for the measurement of pH of respective water samples.

2.8.2 Electrical conductivity

To measure the electrical conductivity value of water samples conductivity meter of HANNA instrument made in Romania was used. Before measuring the conductivity value of water sample, the tester was washed with distilled water and calibrated in standard KCl solution of concentration 0.1M and 0.01M at 25°C.

2.8.3 Total hardness

The total hardness of the collected samples was determined by the complexometric titration with EDTA as a complexing agent and Solochrome black, i.e., Eriochrome black T as indicator. Water sample was taken with buffer solution of NH_4OH-NH_4Cl (pH=10) with addition of few drops of Mg-EDTA solution and also few drops of Solochrome black indicator. The whole mixture was then titrated with 0.01M EDTA solution till wine red color changed into pure blue colour.

2.8.3.1 Estimation of total hardness in water sample

0.01M standard EDTA solution was prepared. NH_4OH-NH_4Cl buffer solution of pH 10 was prepared by mixing 56.8 mL conc.NH_3 and 7 g NH_4Cl in 100 mL solution. 50 mL of bottled sample was taken in a 250 mL conical flask and 2 mL of buffer solution was poured followed by the pouring of 0.1 mL of 0.1M Mg-EDTA solution and few drops of solochrome black indicator. The resulting mixture solution was titrated against standard EDTA solution until wine red colour changed to pure blue. At least two concurrent readings were noted and from the data obtained total hardness in the water sample was calculated. The process was repeated for the different water samples.

2.8.3.2 Estimation of permanent hardness in water sample

250 mL of collected sample was taken in a 500 mL beaker and was heated gently to boil for half an hour. The boiled water was cooled, filtered and was transferred into 250 mL clean volumetric flask and the volume of filtered water was made up to mark by adding small volume of distilled water and was well shaken for the homogeneity. 50 mL of this water sample was taken in a 250 mL conical flask and 2 mL of buffer solution was poured followed by transferring of 0.1 mL of 0.1M Mg-EDTA solution and few drops of solochrome black indicator. The resulting mixture solution was titrated against standard EDTA solution until wine red colour changed to pure

blue. At least two concurrent readings were noted and from the data obtained permanent hardness in the water sample was calculated. Temporary hardness in the water sample was calculated from the data obtained for total hardness and permanent hardness for the same water sample. The hardness of water was expressed in equivalency to $CaCO_3$.

2.8.4 Chloride content

The chloride present in the water was analyzed by argentometric titration employing K_2CrO_4 as an indicator and standard $AgNO_3$ solution. Water sample was poured into a conical flask and 2% K_2CrO_4 indicator was mixed with the water sample. With the standardize $AgNO_3$ solution, the water mixture was titrated and the concentration of chloride was calculated in Normality.

2.8.5 Total dissolved solids (TDS)

At first, the empty porcelain dish was taken and was washed properly and dried, which was weighed in sensitive weighing balance capable of showing 4 digits after decimal point and the weight was noted as W_1. After that, the sample was kept in a porcelain dish, and water sample was boiled to evaporate completely, the porcelain was cooled and weighed, the weight was denoted as W_2. The difference between their weights was taken and converted into units of ppm using following equation:

$$TDS = [(W_2 - W_1)/ \text{volume of water}] \times 10^6 \text{ ppm}.$$

2.8.6 Tests for basic and acid radicals

Various tests for the presence/absence of radicals in the water samples was done following the test procedure mentioned in the practical text book entitled A Core Experimental Chemistry.

2.8.7 Turbidity

During the storage period of approximately 2 months, turbid contents were observed only in the Galyang Drinking Water Sample-G. Thin whitish long flakes were found in almost every sample of the water collected. To quantify the turbidity, the gravimetric method was employed.

The procedure began with a clean and dry filter paper being taken and weighed. The well-shaken turbid water sample was then transferred onto the weighed filter paper and completely filtered. Once the filtration was complete, the filter paper was dried in a hot air oven. Subsequently, the dried filter paper was weighed again using a sensitive digital balance to calculate the actual amount of turbidity present within the water sample.

This gravimetric method was used for the determination of the precise quantity of turbidity-causing materials in a liter sample of water by measuring the difference in weight of the filter paper before and after filtration and drying.

