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Distribution and classification of springs in Bansbari area of Melamchi Municipality, Sindhupalchowk, Nepal

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ABSTRACT

Springs are the primary source of drinking water and irrigation in hills and mountains in Nepal. In recent years, the life sustaining springs are reported to be drying and degrading in quality. However, there is a lack of information and knowledge in various aspects of springs in Nepal. This has limited the scope for groundwater development and management in hills and mountains. The present study focuses on identifying, surveying and keeping records of spring sources in the Bansbari area of Melamchi Municipality, Sindhupalchowk, Nepal, and intends to understand the distribution of springs in the area. Assessment of spring water quality and classification of springs is other major component of this study. Out of forty-one springs observed in the area, 85% are perennial and others are seasonal in nature. It is found that majority of the springs are located in the middle altitude ranging from 1000 to 1350 m above mean sea level and in moderate slope varying from 10° to 35°. In terms of land use, 37% are located in forest followed by 34% in bushes and 29% in agricultural land. In terms of stream density, 61% of springs are located in places with low stream density. In terms of type of deposit, 51% are located in colluviums, followed by 25% in rock and 24% in residual soil. The springs in the study area are classified as depression spring and fracture spring. They are mostly non-thermal with weakly mineralized water ranging from soft to hard. The general order of dominance of major cations in the sampled springs is $Ca^{2+}>Mg^{2+}>Na^{+}>K^{+}$ and major anions is $HCO_3^{-} > Cl^{-}>SO_4^{2-}$. Springs of magnitude fifth and less are observed in the study area with significant decrease of discharge in the dry season. Regular monitoring of spring discharges is recommended to quantify the groundwater in the area.

Keywords: Springs, Physical parameters, Chemical parameters, Discharge

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INTRODUCTION

People living in the hilly and mountainous region are mostly dependent upon spring water for their sustenance, primarily due to unreliable stream flow and degradation of surface water quality. Almost 80% of people in Nepal rely on springs as their primary source of water (CBS, 2012). The settlement pattern in the rural communities, usually clustered in mountain tops, is influenced by the availability of springs. In addition, springs play a vital role in improving livelihood and maintaining balance of the mid-hill ecosystem. The capacity of the aquifer to store and transmit groundwater directly reflects in the nature of spring discharge (Mahamuni and Upasani, 2011). Behaviour of a spring can only be administered and forecasted by studying their temporal discharge variation (Vashisth and Sharma, 2007). In recent years, the life-sustaining springs are vanishing and becoming seasonal indicating the widespread depletion of groundwater. Also, the spring water quality is reported to be deteriorating, being a serious issue for society and the environment. However, the studies on spring hydrogeology in the Nepal region of the Himalayas are very limited (Chinnasamy and Prathapar, 2016). Therefore, it seems necessary to create database on springs at local level so that effective planning, monitoring and protection of groundwater system can be carried out in hills and mountains.

International Union for Conservation of Nature (IUCN) Nepal has worked in Bangsing Deurali VDC, Syangja in 2013 and concluded that spring water discharge was basically controlled by geology, soil types, vegetation and land use patterns. They suggested that the existing forest areas should be restored and afforestation should be initiated to increase water yield in springs. ICIMOD (2015) in partnership with the Nepal Water Conservation Foundation (NWCF) has worked with the local communities in two villages of the Kavre District, Nepal to understand the relationship between rainfall, groundwater recharge and spring water availability, and implications on rural livlihoods. Advanced Centre for Water Resources Development and Management (ACWADAM) in partnership with ICIMOD has worked in Khar, Nepal in 2016 and provided the database on location, discharge, water quality and types of springs in the area along with the recharge measures. Paudel and Duex (2017) observed two main types of flow systems in the Thulokhola watershed of the Nuwakot District, a regional flow system present within metamorphic rocks and a local flow system present within younger unconsolidated

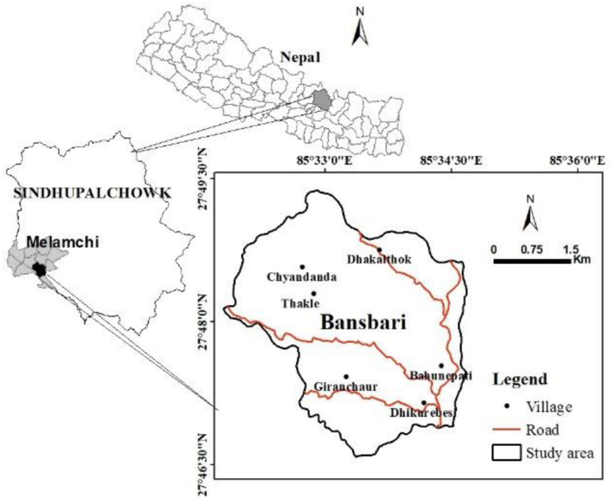

Fig. 1: Location Map of study area

sediments. They stated that groundwater moves slowly through the metamorphic rocks whereas the water flow is rapid in unconsolidated sediments.

The present study focuses on identifying, surveying and keeping records of spring sources in Bansbari area of Melamchi Municipality, Sindhupalchowk, Nepal and intends to understand the distribution of springs in the area. The in-situ tests for measuring pH, EC, TDS and temperature of all surveyed springs have been conducted and sampling of some selective spring has been done for chemical analysis in the laboratory. Eventually, classification of springs has been made based on geological features, discharge and physico-chemical parameters.

STUDY AREA

The study area (Fig. 1) comprises of Bansbari, a ward of Melamchi Municipality located in the Sindhupalchowk District, Nepal.

It is approximately 70 km north east from Kathmandu valley and can be easily reached via Araniko Highway and Melamchi-Helambu Road from the valley. The study area includes Dhikurebesi, Giranchaur, Bahunepati, Dhakalkhahare, Dhakalthok, Bansbari and Chyandada villages and covers an area about 15 sq. km. The major river in the area is the Indrawati River that originates from foothills around the Helambu area and flows from north to south direction. The other rivers include the Sindhu Khola, the Jarke Khola, the Dude Khola and the Dhuseni Khola.

