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RESEARCH ARTICLE

Assessment of Drinking Water Quality and Willingness to Pay for its Quality Improvement in Chitre, Parbat, Nepal

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Abstract

The study was conducted in Chitre village, Panchase area. Water samples from springs, reservoirs, and public taps were collected in April 2016, pre-monsoon season, to analyze various water quality parameters. A total of 17 samples were collected, comprising 9 from springs, 2 from reservoirs, and 6 from public taps. Parameters such as temperature, pH, electric conductivity, chloride, total alkalinity, total hardness, phosphate, ammonia, nitrate, iron and microbiological parameter i.e. total coliform were analyzed following the methods outlined in APHA. Contingent valuation method was used to examine the willingness to pay (WTP) of the respondents to improve drinking water quality. The physicochemical parameters results showed that all water sources had water quality within the permissible range as per Nepal Drinking Water Quality Standards (NDWQS-2006). Similarly, the microbiological analysis of water samples revealed the presence of total coliform in all samples and crossed the NDWQS. Therefore, the water was potable in terms of microbiological point of view in the study area only after disinfection. Contamination at the sources might be due to the lack of protection of springs, leakage in pipe distribution system and lack of proper cleaning of reservoirs. Of the 71 respondents, 97.18 % were willing to pay to improved drinking water quality. The computed mean willingness to pay amounts were NRs 59.95 per month per household. WTP was significantly related to the education, occupation, ethnicity, water quality perception and household water treatment practices. Study showed that there was a demand for an improvement in the drinking water quality.

Keywords: Drinking water; NDWQS; Water quality; Willingness to pay

Introduction

Natural resources are basic to life, water is one of them and water resource plays significant role in human societies [4]. But, 97.5 % of all the water on earth is saltwater, with remaining 2.5 % as freshwater. Around 70 % of the freshwater available on the planet is frozen in the icecaps of Antarctica and Greenland with remaining 0.7 % of the total water resources global accessible for direct human uses. from lakes, rivers, reservoirs and those underground sources that are shallow enough to be tapped at an affordable cost[18] Freshwater is mainly used for household use, agriculture and in industries. Comprehensive assessment of water management in agriculture revealed that one third of people are already facing water shortages [15]. Water resources are limited, the demand of water in most of the developing countries is ever increasing with the growth in population [17].

Safe and enough drinking-water, along with adequate sanitation and hygiene have implications across all Millennium Development

Goals (MDGs), from eradicating poverty and hunger, reducing child mortality, improving maternal health, combating infectious diseases and ensuring environmental sustainability [17]. Nepal, one of the developing countries struggles for availability and then quality of drinking water [8]. Still there are big gaps between demand and supply for water. Most of the people in the Himalaya use surface water for drinking, which is most vulnerable to pollution due to surface run-off. 76% population of Nepal have access to basic drinking water. i. e 81% of people who live in rural areas of Nepal have access to basic drinking water, only 13% have access to safely managed drinking water. Even in the richest households, only 26% have access to safely managed drinking water[19].People are being concerned with preventive behavior against the decline in tap water quality [3]. A substantial portion of Nepal's population is under a higher risk of fecal contamination [7]. This study intends to i) assess the water quality parameters of different sources in Chitre, of Modi Rural Municipality – 8,Parbat district, ii) compare with National Drinking Water Quality Standards (NDWQS - 2006)and iii) to assess people’s willingness to pay for improved drinking water quality. One of the most evident advantages of such improvement is that people can drink clean and safe water directly from the tap without using water-treatment equipment. Objective of this study was to analyze physiochemical and microbiological quality of drinking water from different sources in Chitre.

Materials and Methods

Study area

The study was carried out in Chitre, Modi Rural Municipality – 8,Parbat district of Nepal. Geographically, it is located in the mid hill of Nepal [24] .**(Fig. 1)** The altitude ranges 1120m to 2568m from sea level, GPS point is 28°15'20.43"N and 83°46'23.47"E at the peak of the Panchase hill location. The Panchase forest is major source of water for domestic and agricultural use in the surrounding communities. Chitre village comprises 435 households, 1740 of total population, among them 973 were female and 767 were male [14]. The previous or then Chitre Village Development Committee is ward No. 8 of Modi Rural Municipality, Parbat district at present.