3. Results and discussion

3.1. pH value

The pH values of the supplied drinking water samples collected from Malunga and Galyang are shown in the Figure 3 and Figure 4 in bar-diagrams, respectively.

3.1.1 pH value of Malunga sample

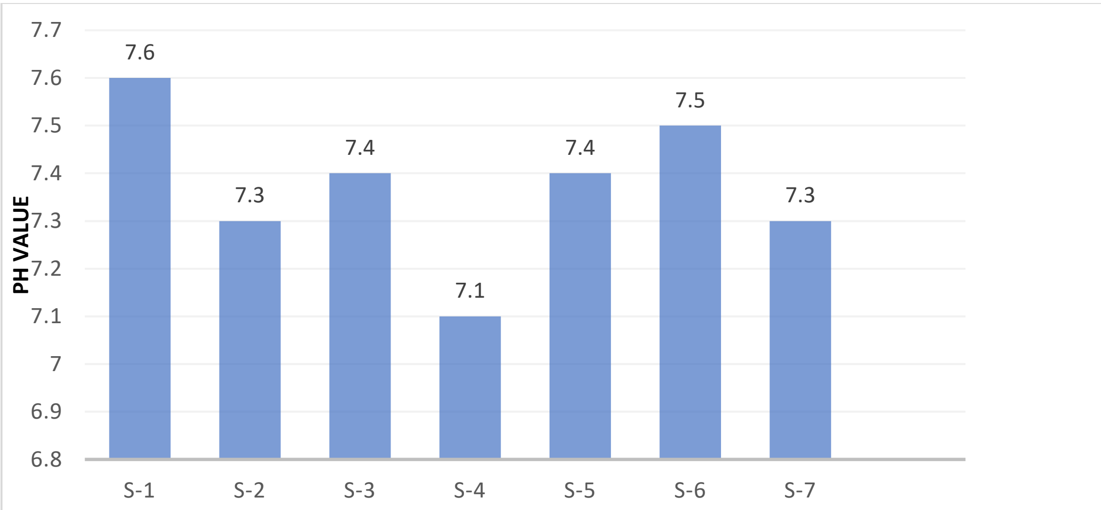


Fig. 3: pH value of Malunga water sample

On viewing the above data, it is found that pH value of Malunga sample has been found in the range between 7.1-7.6 indicating the slight basic nature of water. Corresponding to WHO and NDWQS, the pH value was found to lie within the permissible range of drinking tap water.

3.1.2 pH value of Galyang sample

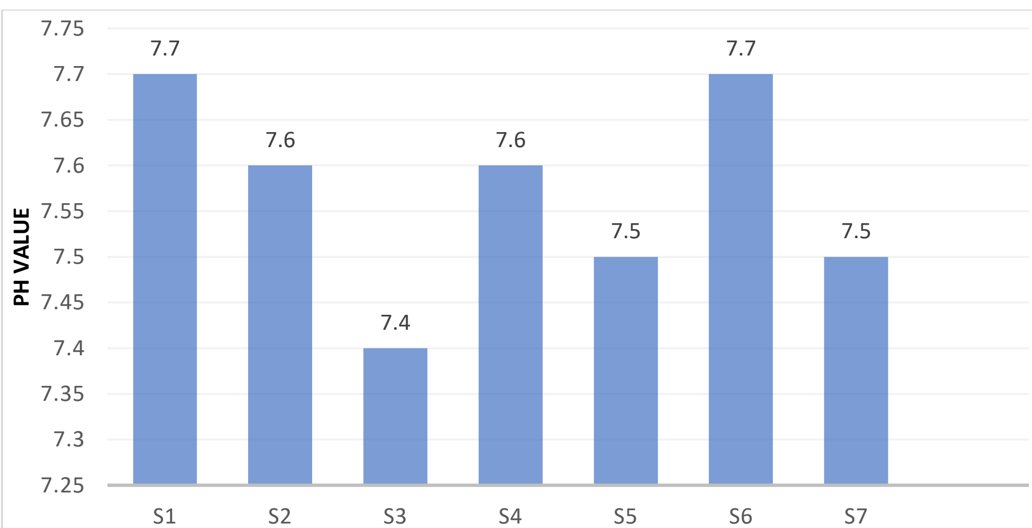


Fig. 4: pH value of Galyang water samples

Based on the data observed, the pH value of the Galyang water sample falls within the range of 7.4-7.7, indicating a slightly basic nature of the water. This pH range is considered acceptable for drinking tap water according to the standards set by the World Health Organization (WHO) and the National Drinking Water Quality Standards (NDWQS).

