केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

In Spiti Valley,Lahul & Spiti District
Himachal Pradseh

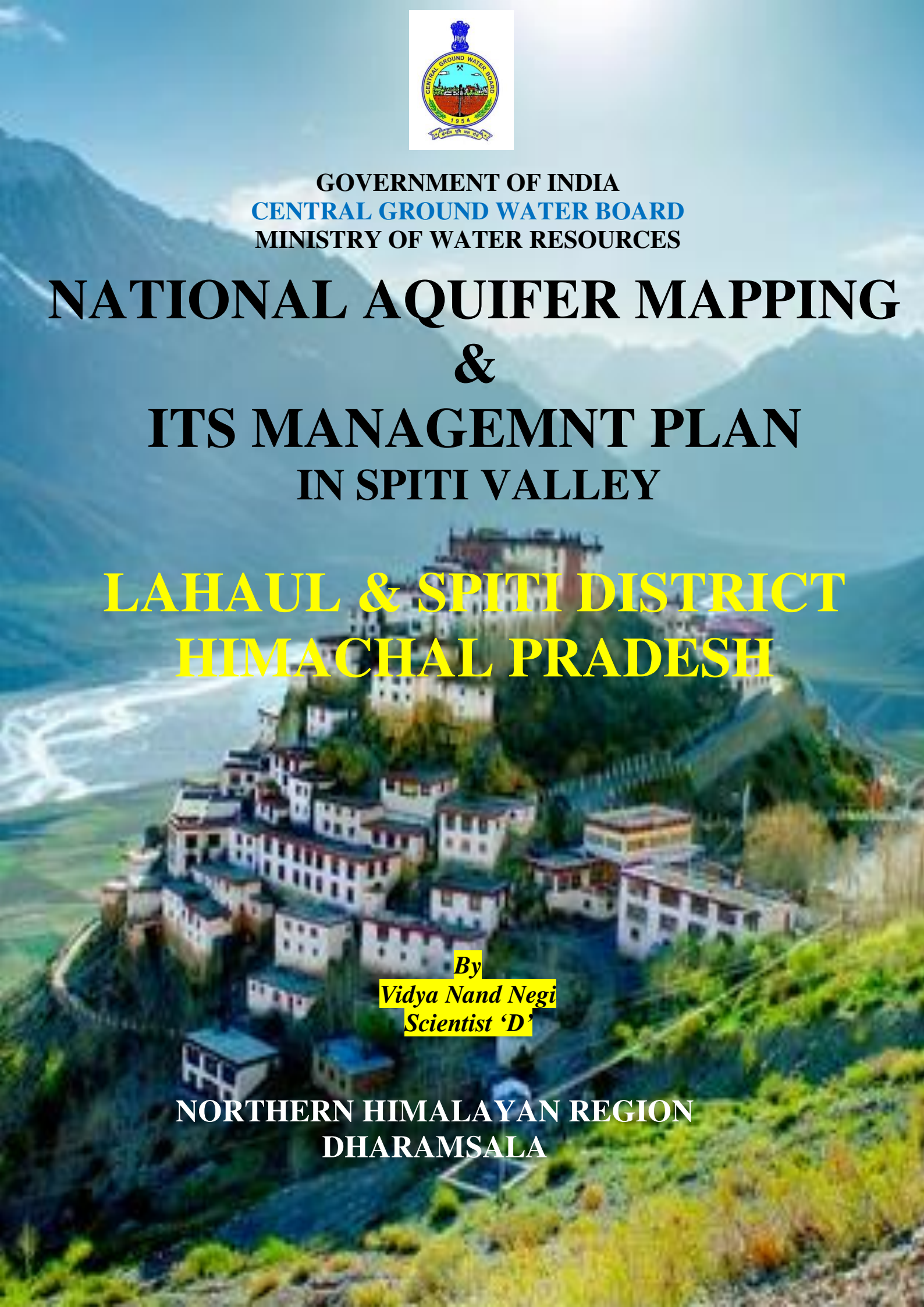
उत्तरी हिमालयी क्षेत्र, धर्मशाला

Northern Himalayan Region, Dharamshala

GOVERNMENT OF INDIA
CENTRAL GROUND WATER BOARD
MINISTRY OF WATER RESOURCES

NATIONAL AQUIFER MAPPING
&
ITS MANAGEMNT PLAN
IN SPITI VALLEY

LAHAUL & SPITI DISTRICT
HIMACHAL PRADESH



By
Vidya Nand Negi
Scientist 'D'

NORTHERN HIMALAYAN REGION
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1.0 INTRODUCTION

1.1 Purpose and scope

The National Aquifer Mapping Studies envisages integration of information available on soil types, agro-climatic conditions, geomorphology, geology, hydrogeology, hydrochemistry, cropping pattern, irrigation statistics, forest cover etc on a GIS platform and formulation of the ground water management plan for individual units of optimal size in accordance with the nature of the aquifer, its quality of water, sustainability and stress on the resource.

With these aims, Aquifer Mapping Study was carried out in Spiti valley, district Lahaul & Spiti under Annual Action Programme 2014-15. These surveys are made to integrate the information on the scenario of groundwater occurrence, availability and utilization in terms of quality and quantity along with exploratory drilling, monitoring of water levels with quality, pumping tests, infiltration tests, geophysical surveys etc.

Development of aquifer mapping at the appropriate scale and formulation of sustainable management plan will help in achieving drinking water security, improving irrigation facility and sustainability of water resources development. It will also result in better management of vulnerable areas.

During this study, 12 key observation points (Springs & Hand fitted umps) were established. Subsequently, all the available data of ground water from the earlier studies are compiled and integrated with these studies. This report brings out the ground water scenario, lateral & vertical characteristics of the aquifer and suggests better management plan of ground water in scientific manner.

1.2 Location, Extent and Accessibility

The Aquifer mapping area, i.e. Spiti valley falls along the Spiti River in Lahaul & Spiti district, which is one of the northeastern district of Himachal Pradesh lying 31°44'57" & 32° 59'57" North latitudes and 76°46'29" & 78°41'34" East longitudes (Fig. 1). It falls in survey of India degree sheet Nos. 52L & 52H and covers area of 122 sq. km.

The complete valley area falls in Kaza block (Fig.1).

There are three routes leading to Spiti Valley. The most picturesque approach is from Manali (Kulu valley) over the Rohtang pass through the Lahaul valley and across the Baralacha (4938 m) and Balamo (4629 m) passes. The second route also takes off from Manali. It lies over the Hampta pass (4629 m) into the Chandra valley and then over the Kunzam pass into Spiti. The third route, open almost year round takes off from the Hindustan-Tibet road from Sumdo in Kinnaur district, but this is much longer and the most part is dull and uninteresting.

1.3 Administrative divisions, Demographic particulars

According to the 2011 census, the Lahaul and Spiti district has a population of 31,564. This gives it a ranking of 638th in India (out of a total of 640). The district has a

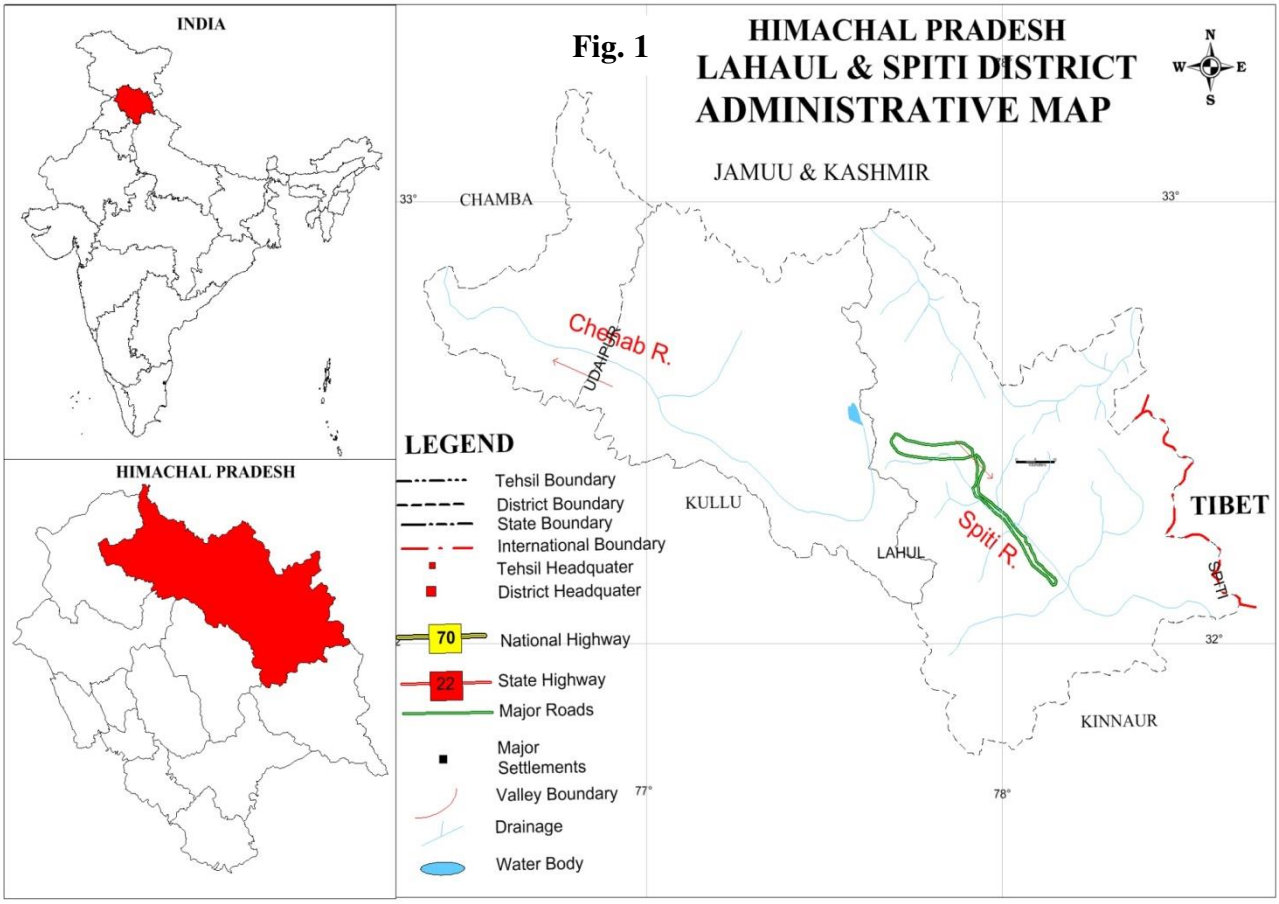


Fig. 1

population density of 2 inhabitants per square kilometre (5.2/sq mi). Its population growth rate over the decade 2001-2011 was -5%. Lahul and Spiti has a sex ratio of 903 females for every 1000 males, and a literacy rate of 76.81%.

According to 2011 census of India, Total Spiti population is 12,457 people are living in this Tehsil, of which 6,691 are male and 5,766 are female. Population of Spiti in 2021 is 15,447 Literate people are 8,726 out of 5,182 are male and 3,544 are female. Total workers are 7,112 depends on multi skills out of which 4,120 are men and 2,992 are women. Total 1,284 Cultivators are depended on agriculture farming out of 587 are cultivated by men and 697 are women. 112 people works in agricultural land as a labour in Spiti, men are 58 and 54 are women.

The detailed population statistics for last 100 years of Lahaul & Spiti district is given in Table-1.

Table 1. Population statistics in Lahaul & Spiti district.

Year	Pop.	±% p.a.
1901	12,392	—
1911	12,981	+0.47%
1921	12,836	−0.11%
1931	13,733	+0.68%
1941	14,594	+0.61%
1951	15,338	+0.50%
1961	23,682	+4.44%
1971	27,568	+1.53%
1981	32,100	+1.53%
1991	31,294	−0.25%
2001	33,224	+0.60%
2011	31,564	−0.51%

1.4 Soil, Land use, irrigation and cropping pattern

Most of the soils in Spiti valley are of alpine sward nature. The upper stratum of earth and vegetable mould is filled with decomposed roots of grass and small plants. The depth of the fertile undisturbed horizon varies from 0.3 to 0.6 m. At lower slopes, the thickness of this fertile soil horizon is more (Fig 2).

The topography, climate and other natural factors determine the utilization of land to a considerable extent. In Spiti valley, there are no natural forests though efforts are being made under desert development project to bring more and more area under green cover. The landuse pattern of the area for the year 2002-2003 is given below in Table – 2 & Fig. 3.

Table 2. Land use pattern in Spiti valley

Land use	Area (hectare)
Total Geographic area	710081
Total Vacant area	542904
Waste/ Pasture land area	158086
Forest area	533
Banjar kadim area	442
Cultivable waste area	4077
Cultivated area	4039

In Spiti valley, it is not far from truth to say that irrigation is synonymous with cultivation. It is typically dry country where it scarcely rains and the harvest is entirely dependant upon artificial irrigation. The water of the small streams are arrested by small dams/bunds with considerable skill and channelized from terrace to terrace and from field to

field. These kulhs usually gets severally damaged by avalanches and have to be repaired every year at great cost with men and material.

According to statistics for the year 2002-2003, total irrigated area in Spiti valley is 40.39 sq km. The total area irrigated by the combine efforts of Irrigation & Public Health department (I&PH) as well as the Agriculture department is 32.38 and 8 sq km, respectively. All these schemes are flow irrigation schemes. About 75 such irrigation schemes have been completed and 20 new schemes are under construction to bring more area under irrigation. The details of the irrigation practices in the valley are given in Table - 3.

Table 3. Irrigation practices, Spiti valley

Parameter	Area under Irrigation in sq.km
Irrigated Area	40.39
Canal Irrigation	Nil
Tank Irrigation	Nil
Well / Tubewell Irrigation	Nil
Other Sources (Kulh) / Surface water	40.39

Barley is the chief crop both because from time immemorial it has remained the staple food of the people and also because it can be grown at higher altitude. Other important crops are Wheat, Peas, Potatoes, Fruit crops etc. All these crops are grown simultaneously from July to September because rest of the period is under snow, so all the crops are taken once in a year.