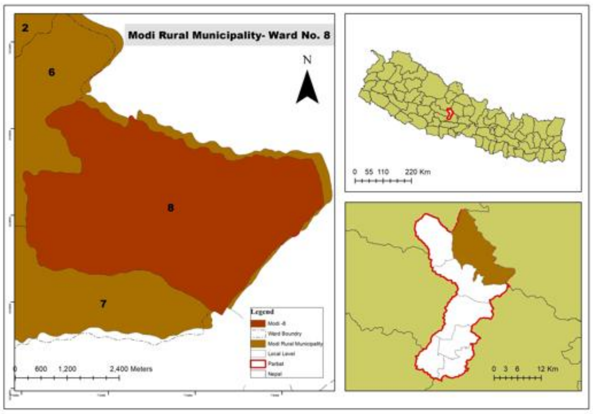

Fig. 1: Study Area Map

Household Survey

The first pre-field visit was conducted on 15th March 2016 which was focused on finding the main drinking sources and their current status by interaction with concerned village people. Key informant interview and questionnaire survey was carried out during field visit. Initially, key local stakeholders were consulted to ease identification of water sources and delineation of map with geographical locations. Questions were asked to four key informants. Household population of Chitre were obtained from [14] report for the structured questionnaire survey. The sample size (n) for the questionnaire survey was determined by using the following formula given by Arkin and Colton (1963) cited in [5] at 95% confidence level.

$$\text{Sample Size (n)} = \frac{N \times z^2 \times P(1-P)}{N \times d^2 + z^2 \times P(1-P)}$$

N = Total number of households (435)

z = value of standard variation at 95% confidence level (1.96)

P = estimated population proportion (0.5)

d = error limit of 5% (0.05)

The description of the house hold survey is as follows:

Table 1: Description of the household survey

S.N.	Ward Number	Total Number of Households	Sampled Households
1.	1	66	11
2.	2	35	6
3.	3	27	4
4.	4	32	5
5.	5	60	10
6.	6	69	11
7.	7	73	12
8.	8	44	7
9.	9	29	5
10.	**Total**	**435**	**71**

Physicochemical and microbiological parameters

Water sampling, preservation and storage

The source/spring, reservoir and taps most frequently used by local community people were sampled. Two samples from reservoir, nine samples from spring and six samples from tap of Chitre were collected in clean polythene bottles and brought to the laboratory. The temperature, pH, conductivity, chloride, hardness, alkalinity of the water samples was determined on the spot by using thermometer; pH meter, conductometer and chemical analysis was done. Various standard methods [23] were used for the determination of physical and chemical parameters. The samples were chemically preserved by the addition of 2 ml concentrated HNO_3 per liter of the sample for monitoring iron, NO_3-N, PO_4-P and NH_4-N contain in water sample. All samples were brought to the laboratory within a week and refrigerated (<4˚C but above freezing). The water samples for microbiological test were performed on the same day.

Physiochemical analysis of drinking water

a. Temperature: The temperature of air and water was measured by using a mercury filled Celsius thermometer. For determination of temperature, the sample water was collected in a beaker. Soon after the collection of the water sample, the thermometer was dipped into the water sample keeping the thermometer away from direct sunlight and noted the reading. While taking the reading, the scale of the thermometer was immersed in the water up to the level of mercury in the capillary column [23].

b. pH: For the determination of pH of water, water sample was taken in a clean beaker and electrode of pH meter was dipped into the water sample. Equilibrium between electrode and water sample was established by stirring water sample to ensure homogeneity. Then the reading of pH meter was noted [23].

c. Electrical conductivity: For measuring the conductivity of water, the electrode was rinsed with distilled water and dipped in the beaker containing the water sample. The reading was noted after the reading stabilized at a certain point.

d. Alkalinity: The alkalinities are determined by titrate the water sample with a strong acid 0.02 N HCl by using the indicators phenolphthalein at first and methyl orange at the second time. The volume of acid used with phenolphthalein indicator corresponds to phenolphthalein alkalinity and the whole of the acid used with both indicators corresponds to the total alkalinity. For the determination of alkalinity, 100 ml of sample was taken in a conical flask and 2 drops of phenolphthalein was added. When the solution remains, color disappeared. This gives phenolphthalein alkalinity. Then 2-3 drops of methyl orange were added to the same sample and titrated further until the yellow color changed to pink at end point. This gives total alkalinity [23].

