STATUS OF GEOTHERMAL ENERGY IN NEPAL

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Key words: Nepal, Main Central Thrust, Balneology, Pollution

Abstract:

Most of the major geothermal springs of Nepal arc localized close to and north of the Main Central Thrust and south of the Main Boundary Fault. Three springs have a surface temperature above 69°C. The geothermameter temperatures of eight springs are in the range of 80 to 115°C. At present the use of these thermal spring waters is largely confined to bathing and laundering purposes. The location of these springs in sparsely populated areas, mostly in the remote, steep Himalayan terrain, and the absence of adequate knowledge of the utilization of low temperature thermal waters have been the major impediments to the promotion of this resource. Heavy dependence on biomass, mainly wood, as the major fuel has given rise to serious environmental problems in the mountainous parts of Nepal. There is a good potential for the use of some of the accessible thermal waters for a wide range of economically productive purposes and for combatting environmental pollution. Detailed scientific studies should be conducted to gain more information about the reservoirs.

Introduction

Twenty-three major geothermal springs have been identified in different pans of Nepal (Fig.1). Most of these are confmed to three distinct tectonic and structural features that characterize the Himalayas in general. The first group lies to the north of the Main Cenual Thrust (MCT) and is located beyond Higher Himal in the geological formation similar to the Tibetan region of China. The second group of thermal springs lies close to the MCI whereas the third group falls on the Main Boundary Fault (MBF) in the Siwalik (Bhattarai, 1986). The MBF developed as a result of the collision of the Indian plate with the Eurasion plate (continent - continent collision) and is of recent formation.

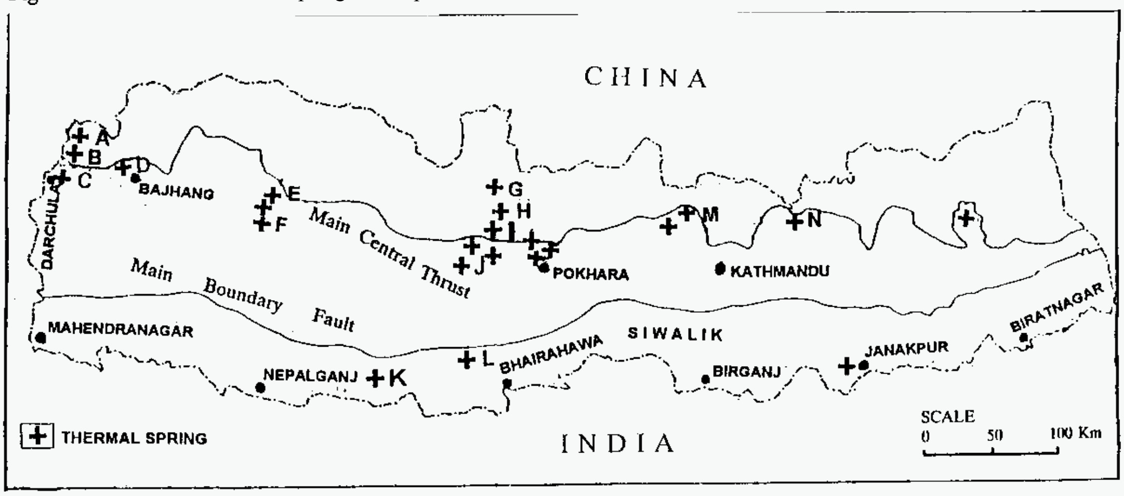
There are more thermal springs in the second group and their average water temperahlre is also higher than that of the other groups. The hot springs in the nonh occur in isolated areas parallel to and south of the thrust. They are generally confined to units of the metasedimentary Lower Himalayan rocks usually in black carbonaceous slate, graphic schist, limestone, quartzite and phyllite.