WHO permissible pH value range for drinking tap water = 6.5-8.5*

NDWQS permissible pH value range for drinking tap water = 6.5-8.5*

A slightly basic pH range is generally considered favorable for drinking water. It is positive to observe that the pH value of the Galyang and Malunga water samples fall within the permissible range for drinking tap water. However, it is important to continue monitoring the water's pH value periodically to ensure that it remains within the acceptable range over time (Werkneh *et al*., 2015).

3.2 Electrical conductivity

The electrical conductivity values of Galyang Drinking Water Sample-G and Malunga Drinking Water Sample-M were determined using a conductivity meter. The obtained data are presented in Table 2.

Table 2: Electrical conductivity of water samples

Sample	**Electrical Conductivity value [µS/cm]**							**Mean Value**	**WHO St. Value**	**NDWQS St. Value**
	S-1	S-2	S-3	S-4	S-5	S-6	S-7			
G-sample	391	384	406	391	410	398	395	396.43	**200-1500 µS/cm**	**1500 µS/cm**
M-sample	451	439	439	432	447	447	443	442.57.		

Based on the data obtained from conductivity meter, the line graph of electrical conductivity values of Malunga and Galyang is shown the Figure 5.

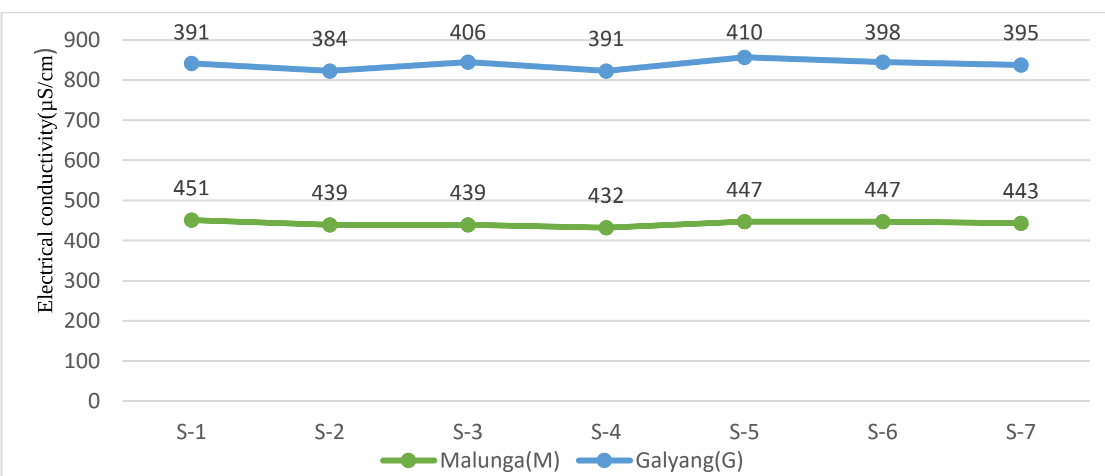


Fig. 5: Electrical conductivity of water samples

Based on the above data, the average electrical conductivity of the Galyang water sample was 396.43 µS/cm, while the average electrical conductivity of the Malunga water sample was 442.57 µS/cm. These values fall within the recommended range of electrical conductivity for potable tap water set by the World Health Organization (WHO), which is 200-1500 µS/cm. The National Drinking Water Quality Standards (NDWQS) also recommended an electrical conductivity value of 1500 µS/cm for drinking water.

The average electrical conductivity values of both samples fall within the recommended range. Though the average electrical conductivity values of the Galyang and Malunga water samples indicate that they fall within the recommended range, further analysis and testing are necessary to determine the overall potability of the water samples (Dianati Tilak et al., 2013).

3.3 Turbidity

It appears that the Galyang water sample stored for a duration of 3-4 months exhibited turbidity. To assess the level of turbidity, a 1-liter water sample was filtered, and the weight of the dry and clean filter paper was measured before and after filtration. Based on the results obtained, the water sample was found to contain 0.0496 gram of turbid residual solid in the 1-liter water sample. The presence of such turbid residual mass may be concerned with the questions in water's potability for drinking purposes.