Calculation PA as $CaCO_3$, mg/L

$$\text{PA as } CaCO_3\text{, mg/L} = \frac{(A \times Normality\ )of\ HCl \times 50}{Volume of sample\ in\ mL} \times 1000$$

$$\text{TA as } CaCO_3\text{, mg/L} = \frac{(B \times Normality\ )of\ HCl \times 50}{Volume of sample\ in\ mL} \times 1000$$

where,

A = mL of HCl used with only phenolphthalein

B= mL of total HCl used with phenolphthalein and methyl orange

N= Normality of HCl used

PA= Phenolphthalein Alkalinity &

TA= Total Alkalinity

e. Chloride: Chloride content of water was determined by "Argentometric method" in which water sample is titrated with 0.0282 N $AgNO_3$ using K_2CrO_4 as indicator. Fifty ml of water sample was taken in a conical flask and 2 ml of potassium chromate was added to it and stirred well. The content in the flask was titrated against $AgNO_3$ solution until persistent red tinge appeared. The chloride is calculated by the following equation [23].

Calculation

$$\text{Chloride(mg/L)} = \frac{(a - b\ ) \times N \times 35.5}{Volume of sample\ in\ mL}\ X1000$$

Where,

a= titrant value for water sample,

b= titrant value for distilled water,

N= Strength of $AgNO_3$

f. Hardness: For the determination of hardness, 50 ml of water sample was taken in a conical flask. Then 1 mL of ammonium buffer solution was added. If the water sample is having higher amounts of heavy metals, 1 ml of Na_2S should be added. Then 100-200 mg of Erichrome Black T was added, and the solution turned into wine red. The content was titrated against EDTA solution. At the end point color changed from wine red to blue. The hardness is calculated by the following equation [23].

$$\text{Hardness (EDTA) as mg } CaCO_3 = \frac{mL\ of\ EDTA\ used \times \mathrm{B}}{Volume\ of sample\ in\ mL} \times 1000$$

where, B = mg $CaCO_3$ equivalent to 1.00 mL of 0.01 M EDTA = 1

g. Calcium Hardness: For the determination of calcium, 50 mL water sample was taken. (If sample contains higher calcium, a small volume could be taken and diluted to 50 mL). 2 mL of NaOH solution and 100 mg-200 mg of murexide indicator was added that developed a pink color. It was titrated against EDTA solution (0.01 M) where pink color changed to purple at the end. It calculated by the following equation [23].

$$\text{Calcium, mg/L} = \frac{mL\ of\ EDTA\ \times 40.8}{Volume of sample\ in\ mL}$$

$$\text{Calcium, hardness as mg } CaCO_3 = \frac{\text{mL of EDTA used } \times \text{B}}{\text{Volumeofsample in mL}} \times 1000$$

where,

B = mg $CaCO_3$ equivalent to 1.00 mL

EDTA of 0.01 M at the calcium indicator end point = 1

h. Magnesium Hardness: Magnesium hardness can be estimated as the difference between hardness and calcium as $CaCO_3$, if interfering metals are present in non-interfering concentrations in the calcium titration. It is calculated by the following equation [23].

Magnesium hardness (mg/L) = [Total Hardness (as mg $CaCO_3$/L) – Calcium hardness (as mg $CaCO_3$/L)] x 0.243

i. Phosphate: For the determination of orthophosphate, 100 ml of filtered clear sample was taken in a volumetric flask. 2 ml of ammonium molybladate followed by 5 drops of stannous chloride solution was added to the flask. Blue color appeared after some time. The reading was taken at 690 nm on a spectrophotometer using a distilled water blank with the same amount of chemicals. The reading was taken after 5 minutes but before 12 minutes of the addition of the last reagent i.e. $SnCl_2$. Finally, the phosphate concentration of the sample was determined with the help of standard calibration curve.

j. Nitrate: Nitrate-Nitrogen is determined by phenol disulfonic acid method. 50 ml of filtered sample or an aliquot to remove chlorides (1 mg/l Cl = 1 ml Ag_2SO_4 solution). The content was heated slightly and filtered to remove the precipitate of $AgCl_2$. The filtrate was evaporated in a porcelain basin to dryness and cooled. 2 ml of phenol disulfonic acid was added to dissolve the residue and the contents was diluted to 50 ml. 6 ml of liquid ammonia was added to develop a yellow color. The reading was taken at 410 nm. The concentration of NO_3-N was calculated from the standard curve.

