Journal of Nepal Geological Society
Vol. 6, 1989, 37 to 50

HYDROGEOLOGICAL CONDITIONS IN THE TERAI PLAIN OF MORANG DISTRICT, EASTERN NEPAL

T.N. BHATTARAI*, & G. Krishna RAO**

ABSTRACT

The Terai Plain of Morang District is underlain by thick alluvium deposits. Alternate sequence of gravel, sand and clay turn into multiaquifer system. Artesian conditions occur in some parts of the middle Terai. The area possesses rich groundwater potential which can be used for industrial and large scale irrigation. Over development of groundwater is suggested to reclaim the land under water-logging and marshy conditions in the middle Terai.

INTRODUCTION

The Kingdom of Nepal is a montainous country, about one third of which is plain called Terai. Bordering India on the south, the Terai Plain has an average width of 30 km and forms a distinct physiographic unit. This plain forms the northern limit of the Gangetic Plain.

The area is located between Latitude 26°20' to 26°45' N and Longitude 87°15' to 87° 45' E, and forms parts of the toposheet nos. 72 N/6, N/7, N/10 and N/11 (Fig. 1).

The area enjoys sub-tropical climate. The minimum and maximum temperatures as recorded at Biratnagar are 4.2 and 41.3 C respectively. The average annual rainfal is 1700 mm.

Topography

The area is, in general, a plain country sloping to the south with the minimum and maximum altitudes of about 60 m and 500 m above m.s.l. respectively. The Terai Plain in the study area is nearly 37 km wide (N - S) and runs east-west bordering Churia (Siwalik) hills on the north. Topographically, the Terai Plain is divided into three zones: Bhabhar Zone, Middle Terai (Terai Zone) and Southern Terai (Flat lands).

Bhabhar Zone is an upland lying 150 m above m.s.l. which slopes to the south at about 100 to 200 m per kilometre. Its southern margin is marked by a spring line which gives rise to the emergence of many streams. To the south of the spring line is the Middle Terai extending over a width of about 19 km upto Duhabi Bazar on the western part (Sharma, 1974). It is an undulating terrain consisting of isolated patches of water logging and marshy conditions. These zones are well observed at Kanepokhari and Hathigauda. Grass and scrubby vegetation mark the marshy patches. Middle Terai slopes at about 5 m per kilometre between altitudes

* Department of Geology, T.C. Campus, T.U. Kathmandu.
** Colombo Plan Expert from India.