METHODOLOGY

This research mainly carried out literature review, field work, laboratory work and data compilation and analysis. Topographical map (Sheet no. 2785 03 C) was used for extracting data for the preparation of DEM, slope, aspect and stream density map of the area. Data on location and discharge of springs, geology and type of deposit and land-use nearby springs were collected during the field work. The field work was conducted two times in 2018, initially in April, the driest period of the year and later during the rainy season (August) to measure the variation in spring discharge. The in-situ tests, for measuring pH, EC, TDS and temperature of all springs were conducted and sampling of eight representative springs was done in 500 ml bottle for laboratory analysis of chemical parameters. The concentrations of four major cations: Calcium, Magnesium, Sodium and Potassium, and three major anions: Bicarbonate, Sulfate and Chloride were measured. Eventually, further processing and analysis of these data were carried out by using different computer tools.

RESULTS AND DISCUSSION

Spring Distribution

Altogether forty-one springs were observed during the fieldwork, including flowing and non-flowing ones. 85% of the observed springs are perennial while 15% are temporary. The springs are coded as SP-1 to SP-41 referring spring source 1 to spring source 41 for easy study (Table 1). The distribution of springs in study area is shown in Fig. 2.

The distribution of springs in the study area has been studied with respect to geomorphology (elevation, aspect and slope), stream density, land use and type of deposit around spring sources.

Elevation

Digital Elevation Model (DEM) has been prepared by the use of the topographic map of the study area. At first, point elevation and the counter intervals of 20 m has been extracted from the map and eventually, DEM with a pixel size of 20 m x 20 m has been derived using "Raster Interpolation" tool in the GIS software. Later, it has been reclassified into three elevation zones. The spring locations have been overlaid over the reclassified DEM to study their inter-relationship (Fig. 3).

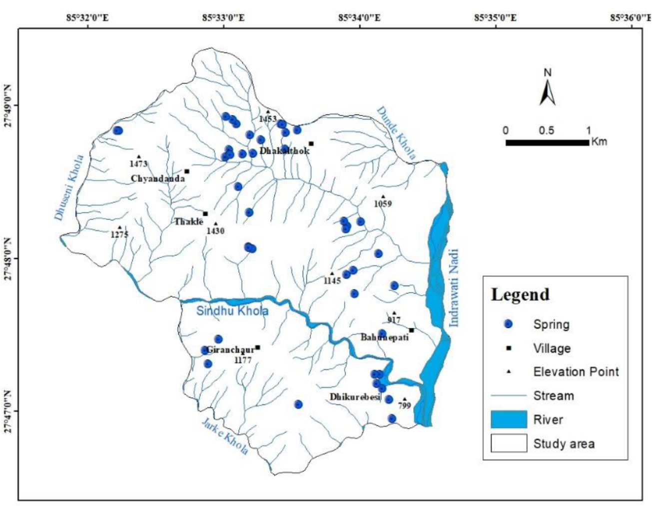

Fig. 2: Spring distribution map of the study area

Table 1: Information of springs of study area

Spring code	Local name of springs	Latitude	Longitude	Elevation (m)	Location
SP-1	NarkateMul	27°48'5.4"	85°33'12.5"	1205	Basbari
SP-2	-	27°48'4.8"	85°33'14.12"	1194	Basbari
SP-3	ManekholaMul	27°48'40.6"	85°33'1.7"	1201	Basbari
SP-4	KhahareKholaMul	27°48'43.6"	85°33'3.2"	1164	Basbari
SP-5	ThuloPadhero	27°47'55.2"	85°33'55.8"	1160	Nepalthok
SP-6	Chisopadhero	27°47'56.9"	85°33'58.7"	948	Nepalthok
SP-7	-	27°47'47.6"	85°33'59.2"	931	Nepalthok
SP-8	KabaseMul	27°48'16"	85°34'1.6"	954	Dhakalkhare
SP-9	BhoterumtiMul	27°48'14.1"	85°33'55.6"	930	Dhakalkhahare
SP-10	-	27°48'16"	85°33'54.2"	903	Dhakalkhahare
SP-11	-	27°48'12.9"	85°33'55.1"	922	Dhakhalkharae
SP-12	-	27°48'3.5"	85°34'9.7"	816	Dhakalkhahare
SP-13	-	27°47'10.7"	85°34'11.9"	767	Dhikurebesi
SP-14	-	27°47'6.2"	85°34'15"	760	Dhikurebesi
SP-15	SiyalePadhero	27°47'29.2"	85°32'59.6"	1113	Giranchaur
SP-16	-	27°47'24.8"	85°32'53.7"	1116	Giranchaur
SP-17	SimpanePadhero	27°47'19.5"	85°32'55.2"	1108	Giranchaur
SP-18	Dhobi Dhara	27°47'3.9"	85°33'35.1"	1070	Lamichanetol
SP-19	PokhareMul	27°48'51.5"	85°33'33.3"	1201	Dhakalthok
SP-20	BhateriMul	27°48'54"	85°33'26.4"	1272	Dhakalthok
SP-21	OpikoPadhero	27°48'53.7"	85°33'26.8"	1265	Dhakalthok
SP-22	KulmaneMul	27°48'49.5"	85°33'12.4"	1289	Dhakalthok
SP-23	DhakalThokMul	27°48'53.8"	85°33'6.2"	1291	Dhakalthok
SP-24	KhareMul	27°48'55.5"	85°33'4.7"	1290	Dhakalthok
SP-25	ThakleMul	27°48'56.5"	85°33'1.6"	1345	Thakle
SP-26	LatiKholsiMul	27°48'47.5"	85°33'17.3"	1266	Dhakalthok
SP-27	-	27°48'41.5"	85°33'3.9"	1153	Dhakalthok
SP-28	KolePahiro	27°48'42"	85°33'9.1"	1157	Dhakalthok
SP-29	-	27°48'42.2"	85°33'13.9"	1165	Dhakalthok
SP-30	ParigharePahiro	27°48'44.1"	85°33'28.0"	1175	Dhakalthok
SP-31	-	27°48'29.0"	85°33'7.5"	1173	Basbari
SP-32	ThuloPadhero	27°48'19.1"	85°33'12.4"	1297	Pipalchaur
SP-33	KhaniKholaMul	27°48'50.6"	85°32'14.5"	1460	Chyandada
SP-34	Khani Kola Mul	27°48'50.6"	85°32'13.6"	1454	Chyandada
SP-35	-	27°48'5.2"	85°33'12.5"	1195	Bansbari
SP-36	-	7°47'16.14"	85°34'8.62"	761	Dhikurebesi
SP-37	-	27°47'50.9"	85°34'16.8"	796	Baunepati
SP-38	-	7°47'12.56"	85°34'9.64"	766	Dhikurebesi
SP-39	-	27°47'16.2"	85°34'10.8"	753	Dhikurebesi
SP-40	-	27°46'52.8"	85°34'14.7"	749	Kirtetar
SP-41	Bhorlakorukh	27°47'32.2"	85°34'11.6"	763	Majhigau