In the Darchula area. the Sina thermal spring issues from the recent slope scree consisting of angular fragments of white sericitic quartzite and the Srihagar thermal water arises from the recent river sediments. The hot water seepage in Jumla is found in recent deposits comprising gravels and boulders with sandy-silty clay where mini-folds and micro-faults can also be observed. Two seepage occur at fracture joints in the calcareous gneiss and marble. The Dhanchauri spring issues from the light-grey platy dolomite but that of Mayangdi from the base of a cliff of poorly cemented Quaternary conglomerates. *An* extensive fault passes through it. carbonaceous schist and siltstone are exposed on both sides of the fault. There are four springs in this locality. 'ihe Jomsom springs are grouped at the foot of a berm about 100 m high on the hank of the Kali Gandaki River, consisting of fme crystalline and pelitic Lias limestones. Five springs can be seen in the area. Chilime spring is the one not situated on the bank of a river and has only one discharge point. In Kodari hot water issues at several points. The surrounding bedrock consists of quartz biotite sandstone overlain by slightly graphitic argillaceous schist and underlain by siliceous limestone. There are two discharge points in the Suraikhola thermal area.

Store of geothermal *development*

Nepal is still in the infancy stage in the field of geothermal energy exploration. *So* far, surface temperature measurements and chemical

Fig.1 Location of thermal springs in Nepal



analysis have been made of 14 thermal springs, albeit on a sporadic basis. The maximum surface temperature recorded was 73°C in Srihagar (Darchula district) followed by 71°C in Tatopani (Mustang district), and 69°C in Sadhu Khola (Rupandehi district). The temperatures of four other springs were recorded above 40°C. The sub-surface temperatures were calculated by the author from the chemical data using the Program WATCH (version 2.0/1993 of ORKUSTOFNUN), employing the Na/K (Arnorsson et al., 1983) and quartz (Foumier and Potter. 1982) geothermometers for the springs lying on the MCT. The chalcedony geothermometer (Foumier, 1977) was used to derive temperatures in the areas lying an the MBF because this belt is in a recent formation and chalcedony is likely to be in equilibrium with ground water in such formations. The results are presented in Table 1. The maximum sub-surface temperature 115.4°C was found in Tatopani (MCT). A lack of agreement was encountered for the sub-surface temperatures obtained by the quartz geothermometer and the Na/K geothermometer in many areas probably because the thermal water was not in equilibrium with the rock with respect to Na and K and values for this geothermometer have not been shown in the table. Such an ambiguity can also be attributed to factors such as geology, flaw conditions of the thermal water and degree of mixing with near surface ground water (Bashyal, 1984). Absence of geohydrological data has made it difficult to interpret. Most of the spring waters are colourless and characterized by low flow rates. Near the Kali Gandaki area an occurrence of postorogenic Alpine granitic Mustang pluton was found by Hagen (1968). Further eastward similar Miocene granitic intrusions occur in the region of Manaslu, Cho Oyu. Mount Everest, and Makalu summits (Bordet, 1961). The magmatization of Dumphu gneiss (Kali Gandaki area) may be due to activity of Alpine granites (Bodenhausen and Egeler, 1971). Near the Trisuli area numerous granitic intrusions occur within the Gosaikund gneiss of the Higher Himalayan structural unit and within metasediments of the Lower Himalayan structural unit (Arita et al., 1973).

The Darchula - Bajhang area, located in the far westem part of the country, is identified as a relatively active seismic zone (Bashyal. 1984). Long-term temperature and chemical data on the thermal springs of this area could provide valuable information,

Currenr *use of* georhermal *spring* wafer

At present, the use of geothermal spring water in Nepal is largely confined to bathing and laundering purposes. The Tatopani spring of the Myagdi district is extensively used for bathing because it is located along the famous Pokhara - Jomsom trekking route. Cement reservoirs have been built there to comfon the tourists Military men of the nearby barracks also use the hat water extensively far bathing and laundering. The Kodari spring situated on the Nepal - China border. is second in popularity. People in Jumla use the hot spring water to cure rheumatism. stomach troubles and headaches. Such locations are visited by people from the adjoining districts, vu. Kalikot. Humla, Mugu and Dailekh. in winter as well as in summer. These areas also possess a great potential for attracting tourists as the organized groups of tourists visiting the Rara Lake find these on their way back to Jumla airport.

The local people of Bajhang observe a great festival at their geothermal site once a year, while in Darchula. a guest house and a temple have been built in the thermal spring area to attract mountaineen.

