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Hydrogeological conditions in Dun valley of Dang, western Nepal: a case study

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ABSTRACT

The Dun Dang Valley constitutes a closed groundwater basin in the midst of Himalaya. It is underlain by fluvio-lacustrine sediments which form unconfined to confined aquifer system. The hydrogeological situation in the valley is inferred from drilling data of the Groundwater Resources Development Board (GWRDB), HMG/N. The study reveals existence of a number of groundwater sub-basins each having its own hydraulic system.

INTRODUCTION

The Dang Valley is an intermontane valley in western Nepal. It is bounded on the north by the Mahabharat Lekh and by Churia hills on the other three sides. It is 80 km in length extending in WNW-ESE direction and has 30 km maximum width with a oval shape.

The Dang Valley has an undulating terrain regionally sloping towards south and deeply indented along stream courses by 8 to 15 m. The terrain is classified,into six terraces by Yamanaka and Yagi (1984). They are highest, higher, middle, lower second and lower third terraces. The elevation of the valley floor varies from 550 m to 750 m above msl with the regional gradient from east to west. River fans and ancient river terraces are found mainly in the northern parts where the streams from the midland descend.

Babai River is the major river in the valley which flows from east to west along its southern margin (Fig. 1). Some prominent streams in the study area from east to west are the Katwa Khola, Sewar Khola, Hapur Khola and Gwar Khola. All other streams are of short courses flowing across the valley from north to south and are nearly parallel. They originate in the Lesser Himalaya, descend into the valley from the Mahabharat Lekh and join the Babai River on the southern side. Some of the streams dry up during summer. But the Babai River is perennial with increasing discharge towards west which shows the characteristic of a gaining river.

Soils in the valley are mostly alluvium and outwash deposits from the hill slopes. In the northern and eastern parts, red soils are encountered with a badland topography. In the central part, the soils are yellowish and grey carbonaceous clays. In the southern part, they are brown or grey containing humus.

Climate in the valley is tropical to sub-tropical. The maximum and minimum temperatures are 35.8°C and 5.8°C, respectively. The average annual rainfall is 1857 mm. Maximum rainfall occurs during the months of June and July. The rainfall increases towards eastern part of the valley.

HYDROGEOLOGICAL SETTING

Geology

The Dang Valley is surrounded by the Siwalik (Churia) hills. On the northern side, however, it is thin and occurs only at lower horizon. It consists predominantly of pale orange, green and grey sandstones interbedded with dark brown, green and red shales. Dhoundial (1959) divided these Siwaliks into lower, middle and upper divisions. The Lesser Himalayan rocks on the northern part are divided into Sharada Group and Daban Supergroup (Dhital and Kizaki, 1987). The Main Boundary Thrust (MBT) separates the Daban Supergroup from the underlying Siwaliks and the fluvial deposits in the south. The Sharada Group and Daban Supergroup are cmposed of shales, siltstones, claystones, phyllites, sandstones, quartzites, limestones, dolomites and conglomerates.

The Dang Valley is filled in the central part with fluvio-lacustrine sediments. A historical depiction of the valley shows it as consisting of a number of ponds all over. At the foot of the Mahabharat Lekh, talus and alluvial cones are located which are composed of angular to subangular pebble to cobble size detritus material. The terrace deposits consist of subangular to subrounded gravel, pebble, cobble and small boulder size sandstone, mudstone, quartzite and limestone. On the southern side, lacustrine deposits such as silt and clay with organic matter with a thickness of more than 23 m is present at some places which mark the lower terrace deposits. The highest terrace is about 80 m above the river bed while it is 5 to 25 m at the lower terrace.