Table 4. Cropping pattern, Spiti valley

Crop	Cultivated Area in sq.km
Wheat	4.50
Barley	2.50
Peas	22.50
Vegetables	0.55
Potatoes	8.50
Pulses	0.02
Oil seeds	0.17
Fruit crops	1.65
TOTAL	40.39

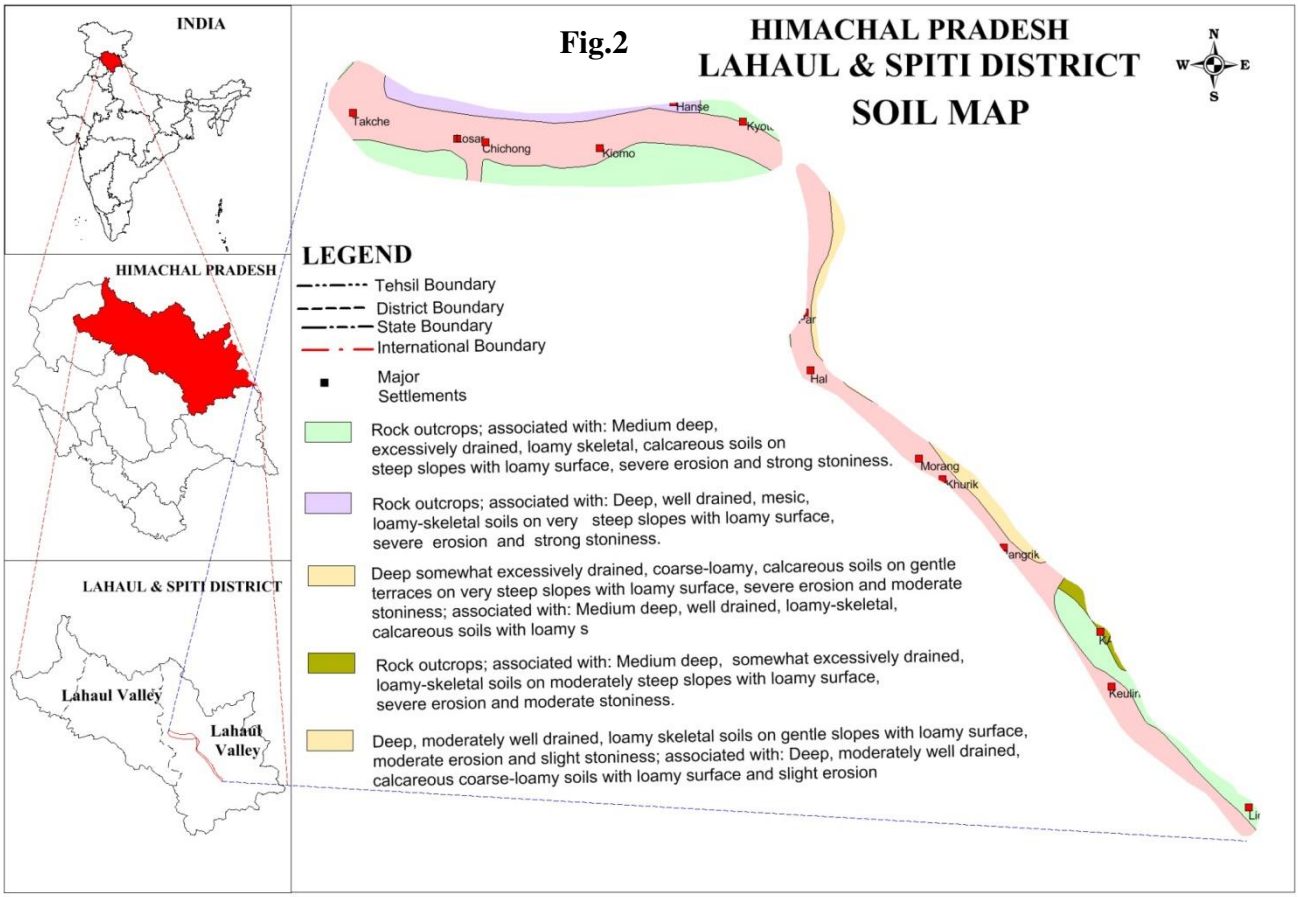

INDIA
HIMACHAL PRADESH
LAHAUL & SPITI DISTRICT
Lahaul Valley
Lahaul Valley
HIMACHAL PRADESH
LAHAUL & SPITI DISTRICT
SOIL MAP
N
W
E
S
Takche
Chichong
Kiomo
Hal
Morang
Khunik
Keulir
LEGEND
Tehsil Boundary
District Boundary
State Boundary
International Boundary
Major Settlements
Rock outcrops; associated with: Medium deep, excessively drained, loamy skeletal, calcareous soils on steep slopes with loamy surface, severe erosion and strong stoniness.
Rock outcrops; associated with: Deep, well drained, mesic, loamy-skeletal soils on very steep slopes with loamy surface, severe erosion and strong stoniness.
Deep somewhat excessively drained, coarse-loamy, calcareous soils on gentle terraces on very steep slopes with loamy surface, severe erosion and moderate stoniness; associated with: Medium deep, well drained, loamy-skeletal, calcareous soils with loamy s
Rock outcrops; associated with: Medium deep, somewhat excessively drained, loamy-skeletal soils on moderately steep slopes with loamy surface, severe erosion and moderate stoniness.
Deep, moderately well drained, loamy skeletal soils on gentle slopes with loamy surface, moderate erosion and slight stoniness; associated with: Deep, moderately well drained, calcareous coarse-loamy soils with loamy surface and slight erosion

Fig.2

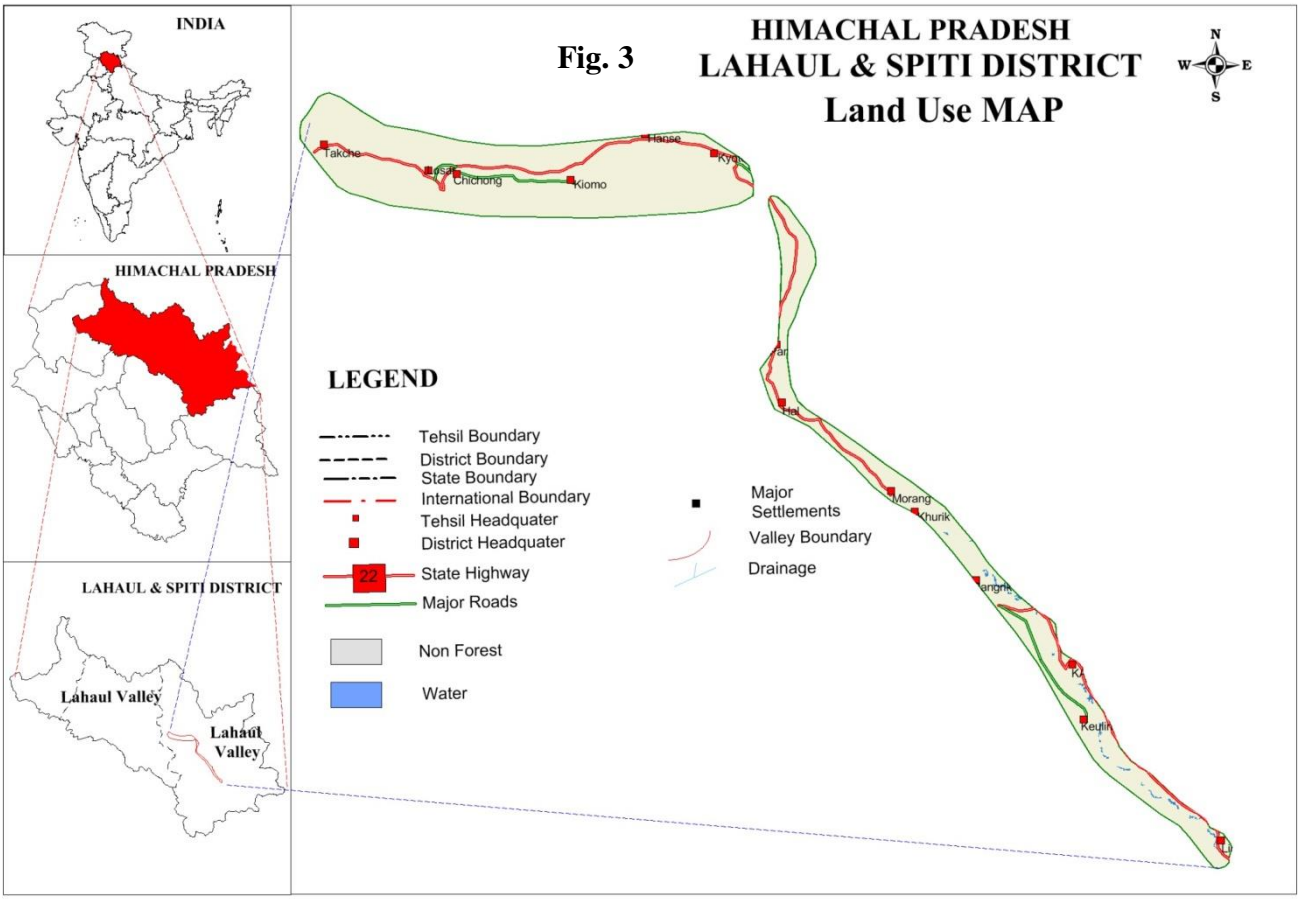

INDIA
HIMACHAL PRADESH
LAHAUL & SPITI DISTRICT
Lahaul Valley
Lahaul Valley
HIMACHAL PRADESH
LAHAUL & SPITI DISTRICT
Land Use MAP
N
W
E
S
Takche
Chichong
Kiomo
Hal
Morang
Khunik
Keulir
LEGEND
Tehsil Boundary
District Boundary
State Boundary
International Boundary
Tehsil Headquater
District Headquater
22
State Highway
Major Roads
Non Forest
Water
Major Settlements
Valley Boundary
Drainage

Fig. 3

2.0 CLIMATE

Spiti has Tibetan climate, dry and refreshing. The seasons correspond generally with those of Lahaul, though the spring is somewhat later and the winter of longer duration. The winter season starts from November to March is followed by the spring, which lasts up to the end of May. The next four months form the summer season, which are clear and cloudless. Spiti is the driest region enclosed by high mountains on all sides. The average yearly rainfall however is around 50 mm; the lowest rainfall recorded for 1991 was only 5 mm. The sun at these altitudes is bright and warm, the days are hot (temperature rises to 30° to 35° C) and nights are extremely cold. In some parts, winds starts blowing in the afternoon but the mornings and nights are usually calm. October is the month of transition from summer to winter. Snow begins to fall in December and remains on the ground until the end of April but seldom exceeds a depth of 60 to 90 cm. The average snowfall recorded in winter is 70 to 75 cm. The cold during the winter is very severe and is aggravated by violent and piercing winds. Spiti valley is one of the coldest in the country with mercury dipping to - 40° C in winter.

2.1 Rainfall & Snowfall

There exists a wide variation in both rainfall and snowfall in Spiti valley as can be seen from the Table-5 and Table-6. The rainfall is received in Spiti valley during the months of May till October. The average annual rainfall in the Spiti valley is 50 mm. Snowfall is noticed from October though less and lasts up to March. During this period, the valley faces severe cold and the mercury reaches upto –40°C. In general 60 to 90 cm of snowfall is noticed in the valley and cutoff all the routes for travelers from the other areas.

2.2 Temperature

Spiti valley experiences variation in temperature during various season of the year. During winter, temperature tends to –40°C while in summer, the temperature reaches to 30 to 35° C. The day and night temperature are observed at extreme ends in all seasons.

3.0 GEOMORPHOLOGY

The geomorphologic setup of the area is highly complex. The terrain has immature topography and is traversed by deep valleys and high hill ranges. The main hydrogeomorphic features demarcated are valley fills both fluvial and glacial, structural hills and glaciers .The various hydrogeomorphic units are briefly described below.

3.1 Structural Hills

The area is underlain by rocks of Palaeozoic to Mesozoic era. The rocks are generally trending in NNE-SSW, NE-SW and NW-SE direction with steep slopes. Escarpment and hogbacks are common features. Both granitic and phyllite rocks are poorly weathered. Granitic terrain around Khoksar is slightly weathered. Schistose rocks are occupying the valleys. These form the run-off zone. Palaeozoics are represented by Haimanta, Sanugbha, Kanwar and Paila groups. These are mostly composed of schists, shales, sandstone and quartzites. These rocks form the high hill ranges with narrow and deep valleys.

Kunzamla formation is less dissected as compared to the other rocks formation. Muth quartzites form a well-defined ridge extending from northeast to southwest. The valleys in these formations are broad and gently sloping in the glaciated area but became deeper and narrow downstream. Lipak formation is highly dissected with well-defined gulleys. Lilang group of Triassic period is highly dissected along the valleys. The limestones are non-karstic. No sinkholes etc have been observed or reported.

3.2 Valley Fills

Valley fills include both fluviatile deposits and morains. These deposits occur as narrow and elongated strips along the main streams. The glacial deposits are under the influence of running water and have been termed as glacio-fluviatile deposits.

Fluviatile terrain is demarcated in the lower reaches of Spiti River. The width of these deposits is generally less than 3 km and is not uniformly distributed. These are covered with thick vegetation.

Glacial deposits are confined to the upper reaches of drainage system. These areas are either along the snowline or near to it and mostly demarcated along the river/stream courses. These valleys are broad and gently slopping and devoid of any vegetation cover. In the Spiti valley, the important glacio-fluviatile deposits are along the Kasima Nadi, Puigulung, Takpo, Parang River and Khemenger River. The intermittent drainage which disappears in these deposits is well defined in the upper reaches of the Spiti River.

3.3 Glaciers

Glaciers are the masses of ice, which under the influence of gravity flow out from snowfield from where they originate. The important glaciers noticed in the district area are Bara Lacha, Gang's Tang, Mulkia Gang and Bara Shingri. These glaciers are originating from the snowfield occurring along the ridges or higher altitude areas. The main glaciers are aligned in EW or WWN-EES direction with their off shoot glaciers in N-S direction feeding the tributaries of various Rivers in either direction.

Bara Shingri glacier is located along the Great Himalayan range contribute water to Spiti River. Mulkia Gang glacier is located in the central part. The other minor glaciers in the southern part are Talshah, Tapri-Lamini, Raighar and Sara-Ugma. These glaciers have been broadly classified as valley or mountain glaciers. Valley glaciers are well defined in the higher reaches and are more pronounced in the Bara Lacha la area.

3.4 Drainage

Most of the area of Spiti valley is drained by the river Spiti, a major tributary of Satluj River. The river passess through the valley area and bisects the valley in almost two equal parts. Spiti River originates near Tango (5870 m amsl) flows from northwest to Southeast (Fig. 2). The River takes southerly turn near Sumdo to join River Satluj. The River valley is broad and wide upstream of Dankar Gompa.