Table 1 Information about geothermal localities and temperature

Locality	Symbol	Location		Flow	Surfac	Geothermometer temp (°C) SiO2	Chalcedony	Na/K	Dissolved solids (mg/kg)
Darchula									
Sribagar	A	80.6°	29.9°	0.85	57-73	86.2			516
Sina-Tatopani	B	80.7°	29.9°	0.76	w. 1/				1000
Chamaliya	C	80.6°	29.7°	0.25	w. 1/	37.6			1320
Bajhang-Tapoban	D	81.2°	29.6°	0.2	w. 1/				444
Jumla									
Dhanchauri- Luma	E	82.3°	29.3°	0.6	24			88 2	803
Tilanadi	F	82.1°	29.2°		36-42				353
Jomsom	G	83.7°	29.8°	0.2- 5	21				889.3
Tatopani-Mustang	H	83.7°	28.5°	1.8	71				1840.8
Sadhu Khola	I	84.2°	28.4°	1.39	69			1153	954
Mayangdi	J	83.5°	28.4°	2	40				1340
	K	82.7°	27.9°	1.5	33		54 2	52 3	788
Surai Khola	L	83.3°	27.8°		31		50 1	100 4	510
Chilime	M	85.3°	28.3°	8	55				148
Kodari	N	83.9°	27.9°	5	42				822

1/ w = warm

Some smell of hydrogen sulphide can be noticed in the Jomsom, Bajhang, Rior and Darchula spring areas. The thermal springs of Mayangdi, Kodari, Rior and Surai Khola are alkaline in character. In all cases, the calcium and magnesium concentrations of the thermal water are smaller than in the local cold water.

In the heat flow map of the world, 1982 (Chapman and Pollack. 1987). the heat flow rate of Nepal falls within the global mean range 60-80 mW/m^2. Since most thermal springs in Nepal are located very close to the MCT or MBF, the heat acting on the spring water is likely to be of tectonic origin. There are no known geologically recent magmatic intrusive and/or volcanic rocks in the Nepal Himalayas. Hence, the heat for the thermal springs is considered to be transported by deeply circulating ground water along faults (Rimal. 1984). The stable isotope composition indicates that the thermal waters in the central part of the Nepal Himalayas generally fit the meteoric water line and probably exhibit the influence of the effect of altitude (Grabczak and Kotarba, 1985). In this region there is some geological evidence for the heating of underground waters.

The energy situation in Nepal

Nepal's energy problems are twofold an excessive reliance on non-renewable energy sources and the consumption of one form of renewable energy at an unsustainable rate while keeping the other ones virtually unused. As can be seen from Table 2, fuel wood remains the major energy source of Nepal. It accounts for 19 % of the traditional and 73 % of the total energy consumption. Despite the intensive efforts made in the past to reforest and conserve this resource. the forest area is declining every year, inviting ecological stress, land degradation and a decline in agricultural production and productivity. Moreover, the supply gap in this traditional energy resource is causing a diversion of organic plant nutrients into domestic energy use. Evidently, this can continue only at a cost to agricultural productivity.

Table 2 Energy Consumption in Nepal
(Thousand tons of coal equivalent/year)

	1980/81	1985/86	1990191	1992/93*
Traditional				
	4476.4	6248.0	6834.3	6890.0
Agri. waste	79.2	893.0	1067.1	1060.0
Animal dung	30.0	696.0	761.3	831.0
Commercial				
Petroleum	174.4	268.0	355.2	496.0
	32.3	46.0	58.0	91.0
Hydroelectr.	20.2	39.0	72.0	96.0
Total	4812.5	8190.0	9148.3	Y464.0

* Estimate
Source: Water and Energy Commission,
His Majesty's Government of Nepal

Biomass is the major furl used for cooking and heating purposes in rural households. Indoor air pollution caused by the combustion of biomass such as fuel wood, dried animal dung and dried agricultural residues is receiving increased attention. Combustion of such fuels emits relatively high level of respirable hydrocarbons, particulates of several types, as well as carbon monoxide. Poor ventilation contributes to high concentrations of emission products especially in kitchens in rural areas. This is even more common in alpine environments. where houses are tightly sealed against the cold. Pandey and Basnet (1987) have shown that the prevalence of chronic bronchitis in Nepal has a strong relation to domestic smoke pollution; in Jumla, 31% of the bronchitis cases were due to smoke pollution.