Turbidity can indicate the presence of suspended particles, including sediments, organic matter, or other contaminants. High levels of turbidity can affect the aesthetic qualities of water, such as its appearance, taste, and odor. Moreover, it can also serve as a potential indicator of the presence of other harmful substances or microorganisms that may pose health risks.

Weight of dry and clean filter paper (W_1) = 0.5538 g
Weight of well dried filter paper after filtration (W_2) = 0.6034 g
Turbidity concentration (ppm) = $[(W_2 - W_1)/ \text{volume of water taken}] \times 10^6$ ppm

$$= [(0.6034-0.5538) / 1000] \times 10^6 \text{ ppm}$$
$$= 49.6 \text{ ppm}$$

The above obtained data when converted to standard NTU unit (where 1 ppm is equal to 3 NTU), it was found that the drinking water samples has exceeded the concentration limits of Turbidity present in the drinking water sample as per the standard concentration limit provided by WHO and NDWQS.
Galyang water sample was found to contain turbidity when it was stored for long duration of time *i.e.*, for almost about 3-4 months of time period. The turbidity observed is presented in Figure 6.

Fig. 6: Turbidity presence in water sample

The elevated turbidity level of 49.6 ppm in the Galyang water sample stored for three months requires thorough investigation. Factors such as the settling of suspended particles, temperature effects, microbial growth, container quality, and the initial turbidity level likely influenced the observed turbidity. Further research and analysis are necessary to identify the specific causes and address the potential concerns regarding the water quality in Galyang (Davis-Colley et al., 2001).

3.4 Total hardness and permanent hardness

The amount of total hardness and permanent hardness present in the samples of supplied drinking water of Malunga and Galyang are shown in the Figure 7 and Figure 8 in the bar-diagram accordingly.