k. Ammonia: For the determination of Ammonia colorimetric method was used. 50 ml of filtered clear sample was taken in a volumetric flask. 1 ml of Phenol followed by 1 ml of Sodium nitropruside and 1 ml of oxidizing agent solution was added to the flask. The mouth of the flask was covered with aluminum foil and kept in the dark place for few minutes. Blue color appeared after some time. The reading was taken at 635 nm on a spectrophotometer using a distilled water blank with the same amount of chemicals. Finally, the ammonia concentration of the sample was determined with the help of standard calibration curve.

l. Iron: The iron contained in water is usually determined by Phenanthroline method 50 ml of water sample was taken in a conical flask. 2 ml of conc. HCl and 1 ml of Hydroxylamine hydrochloride solution was added to the sample. Some glass beads were added in the flask and heated. The content was boiled to half of the volume for dissolution of all the iron. 10 ml of Ammonium acetate buffer and 4 ml of Phenanthroline were added. An orange red color appeared. The volume was made 100 ml by adding distilled water and the flask was shaken well. The solution was kept for 10 minutes for maximum color development. The reading was taken for the absorbance at 510 nm on a spectrophotometer. The concentration of Fe was directly determined from the standard curve.

iii. Microbiological Analysis of Drinking Water

A water sample for microbiological examination was collected in bottles (poly reagent plastic bottles) that had been cleansed and sterilized by Autoclaving. Sample bottle for microbiological examination in one hand have been hold and removed the cap without touching the neck of the bottle. Without taking cap on any surface, bottled were filled with water leaving a small air gap. Flow rate of water did not alter at the time of sample collection. Sample bottles were placed in an ice box for transport to the laboratory of CDES (Central Department of Environmental Science, Tribhuvan University). Samples were delivered to the laboratory within a week of sampling. They were brought to the laboratory and total coliform were premeditated by using MPN method.

The Most Probable Number (MPN) method

In the multiple-tube method, a series of tubes containing a suitable selective broth culture medium is inoculated with test portions of a water sample. After a specified incubation time at a given temperature, each tube showing gas formation is regarded as "presumptive positive" since the gas indicates the possible presence of coliforms. However, gas may also be produced by other organisms, and so a subsequent confirmatory test is essential. The two tests are known respectively as the presumptive test and the confirmatory test. For the confirmatory test, a more selective culture medium is inoculated with material taken from the positive tubes. After an appropriate incubation time, the tubes are examined for gas formation as before. The most probable number (MPN) of bacteria present can then be estimated from the number of tubes inoculated and the number of positive tubes obtained in the confirmatory test, using specially devised statistical tables. This technique is known as the MPN method.

Total coliforms

The term "total coliforms" refers to a large group of Gram-negative, rod-shaped bacteria that share several characteristics [20]. The group includes thermotolerant coliforms and bacteria of faecal origin, as well as some bacteria that may be isolated from environmental sources. Thus, the presence of total coliforms may or may not indicate faecal contamination. In extreme cases, a high count for the total coliform group may be associated with a low, or even zero, count for thermotolerant coliforms. Such a result would not necessarily indicate the presence of faecal contamination. It might be caused by entry of soil or organic matter into the water or by conditions suitable for the growth of other types of coliform. In the laboratory total coliforms are grown in or on a medium containing lactose, at a temperature of 35°C or 37°C. They are provisionally identified by the production of acid and gas from the fermentation of lactose.

Water Quality Parameter through correlation coefficient

The mathematical models used to estimate water quality require two parameters to describe realistic water situations. In water quality it is used for the measurement of the strength and statistical significance of the relation between two or more parameters [20]. A systematic study of correlation and regression coefficients of the water quality parameters not only helps to assess the overall water quality but also to quantify relative concentration of various pollutants in water [1]. Correlation analysis measures the closeness of the relationship between chosen independent and dependent variables. Direct correlation exists when increase or decrease in the value of one parameter is associated with a corresponding increase or decrease in the value of the other parameter [21]. If the correlation is near to +1 or -1, it shows the probability of linear relationship between the variables and thereby provides a mechanism for prediction or forecasting [22].