The study shows that 59 % of the observed springs are located in the medium elevation zone ranging from 1000 to 1350 m followed by 24 % in the low elevation zone ranging from 740 to 1000 m and 17 % in the high elevation zone ranging from 1350 to 1758 m. Precipitation received at topographic highs infiltrate through the earth surface to the lower elevation and emerges as springs in the topographic depressions/zones of weaknesses in rocks (Khadka, 2017).

Slope aspect

Aspect map of the study area has been prepared from DEM by the use of surface tools in GIS and has the same pixel size as DEM. The aspect map of the study area is reclassified into nine different classes; flat, north, northeast, east, southeast, south, southwest, west and northwest. The spring locations overlay over the reclassified aspect map shows that 29% of the observed springs are located in the south aspect, followed by 20% in both southeast and northeast aspect, and 12% in east aspect.

Slope

Similar to that of the aspect map, DEM has been used to prepare the slope map of the study area. The slope map of the study area is reclassified into three classes: gentle, moderate and steep. The spring locations overlay over the reclassified slope map shows that majority of the surveyed springs (76 %) are located in moderate slope varying from 10° to 35° followed by 22 % in steep slope, varying from 35° to 56.2° and 2 % in gentle slope, varying from 0° to 10°. This is attributed to the fact that such slopes reduce the velocity of run-off, increases contact time with the ground and impart higher infiltration. Very few springs are observed in steep slopes as there is less possibility of water infiltrating into the ground at steeper groundwater surface favoring overland flow (Pathak and Shrestha, 2016).

Stream Density

Stream density refers to the total length of all streams in any boundary divided by the total area of that boundary and is