Undoubtedly, the long-term path for the sustainable development of Nepal lies in exploiting the abundant hydropower for energy. Clean energy is one of the major goals; hydroelectricity can provide it. However, the basic option rests on a choice between a mega-approach in water resource development and a decentralized approach with the emphasis on suitable plant sizes. The fundamental questions an the utilization of energy resources arc whether investment will (i) lead to a wider participation of the population in sharing the benefits of the investment, (ii) act as a stimulus to agricultural and agro-processing industries, (iii) serve as an overall impetus to rural industrialization. and (iv) minimize adverse environmental consequences. Experience has shown that the mega-project approach takes a long time and entails a huge investment for which the country has to rely on foreign loan assistance and aid. It would be extremely costly to execute any strategy that aims at covering a fairly large geographical area for the supply of abundant domestic energy by hydropower particularly in the mountainous region where the population is scattered. Even though His Majesty's Government of Nepal (HMG/N), in recent years, put much emphasis on the utilization of this resource on a mini/micro scale by attracting private entities through the provision of subsidies, the effort has a long way to go in order to be realized.

Prospects *for geothermal* energy in Nepal

In view of the above situation, the utilization of geothermal resources can be a very good option for many purposes. It complies with all the four sets of condition outlined above. Geothermal energy is a renewable resource. entails low capital for operation and requires low investment compared to mini/micro hydro plants. Given attention, the available low temperature geothermal fields in Nepal can be extensively used far a wide range of economically productive purposes, for example, hatching of fish and fish farming in most of the colder areas in the north where fish is scarce and available only at a very high cost because of the need to import from distant sources. Sail heating in such areas would also allow double cropping rather than the present single cropping. Space heating would not only provide clean environment but also reduce the dependence on the scarce domestic energy resources of the present. Likewise, mushroom growing and greenhouse production employing this resource can increase food production. Electricity will. however. mostly be produced by hydropower, as the geothermal springs are of relatively low temperature.

Extremely cold climatic conditions in the northern hilly regions have made it very difficult for people of the population centres seeking to have regular baths. Swimming pools built in such areas could indeed be important from the hygienic viewpoint and the general wellbeing of the people.

Tourism occupies a pivotal role in boosting the agro-based economy of Nepal. Thousands of tourists visit Nepal every year to see its unique beauty. The high Himalayas, beautiful landscapes, lakes (Phewa, Rara, Begnas, Rupa etc.) are some of the major attractions. In this country eight of the eighteen mountains in the world exceeding 8000 meters height are located. A significant proportion of the tourists undertaking mountaineering and trekking activities are known to enjoy the hot springs on their way. It is for this reason that HMG/N is motivated to develop geothermal areas as tourist centres.

Absence of adequate knowledge of the utilization of low temperature springs has remained the major impediment to the promotion of geothermal energy in Nepal. This energy sub-sector is treated only with a view to electricity generation which evidently precludes its viability as an alternative source. It is further overshadowed by the availability of abundant hydroelectric potential. optimally estimated at 83 thousand MW.

The location of the geothermal springs in sparsely populated areas, mostly in the remote and steep Himalayan terrain is the natural constraint inhibiting their development. Lack of road networks precludes the possibility of detailed reservoir estimates. However. where such an infrastructure exists, scientific studies should be made to gain more information on the reservoirs.

In the current Eighth Plan (1991-96) of Nepal a modest beginning has been made to prepare an inventory of all the geothermal resources of the country . A definite program on their utilization is, however, yet to emerge. The need to conduct geothermal exploration and development projects in areas near the population centres is panicularly important. The existing personnel trained in various disciplines of geothermal energy. albeit very few, should be mobilized for such activities.

Acknowledgement

I am greatly indebted to Dr. Ingvar B. Friðleifsson, Director, UNU Geothermal Training Program (Iceland). Dr. Guðmundur Pálmason, Chairman of the Technical Program Committee (WGC 1995), and Dr. Halldór Ármannsson, National Energy Authority (Iceland) far their inspiration and valuable suggestions in preparing this paper.

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