Willingness to pay through contingent valuation method

This study used the structured questionnaire survey approach to elicit the willingness to pay. Firstly, an explanatory research among households' heads was performed to achieve a better idea about the variables that affect the household's WTP, which is an important key to elicit the range of values of WTP (the price tiers) by using close ended question. To reduce potential biases, clear information about questionnaire was delivered to all the respondents. To test the validity of the responses, the questionnaire contained questions about the respondents' demographic and socio-economic backgrounds as well. The WTP bid was model as a function of different potential, explanatory variables (age, gender, education, ethnicity, economic class, HH size, livestock unit, daily water consumption, house distance from water source, type of source, household water treatment practice, water quality perception and water shortage). Wealth status of the household is analyzed according to the VDCs report which was based on participatory rural appraisal method. For this, multiple linear regression model of the following form was used [2]:

$$WTP = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots + \beta_n X_n + e_i$$

where,

WTP is the willingness to pay for improvement in drinking water quality (dependent variable),

$\beta_0 \ldots\ldots \beta_n$ = the parameters estimated,

$X_1 \ldots\ldots X_n$ = explanatory variables influencing WTP and e_i = random error.

Statistical analysis

Qualitative and Quantitative form of data and information were coded and then entered for analysis, percentage table was interpreted. Statistical analysis such as t-test was also performed to study the relationship of the variables. Microsoft Excel and R (R Core Team, 2018) (Version 3.5.1) was used for the statistical analysis [16]

Results and Discussion

Mapping different sources of water

Various sources of drinking water such as stone spout /springs, reservoirs and taps were identified and mapped. For the purpose of survey, the location of water source was recorded using GPS **(Fig. 2)**. On the basis of public health risk, these sources were categorized into three groups i.e. low risk, high risk and very high risk. The map was delineated using those points through QGIS.

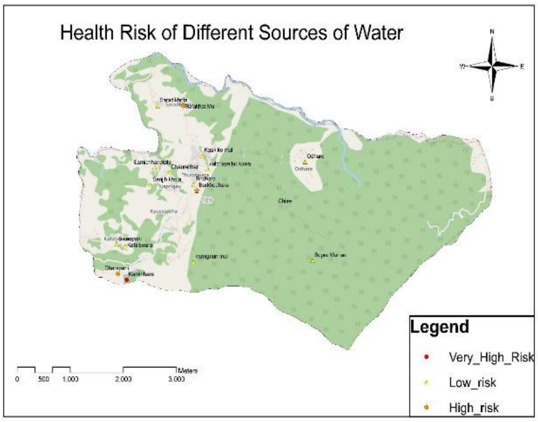

Fig. 2: Mapping of different types of drinking water source

Water quality assessment

Table 2: Comparison of measured parameters with NDWQS 2006

Parameters	Unit	Study Value Range	Mean	SD	NDWQS
A. Physical					
Temperature	°C	16-22.6	19.19	1.8	-
EC	µS/cm	18.36-41.5	25.74	6.98	1500
B. Chemical					
pH	-	6.5 -7.9	7.06	0.34	6.5-8.5
Chloride	mg/L	1.42-9.98	6.41	2.28	250
Total Hardness	mg/L	4-20	9.88	4.87	500
Calcium Hardness	mg/L	2-16	6.94	4.06	-
Magnesium Hardness	mg/L	2-4	2.94	1.02	-
Total Alkalinity	mg/L	15-40	26.17	7.97	-
Phosphate	mg/L	0.09-0.52	0.28	0.13	-
Nitrate	mg/L	0.19-0.62	0.35	0.14	50
Ammonia	mg/L	0.09-0.35	0.14	0.06	1.5
Iron	mg/L	0.2-0.4	0.31	0.05	0.3
C. Bacteriological					
Total coliform	MPN/100 mL	2-175	21.55	41.87	0 (In 95%)

Average result for water quality parameters were determined from the field and lab analysis. Results of all physical and chemical parameters of water samples lied within the NDWQS - 2006 guideline. The bacteriological parameter, total coliform showed the value above NDWQS – 2006 guideline (0 MPN/100 ml). The maximum, minimum, mean and standard deviation values and NDWQS drinking water standards of these parameters have been shown in **Table 2**.To protect public health, microbiological standards have to be met at each individual source, reservoir and tap. A total of 17 water samples were analyzed for presence of coliform by Most Probable Number technique. Water testing result showed high proportion of water samples to be contaminated. For the spring water, total coliform was recorded in a range of 7MPN/100ml to 175MPN/100ml. Similarly, for tap water total coliform was recorded in a range of 4MPN/100ml to 7MPN/100ml.**Table 3** shows the percentage of total coliform contamination for all 17 samples. The contaminated samples were also categorized to the risk grade in compliance with WHO guidelines for natural source, reservoir and tap water. The data revealed that there was low risk in reservoir and tap water but high risk in spring water.