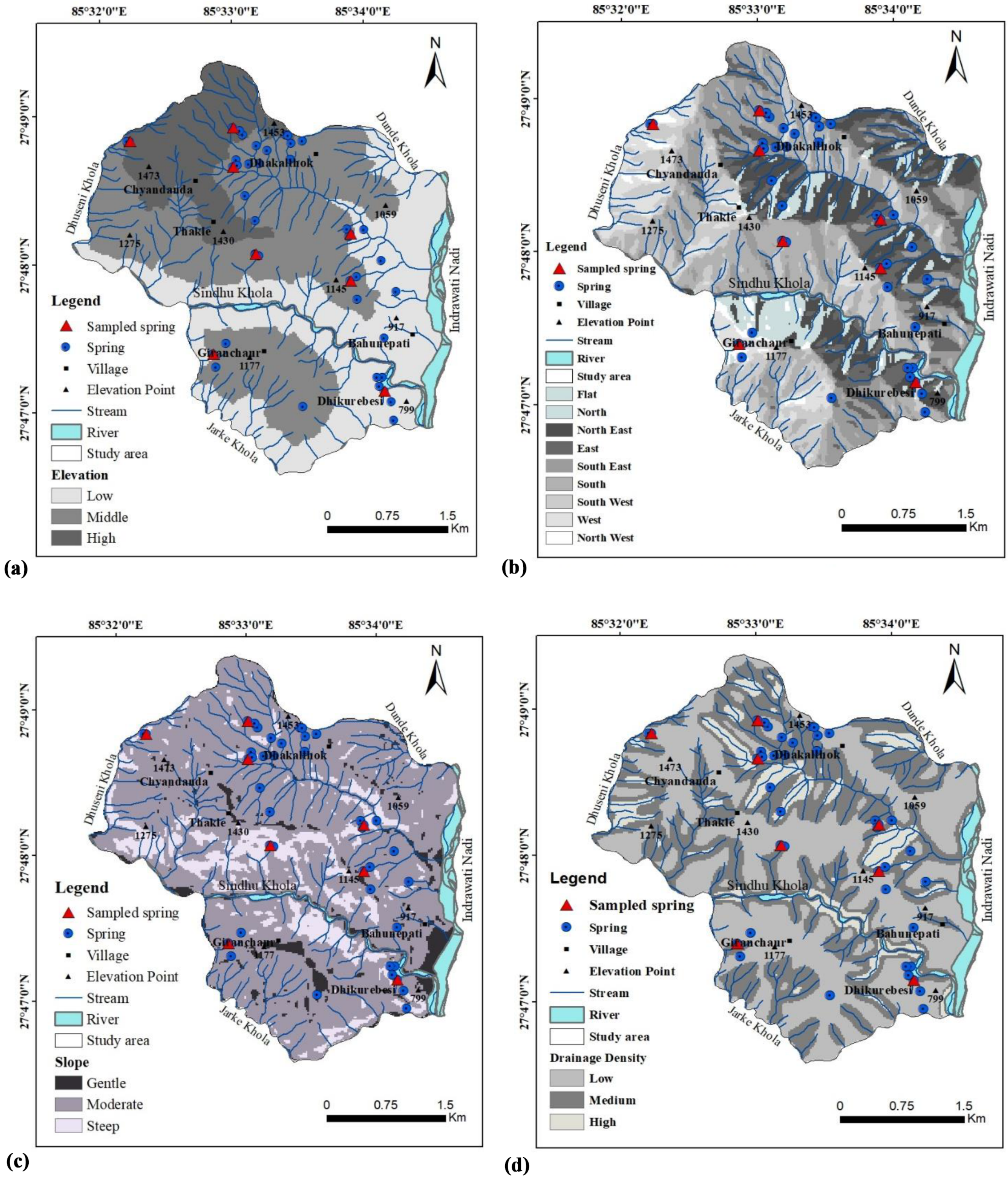

Fig. 3: a) Digital Elevation Model, b) Aspect map, c) Slope map, and d) Drainage density map of the study area with spring locations

expressed in m/m². The stream density map of the study area is prepared in the GIS using the Kernel density tool and is reclassified into Low, Medium and High. The spring locations overlay over the reclassified drainage density map shows that majority of the surveyed springs (61 %) are located in places with low stream density followed by 32 % in places with medium stream density and 7 % in places with high stream density. The places with low stream density show higher number of springs.

Land use

The study of inter-relationship of land use and distribution of springs in the area shows that 37 % of springs are located in forestland, followed by 34 % in bush/grassland land and about 29 % in agricultural land. Forest traps the rainfall; increases the contact time with the ground and loosen the ground through their roots. All these factors enhance infiltration and increase the water availability in springs.

Type of deposit

The study of inter-relationship of type of deposit and distribution of springs in the study area shows that majority of the springs i.e. 51 % are located in colluvial deposits, followed by 25 % in rock and 24 % in residual soil deposits. This is attributed to the fact that colluvial deposits have greater porosity and permeability favoring the flow of groundwater and emergence of springs.

Classification of spring

Discharge

The discharge measurement of seventeen feasible springs has been carried out in dry and rainy season. The variation in discharge of these springs during the two seasons is shown in Fig. 4. Mean discharge of each spring ranges from 0.02 to 1.1 lps in the study area. The springs are classified as the fifth, sixth and seventh magnitude springs under classification system of Meinzer (1923). Most probably, the aquifer feeding these springs are unconfined and shallow in nature as suggested by increase in discharges of these springs right after the intensive rain. It further suggests that precipitation is the major source of groundwater recharge in the area. SP-24 (Khare Khola Mul) at Dhakalthok is the largest spring with highest average discharge in the area.

Geology

The study area lies in the Higher Himalayan Zone and is covered by Talamarang Formation(Fig. 5, Dhital et al., 2002). The part of study area south to the Sindhu Khola exhibits medium to thick bedded, slightly weathered and mostly medium- to coarse-grained schist. The major minerals are muscovite, biotite, feldspar and quartz while garnet is also observed at the Dhikurebesi village showing presence of biotite to garnet grade schist. The part of the study area north to the Sindhu Khola exhibits highly weathered and fractured, fine- to medium-grained banded gneiss and augen gneiss. The dipping trend of the rock sequence has been observed to be northwest to northeast with dip amount ranging from 10° to 60°. These rocks are overlain by Pleistocene to Holocene alluvial and colluvial deposits. Most of the surveyed springs in the study area emerge from the unconsolidated sediments due to depression of the land surface down to or below water table. They are either in the form of concentrated discharge or pools of water or seeps (Fig. 6). Other springs in the study area are observed along planes of weakness in rock, especially bedding, foliations and joint. The springs in the study area, thus, are classified as depression springs and fracture spring under classification system of Fetter, 1980 and Kresic and Stevanovic (2010).

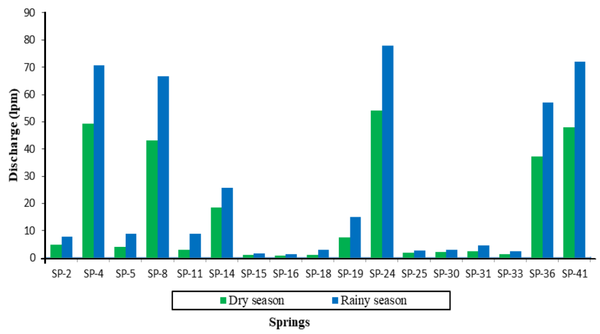

Fig. 4: Bar graph showing variation of spring discharge in dry and rainy season

Open joints/fractures were observed in gneisses and mica-schist in the Majhigau, Dhakalthok, Dhakalkhahare, and Chyandada villages located in northern parts of the study area unlike schist exposed in southern parts. The degree of weathering is also high in rock outcrops in these villages in comparison to the southern parts (Fig. 7). Likewise, greater numbers of springs, mostly perennial in nature, have been observed in these villages with relatively higher discharge.

The highest yielding springs SP-8 (Kulmane Mul) at Dhakalkhahare, SP-24 (Mane Khola Mul) at Dhakalthok and SP-41 (Bhorlakorukh Mul) at Majhigau emerge from planes of weaknesses in schists and gneiss. In contrast, Lamichannetol and Giranchaur villages in the southern part of the study area have few springs with low discharge. The greater number and high yield of springs in the northern parts can be correlated with the high degree of weathering and fracturing of gneisses in area. This shows that the occurrence and discharge of springs is influenced by the spatial variation in geology (Chinnasamy and Prathapar, 2016).