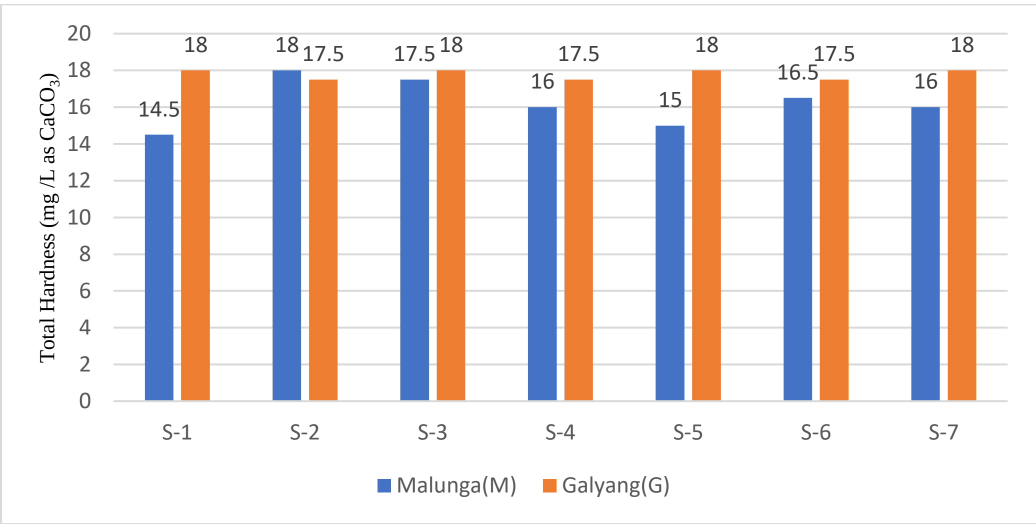


Fig. 7: Total hardness of water samples

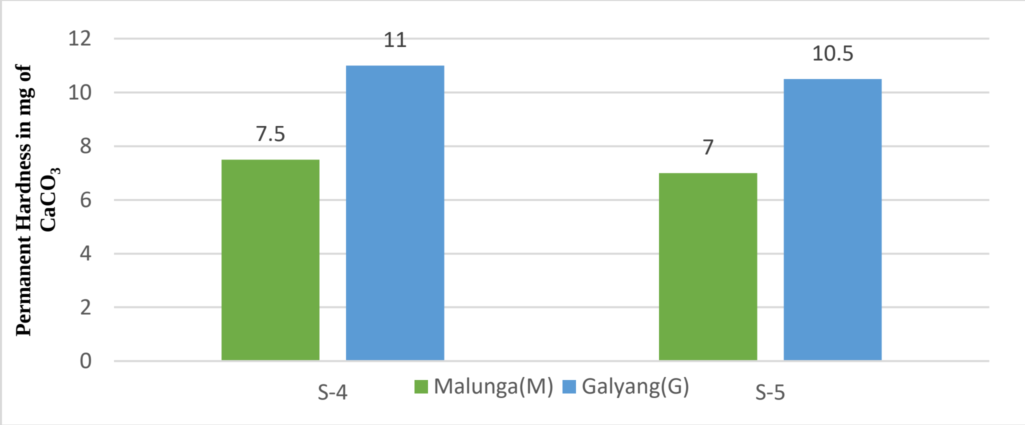


Fig. 8: Permanent hardness of water samples

It appears that both the Malunga and Galyang drinking water samples meet the concentration limits for total hardness and permanent hardness set by the WHO and the (NDWQS). The WHO and NDWQS have set a concentration limit of less than 500 mg/L as $CaCO_3$ for total hardness and permanent hardness. In the case of Malunga, the total hardness is in the range of 14.5-18 mg/L as $CaCO_3$, which is well below the limit. The permanent hardness in the Malunga sample is within the range of 7-7.5 mg/L as $CaCO_3$, which is also below the limit. Similarly, for the Galyang drinking water sample, the total hardness falls within the range of 17.5-18 mg/L as $CaCO_3$, which is below the limit of 500 mg/L. The permanent hardness in the Galyang sample is in the range of 10.5-11 mg/L as $CaCO_3$, which is again within the concentration limit. Therefore, based on the comparison with the WHO and NDWQS standards, both the Malunga and Galyang drinking water samples meet the required limits for total hardness and permanent hardness, as their concentrations are below the specified limit of 500 mg/L as $CaCO_3$ (WHO, 2010).

3.5 Chloride content

Based upon the data obtained from the research work for the findings of Chloride ions concentration present in the drinking water samples collected from Malunga and Galyang, it is represented in Figure 9.

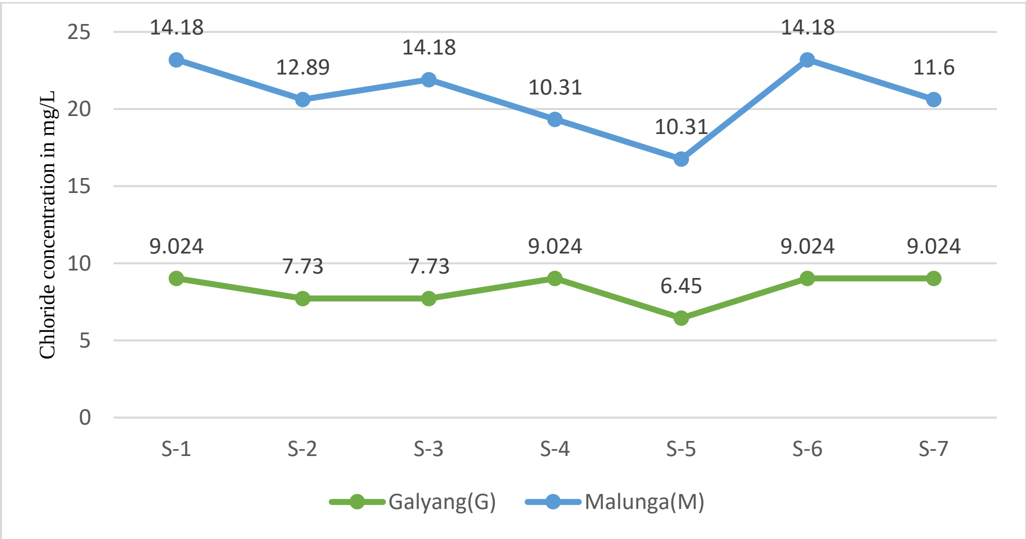


Fig. 9: Chloride concentration

The chloride concentration in the water sample is below the recommended limit of 250 mg/L, it suggests that the water sample meets the provisions set by both the NDWQS and the WHO for drinking tap water. It's important to note that chloride ions themselves are not typically considered harmful at concentrations within the recommended limits (Bashir *et al*., 2012). It is essential to conduct a comprehensive analysis of multiple parameters and conduct regular monitoring to ensure the safety and quality of the drinking water supply.