Table 3: Range of Total coliform in natural source, reservoir and tap water sample in compliance with WHO guideline

Total Coliform	Risk Grade	Spring (n=9)	Reservoir (n=2)	Tap Water (n=6) %
0	A (No risk)	0	0	0
1-10	B (Low risk)	4	2	6
11-100	C (high)	4	0	0
101- >1000	D (Very high risk)	1	0	0

Correlation and Regression Analysis

The mathematical values of correlation coefficient, r for the twelve physicochemical water quality parameters are tabulated in **Table 4.** It is shown that single parameter analyzed has relationship with other parameters. To study the correlation the various water quality parameters, the regression analysis was carried out using R^2.Strong negative correlation was observed between pH and temperature (r= -0.72). Moderate negative correlation was observed between temperature and phosphate (r= -0.68), temperature and nitrate (r= -0.57) and pH iron (r=0.55).

Table 4: Correlation coefficient among various water quality parameter

	Temp	EC	pH	Cl^-	TA	TH	Ca-H	Mg-H	PO_4^{3-}	NO_3^-	NH_3	Fe_2^+
Temp	1											
EC	0.49	1										
pH	**-0.72**	-0.4	1									
Cl^-	-0.18	-0.1	0.3	1								
TA	0.01	-0.3	0.24	-0.2	1							
TH	0.03	-0	0.09	-0.05	0.8	1						
Ca-H	-0.03	0	0.06	0.01	0.7	1	1					
Mg-H	0.21	-0	0	-0.07	0.7	0.6	0.43	1				
PO_4^{3-}	-0.68	-0.3	0.71	0.36	0.1	0	0.03	0.11	1			
NO_3^-	-0.57	-0	0.55	-0.31	0	-0.1	-0.08	-0.24	0.47	1		
NH_3	0.07	0.18	0.23	-0.17	0.2	0	-0.09	0.42	0.2	0.26	1	
Fe_2^+	0.27	0.11	-0.6	-0.05	-0.5	-0.4	-0.34	-0.5	-0.56	-0.5	-0.4	1

Strong positive correlation was observed between total hardness and calcium hardness (r=0.98), pH and temperature (r=-0.72) and phosphate and pH (r=0.71). Similarly, strong positive correlation was observed between total hardness and total alkalinity (r=0.75). Moderate positive correlation was observed between total hardness and magnesium hardness (r=0.57). Same relation was observed between nitrate and pH (r=0.55).

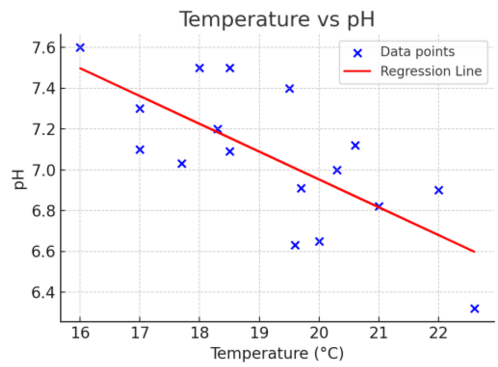

Fig. 3: Regression analysis between Temperature (°C) and pH

The regression analysis between Temperature (°C) and pH shows a moderate negative correlation, with the equation pH = 9.6782 - 0.1363 × Temperature**.** This suggests that for every 1°C increase in temperature, the pH decreases by approximately 0.1363. The R-squared value of 0.515 indicates that about 51.5%