Physico-chemical parameters

In-situ tests of thirty-five springs were carried out, during the field work in April, to measure the physico-chemical parameters (pH, EC, TDS and temperature) of the spring water (Table 2). The study shows that the pH of the spring water ranges from 6.07 at SP-5 (Thulo Padhero), Nepalthok to 7.85 at SP-10, Dhakalkhahare with an average value of 6.97. EC of the spring water ranges from 50 µS/cm, (SP-9, Bhoterumti Mul) at Dhakalkhahare to 440 µS/cm (SP-16) at Giranchaur with an average value of 120.3µS/cm while TDS of the spring water ranges from 30 µS/cm (SP-9, Bhoterumti Mul) at Dhakalkhahare to 260 µS/cm (SP-16) at Giranchaur with an average value of 65.3 µS/cm. Similarly, the temperature of the spring water ranges from 17.9°C at Dhakalthok (SP-24, Khare Mul) to 26.4°C at Bahunepati (SP-17) with an average value of 20.1°C. Thus, springs in the area are classified as non-thermal springs having

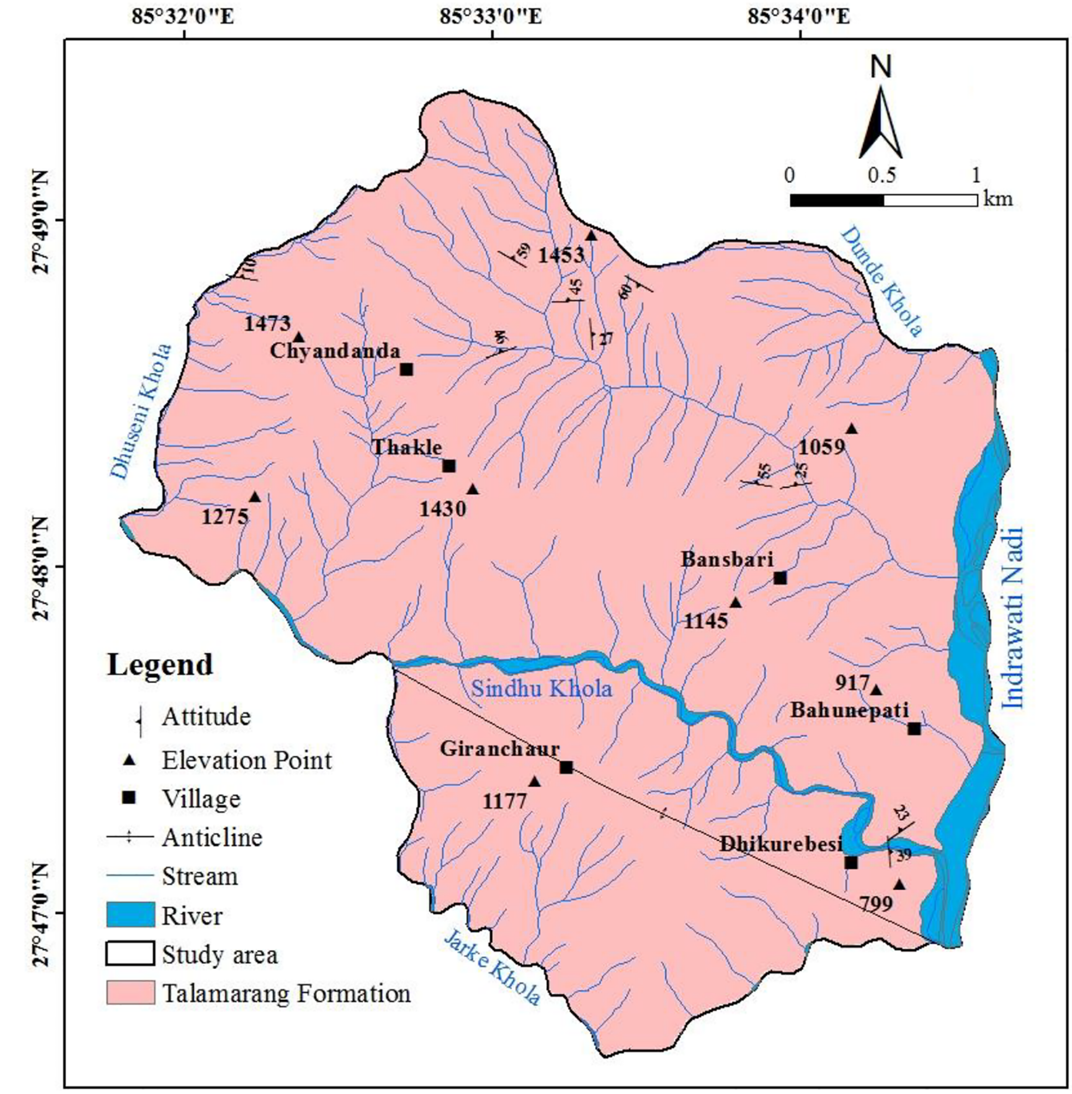

Fig. 5: Geological map of the study area (after Dhital et al., 2002)