The major tributaries of Spiti River are Pin River and the Lingthi River. The Pin River originates at a height of about 5590 m amsl. The river travels northerly and then northeasterly to join the Spiti River near Dhankar. The major tributaries of Pin River are Parahio River, Khamengar River, Kuokli Gad and Debra Khad. All these rivers and Khads are perennial. Pin River has developed in the downstream along its bank very fertile lands in patches where cultivation for the major crops is done. During summer, the discharge of Pin river increases and many a time, the flow in the river is turbulent. Pin valley also present a scenic beauty as one travels along its course.

Lingthi River is another major tributary of Spiti River and travels through a more or less deep valley. The major tributaries of Lingthi River are Tangma River, Khukhe River, Sheru nala and Shama nadi. The river is perennial and during summer the discharge increases because of melting the glaciers. In comparison with the Pin River, the Lingthi River has a narrow river valley and has not developed fertile lands.

A small part of the Spiti valley in its north-eastern part is drained by the river Parang also locally called as Pare Chu River. This is a perennial river and originates from the village Parang La located at a height of 5648 m amsl. The river travels north easterly and crosses the

boundary of Spiti valley near village Narbu Sumdo. The river then travels southerly and runs parallel to the boundary of Spiti valley and again re-enter the valley near village Shugar. The river then joins the Spiti River near Sumdo.

Chharap nala drains a small part of Spiti valley in its northernmost end. The major tributaries of this nala are Mlung nadi and Lungar Lumpa nadi both originates at a height of about 6100 m amsl. The Chharap nala drains into the Ladakh region of Jammu & Kashmir.

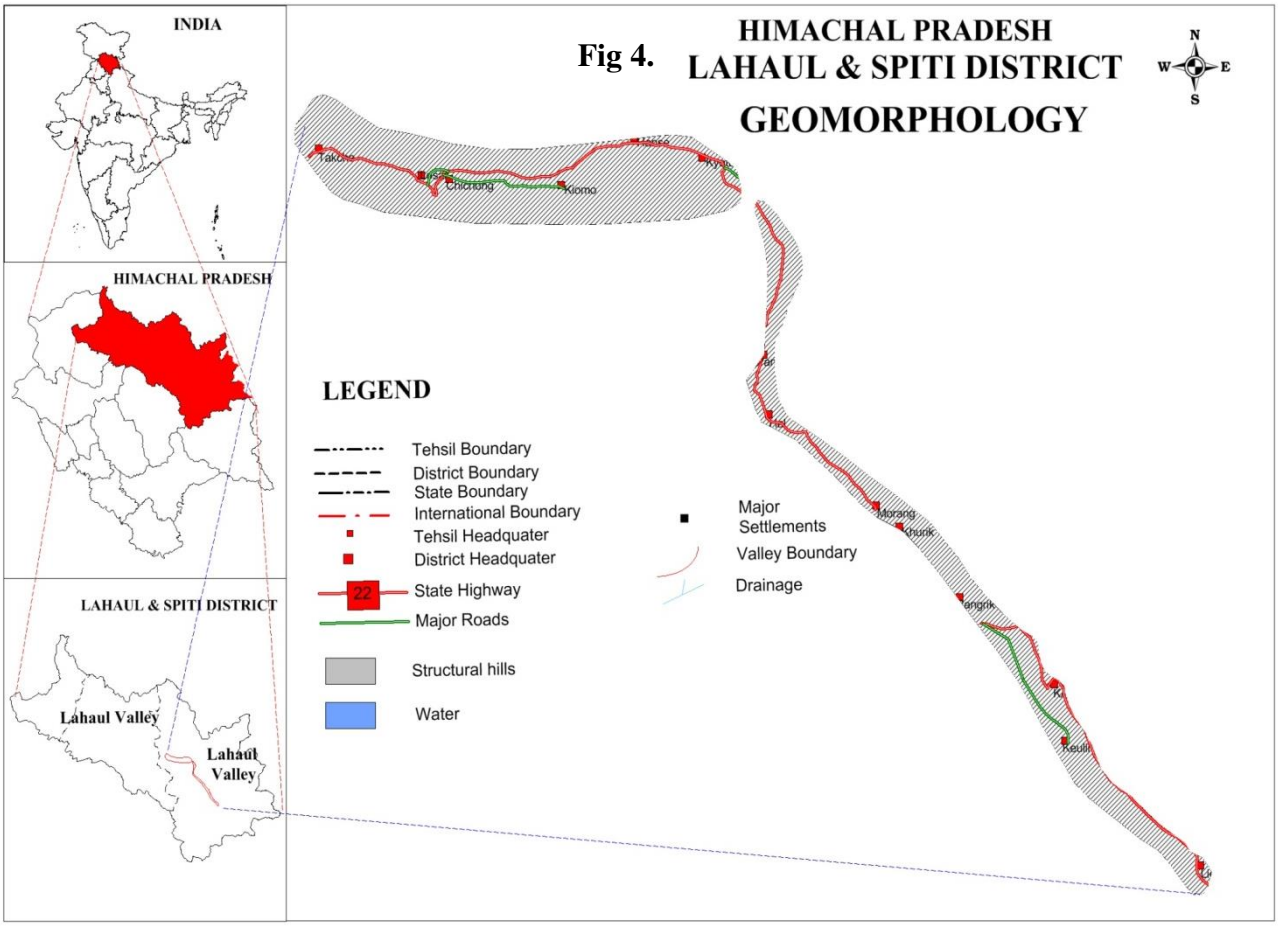


Fig 4.

4.0 GEOLOGY

The geology of the district has been studied by Hayden H. N. (1912) and subsequently by the Geological Survey of India. The geological succession of the area is given in Table-5 and is shown in Fig. 3 and is discussed below.

Table 5: Geological succession in Spiti valley, Lahaul & Spiti district

ERA	GROUP	FORMATION	PERIOD	LITHOLOGY
Cenozoic		Alluvium	Quaternary	Sand, Silt, Pebbles, Cobbles, Gravels and boulders
Mesozoic		Giumal Formation	Cretaceous	Shale and Sandstones
		Spiti Formation	Jurassic	Black Shale.
	Lilang Group		Triassic	Shales, Sandstone, Limestone and Dolomites.
Palaeozoic	**Paila Group**	Kuling Formation	Permian	Quartzites, Sandstones and Black Shales
		Gammachidam Formation	Carboniferous to lower Permian	Shale, Siltstone
	Kanwar Group	Po Formation	Carboniferous	Shales & Quartzites
		Lipak Formation	Carboniferous	Bedded crystalline limestone with interbands of Shales and siltstone.
		Muth Formation	Devonian	Sandstone & Quartzites
	Sanugbha Group	Tache Formation	Silurian	Shales, Sandstones and Dolomites
		Thango Formation	Ordovician	Sandstone and Conglomerates
	Haimanta Group	Kunzamla Formation	Lower to Middle Cambrian	Shales, Sandstones, Dolomites and Shcists.
		Batal Formation	Lower Cambrian	Slate, phyllites and Quartzites

4.1 Haimanta Group

The Cambrian succession of the Spiti valley includes the upper parts of the Haimanta Group comprising predominantly of slates, quartzites and dolomites. The group consists of about 800 metre thick soft ferruginous clay slates, grey and purple quatzites and grits overlain by a 300 metre thick succession of pyritiferous purple and grey slates and green/ red quartzites. The top of the Haimanta shows an abrupt change from argillaceous to arenaceous facies. The succession is poor in fossil record.

The group comprises of Batal formation and Kunzamla formation (Shrikantia 1991). The Batal formation, in the basal part comprises of grey-green phyllites, grey quatzites and carbonaceous phyllites. In the middle part of the sequence, the Batal formation is composed of quartzite alternating with carbonaceous phyllites forming the dominant lithology. The

upper part of the Batal formation comprises of green coloured chlorite phyllite, carbonaceous phyllites, and quartzose phyllites with interbands of quartzites.

The Kunzamla formation is named after the Kunzam La pass in Lahaul by Srikantia (1981) and is comprises of greenish grey siltstone, shales, slates, quartzites, sandstones, dolomites in the upper part and local pebble beds. Broadly the Kunzam la formation can be divided into two divisions. The lower division is called Debsa khad member consist of grey quartzies, flaggy to massive with slate partings, grayish green shale, slate, siltstone, sandstone and flaggy quartzites. The upper division is called parahio member and is characterized by the development of brown dolomite associated with cross-bedded calcarenite and quartzite in alteration with olive green shale and siltstone.

4.2 Sanugbha Group

The rock formations ranging from Ordovician to Silurian period are represented by the Sanugbha Group in the Spiti valley and comprises of Thango and Takche formations. The Thango formation of Ordovician period consists of purple quartzites, shales, siltstone, grits and conglomerates and dolomite. The Thango formation is overlain by the Takche formation of Silurian period and has a gradational to intercalated contact with the Thango formation. The formation comprises of a sequence of limestone, dolomites, shales, siltstone and sandstone. The formation shows several prograding cycles showing parallel and low angle cross beds in basal part and cross bedding and low angle discordance in upper part.

4.3 Kanwar Group

The Kanwar Group comprises of three formations namely Muth, Lipak and Po. The Muth formation of Devonian period rests over the Takche formation and is constituted of compact to granular, medium to fine grained quartz- anenites, dolomites beds, olive green shales and sandstone. The overlying Lipak formation of Carboniferous period comprises dominantly of dark grey to black limestone and dolomite, grey shale, pink limestone and lenticular snow-white and powdery gypsum beds in upper part. There are interbands of quartz-arenites with in the carbonate sequence. The Po formation has conformable and gradational contact with the underlying Lipak and overlying Gammachidam formation. It comprises of a thick sequence of white to grey, medium grained quartz-arenite, siltstone, sandstone and grey, black locally pale green shales.

5.4 Paila Group

The group comprises of Gammachidam and Kuling formations. The Gammachidam formation of Lower Carboniferous to Permian period has a gradational contact with the underlying Po formation. It comprises of pebble mudstone, pebbley siltstone, pebbley sandstone, conglomeratic sandstone and black shale alterations. The overlying Kuling formation of Permian period is composed of calcareous sandstone, local conglomerates, black shales, quartzites, cherty and calcareous nodules and thin limestone lenses.

5.5 Lilang Group

The Lilang group, a dominant carbonate sequence of an enormous thickness covers a wide area in Lahaul & Spiti, Kinnaur and Zanskar basin. The Group forms a conspicuous topography with high ridges and valleys in the higher Himalaya of Himachal Pradesh. The Group comprises of a total of over 1000 metre thick succession of limestone and shale intercalations topped by massive limestone. Nunuluka formation comprises of quartzites, limestone and shales while Kioto formation includes limestone and dolomites in upper part. No karst topography is developed in these limestones.

5.6 Spiti Formation

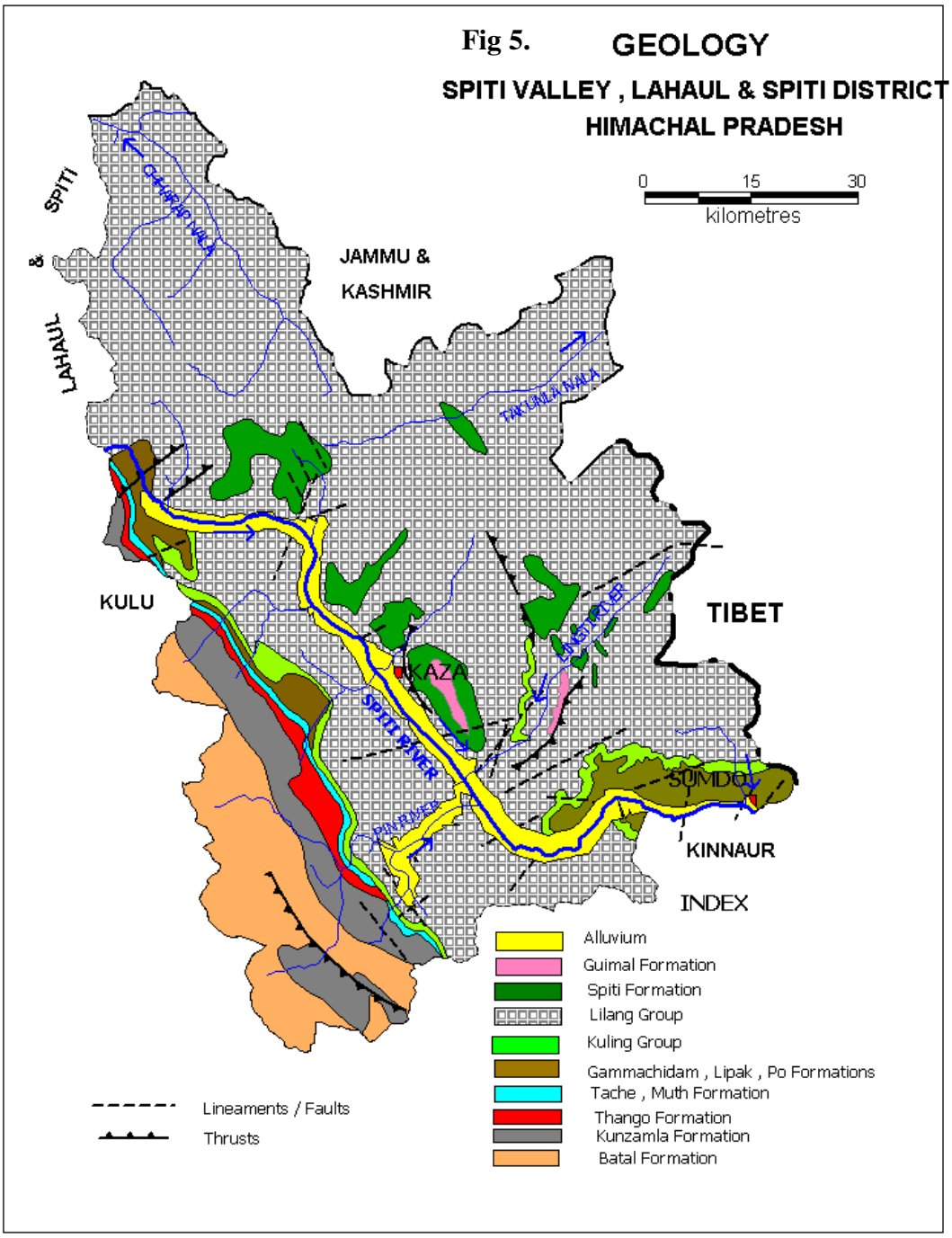
The Spiti formation comprises of pyritiferous and splintery black shales with few interbeds of impure limestones along with fine grained sandstone and siltstone. The thickness of the formation varies from about 100 to 300 metre. The shales contain numerous calcareous concretions enclosing well preserved ammonites and other fossils. The Spiti shales form the most characteristic stratigraphic unit of the Tethyan Himalaya.