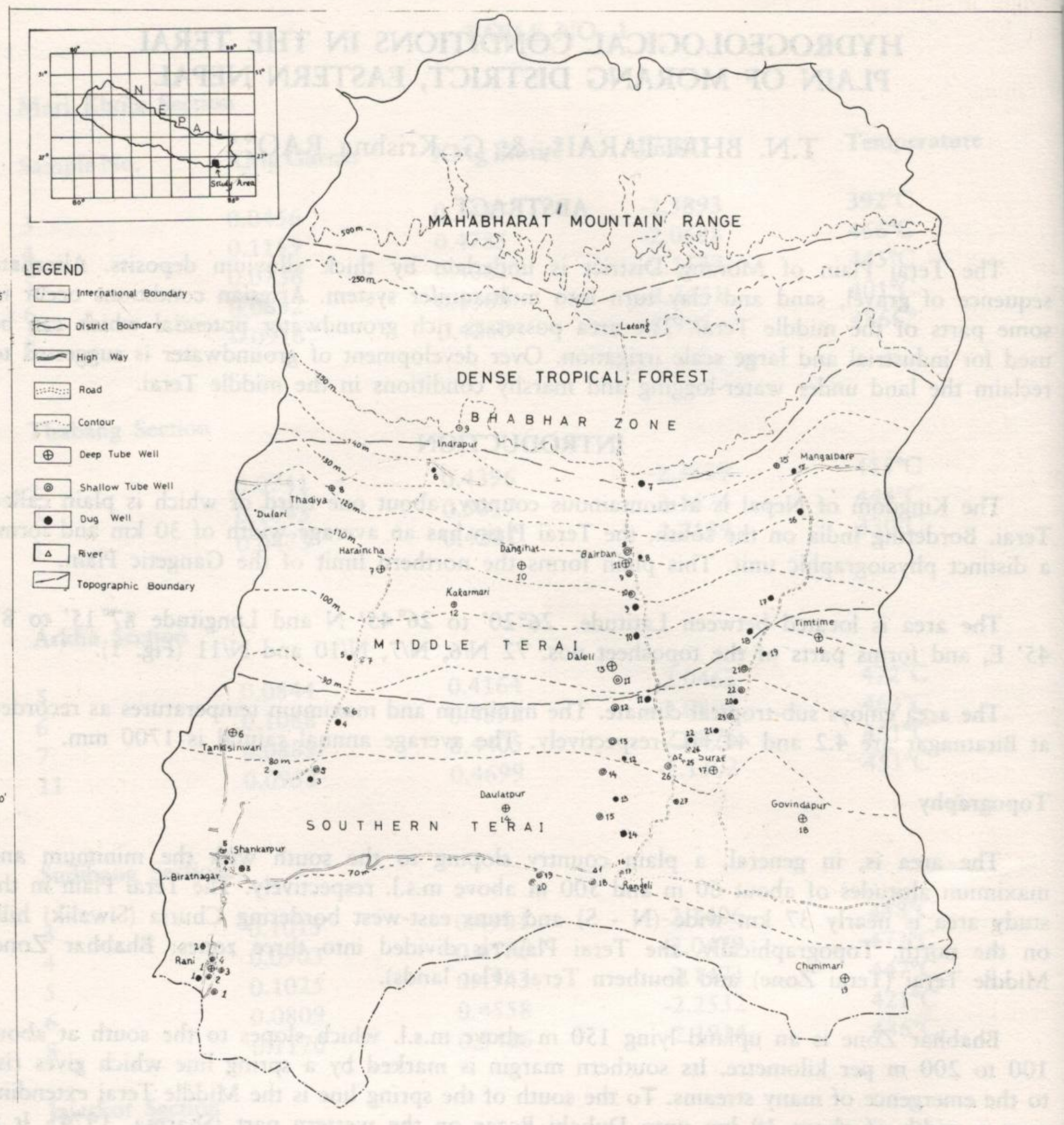


FIG. 1 TOPOGRAPHIC ZONES AND WELL LOCATIONS

90 to 150 m above m.s.l. The Southern Terai stretches along the Nepal - India border. It ranges in altitude from 60 m to 90 m above m.s.l. with a topographic gradient of about 2 m per kilometre.

Drainage

Three types of rivers flow through the Terai Plain - those originating from the 1) Higher Himalaya 2) Mahabharat and Churia Hill Ranges, and 3) from the Terai Plain itself (Sharma, 1978). There are no major rivers from the Higher Himalaya flowing through the study area. However, SaptaKoshi, the biggest river of Nepal, whose seven tributories originate from the Higher Himalaya, flows about 35 km west of the study area. Two centuries ago, the SaptaKoshi River flowed from near Purnea (about 80 km south east of Biratnagar) in India, but now its main braided channel is 96 km to the west (Holmes, 1964). It seems, therefore, that the SaptaKoshi flowed through some parts of the study area in the geological past.

Originating in the Mahabharat Mountain Ranges, most of the existing rivers in the study area from a parallel river system. Some of these kholas and rivers from east to west are Ratuwa, Bakra, Dans, Chisang, Lohendra and Kesalya. Emerging from springs in the Terai Plain, Singhiya Khola, Juri Nadi, Karchiya Khola, Cheka Nadi Kochini Nadi, and Karia Nadi flow from the central part of the area.

The courses of most of the streams in the study area are of meandering type. Contrary to the general nature of the stream courses which enlarge their size towards downstream, the streams in the study area, which are wider in the Bhabhar zone, become narrower or almost missing over some distance downstream in the Middle Terai. Some local streams even disappear in the Middle Terai.

Some streams like Chisang Khola and Dans Khola with low base flow during summer lose their discharge as they pass through the Bhabhar Zone and gain water again at the contact between Bhabhar Zone and Middle Terai. Some streams, like Pathari Khola, again lose and gain water as they pass through the Terai Plain.