Subsurface Geology

Subsurface geology of the area is revealed through lithologs of the tube wells constructed by the GWRDB, HMG/N which are located mostly on the southern part of the valley. There are 16 deep tube wells with depths of 45 to 150 m and 10 shallow tube wells with depths 20 to 45 m. The shallow tube well programme is under the United Nations Department of Technical co-operation for Development (UNDTCD). Of these, 12 deep tube wells and 4 shallow tube wells fall in the study area between Ghorahi and Tulsipur (Fig. 1) and the rest in the far western part of the valley (Upreti and Karanjac, 1989).

Along the northern part where the fan deposits are common, the sediment sequence is dominant with boulders, pebbles and gravels. The tube wells at Tarigaon, Beljhundi, Tari and Ammapur reveal predominance of sand and gravel constituting more

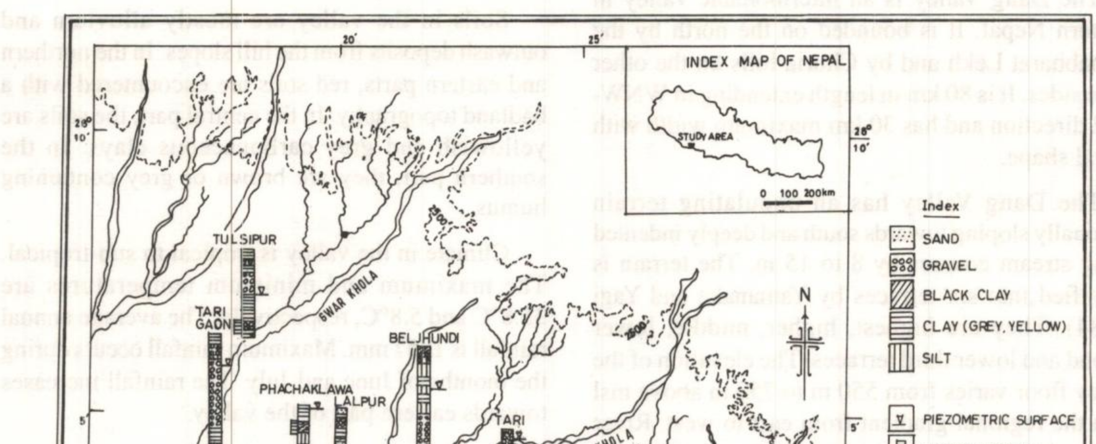

Fig. 1: Lithologs of tubewells in Dang Valley, western Nepal (Source: GWRDB, HMG/N).

than 80% of the total sediment. They form thick layers in some places and occur in four or five layers alternate with clays or admixture of clay, silt, sand and gravels in others. On the southern side of the valley, the percentage of gravels decreases and clay increases. Maximum thickness of clay is found at Jaspur. Other places where clay predominates are Dundra, Dhikpur, Amraiya and Pakkoi. Black clay characteristic of marshy zones is present at different depths all along the southern part. These black clay is generally absent on the northern parts. Grey and yellow clay occurs all over the area at different depths. At a few places close to the Babai river, granular zones of considerable thickness occur as at Bhojpur. There are a few places in the northern part of the valley where clay is predominant as at Tulsipur. The sediment distribution in the valley is highly variable in east-west as well as in north-south directions because of the influence of different streams. The clay as well as granular beds are with limited aerial extent.

Groundwater Conditions

Along with variations in the sediment distribution in the valley, the granular zones at depth form aquifers of varied nature from water table to confined conditions depending on the nature and extent of confining beds. The soil and clay zones at the surface which have considerable thickness in many parts and alluvium in some parts form phreatic aquifer and it is tapped by dug wells with a depth range of 4 to 25 m. Water table as measured in the month of October, 1989 lies at a depth range of 0.15 to 10.3 m bgl (below the ground level). Its seasonal fluctuation is reported as 4.0 to 20.0 m. These parameters have higher values towards northern part controlled by topography. Water table rises rather sharply in the month of July, remains at constant elevation steadily upto September and then starts declining gradually in some places and rapidly in other places. Some shallow tube wells upto a depth of 27 m show water table conditions. Specific instances are Tarigaon and Lalpur tube wells where the aquifer zones are located beyond the depths of 12.2 and 27.4 m and water table is at depths of 15.2 and 37.5 m bgl respectively (Table 1).