5.7 Giumal Formation

The lower Cretaceous sequence of Giumal formation is named after the type area Giumal village in Spiti valley and consists of about 100 metre thick yellow coloured siliceous sandstone and quartzites, siltstone, silty shale, shale and local conglomerate lenses. The interbedded black shale in its basal part forms a sort of passage bed between the underlying Spiti formation and the Giumal formation.

5.8 Quaternary Deposit

The quaternary deposit includes both fluviatile sediments and morains. The fluviatile deposits are confined to the River valleys with increasing thickness and width downstream. These are composed mainly of boulders, cobbles, pebbles, gravel, sand, silt etc. The morains are confined to upper reaches. The sediments have been classified as glacio-fluviatile deposits. They are commonly distributed in sedimentary formations. These deposits are not uniformly distributed either along the River or in the upper reaches in glacial region.



5.0 HYDROGEOLOGY

Based on the geomorphology and existing ground details, Ground water is distributed mainly in the alluvial terrain. The rock formation other than alluvium is schist, phyllites, gneisses, granites, quartzites, conglomerates, limestones, dolomites and sandstones. The streams/rivers draining the area are generally perennial and snow fed. A number of natural water springs are reported from the Spiti valley. The distribution of the Ground water in various formations is discussed below

5.1 Quaternary deposits

Fluviatile sediments have been deposited along the Spiti River are almost uniformly distributed and are varying in width from less than 500 m to about 1.5 km. These fluviatile sediments are generally confined to the northern bank of the River except near Hansi, Morang and Dhankhar Grouppa village. Agricultural developments are limited to the area where soil cover exists. In the area around Hansi upstream of it only limited vegetation cover is delineated and the major part is barren. In the Spiti River valley around Morang and further downstream upto Dankhar Grouppa, the alluvial deposits seams to be continuously deposited with increasing intensity of vegetation downstream.

The width of the bed is upto about 500 m. The depth of the riverbed is varying between 80 m to 200 m below the general ground level. The thickness of these fluviatile sediments may be between less than 10 m to about 100 m. In the area between Poh and Sumdo, the fluviatile deposits are varying in width upto 200 m. The Riverbed is 10-20 m deep. The approximated thickness of the alluvium is around 50 metres (Kapoor, 1975).

5.2 Older Formations

Geological formations older to the quaternary deposits have been included in this ranging in age from Cambrian to Cretaceous period. Batal formation are composed of gneisses, schists, granites and shales occupying the upper reaches of Spiti River with moderate to steep slopes are poorly weathered. Thick vegetation occurs over the areas with weathered mantle. These rocks rarely form an aquifer but forming only a run-off zone. Ground water potentialities may occur only along the lineaments in the valleys.

Thango formation of Sanugbha group comprised of sandstone and conglomerates occur as a thin band in the west of Muth Sandstone is highly weathered. This is more prominent in the Sarchu area and may form a good aquifer. Sandstone occurring in Tache, Lipak, Kuling, Lilang and Guimal formations has also indicated a tendency towards weathering. This can also form an aquifer. Karst topography has not been developed in the limestone and dolomites in the Spiti valley. No cavities, sinkholes have also been reported.

5.3 Springs

Spring is a "concentrated discharge of Ground water appearing at the ground surface as a current of flowing water." Seepages are the slower movement of Ground water to the ground surface. Springs occur in many forms and have been classified as to cause, rock structure, discharge, temperature and variability. Bryan divided all the springs into following main two types depending on the origin.

Non–Gravitational Forces	A	Volcanic spring
	B	Fissure spring
Gravitational Forces	A	Depression spring
	B	Contact spring
	C	Artesian spring
	D	Impervious spring
	E	Tubular or Fracture spring

6.0 DATA GAP ANALYSES

The data gap analysis for Aquifer mapping in Spiti valley, district Lahaul & Spiti has been carried out on the basis of EFC guidelines for soft rock area. The base map for data gap analysis is sown in Fig. 6 and given in table 6.

The analyses done are detailed below:

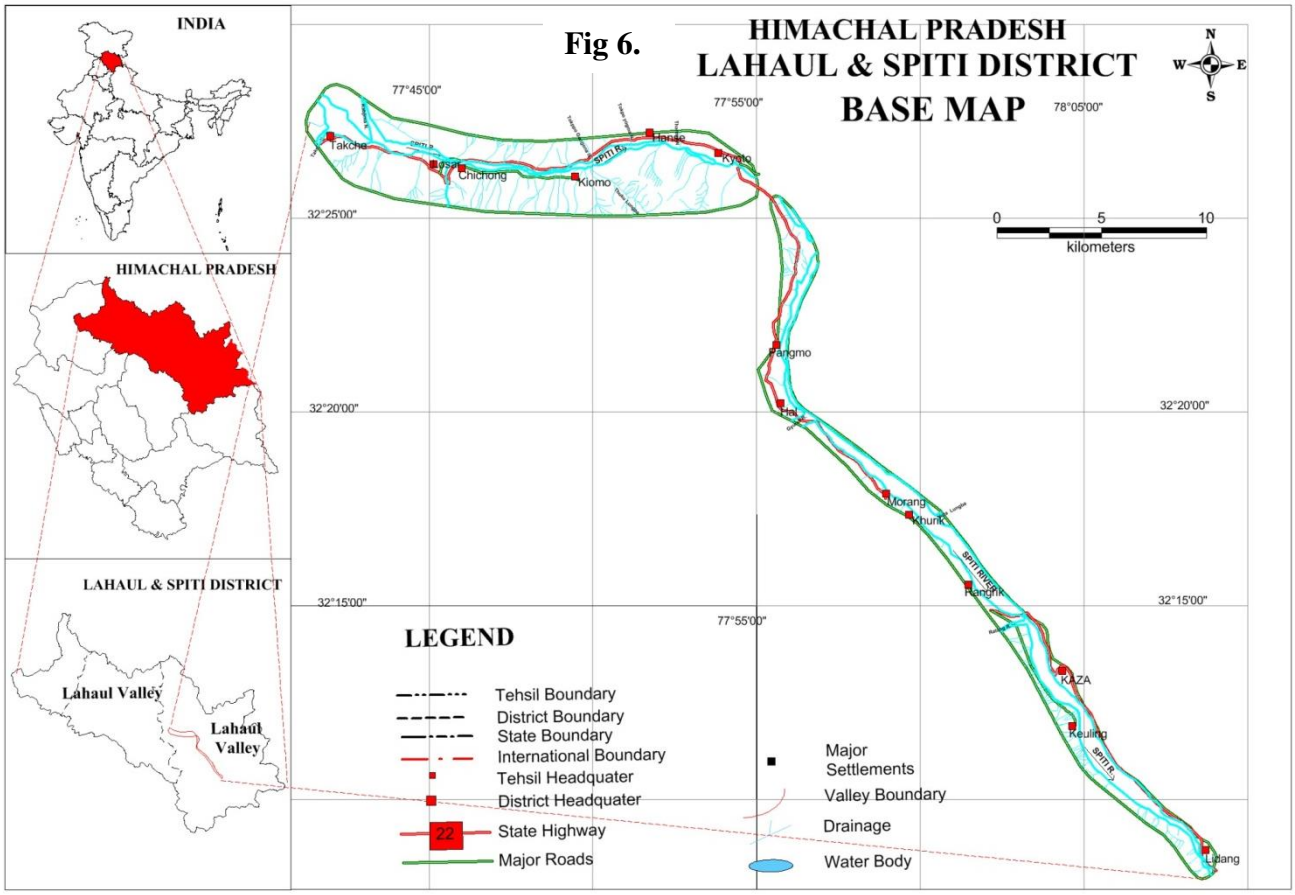


Fig 6.

6.1 Ground Water Exploration

As per the EFC guidelines there should be one well field and three special purpose wells i.e. 2 EW, 2 OW and 2 SPW (Special Purpose Well). 3 EW for first aquifer and 3 OW for the second aquifer should be constructed (Shown in fig.7).The proposed sites for EW & OW are also given (Fig. 8).

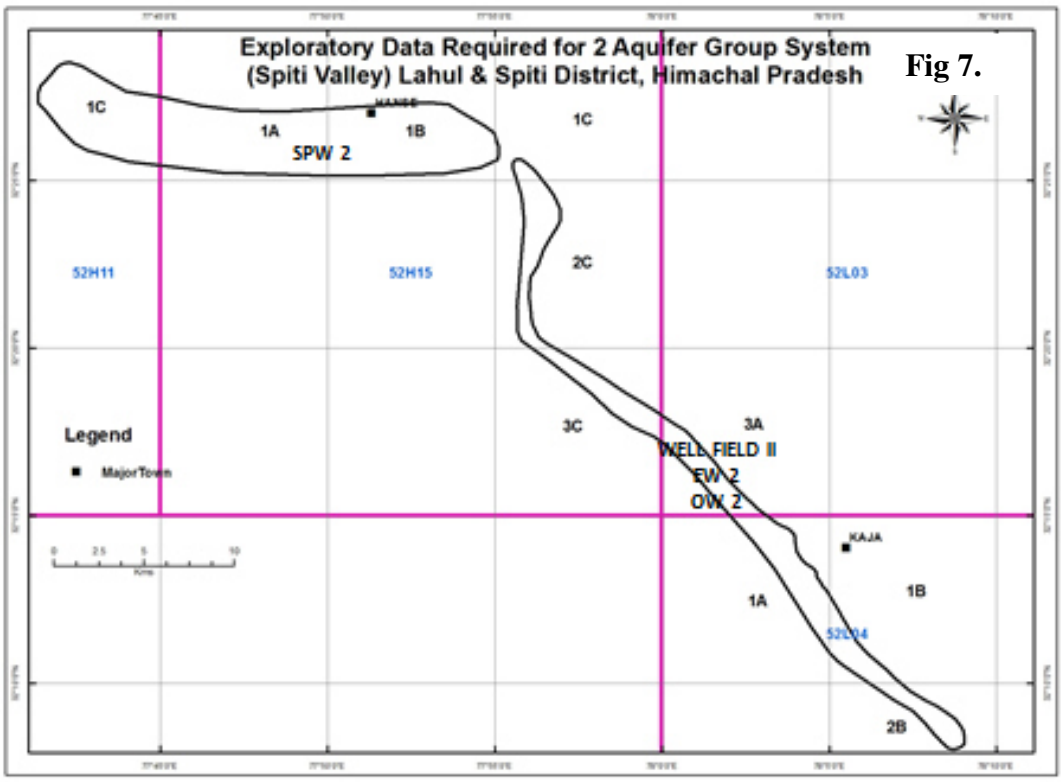


Fig 7.