Geology

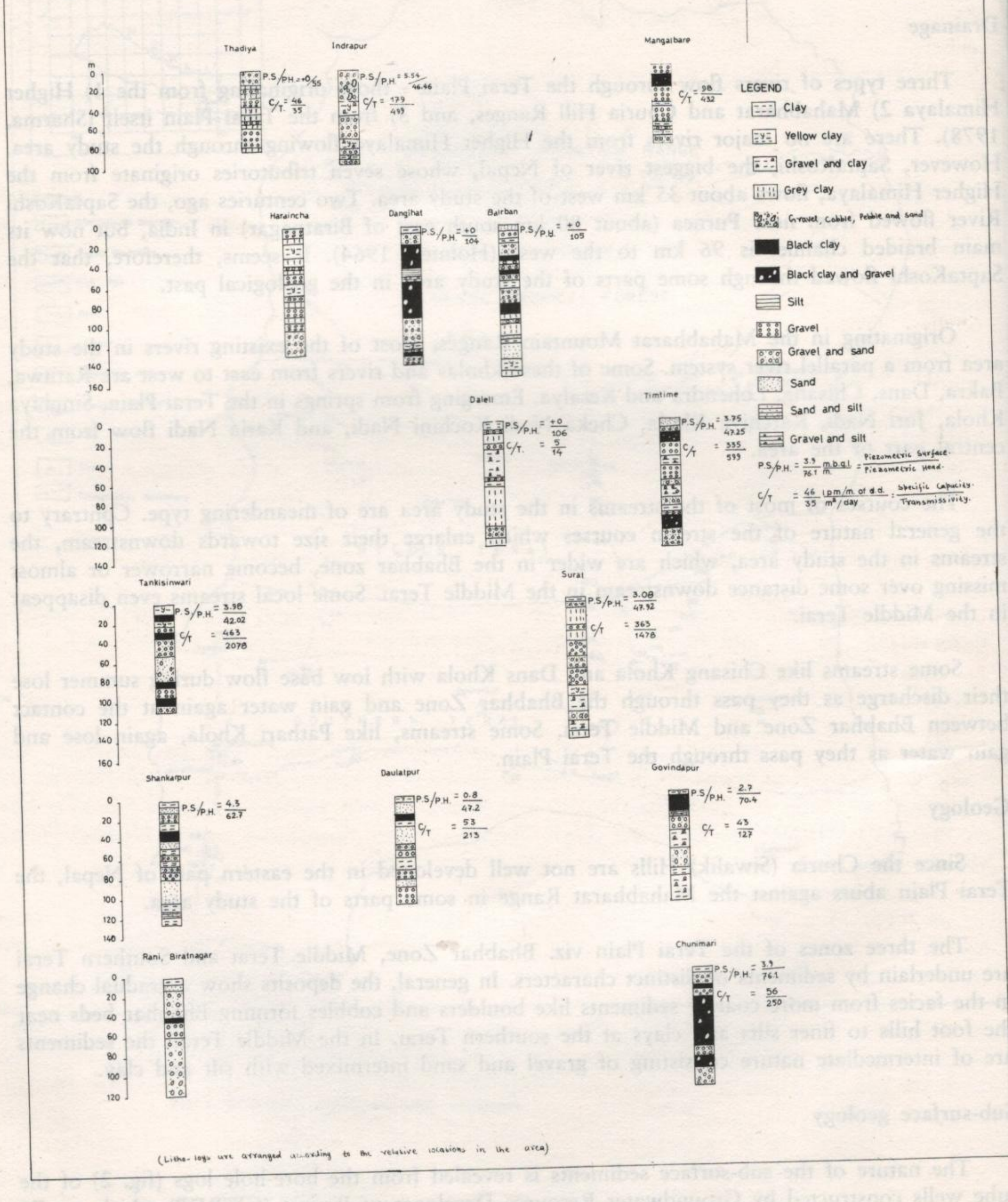
Since the Churia (Siwalik) Hills are not well developed in the eastern part of Nepal, the Terai Plain abuts against the Mahabharat Range in some parts of the study area.

The three zones of the Terai Plain viz. Bhabhar Zone, Middle Terai and Southern Terai are underlain by sediments of distinct characters. In general, the deposits show a gradual change in the facies from more coarser sediments like boulders and cobbles forming Bhabhar beds near the foot hills to finer silts and clays at the southern Terai. In the Middle Terai, the sediments are of intermediate nature consisting of gravel and sand intermixed with silt and clay.

Sub-surface geology

The nature of the sub-surface sediments is revealed from the bore-hole logs (fig. 2) of the tube wells constructed by Groundwater Resource Development Project (GWRDP) which are 76 to 153 m deep. Bulk of the sediments in the northern part of the area consist of very coarse

FIG. 2 LITHO-LOGS OF TUBE WELLS, MORANG DISTRICT



(Litho-logs are arranged according to the relative locations in the area) materials like cobbles, pebbles and gravels in the upper layers, and gravel and sand below 46 m depth. In the Middle Terai, clays predominate over granular zones occurring at various depths. Granular zones in this part are rich in gravel. In the Southern Terai, sands predominate over gravel forming intermixed zones but bulk of the sediments are composed of silts and clays. Clays are black and yellow in colour. Any lithological horizon is hardly found to be continuous either in N-S or in E-W directions across the plain. It infers that the sedimentation pattern is highly variable within small distances.

GROUNDWATER CONDITIONS

The above descriptions show that there are many granular zones at different depths occuring alternate with clay horizons. Such a disposition gives rise to confined multiaquifer system. The vertical and lateral dimensions of different beds and their discontinuities suggest that these aquifers are likely to be interconnected laterally and some of them may also form leaky aquifers.

Shallow aquifers

In some parts of the study area fine sediments such as silts and clays intermixed with sands form the surficial deposits and these are tapped by dug wells to a depth of 3 to 6 m. However, in the Bhabhar Zone and Middle Terai, the surficial deposits are composed of gravel and gravel intermixed with sand respectively. In the Southern Terai sandy and silty sediments constitute shallow aquifers.