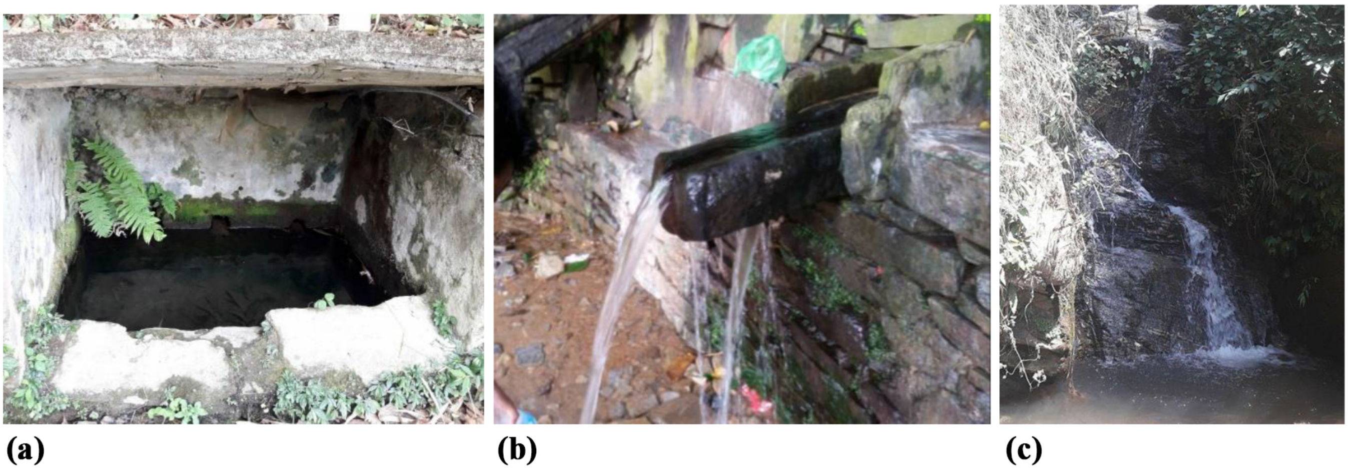

Fig. 6: Springs observed in the study area: (a) Depression spring at Dhakalthok, Latikholsi Mul. (b) Fracture spring at Majhigau Bhorlakorukh Mul. and (c) Fracture spring at Chyandanda, Khani Khola Mul

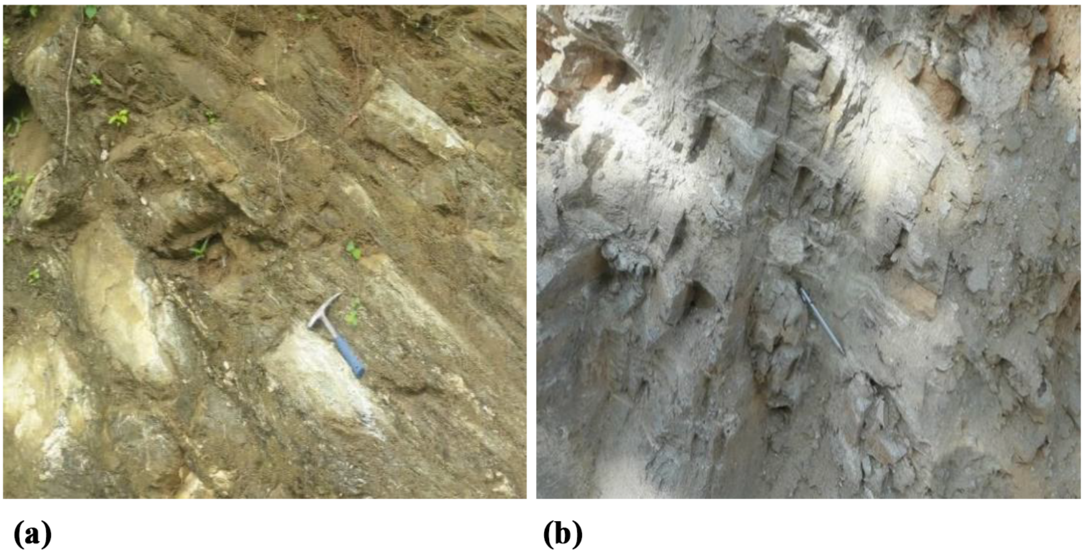

Fig. 7: Rock exposures in the study area: (a) mica-schist exposed at southern part, Dhikurebesi and (b) completely weathered banded gneiss at northern part, Dhakalthok

Table 2: In situ physical parameters (Dry seasons

Spring Code	pH	EC (s/cm)	TDS (g/l)	Temperature (°C)
SP-1	6.7	100	60	23
SP-2	6.8	100	45	21
SP-3	6.95	90	50	19.5
SP-4	8.05	80	40	20.1
SP-5	6.07	190	110	22
SP-6	6.2	120	80	21.5
SP-7	7.54	100	50	21
SP-8	7.74	90	50	21.5
SP-9	7.41	50	30	18.9
SP-10	7.85	50	50	22.6
SP-11	7.54	400	200	20.8
SP-12	7.2	90	60	20.1
SP-13	6.24	130	70	21
SP-14	6.54	120	60	20.2
SP-15	6.83	130	70	21.5
SP-16	6.9	440	260	20.4
SP-17	6.7	110	70	21.2
SP-18	6.8	100	60	19.8
SP-19	6.9	110	60	20.1
SP-20	6.93	90	40	21.2
SP-22	6.93	80	40	23
SP-23	6.9	90	40	22
SP-24	7.05	70	30	18
SP-25	7.06	90	40	22.2
SP-26	7.05	60	40	20.5
SP-27	7.06	90	40	19.7
SP-29	7.01	100	50	20.2
SP-30	7.04	140	70	21.4
SP-31	6.98	90	60	19.9
SP-32	7.09	60	30	19.5
SP-33	7.05	90	30	18.5
SP-34	7.03	110	60	18.2
SP-37	6.9	90	50	25.8
SP-39	7.01	90	40	23.5
SP-41	6.78	270	150	22.8

weakly to very weakly mineralized water under classification system of Detay (1997). The spring SP-34 (Khani Khola Mul) at an altitude of 1460 m has temperature of 18.2°C while SP-36 at an altitude of 796 m has temperature of 26.4°C. The consistency of temperature of the spring water with the atmospheric temperature indicates that the springs in the study area are fed by shallow aquifer.

Chemical parameters

Spring water was sampled from eight representative springs (SP-1, SP-3, SP-5, SP-9, SP-13, SP-16, SP-26, SP-34) to determine the concentration of major cations i.e. Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} and major anions i.e. HCO_3^-, SO_4^{2-} and Cl- (Fig. 8). The general order of dominance of major cations and anions is $Ca^{2+}>Mg^{2+}>Na^{+}>K^{+}$ and $HCO_3^->Cl^->SO_4^{2-}$ respectively.