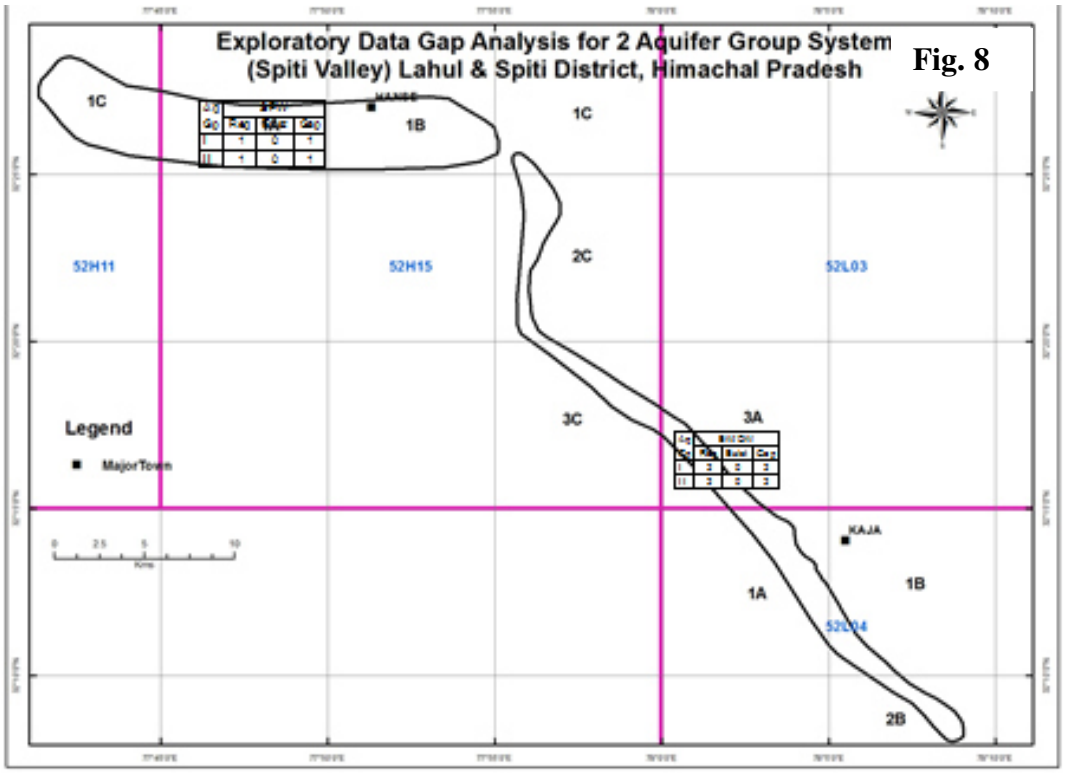
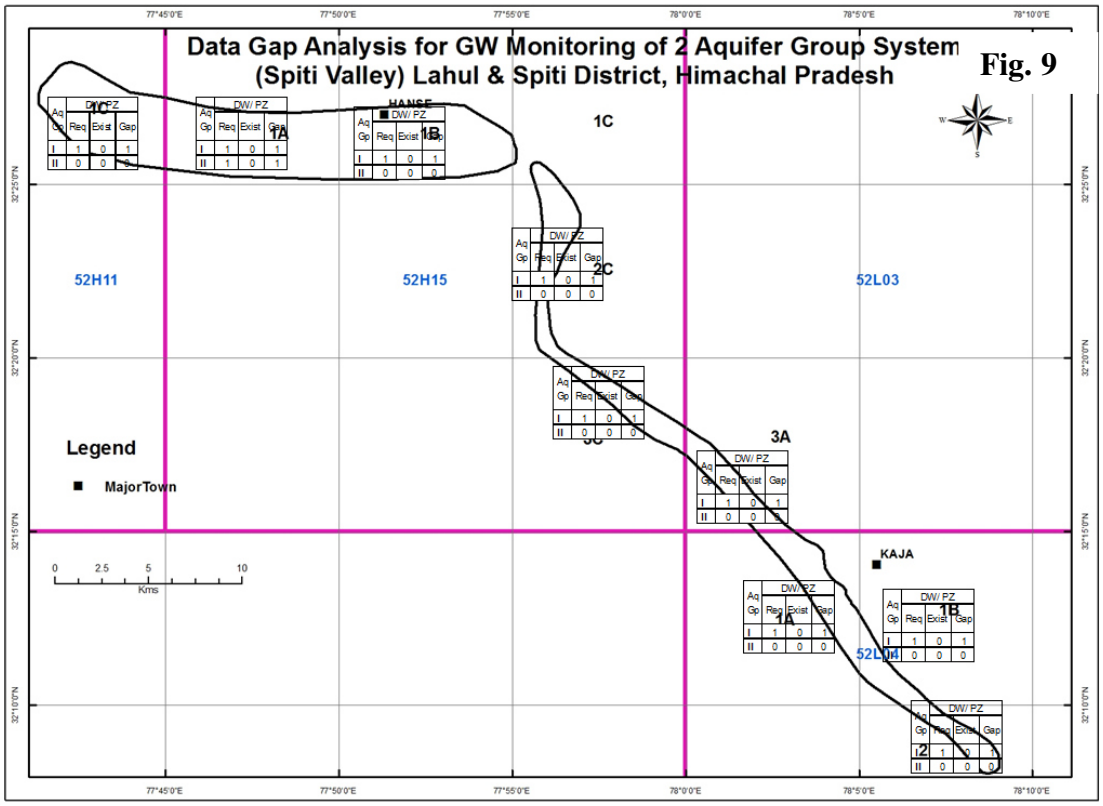
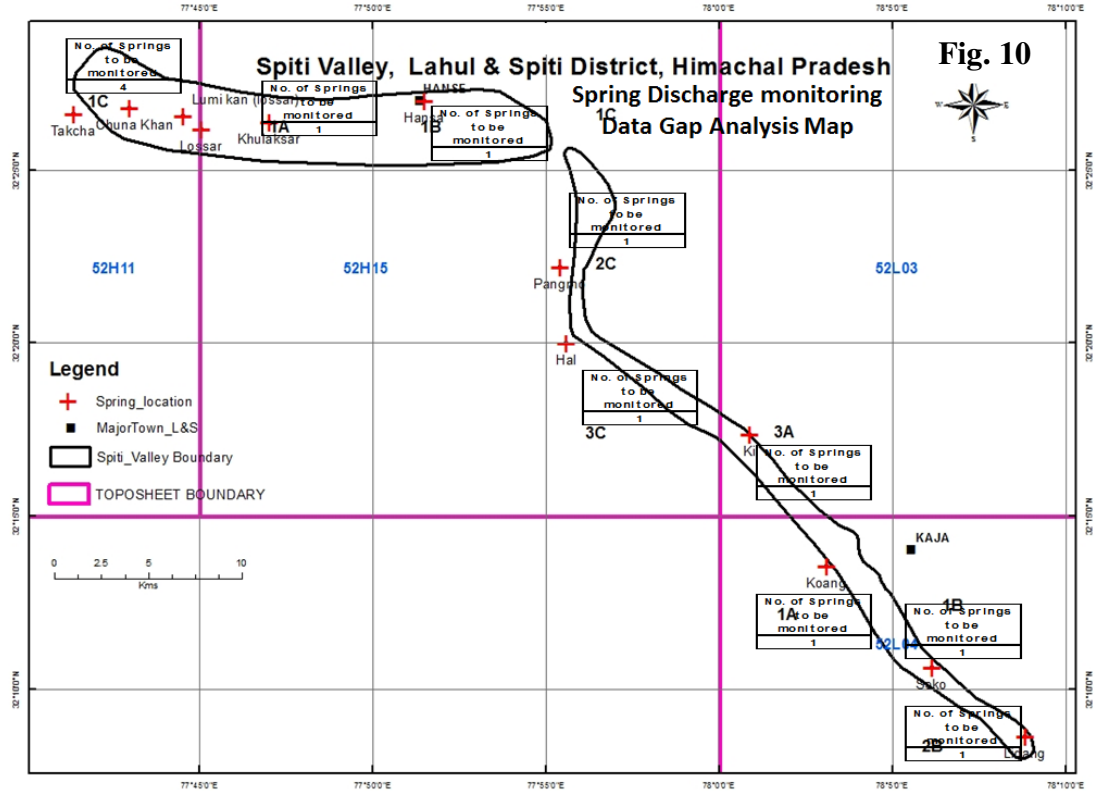


Fig. 8

6.2 Ground Water Level & Spring Discharge Monitoring

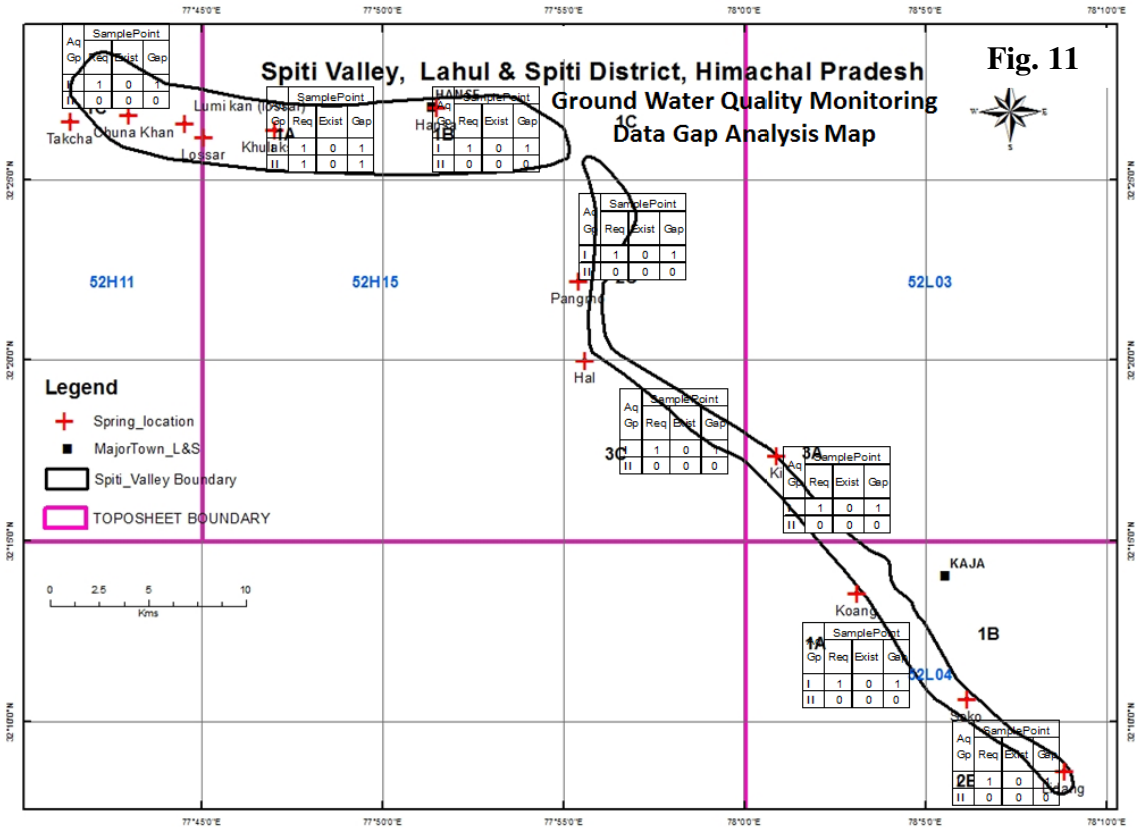
As per the EFC guidelines there should be 09 No. of monitoring stations and 12 Spring discharge monitoring stations. The list of observation wells and data gap analysis is shown in the Fig.9 & 10.





6.3 Ground Water Quality

As per the EFC guidelines there should be 09 No. sampling locations. The list of tentative sampling points and data gap analysis is shown in the Fig. 11.



6.4 Subsurface Geophysical Survey (VES):

As per the EFC guidelines there should be 09 No. sites for VES for subsurface geophysical survey. The data gap analysis is shown in the Fig.12.

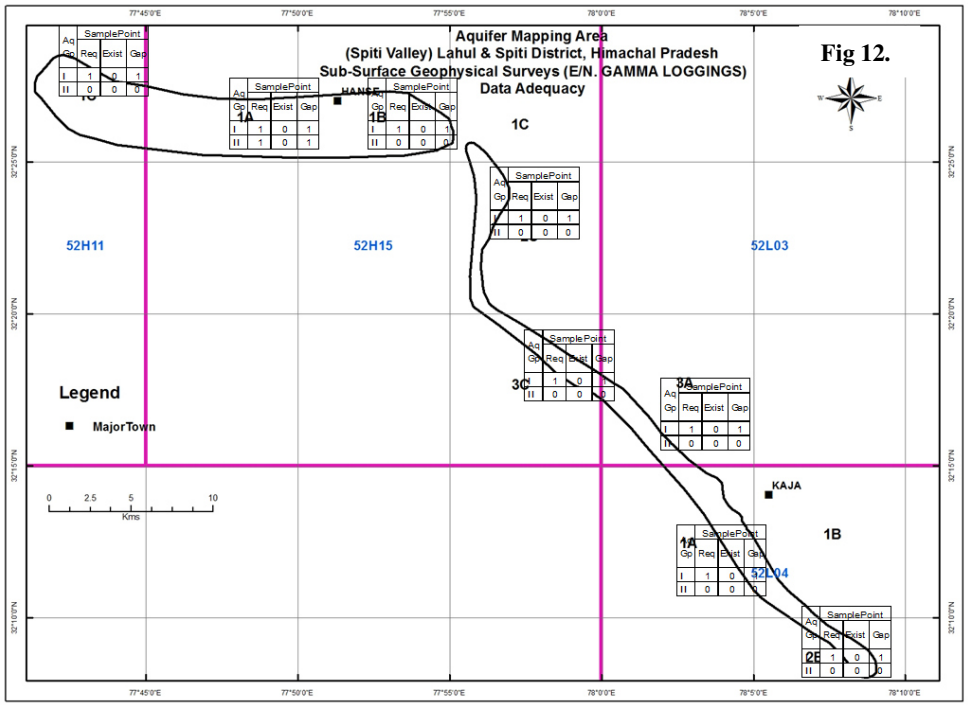


Table 6. AQUIFER MAPPING IN SPITI VALLEY, LAHUL & SPITI DISTRICT, H.P. DATA GAP ANALYSIS (AAP 2014-15)													
Toposheet No.- 52 H/11, 15, 52 L03 & L04													
Quadrant no.	**No. of additional EW's Required**		**No. of additional OW's Required**		**No. of SPW's Required (EW /PZ)**		**No. of additional VES/TEM Required**		**No. of additional EL/NG logging Required**		**No. of additional water level monitoring Stations(PZ's) Required**	**No. of Soil Infiltration test Required**	**Monthly Spring Discharge Monitoring**
	Aq- I	**Aq- II**	**Aq- I**	**Aq- II**	**Aq- I**	**Aq- II**	**Aq- I**	**Aq- II**	**Aq- I**	**Aq- II**	**Aq- I**		
52 H/11 1C	0	0	0	0	0	0	1	0	0	0	1	1	4
52 H/15 1A	0	0	0	0	1	1	1	1	1	1	1	0	1
52 H/15 1B	0	0	0	0	0	0	1	0	0	0	1	1	1
52 H/15 2C	0	0	0	0	0	0	1	0	0	0	1	1	1
52 H/15 3C	0	0	0	0	0	0	1	0	0	0	1	1	1
52 L03 3A	1	1	1	1	0	0	1	0	2	2	1	0	1
52 L04 1A	0	0	0	0	0	0	1	0	0	0	1	1	1
52 L04 1B	0	0	0	0	0	0	1	0	0	0	1	0	1
52 L04 2B	0	0	0	0	0	0	0	0	0	0	1	1	1
Total	**1**	**1**	**1**	**1**	**1**	**1**	8	1	3	3	**9**	6	**12**

During the traverse 12 no. of springs were inventories and discharge of all the springs were monitored for 3 times during 2015-16. Most of the springs were contact springs and discharges observed were ranging from 0.58 LPM (Hal) to 1250.50 LPM (Takcha) (Table 7). The Spring discharge map of July, 2015 and July, 2016 is given in Fig. 13 and Fig. 14 respectively.