Depth of water as observed in the dug wells (except in the Bhabhar Zone) during December, 1987 ranges from about 1 to 5 m, below ground level (b.g.l.) with deeper levels towards northern and mid-eastern parts and shallower levels in the middle and southern parts depending upon the topography i.e. deeper in the topographic high and shallower in the topographic low. In most parts of the area including central part, water table is at a dept of 2 to 3 m b.g.l. Water table fluctuation is, in general, less than 2 m (table 1). The average hydraulic gradient is almost the same as the topographic gradient.

Deep acquifers

Deep aquifers, which form confined aquifers occur at different depths. These aquifers are mainly composed of gravel mixed with sand but pure sand and gravel zones also occur in some horizons. The uppermost confined aquifer occurs at a depth of 4 to 20 m b.g.l. in general and 20 to 40 m in some parts. Generally, the individual aquifers have a thickness of 2 to 20 m. These aquifers are separated from one another by clay formations which ragne in thickness from 2 to 50 m.

Shallow tube wells

Shallow tube wells, generally 5 to 30 m deep, are sunk to extract groundwater for domestic purposes in the villages and towns of the study area. Generally brass screen of about 2 m length is used at the bottom of these wells. Iron pipes and polythene pipes (4 cm diameter) are used as casing. In case of polythene pipe, man made screens are used (at the lower end of the polythene pipe, circular holes about 0.5 cm diameter are made and these holes are covered with a nylon cloth. This works as a screen). These tube wells are fitted with hand pumps.

Table 1 : Hydrogeological Particulars of Dug Wells in Parts of Morang District

Well No.	Location of Wells	Depth to water table b.g.l (m)	Reported post-monsoon water b.g.l. (m)	reported premonsoon water level b.g.l. (m)	Water level fluc-tua tion	Reported Geological Section	Remarks
1.	Rani	4.3	3.5	5.0	1.5	0-1.5m Surface soil; 1.5-3m yellow sand 3-6m coarse sand.	
2.	Khunighat	0.96	0.9	2.14	1.24	0-1.2m black clay; 1.2-3 sand.	
3.	Jhorahat	1.93	1.5	2.7	1.20	0-1.5 black clay; 1.5-4 sand.	Fe problem
4.	Pidarboni chowak	2.24	1.8	3.4	1.60	Litho-log not reported.	old well
5.	Titaria	3.17	2.7	4.6	1.90	0-2m sandy soil; 2-5m coarse sand.	
6.	Khorsane	1.7	1.53	3.35	1.85	Litho-log not reported.	
7.	Kanepokhari	3.58	3.05	5.03	1.98	Litho-log not reported.	old well
8.	Mangalbare Village	0.96	0.76	1.83	1.07	0-0.6m Surface soil; 0.6-2m sand 2-4m sand mixed with gravel	
9.	Lal Jhora	1.88	1.53	2.74	1.21	0-0.9m sandy soil; 0.9-4m coarse sand.	
10.	Bansbari	2.23	1.83	3.05	1.22	0-0.9m Silty clay; 0.9-2m Yellow sand; 2-5m fine sand.	
11.	Keraun	2.69	2.13	3.66	1.53	Litho-log not reported	
12.	Pharsadangi	2.54	2.13	3.96	1.83	0-1.2m Silty Clay; 1.2-3m Yellow sand; 3-5m white sand.	old well
13.	Darbesabazar	2.33	1.83	3.66	1.83	Litho-log not reported.	
14.	Rangeli	2.21	1.98	3.66	1.68	0-0.9m Sandy clay; 0.9-4m sand.	old well
15.	Mangalbare Bazar	3.36	2.89	4.88	1.99	Litho-log not reported.	old well
16.	Lali Jhora	2.03	1.53	3.05	1.52	0-2m Sandy soil; 2-5m sand and gravel	
17.	Bhoteghumti	3.0	2.44	4.27	1.83	0-2m Sandy soil; 2-4m black clay;4-7m sand & gravel.	
18.	Hasandaha-9	2.9	2.44	3.66	1.52	Litho-log not reported	Fe-problem
19.	Hasandahabazar	5.04	3.66	4.57	0.91	Litho-log not reported	old well
20.	Thapagaon	2.21	1.83	2.74	0.91	0-1.5m Silty clay; 1.5-3m sand	old well
21.	Amardahabazar	3.2	2.89	4.27	1.38	wLitho-log not reported	old well
22.	Hardibari	2.9	2.13	3.66	1.53	0-0.9m Sandy Soil; 0.9-5m sand mixed with gravel.	old well

Deep tube wells

Exploratory tube wells were constructed mainly in the middle and southern Terai by the GWRDP. Most of the tube wells were provided with a single screen of generally 5-8 m and exceptionally of 15 m length. Few tube wells were constructed with multi-screens at different depths tapping different granular zones (table 2).

Depth of piezometric surface as recorded in these tube wells by the GWRDP ranges from above ground surface in some parts of middle Terai resulting in flowing conditions to about 6 m b.g.l. in other parts. The piezometric head varies from 42 m to more than 106 m increasing with the depth of aquifer tapped (Fig. 3). This results in an upward leakage of groundwater. Flowing conditions occured where the tube wells tapped deep aquifers. But in a few cases, it appears to be due to local topographic depression resulting in the piezometric surface to fall above ground level.