The confining nature of the deep aquifer zones is revealed from their piezometric head. Confining nature is developed in the granular beds from a depth of 7.0m onwards. Piezometirc head which indicates the fluid potential above the uppermost aquifer screened is in the range of 3.9 to 57.7 m. Piezometric surface of the confined and semiconfined aquifers is at a depth range of 1.1 to 37.5 m bgl. Seasonal fluctuation of piezometric surface is in the range of 1.5 to 18.4 m with the higher values towards northern part. High fluctuation may indicate loss of groundwater as subsurface outflow. The water levels show maximum rise during August and starts declining from October onwards gently in some cases and steeply in others depending on the topography. This shows a time lag of 1 month between the dug well zones and tube well zones for their recharge. Yields of the tube wells zones for their recharge. Yields of the tube wells range from 0.4 to 23 lps (liters per second) and their sp. capacity varies from 0.01 to 15.9 lps for per m of dradown. Hydraulic conductivity varies from 2.3 to 128.8 m/day and in some cases upto 418m/day (Upreti and Karanjac, 1989).

The fluid potential distribution and nature of hydraulic system in the Dang Valley is inferred from the relation of piezometric head and the depth of aquifer as shown in Fig. 2. The data plots for the entire valley depict poor correlation. It also reveals that the hydraulic relation of P μ wh (P is hydrostatic pressure, w is specific weight of water and h is depth of the aquifer) is not satisfied. A strong correlation between these two parameters is observed in other parts of the Terai in the Morang district (Bhattarai and Rao, 1989), Nawalparasi district (Pathak, 1991, and Rao and Pathak, 1993) and also in the Kathmandu valley (Gautam and Rao, 1991). In the Dang valley, however, a fair correlation is observed when the tube wells are categorized according to drainage sub-basin in which they are located. In a few exceptions some wells do not conform to this relation. For instance, well no. 10 (Beljhundi) in the Hapur Khola sub-basin does not develop requisite head on par with the other wells 1 and 11. Similarly, well no. 13 (Bargadi) and 14 (Pakkoi) in the Katwa Khola sub-basin develop very little head compared to the wells 3 and 12 in that basin. Such wells are found to be semiconfined with admixtures of gravel and fine sediments as confining beds. Secondly, they are located relatively at a higher elevation than the other wells.

Table 1: Aquifer and well parameters, Dang Valley, western, Nepal (after Upreti and Karanjac, 1989).