Table 7. Spring Locations with discharge in Spiti valley, district Lahaul & Spiti district

S. No.	Location	Latitude	Longitude	Source	Jul-15	Oct-15	Jul-16
					Discharge in LPM		
1	Seko	32.1773	78.102	Spring	2	1	1.5
2	Ki	32.2893	78.0145	Spring	2.4	1.2	2.2
3	Koang	32.226	78.0514	Spring	4	3.5	3.8
4	Hal	32.3331	77.9263	Spring	1.62	0.58	1.68
5	Pangmo	32.3697	77.9231	Spring	8	6	7
6	Hansa	32.4498	77.858	Spring	2	1	1.8
7	Lossar	32.4363	77.7507	Spring	300	210	310
8	Lumi Kan	32.4426	77.7418	Spring	2	1.5	2.2
9	Takcha	32.4434	77.6893	Spring	1200	840	1250.5
10	Chuna Khan	32.4465	77.7161	Spring	900	850	910.2
11	Khulaksar	32.4396	77.7833	Spring	800	770	780.5
12	Lidang	32.1441	78.1472	Spring	3.75	3	3.6

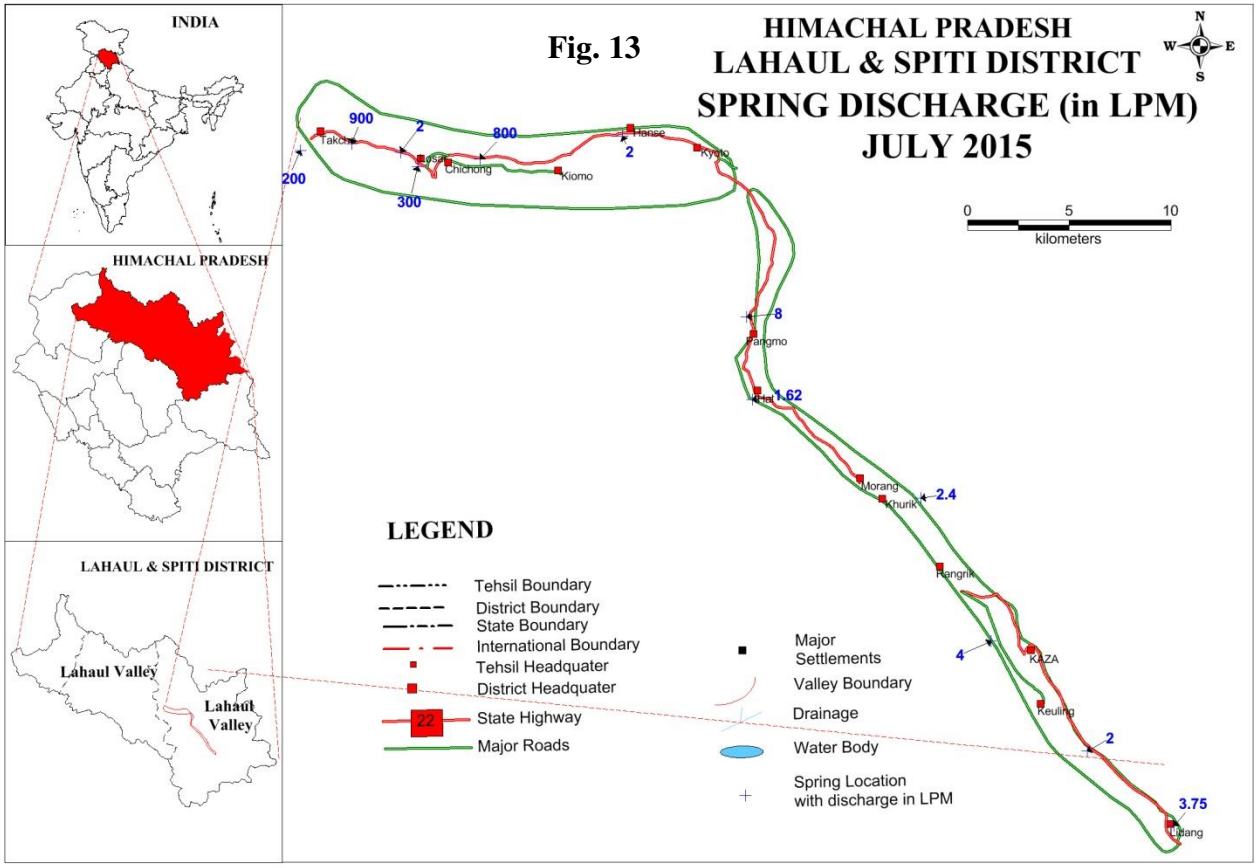

INDIA
HIMACHAL PRADESH
LAHAUL & SPITI DISTRICT
Lahaul Valley
Lahaul Valley
HIMACHAL PRADESH
LAHAUL & SPITI DISTRICT
SPRING DISCHARGE (in LPM)
JULY 2015
N
W
E
S
0 5 10
kilometers
900
2
800
2
200
300
8
1.62
2.4
4
2
3.75
Takche
Chicheng
Kiomo
Hanse
Kyato
Rangmo
Morang
Khurik
Rangrik
KAZA
Keuling
LEGEND
Tehsil Boundary
District Boundary
State Boundary
International Boundary
Tehsil Headquater
District Headquater
22
State Highway
Major Roads
Major Settlements
Valley Boundary
Drainage
Water Body
Spring Location with discharge in LPM

Fig. 13

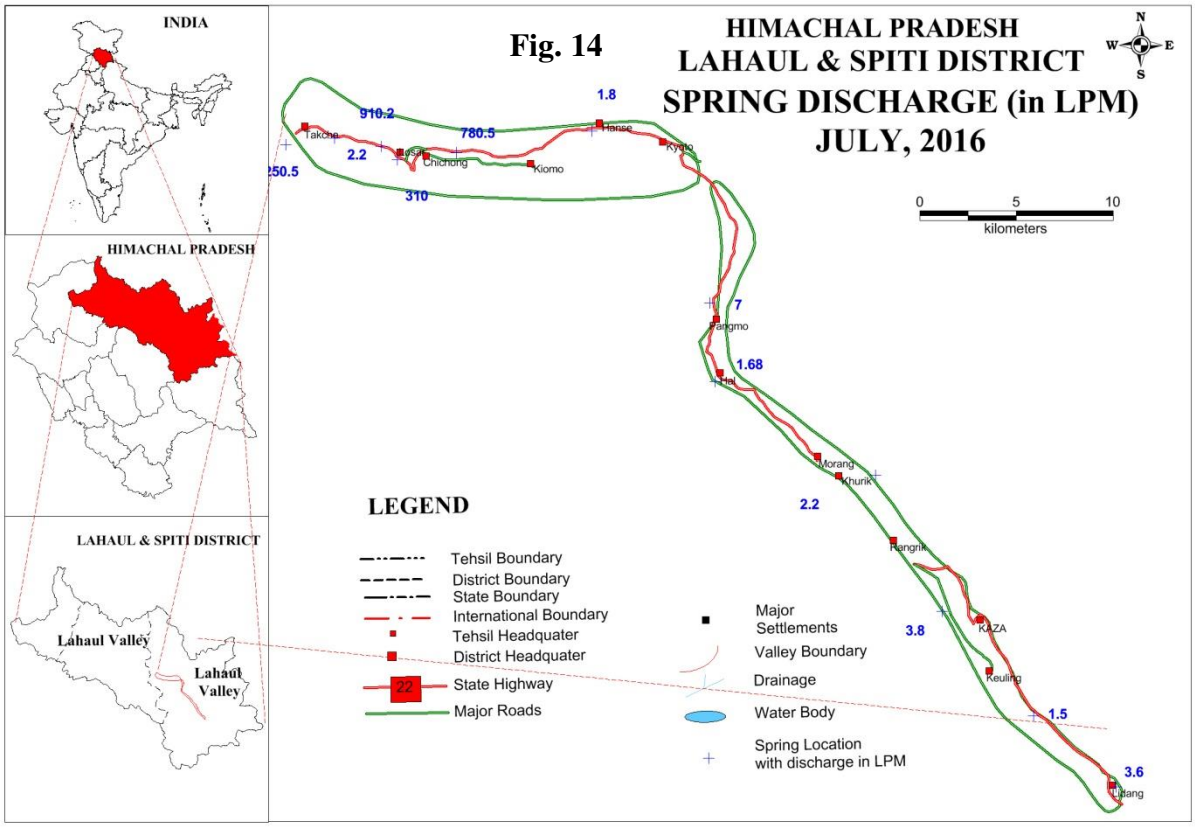

INDIA
HIMACHAL PRADESH
LAHAUL & SPITI DISTRICT
Lahaul Valley
Lahaul Valley
HIMACHAL PRADESH
LAHAUL & SPITI DISTRICT
SPRING DISCHARGE (in LPM)
JULY, 2016
N
W
E
S
0 5 10
kilometers
910.2
1.8
780.5
2.2
250.5
310
7
1.68
2.2
3.8
1.5
3.6
Takche
Chicheng
Kiomo
Hanse
Kyato
Rangmo
Morang
Khurik
Rangrik
KAZA
Keuling
LEGEND
Tehsil Boundary
District Boundary
State Boundary
International Boundary
Tehsil Headquater
District Headquater
22
State Highway
Major Roads
Major Settlements
Valley Boundary
Drainage
Water Body
Spring Location with discharge in LPM

Fig. 14

7.0 Hydrochemistry

The chemical composition of natural water is inter-related with the geology and hydrogeology of the area, physiochemical characteristics of the soils and rocks through which water percolates, extent of pollution, nature of plant cover and various regional and local factors. The various chemical constituents and their concentrations determine the quality of Ground water at a particular place.

To have an idea about the quality of water 11 No. of both surface and subsurface, water samples were collected from various sources like river, springs & bore wells fitted with hand pumps. The sampling location is given in Fig.15.

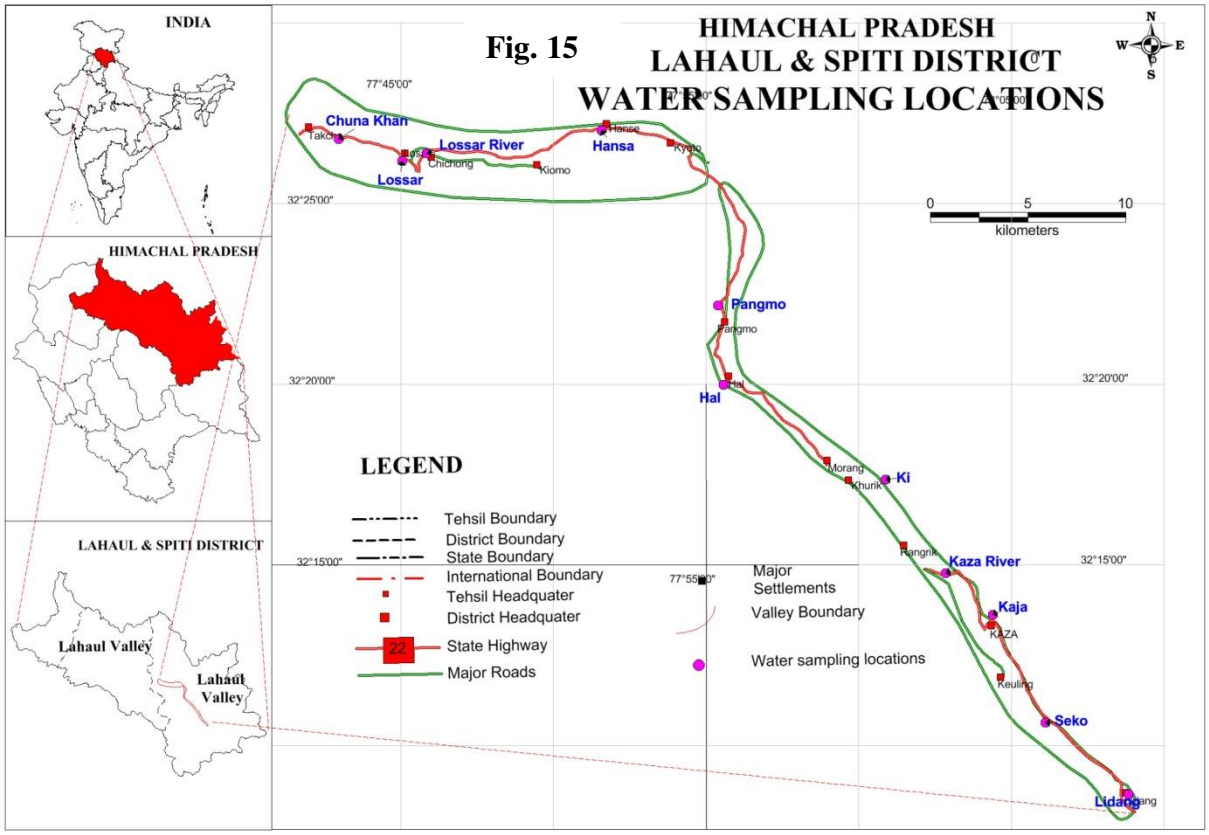


Fig. 15

Water samples collected from these sources were analyzed for various chemical constituents at Regional Chemical Laboratory, Jammu. The range of chemical constituents and the results of chemical analysis of surface and sub-surface water are given in Table-8 and Table-9 respectively. The suitability of Ground water for drinking purposes has been evaluated as per the standards prescribed by BIS, 1991 (Table 8).

Table 8. Characteristics for Drinking Water (IS: 10500:1991)

S. No	Parameters	Desirable Limit	Permissible Limit
Essential Characteristics			
1	pH	6.5-8.5	No relaxation
2	Total Hardness as $CaCO_3$ (mg/l)	300	600
3	Chloride (Cl) mg/l	250	1000
4	Fluoride (F) mg/l	1.0	1.5
Desirable Characteristics			
5	Dissolved solids mg/l	500	2000
6	Sulphate (SO_4) mg/l	200	400
7	Nitrate (NO_3) mg/l	45	100
8	Calcium (Ca) mg/l	75	200
9	Magnesium (Mg.) mg/l	30	100

Quality of ground water:

On the basis of the water quality analysis it following observations were made (Table 9).:

The pH in shallow ground water i.e spring ranges between 7.90 and 8.27 indicating that ground water at all the places is alkaline in nature (Fig. 16).

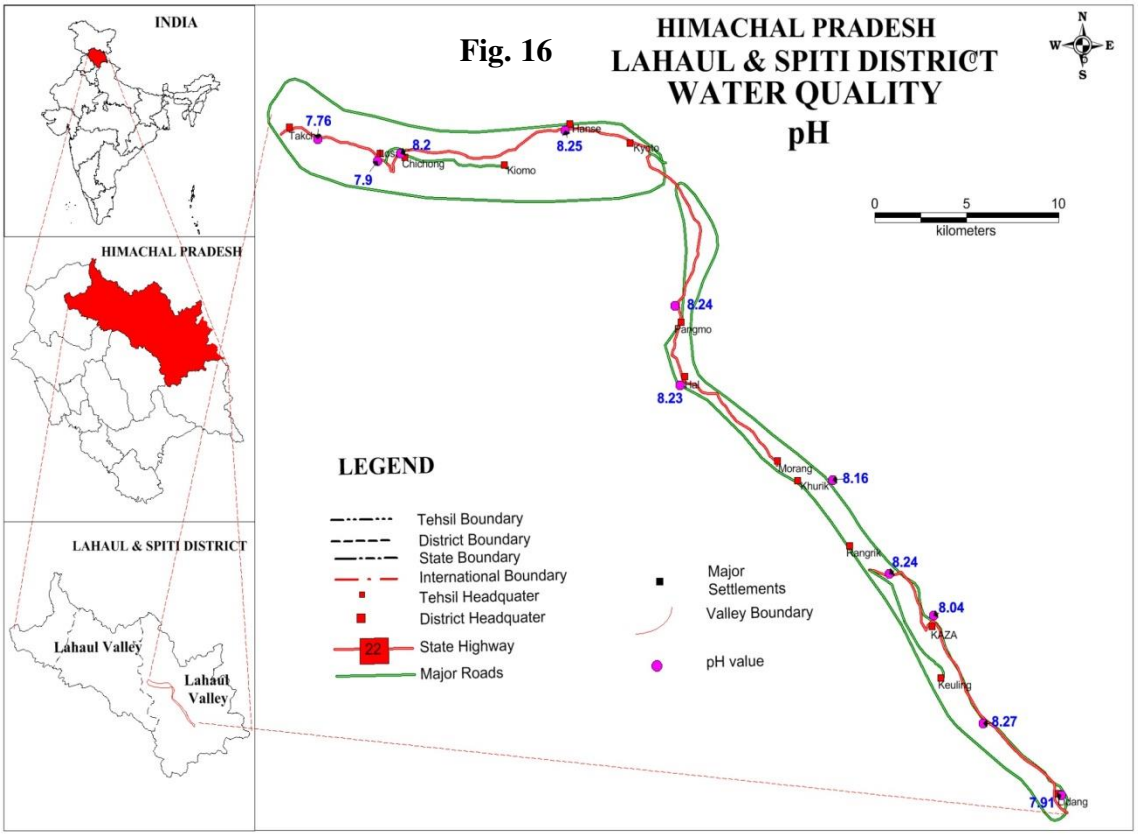


Fig. 16

The electrical conductivity in spring water samples ranges between 160 and 455 micro-mhos/cm, indicates that ground water in the area is fresh (Fig. 17).