Specific capacity of the tube wells in the study area ranges from 5 to 743 lpm/m of drawdown. Considering only half of these values in view of probable well losses, the maximum yields of the tube wells for the maximum available draw-down would be in the range of 75 to more than 500 cu m/hr leaving certain pockets of very low yields as obtained for flowing wells. These yields are quite adequate for the large scale development either for industrial or for irrigation purposes.

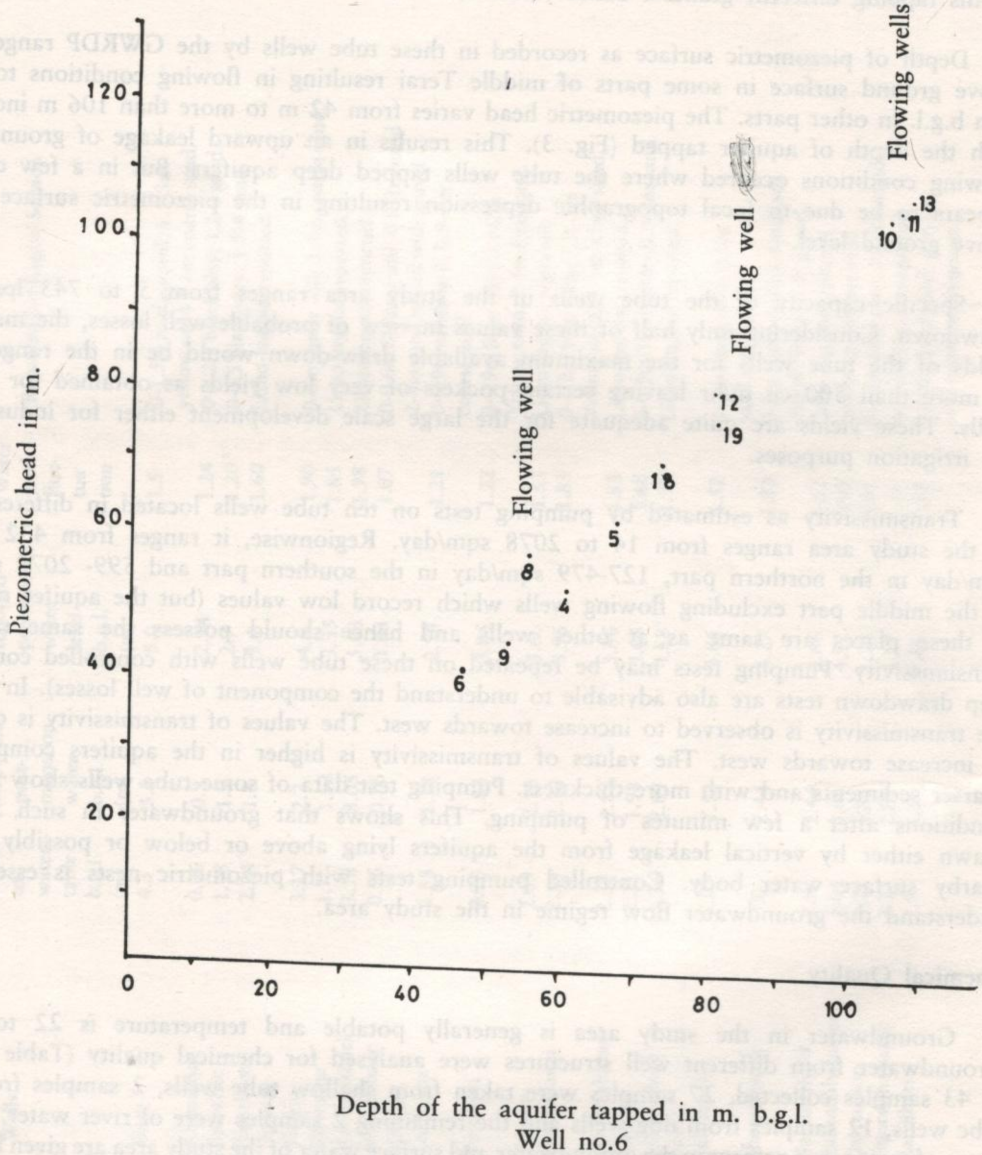
Transmissivity as estimated by pumping tests on ten tube wells located in different parts of the study area ranges from 14 to 2078 sqm/day. Regionwise, it ranges from 432 to 499 sqm/day in the northern part, 127-479 sqm/day in the southern part and 599- 2078 sqm/day in the middle part excluding flowing wells which record low values (but the aquifer materials in these places are same as at other wells and hence should possess the same range of transimissivity. Pumping tests may be repeated on these tube wells with controlled conditions. Step drawdown tests are also advisable to understand the component of well losses). In general, the transmissivity is observed to increase towards west. The values of transmissivity is observed to increase towards west. The values of transmissivity is higher in the aquifers composed of coarser sediments and with more thickness. Pumping test data of some tube wells show a steady conditions after a few minutes of pumping. This shows that groundwater in such zones is drawn either by vertical leakage from the aquifers lying above or below or possibly from a nearby surface water body. Controlled pumping tests with piezometric nests is essential to understand the groundwater flow regime in the study area.