S N.	Well No.	Well location	Reduced level of the ground surface sl.	Total depth m.bgl.	Piezo- m.bgl.	Surface mmsl	Piezo- metric head (available draw down m)	Dis- charge lps	Max. draw down m	Speci- fic capa city Lps/m of draw down)	Expe- cted max. yield lps	Trans- missi- vity T m^2/day	Hydrau- lic condu- ctivity K m^2/day	Cumula- tive thick- ness of aquifer tapped	Depth of aquifer m.bgl.	Aquifer materials
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
1.	DGSTW5	Phachaklawa	617.7	41.0	1.1	616.6	7.1	23.0	5.3	4.35	30.8	495	38.9	12.7	8.2	Gravel with sand
2.	DGSTW6	Dundra	593.1	38.1	5.0	588.1	22.4	23.0	-	-	-	-	-	10.7	27.4	Gravel
3.	DGSTW7	Ammapur	674.3	20.1	3.0	671.3	3.9	11.0	4.8	2.2	9.0	745	67.7	11.0	7.0	Sand and Grvel
4.	DGSTW10	Tulasipur	676.6	45.7	23.5	653.1	12.9	-	-	-	-	-	-	4.3	36.5	Gravel
5.	GW 1	Dhikpur	605.0	140.2	9.6	595.4	57.5	1.8	12.2	0.1	8.2	-	-	28.0	67.1	Sand and Gravel
6.	GW 2	Tarigaon	622.7	70.1	15.2	607.5	0.0	16.7	1.0	15.9	-	3440	75.2	45.7	12.2	Gravel
7.	GW 3	Amraiya	626.3	149.4	13.8	612.5	-	2.5	21.9	0.1	-	-	-	-	66.1	-
8.	GW 4a	Bhojpur	582.1	117.3	14.8	576.3	29.3	7.3	16.2	0.4	13.2	-	-	49.2	44.2	Gravel andSand
9.	GW 5	Amuvapur	633.1	68.9	23.7	609.3	18.6	4.9	22.0	0.2	4.1	-	-	15.5	-	Gravel
10.	GW 6	Beljhundi	646.1	100.6	22.6	623.4	12.4	-	-	-	-	-	-	48.7	35.1	Gravel
11.	GW 9	Tari	627.4	96.0	4.7	622.7	45.9	1.2	36.2	0.03	1.56	-	-	30.6	50.6	Gravel
12.	GW 12	Guleriya	649.3	99.1	5.1	644.2	57.7	0.4	25.0	0.01	0.9	-	-	16.4	62.8	Sand and Gravel
13.	GW 13	Bargadi	655.5	59.7	30.0	625.5	4.1	7.0	25.0	0.2	1.1	-	-	25.6	24.1	Sand and Gravel
14.	GW 14	Pakkoi	616.3	72.5	21.1	595.1	14.5	10.0	18.2	0.4	7.1	25	2.3	10.9	35.7	Gravel
15.	GW 15	Lalpur	613.0	74.4	37.5	575.5	00.0	9.7	1.3	7.1	-	5670	128.8	44.0	27.4	Sand and Gravel
16.	GW 16	Jaspur	584.4	68.9	21.1	563.2	28.2	13.0	1.8	7.0	199.3	2925	417.8	7.0	49.4	Gravel

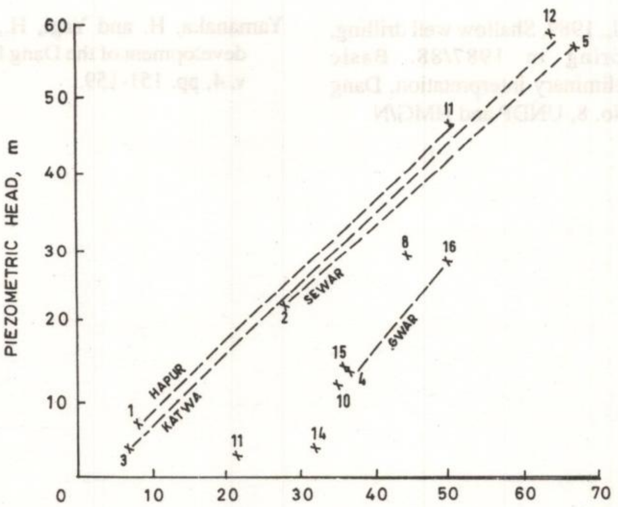

Fig. 2: Depth of the aquifer, m bgl.

The second important characteristic of fluid potential distribution is that each sub-basin has its own hydraulic system with different hydraulic heads at different levels as indicated by their positions in Fig. 2. Contrastingly, the Kathmandu Valley is also an intermontane valley, but it acts as a single groundwater basin with a single hydraulic system because the drainage is of centripetal type converging at the centre of the valley (Gautam and Rao, 1991).

CONCLUSIONS

Dang valley constitutes a number of groundwater sub-basins which coincide with the drainage sub-basins. The aquifers in the valley are under unconfined, semi-confined and confined conditions. Each sub-basin has its own hydraulic system with different levels of fluid potentials. The subsurface outflow from the valley may be checked by constructing subsurface dams across the Babai River at the outlet of the valley and at the confluence points of each stream with the Babai river.

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