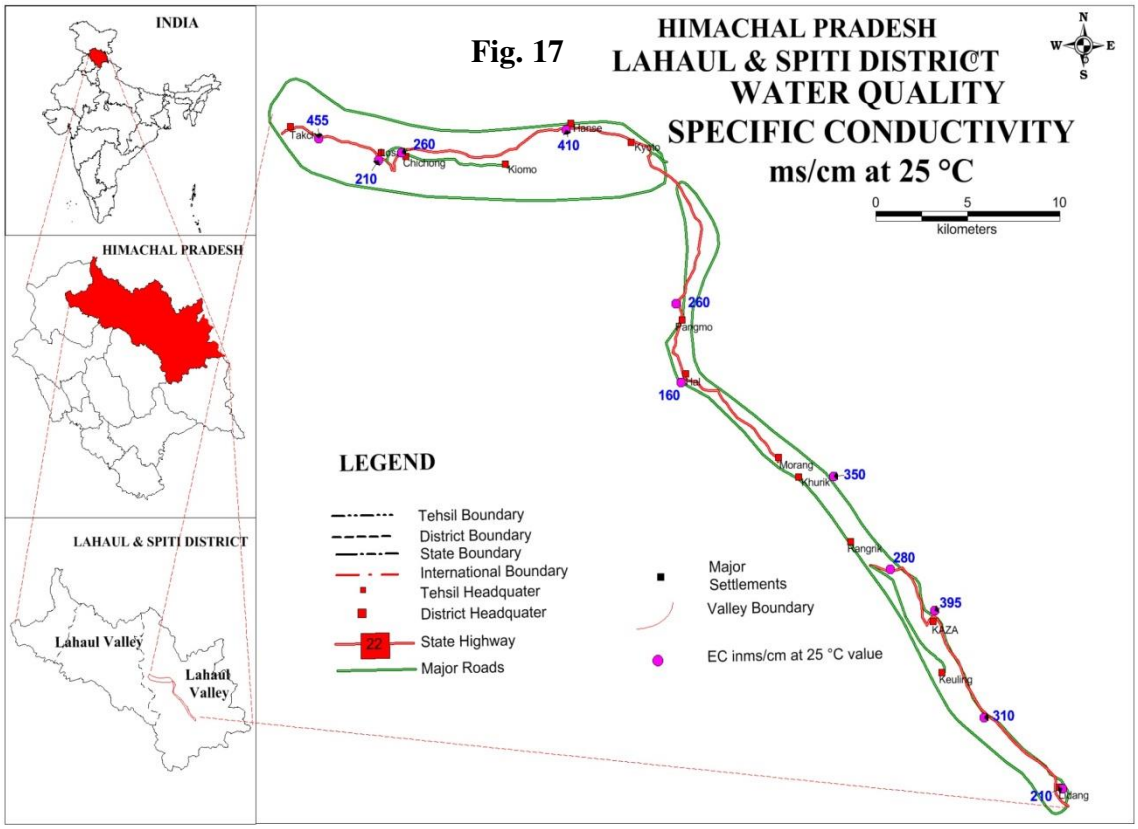


Fig. 17

The chloride content varies from 3.5 mg/l to 14.0 mg/l (Fig. 18).

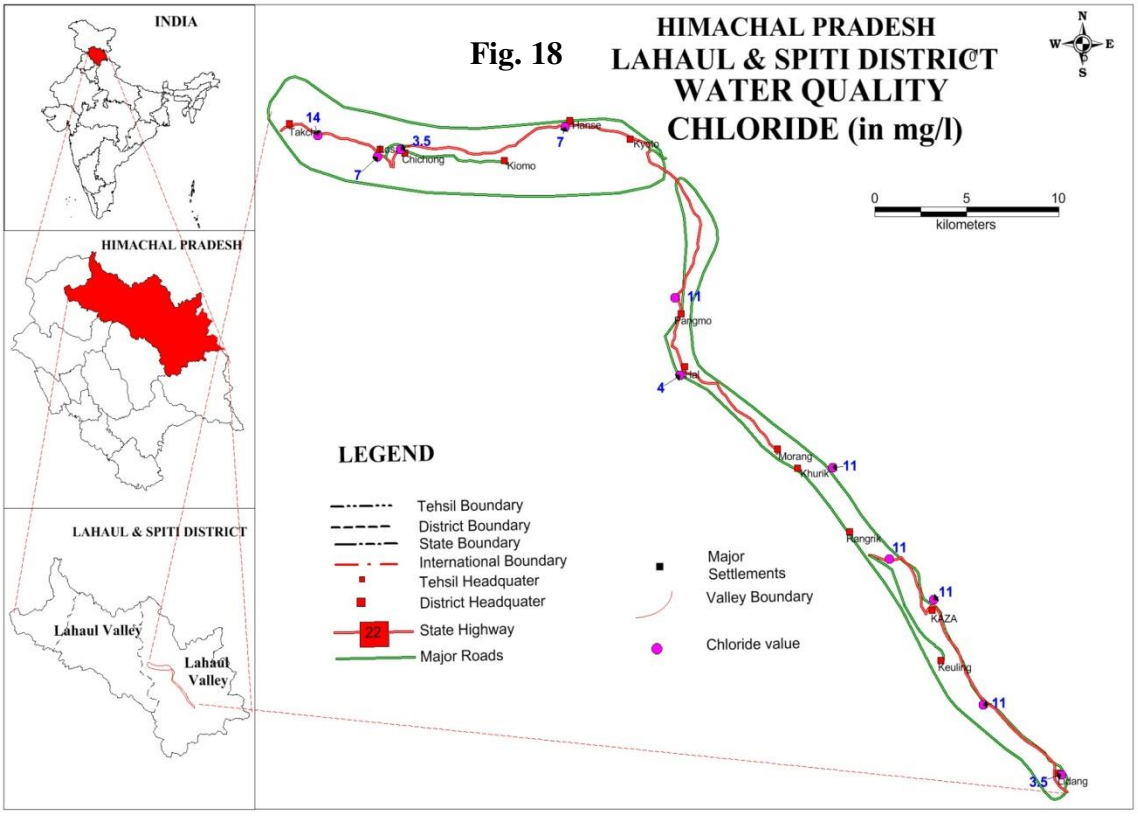


Fig. 18

The nitrate concentration varies from 1.50 to 9.0 mg/l (Fig. 19).

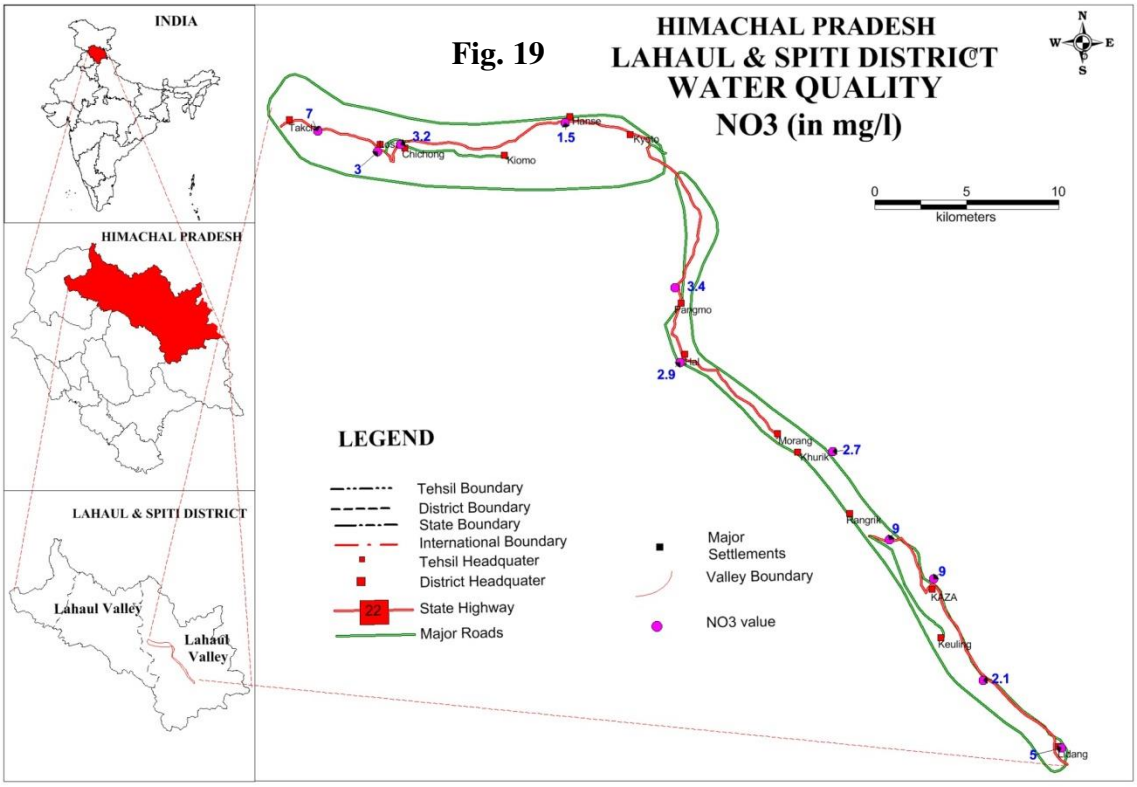


Fig. 19

The fluoride content ranges from not dateable limit to 0.57 mg/l (Fig. 20).