Chemical Quality

Groundwater in the study area is generally potable and temperature is 22 to 25 C. Groundwater from different well structures were analysed for chemical quality (Table 3). Out of 43 samples collected, 27 samples were taken from shallow tube wells, 2 samples from deep tube wells, 12 samples from dug wells and the remaining 2 samples were of river water. General range of major ions present in the groundwater and surface water of the study area are given below.

On the basis of salinity and major ions content, the groundwater can be classified under excellent category. There is no significant variation among the water form the three well structures with respect to PH, total dissolved solids and other chemical parameters. It is significant

Fig. 3. Graph between depth of the aquifer tapped and piezometric head.



	PH	TDS mg/1	Alkalinity mg/1	Bicarbonate mg/1	Chloride mg/1	Total hardness as Ca Co mg/1	Calcium mg/1	Magnesium (Calculated) mg/1
Dug well	7.4-8.4	61-657	190-950	20-122	14-298	180-880	45-200	5-120
Shallow tube well	7.4-7.9	47-314	140-1060	34-120	12-120	70-430	20-125	4-41
Deep tube well	7.7	165-201	490-630	8-73	23-120	180-200	55-75	2-13
River	7.7-8.2	98-139	350-500	41-49	10-31	160-200	50-60	2-18

to note that the total dissolved solids of rivers water are higher than the minimum range of the dug well and shallow tube well water. It confirms that the base flow of the rivers water is derived from the seepage zones or that these rivers are of gaining nature. The maximum range values are higher in the dug well water followed by shallow tube well and deep tube well water. The dug well water are from finer sediments of low permeability as the dissolved solids increase with sluggish flow conditions (Suryanarayan and Krishna Rao, 1985) or pollutted.

The only chemical constituent that disqualifies these groundwater for any purpose (except perhaps irrigation) in certain pockets is the high Fe content. Black clays are considered as the source beds for iron content (Krishna Rao et al., 1989).

Groundwater Resource Evaluation

Rainfall and surface water become sources of groundwater recharge in the study area. As reflected in the stream flow, Bhabhar Zone forms the reacharge area for the deep confined aquifers constituted with the Bhabhar beds. The overlying aquifers may have other areas of recharge where those granular zones are exposed on the surface or connected to such beds.

The present state of groundwater development in the study area is very limited as it is confined mainly to the domestic needs. Water level (water table or piezometric surface) fluctuation in the wells is on the minimum side as it is mainly responsive to the natural recharge and discharge conditions.

An approximate estimate of perennial yield of the confined aquifer system comes to only 0.2 million cu m/yr (considering the area of 1526 sq km, approximate flucutation of piezometric surface, 1.5 m and storage coefficient assumed 1 × 10 to the power minus 4). The maximum exploitable groundwater resource (static reserves) comes to about 10 million cu m (considering an average piezometric head of 67 m). This figure may become the maximum parennial yield if the recharge is increased by all possible means in the area and the piezometric surface returns to the initial level every year. However, since the area is underlain by confined aquifer system, perennial yield can also be calculated on the basis of flow through the aquifers when there is a perennial recharge source such as river water. On this basis, the maximum groundwater that can be transmitted through the granular zones upto a maximum depth of 150 m and under normal hydraulic gradient is found to be about 34 million cu m/yr. Under pumping conditions with a maximum drawdown of 67 m and consequently with increase in hydraulic gradient to 0.008 or more, it may increase upto about 69 million cube m/yr or more (the flow is assumed through the entire width of the district in E-W direction i.e., 27.5 km and a total thickness of aquifer zones of 57 m and a normal hydraulic gradient of 0.004 and an average hydraulic conductivity of 15 m/day).

Intensive exploitation of groundwater in the area may induce more recharge from the parennial rivers. As the alluvium in the Terai is very thick, groundwater exploitation can be extended further deeper to a maximum depth of about 1000 m subjected to the economic viability. Middle Terai should be overdeveloped to lower the water table in the water logged zones and to reclaim the land. The groundwater regime in the Terai Plain forms an open system unlike the normal groundwater basins where it is genrally closed on three sides. Therefore, the conventional methods of recharge estimates like water level fluctuation method, water balance method, etc. are not appropriate to this terrain.

The Terai Plain, therefore, should be subjected to intense groundwater development initially but cautiously observing its effect on the aquifers. Actual perennial yield of these aquifers can be estimated in course of such planned development of groundwater resources.