The concentration of Calcium is maximum at SP-16 (Giranchaur) with value of 100 mg/l and minimum at SP-9 (Bhoterumti Mul) and Dhakalkhahare with value of 25 mg/l (Fig. 9). The concentration of Magnesium is maximum at SP-16, Giranchaur with value of 60 mg/l and minimum at SP-5 (Thulo Padhero), Nepalthok and SP-9 (Bhoterumti Mul), Dhakalkhahare with value of 15 mg/l. Likewise, the concentration of sodium is maximum at SP-16, Giranchaur with value of 30.26 mg/l and minimum at SP-34 (Khani Khola Mul), Chyandada with value of 16.23 mg/l. The concentration of potassium is maximum at SP-16, Giranchaur with value of 6.65 mg/l and minimum at SP-1 (Narkate Mul), Bansbari with value of 2.46 mg/l.

The concentration of bicarbonate is maximum at SP-16, Giranchaur with value of 85 mg/l and minimum at SP-1 (Narkate Mul), Bansbari and SP-26 (Lati Kolsi Mul), Dhakalthok with

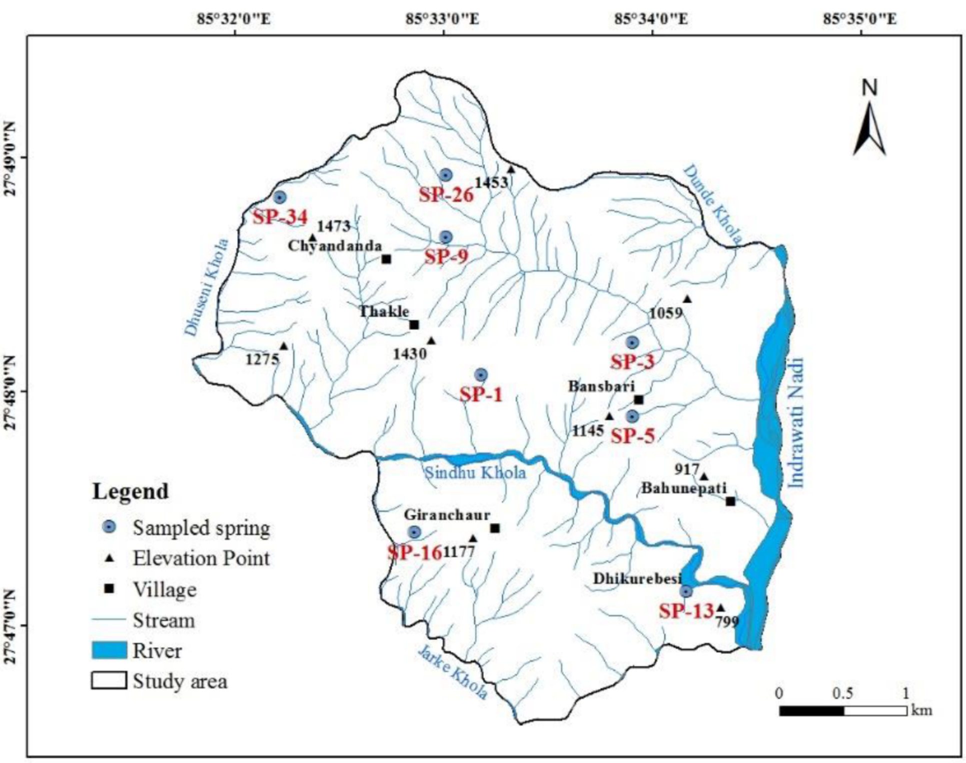

Fig. 8: Location of sampled spring for chemical analysis

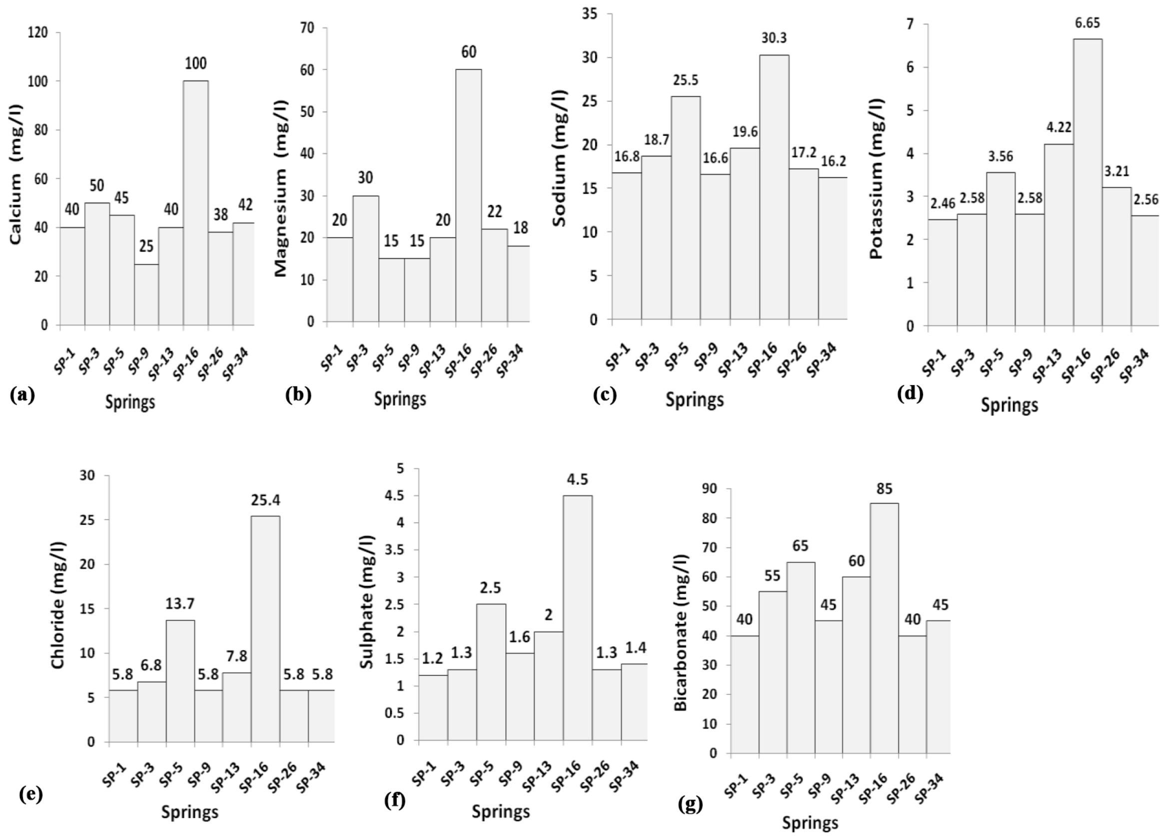

Fig. 9: Bar-graph showing concentrations of major cations and anions in the sampled spings:va) Ca^{2+}, (b) Mg^{2+}, (c) Na^{+} (d) K^{+} (e) Cl^{-} (f) SO_4^{2-}, and (g) HCO_3^{-}

value of 40 mg/l. The concentration of sulphate is maximum at SP-16, Giranchaur with value of 4.5 mg/l and minimum at SP-1 (Narkate Mul), Bansbari with value of 1.2 mg/l. Likewise, the concentration of chloride is a maximum at SP-16, Giranchaur with value of 25.4 mg/l and minimum at SP-1 (Narkate Mul, Bansbari), SP-26 (Lati Kolsi Mul, Dhakalthok) and SP-34 (Khani Khola Mul, Chyandada) with value of 5.8 mg/l.

The high concentration of calcium, magnesium and bicarbonate in the spring SP-16 at Giranchaur in comparison to other sampled springs can be correlated with the occurrence of few bands of white or pale green, sporadically calcareous quartzite in the area (Dhital et al., 2002).

The hardness (mg/l as $CaCO_3$) of the sampled springs in the study area ranges from 40 to 160 mg/l and are classified as soft to hard water under classification system of Sawyer and McCarty, 1967. SP-16 at Giranchaur is the hard water spring. SP-3 (Mane Khola Mul) at Bansbari is the moderately hard water spring.