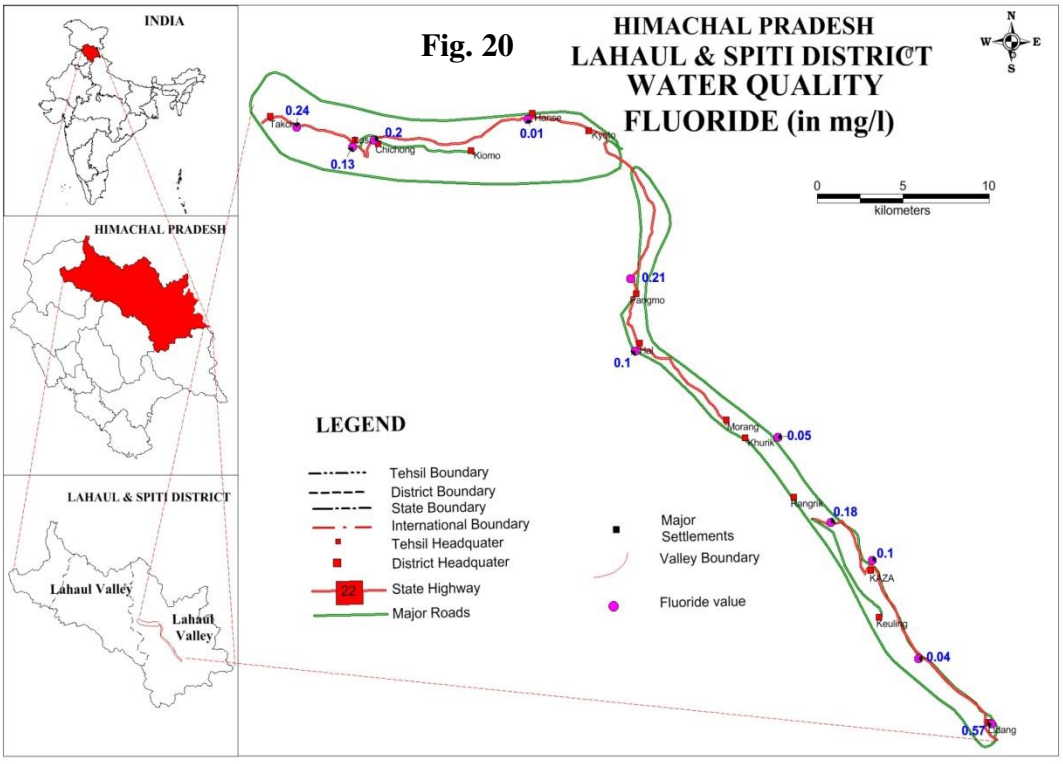
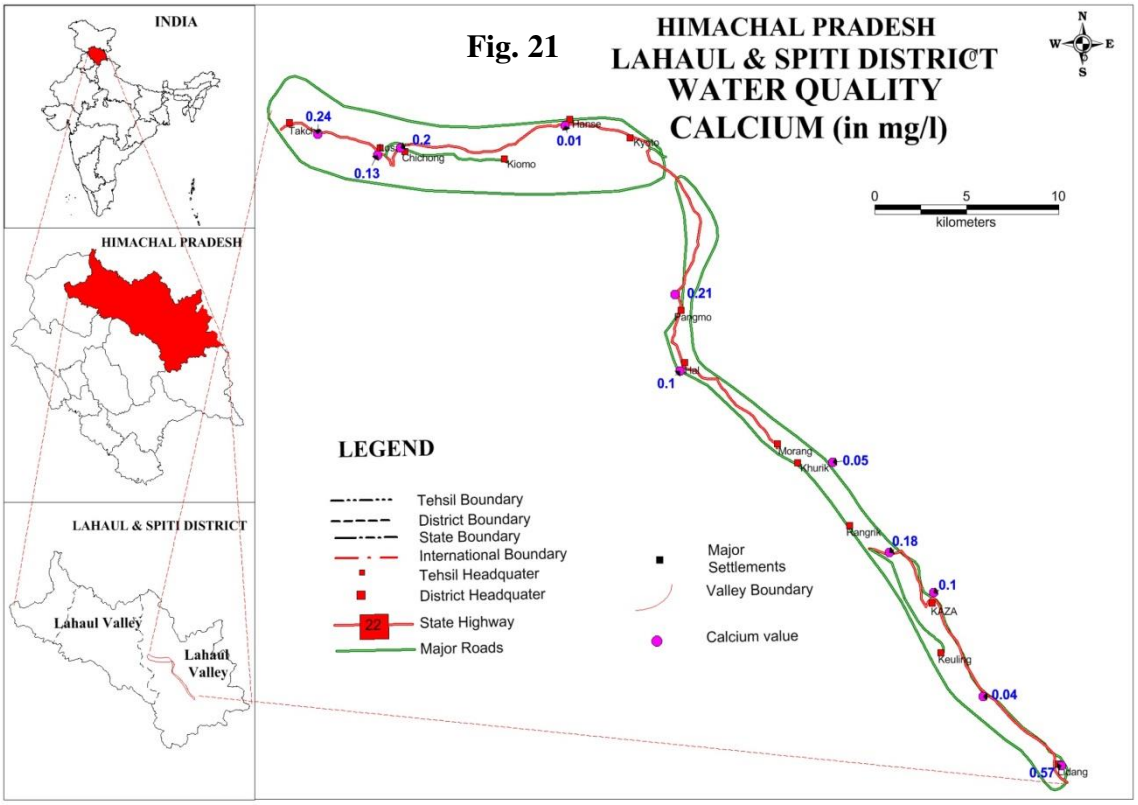
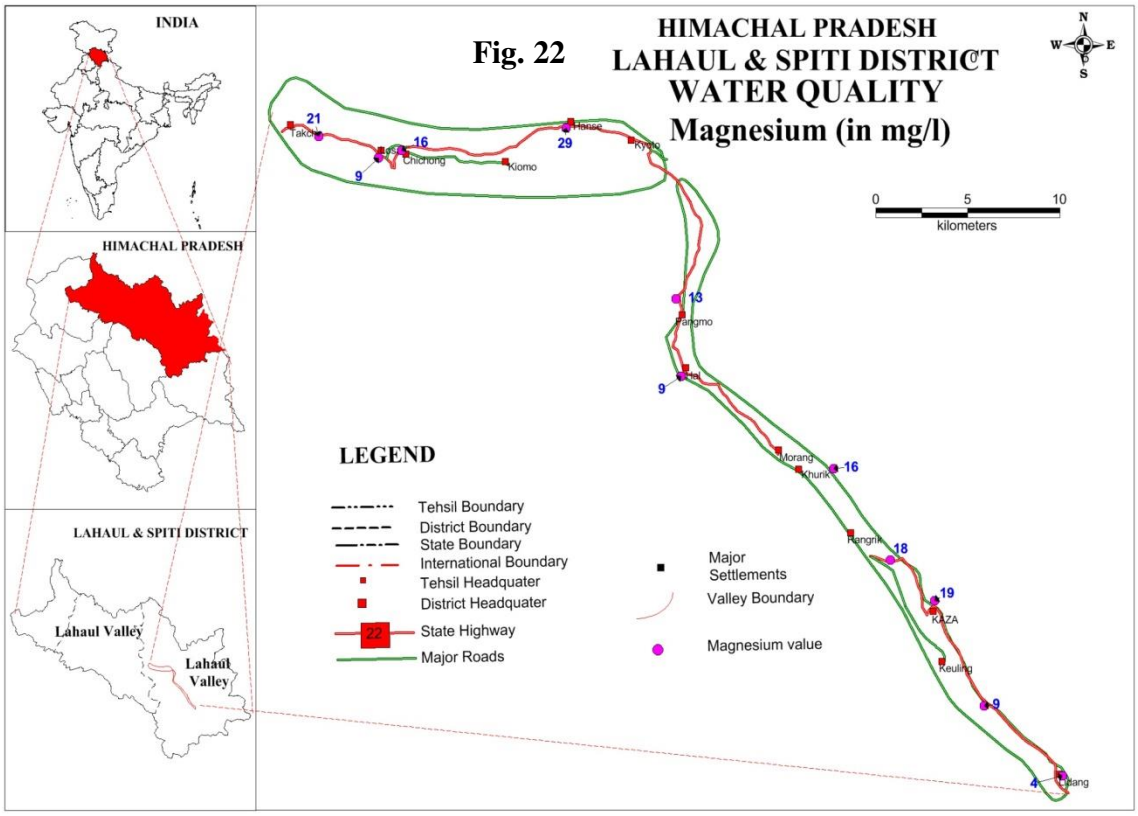


Fig. 20

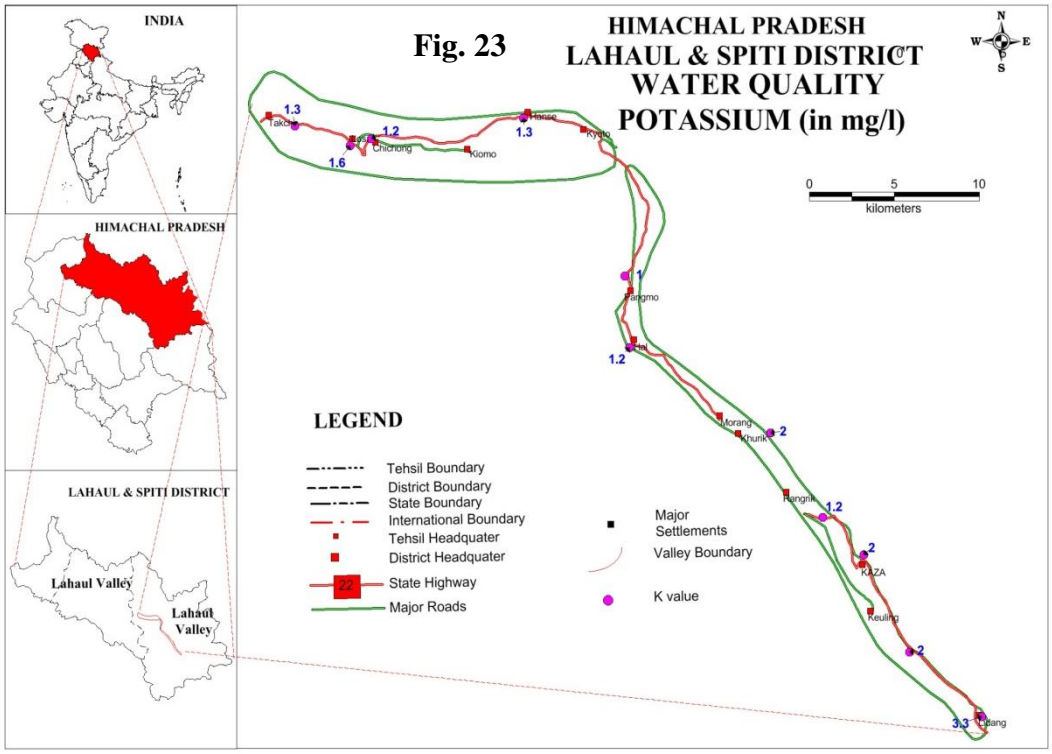
Calcium content ranges between 10 mg/l and 58 mg/l (Fig. 21).



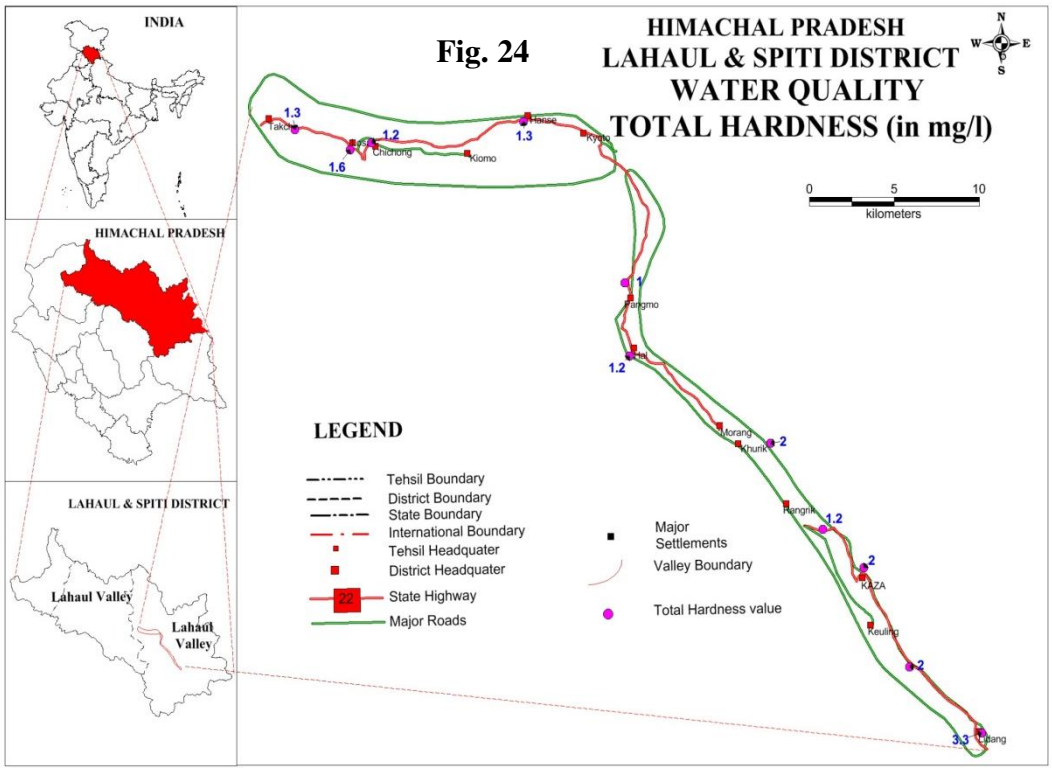
Magnesium content ranges between 4 and 29 mg/l (Fig. 22).



Similarly and Potassium content varies from 1 to 3.3 mg/l (Fig.23).



Total hardness varies from 83to 249 mg/l (Fig. 24).



Hence, in the area all chemical constituents are within the limit as prescribed by BIS, 1991, as such ground water quality of shallow aquifer is fresh and suitable for drinking, irrigation and other domestic purposes.

Table 9. Chemical Analysis of water samples in Spiti valley, Lahaul & Spiti district

S. No.	Location	Lat	Long	Source	pH	Sp Cond ms/cm 25°C	HCO_3	Alkalinity	Cl	SO_4	NO_3	F	Ca	Mg	Na	K	TH	TDS
1	Seko	32.1772778	78.1019722	Spring	8.27	310	140	115	11	31	2.10	0.04	46	9	5	2	150	160
2	Ki	32.28925	78.0145	Spring	8.16	350	177	145	11	18	2.70	0.05	40	16	5	2	168	182
3	Hal	32.3331389	77.9262778	Spring	8.23	160	98	80	4	11	2.90	0.10	30	9	3	1.2	90	83
4	Pangmo	32.3696667	77.9230833	Spring	8.24	260	116	95	11	19	3.40	0.21	30	13	0.5	1	130	135
5	Lossar	32.4363056	77.7506944	Spring	7.9	210	104	85	7	10	3.00	0.13	26	9	1.5	1.6	101	109
6	Chuna Khan	32.4465	77.7160556	Spring	7.76	455	212	174	14	35	7.00	0.24	58	21	2	1.3	230	237
7	Lidang	32.1440556	78.1472222	Spring	7.91	210	85	70	3.5	29	5.00	0.57	10	4	30	3.3	40	109
8	Kaja	32.2269722	78.0731389	Handpump	8.04	395	183	150	11	48	9.00	0.10	48	19	8.2	2	200	205
9	Hansa	32.4505833	77.8594167	Handpump	8.25	410	171	140	7	67	1.50	0.01	36	29	4	1.3	210	213
10	Kaza River	32.2462222	78.0474444	River	8.24	280	104	85	11	37	9.00	0.18	26	18	2	1.2	140	146
11	Lossar River	32.4398611	77.7641111	River	8.2	260	116	95	3.5	39	3.20	0.20	30	16	1	1.2	140	135

8.0 Ground water Development and Management

The entire area of Spiti valley represents the true picture of traditional practices, tapping both surface and subsurface water resources. However, in recent years, some modern technologies are introduced in the valley for developing the Ground water resource. Also with time, efforts are being made to bring more and more land under cultivation by irrigation and also under forests. This has demanded for developing the Ground water as well as surface water sources and further management.

The average elevation of the area is 3600 m amsl. At such a high elevation, it is only the snow-melted water from the glaciers flowing along the nallahs and Rivers and Ground water from spring sources that provide water to the inhabitants. The area is under thick snow cover with varying thickness for about 6 to 7 months. This is also the period when surface water sources do not contribute much water for various uses. In such period, spring sources form the major contributors of water.

Ground water potential areas are occurring all along Spiti River and its major tributaries in Spiti valley. The thickness of the alluvium and the riverine deposits is more along the Spiti River. This is also the reason that most of the settlements are established on the bank of River Spiti. The bore wells fitted with hand pumps are also constructed along the River valley. The thickness of the alluvium is however variable from place to place and is generally increases in the downstream.

All the crops grown in Spiti valley are taken during the month of July to September as rest of the period remains under thick snow cover. Because all the agricultural practices in the valley and dependent on the irrigation, various flow irrigation schemes are provided by Irrigation & Public Health department. The sources for these schemes are either nallah or springs and are gravity based. Similarly the water supply schemes are also based on either nallah or spring sources.

Ground water is developed in the valley by construction of bore wells fitted with hand pumps to meet the drinking and domestic needs, in addition to tapping natural sources of Ground water likes springs. However these hand pumps installed in the valley are constructed in last few years only. Till date no water supply schemes are so far based on bore wells. The spring sources, which are tapped for providing the water supply schemes, are generally having enough discharge and are perennial in nature. Some of the spring sources which are occurring in various villages and hamlets are used locally for domestic use.

The discharge of the hand pumps generally ranges from 12 to 16 lpm and the overall quality of water is good for domestic use. The discharge of the spring sources ranges from

minor seepages to more than 25 lpm. The spring sources are well maintained by the local people and the overall quality of water is good.

The Spiti valley remains under thick snow cover from the month of October/November till the month of April/May. This is also the period when a surface water source like nallahs does not contribute much water for domestic use. In such situation it is only the Ground water sources like springs and bore wells fitted with hand pump, which are available for domestic utilization. The water discharged by these springs is collected in underground and tanks covered from the top by thick slab of either cement concrete for locally available material like wood and clay. The water thus stored in such tanks remains unfrozen even during the month of snow. This water is utilized during snow covered period when no water is available from surface water sources. The hand pumps installed in Spiti valley are also important source of Ground water in addition to springs.

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