CONCLUSION

The study area comprises of multi-aquifer system since the intermittent clay formations occur as lenses and layers. These aquifers are likely to be interconnected laterally. Some aquifers may also have vertical hydraulic continuity.

Water table ranges in depth from about 1 to 5 m b.g.l. The piezometric surface in the tube wells varies from above ground level in some parts to about 6 m b.g.l. in other parts. Tube wells are capable of giving yields in the range of 75 to more than 500 cu/m/hr.

Quality of groundwater from shallow and deep aquifers is, in general, excellent with TDS ranging from 47 to 657 mg/1 except for iron problem in certain zones.

Stream recharge of groundwater is important in the study area. By inducing recharge from these surface water bodies, the maximum groundwater resource that can be obtained in the area would be more than 39 million cu. m/hr. However, with increase in depth of aquifer tapped, more groundwater can be exploited.

Over development of groundwater is necessary in the middle Terai for land reclamation which is under marshy and water-logging conditions.

Check dams may be constructed across the river courses to impound surface run-off and increase groundwater recharge.

ACKNOWLEDGEMENTS

The authors are highly grateful to Dr M.P. Sharma, Head, Central Department of Geology, T.U., Kirtipur, for his constant encouragement and providing necessary facilities to carry out this study. Certain aspects of this paper have been discussed with Dr. Sharma and Dr. B.N. Upreti, Chairman, Geology Department, Tri-Chandra Campus, for which the authors are thankful. They extend their sincere thanks to Mr. Y.L. Vaidya, Member-Secretary, Groundwater Resource Development Board, for giving access to the groundwater reports of the area. The help and co operation extended by Mr. Prem Bahadur Karki, Hydrogeologist, and Mr. Badri Bhattarai, Chemist, GWRDP, Biratnagar Division for the field work is duly acknowleged. The assistance received from Mr. S.M. Rai, Assistant Lecturer, Geology Department, Tri-Chandra Campus, who had accompanied the first author during the field work, is duly acknowledged.

REFERENCES

Holmes A. 1964. Principle of Physical Geology.

Krishna Rao, Bhattarai, T.N., Rai, S.M. and Sharma, M.P. 1989. A Note on Iron-Rich Groundwater in the Terai Plain of Morang District, Eastern Nepal-Causes and Solutions. Nepal Geol. Soc. Bulletin Vol. 6, 1989.

Sharma, C.K. 1974. Groundwater Resources of Nepal.

Sharma, C.K. 1978. Natural Resources of Nepal.

Suryanarayan and Krishna Rao 1985. Impact of Environment on Quality of Groundwater in Eastern Ghats. Current Trends in Geology Vol. 8-IV Indian Geological Congress, pp. 595-603. Today and Tomorrow's Printers and Publishers, New Delhi.

Table 2 : Hydrogeological Particulars of Exploratory Tube Wells in Parts of Morang District

Well No.	Well Location	Total Depth of Well (m)	Cumulative thickness of the Aquifer Zones (m.)	Cumulative thickness of the Aquifers tapped (b) (m.)	Screen Position b.g.l. (m.)	Piezometric Surface b.g.l. (m.)	Piezometric head (avai.d.d.) (m.)
1.	Rani	123	116	78	46-58 73-104	-	-
2.	Rani	93	58	11	72-78	4.64	67.36
3.	Thakurbari	116	57	-	-	3.6	-
4.	Koshi Zonal Hospital	76	43	18	60-72	6.25	53.75
5.	Shankarpur	123	67	40	67-81 85-100 46-52	4.3	62.7
6.	Tankisiwari	103	66	56 65-75	46-52 81-84	3.98	42.02
7.	Haraincha	124	68	12	50-56	-	-
8.	Thadiya	76	48	18	55-61	+0	+55
9.	Indrapur	101	50	26	52-67	5.54	46.46
10	Dangihat	128	39	21	104-110	+0	+104
11.	Bairban	138	63	16	105-111	+0	+105
12.	Kakarmari	127	38	7	80-85	+0	+80
13.	Daleli	124	22	12	106-114	+0	+106
14.	Daulatpur	100	65	30	48-54	0.81	47.19
15.	Mangalbare	78	52	-	-	4.54	-
16.	Timtime	133	78	21	51-57	3.75	47.25
17.	Surat	153	71	60	51-58 68-72 88-91 109-113 131-134	3.08	47.92
18.	Govindapur	113	35	20	73-78	2.65	70.35
19.	Chunimari	122	53	11		3.93	76.07

+ Above ground level
- Data not available
Basic Data Source : GWRDP.