3.6 Acid radicals

The qualitative analysis of supplied drinking water samples collected from Malunga and Galyang were found to contain the anionic radicals mentioned in Table 3.

Table 3: Tests for acid radicals

Drinking water sample's location	**Chloride (Cl^-)**	**Carbonate (CO_3^{--})**	**Sulphate (SO_4^{--})**	**Bicarbonate (HCO_3^-)**	**Nitrate (NO_3^-)**
Malunga	✓	×	✓	×	×
Galyang	✓	×	×	×	×

Based on the qualitative analysis of the drinking water samples from Malunga and Galyang, it was found that both samples contain chloride (Cl^-) anionic radicals. However, the Malunga sample was found to contain SO_4^{--} (sulphate) radicals in the drinking water, while they were not observed in the Galyang drinking water sample. The specific concentration of these ions would need to be evaluated to determine if it falls within the acceptable range for drinking water (Von Gunten, 2003).

3.7 Basic radicals

The qualitative analysis conducted on the supplied drinking water samples collected from Malunga and Galyang has revealed the presence of basic radicals of the different metal ions group is shown in the Table 4.

Table 4: Basic radicals

Drinking water sample's location	**Group I**	**Group II**	**Group IIIA**	**Group IIIB**	**Group IV**	**Group V**
Malunga	×	×	✓	✓	×	✓
Galyang	×	×	×	✓	×	✓

On qualitative analysis of basic radicals/cations present in the supplied drinking water samples from Malunga and Galyang, both of the water sample were found to contain trace amount of metal ions precipitation of Group IIIB and Group V. But, the Malunga drinking water samples were found to contain the precipitation of Group IIIA metal ions.

Conducting confirmatory tests for specific basic radicals in the water samples were not possible due to minimal formation of the respective precipitates. However, their presence in trace amounts has been justified based on other indications or observations. Trace amounts of these basic radicals may not pose immediate health risks, but their presence should be monitored and evaluated regularly to ensure that their concentrations remain within acceptable limits (Yadav, *et al*., 2015).

3.8 Total dissolved solids

The bar diagram presented in Figure 10 illustrates the total dissolved solids (TDS) content within the collected drinking water samples from Malunga and Galyang. The varying heights of the bars depict the respective TDS levels found in each sample.

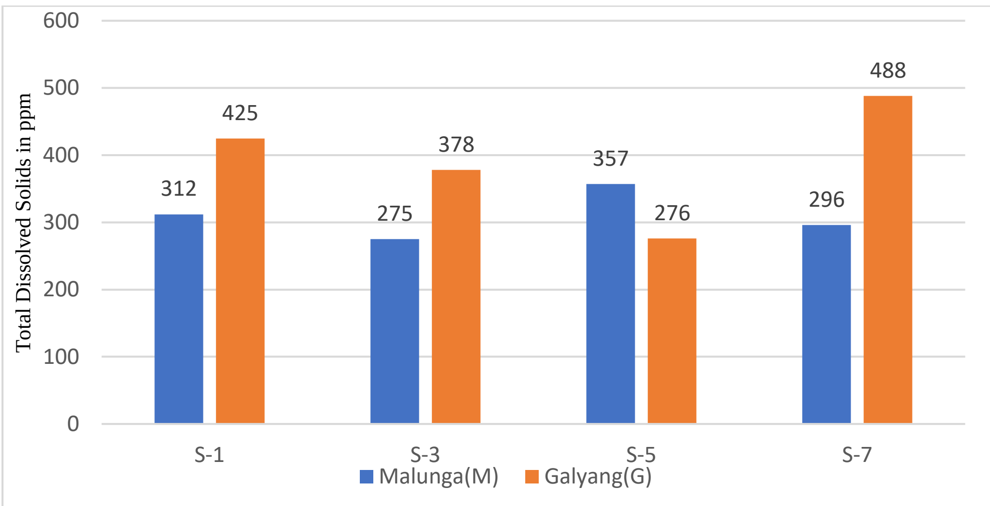


Fig. 10: Total dissolved solids

The Malunga drinking water sample has a TDS concentration in the range of 275-357 ppm, which falls within the" Excellent-Good" category according to the WHO guidelines. It also complies with the NDWQS concentration limit of 1000 ppm.