The classification of sampled springs based on hydro-chemical facies has been carried out by plotting the values of the major cations and anions on Piper diagram (Piper, 1944). The piper diagram has been prepared through macro-programming in excels. The middle diamond plot of Piper diagram is analyzed for identifying the types of groundwater sample. Samples in the top quadrant are calcium sulfate waters, samples in the left quadrant are calcium bicarbonate waters, samples in the right quadrant are sodium chloride waters and samples in the bottom quadrant are sodium bicarbonate waters.

The piper diagram (Fig. 10) shows that all the eight spring-water samples in the study area are clustered in the left quadrant of the diamond indicating Ca-HCO_3 water type. The presence of Ca-HCO_3 water type in all sampled springs gives the indication that the springs are fed by fresh water shallow aquifer.

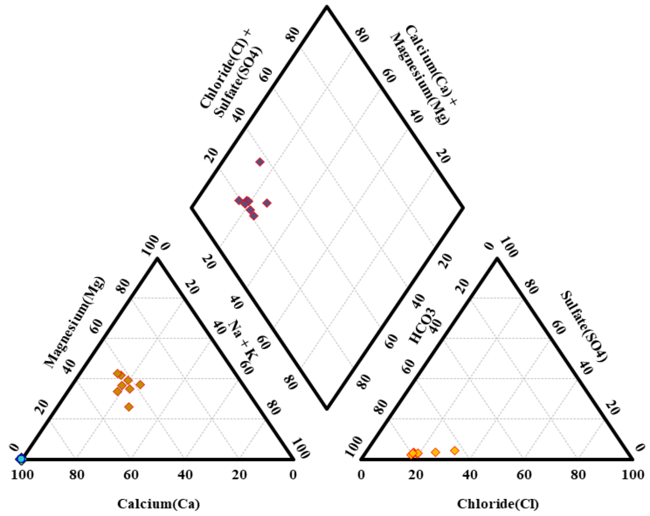

Fig. 10: Piper Plot of the sampled springs

CONCLUSIONS

Altogether forty-one springs have been observed in the study area, including flowing and non-flowing ones. Majority of them are perennial and located in forests, at elevation 1250 to 1400 m above mean sea level and in slope varying from 25° to 35°. Mostly, they emerge from colluvial deposits and fractured schist and gneiss and lie in places with low stream density. Conditions favoring the infiltration and reducing runoff govern the occurrence and distribution of springs.

Springs in the study area are classified as non-thermal springs with weakly mineralized water ranging from soft to hard. Based on geology, the springs of the area are classified into: depression spring and fracture spring. Based on discharge, springs of magnitude fifth and less are observed in the study area. The discharge of spring significantly rises in the rainy season suggesting that precipitation is the major source of groundwater recharge in the area. The lower values of EC and TDS of the spring water, as measured during the field work, also suggest the same. The general order of dominance of major cations are $Ca^{2+}>Mg^{2+}>Na^{+}>K^{+}$ and anions are $HCO_3^{-}>Cl^{-}>SO_4^{2-}$. The presence of Ca-$HCO_3$ water type in all sampled springs indicates that the springs are fed by fresh water shallow aquifer. Also, the temperature of the spring water is coherent with the atmospheric temperature which also gives the same indication. Regular monitoring of spring discharges is suggested to quantify the groundwater in the area and find out the potential of the aquifers.

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