Pumping Discharge (Q) (1pm.)	Test Maximum drawdown (s) (m.)	Sp. Capacity (Q/s) (C) (lpm/m of d.d.)	Max. Yield (cx avai.d.d.) m3/hr.	Transmissitivity (T) m2/day	Hydraulic Conductivity T/b=m/day
-	-	-	-	-	-
163.4	0.22	743	3000	-	-
	-	-	-	-	-
91.2	0.58	145	468	-	-
-	-	-	-	-	-
1148	2.48	463	1170	2078	37
-	-	-	-	-	-
114	2.5	46	150	35	2
91.2	0.51	179	498	499	19
-	-	-	-	-	-
-	-	-	-	-	-
114	6.5	18	84	33	5
-	14.12	5	32	14	1
114	2.15	53	150	213	7
91.2	0.93	98	-	432	-
114	0.34	335	948	599	29
2926	8.06	363	1044	1478	25
114	2.65	43	181	127	6
114	2.02	56	256	250	23

Table 3 : Chemical Analysis of Groundwater in Parts of Morang District

Well No.	Village	pH	TDS (mg/1)	Alka-linity (mg/1)	Carbonate Bicarbo-nate (mg/1)	Chlo-ride (mg/1)	Total hardness (mg/1)	Calcium (mg/1)	Magnesium (calculated) (mg/1)	Fe (preci-pitation in the sampling bottle)
	Dug Wells:									
1	Rani	7.6	181	430	-/32	34	200	45	21	-
2.	Khunighat	7.9	344	890	-/93	47	360	75	42	brown ppt
3.	Jhorahat	7.8	657	830	-/122	171	880	155	120	-
4.	Pidarbonichowk	7.9	258	940	-/90	83	360	105	24	-
5.	Kanepokhari	8.4	113	640	5/61	24	250	90	6	-
6.	Laljhora	7.5	61	190	-/20	14	180	60	7	-
7.	Bansbari	7.5	168	630	-/83	20	210	75	5	-
8.	Keraun	7.8	195	680	-/81	14	260	70	21	-
9.	Rangeli	7.5	517	790	-/76	120	580	200	20	-
10.	Lalijhora	7.7	134	450	-/44	17	190	45	19	-
11.	Bhoteghumtee	7.6	241	370	-/51	23	270	80	17	brown ppt
12.	Hasandaha-9	7.4	258	950	-/93	298	610	125	73	-
Shallow Tube Wells:										
1.	Rani	7.6	181	470	-/49	32	250	55	27	-
2.	Rani	7.7	113	400	-/37	14	180	35	23	brown ppt
3.	Rani	7.6	201	600	-/54	41	210	60	15	brown ppt
4.	Rani	7.4	213	500	-/46	45	230	45	29	brown ppt
5.	Jhorahat	7.6	233	820	-/78	21	300	80	24	brown ppt
6.	Pidarbonichowk	7.9	258	980	-/98	16	330	80	32	-
7.	Titaria	7.6	314	1060	-/98	32	430	125	29	brown ppt
8.	Bairban	7.4	183	210	-/51	24	70	20	5	brown ppt
9.	Aitabare	7.8	125	440	-/63	13	170	35	20	-
10.	Laljhora	7.9	241	1010	-/102	20	380	85	41	-
11.	Daleli	7.4	125	390	-/51	18	140	35	13	brown ppt
12.	Baelgachhichowk	7.5	110	410	-/71	19	140	65	5	brown ppt
13.	Darbesa	7.5	100	460	-/37	21	120	30	11	-
14.	Darbesabazar	7.5	181	450	-/41	16	220	40	29	brown ppt
15.	Darbesa-4	7.5	190	360	-/67	18	210	55	18	-
16.	Rangelibazar	7.5	207	600	-/61	28	190	70	4	brown ppt
17.	Rangelibazar	7.4	125	530	-/78	120	310	65	36	-
18.	Rangelibazar	7.4	201	790	-/68	15	270	80	17	brown ppt
19.	Betaunia	7.9	148	580	-/59	13	210	55	18	brown ppt
20.	Betaunia	7.6	90	280	-/51	13	150	40	12	-
21.	Hasandahabazar	7.4	160	205	-/47	28	210	75	5	-
22.	Hasandaha-6	7.5	105	180	-/57	32	200	45	21	-
23.	Amardaha	7.8	47	140	-/54	14	130	25	16	-
24.	New Domanabazar	7.6	154	340	-/34	35	160	75	7	-
25.	Domanabazar	7.5	200	160	-/67	25	300	80	24	-
26.	Domanabazar	7.7	225	150	-/60	25	270	80	17	-
27.	Jhapa Vaija-hathput	7.9	268	1040	5/120	12	310	70	33	-

	Deep Tube Wells												
1.	**Rani**	7.7	201	490	-/8		23	190	55		13		-
2.	**Daleli**	7.7	165	630	-/73		120	180	75		2		-
	River Waters:												
1.	Damunabazar (Bakra river)	7.7	98	350	-/41		31	200	50		18		-
2.	Rangeli (Chisang river)	8.2	139	500	-/49		10	160	60		2		-