On the other hand, the Galyang drinking water sample has a TDS concentration in the range of 276-488 ppm. According to the WHO guidelines, this range falls within the "Excellent-Good" category. Also, it lies in the NDWQS concentration limit of 1000 ppm.

In summary, based on the comparison with both the WHO guidelines and the NDWQS concentration limit, both the Malunga drinking water sample and Galyang drinking water sample are considered potable, meeting the standards (NDWQS, 2005; WHO, 2011).

The Table 5 presents the values of various physicochemical parameters detected in the supplied drinking water samples obtained from Malunga and Galyang. This consolidated overview allows for a direct comparison of the water quality attributes between the two locations along with the standards set by WHO and NDWQS-Nepal.

Table 5: Overall results table

Sample No.	**pH**	**Electrical Conductivity** [µS/cm]	**Total Hardness** [mg/L as $CaCO_3$]	**Permanent Hardness** [mg/L as $CaCO_3$]	**Total Dissolved Solids** [ppm]	**Chloride** [mg/L]	**Acid Radicals**	**Basic Radicals**	**Turbidity** [NTU]
Malunga									
M-1	7.6	451	14.5	-	312	14.18	√	√	×
M-2	7.3	439	18.0	-	-	12.89	√	√	×
M-3	7.4	439	17.5	-	275	14.18	√	√	×
M-4	7.1	432	16.0	7.5	-	10.31	√	√	×
M-5	7.4	447	15.0	7.0	357	10.31	√	√	×
M-6	7.5	447	16.5	-	-	14.18	√	√	×
M-7	7.3	443	16.0	-	296	11.6	√	√	×
Galyang									
G-1	7.7	391	18.0	-	425	9.024	√	√	
G-2	7.6	384	17.5	-	-	7.730	√	√	
G-3	7.4	406	18.0	-	378	7.730	√	√	
G-4	7.6	391	17.5	11.0	-	9.024	√	√	
G-5	7.5	410	18.0	10.5	276	6.450	√	√	
G-6	7.7	398	17.5	-	-	9.024	√	√	
G-7	7.5	395	18.0	-	488	9.024	√	√	
WHO Standards	**6.5 - 8.5***	**200-1500**	**<500**	**-**	**<1000**	**250**	**-**	**-**	
NDWQS-2005	**6.5 - 8.5***	**1500**	**500**	**-**	**<1000**	**<250**	**-**	**-**	

* These values show lower and upper limits

4. Conclusions

The quality of drinking water supplied to the local residents of two different places within the Galyang municipality of Syangja district was explored in detail. The major parameters that determine the potable quality of supplied water such as pH, electrical conductivity, suspended solids, chloride ion concentration, toxic metal ions, total hardness, and permanent hardness were investigated.

The data obtained from pH measurement revealed that the pH values of all samples were within the limits of safe drinking water. Similarly, the electrical conductivity values were also within the standard limits indicating that the water samples do not contain excessive amounts of ionic species that may contaminate the drinking water. Moreover, the presence of chloride, total hardness, and permanent hardness in both water samples was reported within the concentration limits specified for potable water. This suggests that the levels of these substances are within the acceptable range for drinking water, as advised by WHO and NDWQS.

Although the presence of acid and basic radicals was analyzed qualitatively, their actual concentrations could not be determined due to the presence of such species in micro gram or even lesser quantity in the collected one liter sample. Therefore, it was not possible to make a quantitative assessment of their impact on water potability based on the qualitative information only.

Since the observed values for most parameters (i.e., for pH, electrical conductivity, chloride ion concentration, total hardness and permanent hardness) fall within the limits specified by both the World Health Organization (WHO) and the National Drinking Water Quality Standards (NDWQS), the drinking water samples from Malunga and Galyang are likely to be considered potable. However, additional information on the concentration of acid and basic radicals would be necessary to make a comprehensive evaluation of the water sample's potability.

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