of the variance in pH can be explained by temperature. The p-value for the slope is 0.001, which is statistically significant, confirming a meaningful relationship between the two variables. The intercept value of 9.6782 represents the expected pH when the temperature is 0°C, though it may not hold practical relevance. Overall, the analysis confirms a significant negative relationship between temperature and pH. Pant et al. in their study on the hydrogeochemistry in the Gandaki River Basin underscores the need for regular monitoring and management of water quality in areas with complex water systems like those in Nepal [9]. Pant et al. showed that during the lockdown, there was a reduction in industrial discharge and a slight improvement in water quality [10]. This aligns with the trends observed in this study as well (for instance, a drop in EC or changes in pH) if similar external factors influenced water quality during this study period. Thapa et al. (2020) in their study on spring water quality in the Jhimruk River watershed highlighted pH, EC, and Total Hardness (TH) as key parameters to assess the suitability of water for consumption [11]. The results from this study is showing pH levels and EC values fall in line with the conclusions of Thapa et al., emphasizing the need to maintain water quality standards for public health. Tiwari et al. (2023) looked at surface water quality in Pokhara and found significant issues with pollution levels in urban water bodies [11], which might be reflected in higher EC and varying pH in urban water systems.This could suggest that the water quality parameters in this study especially those related to urban or peri-urban areas, might show similar trends influenced by urbanization and human activities.

Factors influencing WTP

The WTP was regressed against all potential explanatory variables (full model), and variables with non-significant estimates ($p>0.05$) were excluded. Then, the WTP was regressed against the remaining variables (reduced model) presents parameter estimates and fit statistics. The best reduced model explained 56 % of the total variability of WTP, indicating that the estimated model was fairly satisfactory. Some of the explanatory variables were not significant ($p>0.05$). Higher WTP bids were highly significant with occupation and water quality perception of the respondent. Household drinking water treatment practice and ethnicity status of the respondents also played significant influence on the individual's WTP. The coefficient of determination of the model shows that 56.38 % of variations in WTP is attributed to the explanatory variables and the remaining 43.62 % is unexplained.

Relation of WTP and associated determinant factors

Table 5: Results of the regression analysis to the WTP model

Variable	Coefficient	Std Error	t-statistic	Pr (>|t|)
Constant	35.70	24.39	1.46	0.14
Education (Master)	74.42	32.45	2.293	0.025770 *
Occupation (Business)	73.366	18.46	3.974	0.000211 ***
Occupation (Service)	29.989	15.916	1.884	0.064923.
Ethnicity (Dalit)	-22.499	12.169	-1.849	0.069965.
Water quality perception (Poor)	196.862	51.069	3.855	0.000310 ***
Water treatment (No)	29.872	14.139	2.113	0.039256 *

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Residual standard error: 39.03 on 54 degrees of freedom

Multiple R-squared: 0.6635, Adjusted R-squared: 0.5638

F-statistic: 6.654 on 16 and 54 DF, p-value: 5.897e-08

R-squared (66.35%) shows that the model explains a substantial amount of variation in the dependent variable (pH). The adjusted R-squared value (56.38%) suggests a good fit after adjusting for the number of predictors. The F-statistic and its p-value (5.897e-08) indicate that the model as a whole is statistically significant, suggesting that temperature is a significant predictor of pH.

Conclusions

Analysis of water samples from various sources showed that the physicochemical parameters, including temperature, pH, chloride, and hardness, were within the NDWQS-2006 permissible range, indicating the water is safe for drinking. However, total coliform counts exceeded the acceptable limits, making the water non-potable from a bacteriological perspective. This contamination is likely due to inadequate cleaning of water tanks, poor sanitation, lack of source protection, leaks in the distribution system, and environmental factors. Water quality tends to degrade during the rainy season, increasing the risk of waterborne diseases. Contingent Valuation Method (CVM) revealed a demand for improved drinking water quality, with a mean Willingness to Pay (WTP) of NRs. 60 per household per month. WTP was significantly influenced by factors such as education, occupation, ethnicity, perception of water quality, and household water treatment practices. This indicates a potential to generate funds for sustainable drinking water quality improvement programs in Chitre. The study highlights the critical role of monitoring water quality parameters such as pH and EC to ensure safety and prevent health risks. Communities are more inclined to support water quality investments if they experience direct health benefits, fewer waterborne diseases, and reliable access to clean water. These findings can help estimate WTP levels in similar areas, fostering better water management strategies.

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Author’s Contribution Statement

Sarala Regmi: Conceptualization, Methodology, Investigation, Writing - Original Draft, **Prem Sagar Chapagain:** Data Curation, Formal analysis, Supervision, Validation, Visualization, **Yogesh Rana Magar:** Writing - Review & Editing.

Conflict of Interest

The authors do not have any conflict of interest throughout this research work.

Data Availability Statement

The data supporting this study's findings are available from the corresponding authors upon reasonable request.

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