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GROUNDWATER RESOURCE EVALUATION OF THE KATHMANDU VALLEY

Ramesh Gautam[1] and G. Krishna Rao[2]

1 Ground Resources Development Board, Nepal
2 Andhra University, Visakhapatnam, India. Presently, Central Department of Geology, Tribhuvan University, Kathmandu, Nepal.

ABSTRACT

This article briefly deals with the nature of the aquifers and total groundwater reserves of the Kathmandu Valley. It is attempted to evaluate and estimate the total groundwater resources in the Valley. Based on the present condition it is suggested to prevent over exploitation situation of groundwater resource and to increase the perennial yield through artificial methods of groundwater recharge.

INTRODUCTION

The projected water demand of the Kathmandu valley by 2001 is reported as 272,000 m^3 /day. 40,000 m^3/day of water is expected to be supplied from surface water resources whereas 232,000 m^3/day of water is to be supplied from groundwater resources to fulfil the water demand of the Kathmandu valley. Thus it became necessary to evaluate the ground water reserves of the basin.

Various hydrogeological investigation works have been carried out in the Kathmandu valley since 1961. Sharma and Singh (1966) conducted detailed hydrogeological investigations followed by drilling. Several bore holes were drilled all over the basin and some tubewells were constructed. Binnie and partners (Anon, 1973), constructed additional tubewells for the 'water supply and sewerage' under WHO, UNDP. Binnie and Partners (Anon, 1988) made a reappraisal study on 'Groundwater Resources Within the Valley' for water supply on the basis of previous hydrogeological works and some new additional tubewells. Basic data from these reports have been utilized for this study.

HYDROGEOLOGICAL SETTING

Kathmandu Valley is one of the large intermontane basins developed in the 'Lesser Himalayan Midland Zone' of Central Nepal. The basin area lies at an elevation of about 1300 m. above mean sea level in between latitude 27 32' - 27 49' N and longitude 85 34' E. It is a tectonic basin of synclinorium type formed by folding and faulting. The basement rock types which are exposed around the basin are mainly phyllites, limestones, gneisses and granites. About 350 sq. km basin area is filled by lacustrine as well as fluvial deposits of Tertiary to Quaternary age. The maximum thickness of the sediments exceeds 457 m, and the minimum thickness is only 79 m.

Subsurface Geology

A fence diagram (Fig. 1) was drawn on the basis of lithology of the tubewells. The maximum thickness of the sediments in the basin is found at Harisiddhi, in the southern part of the valley; and the minimum thickness is at Bansbari, on the northern part of the valley. Boreholes at Gaushala (Pashupatinath) and Katunje in the central part of the valley touched the bed rock at a depth of 113 m and 160 m, respectively. But, boreholes at Gokarna, Koteshwar, Sanuthimi and Bhadgaon drilled to the depths of about 300 m, did not touch the bed rock. This indicates that there may be a ridge below the valley fill extending from Bansbari to Gaushala. Probably the ridge divides the Kathmandu Valley into two groundwater basins.

Although sediments were brought into the basin from all directions, it can be postulated that the northern and northeastern part of the valley were the main source of the valley sediments. Thickness of these sediments increases gradually towards south and attains the maximum value in the central and the southern parts of the basin.

From the lithologs, it is proved that the coarse granular sediments occupy the northern part of the basin, while the fine-grained deposits lie towards south. The granular deposits in the northern part of the basin are generally poorly sorted. They constitute the maximum thickness of the sediment column. There are several granular beds in this part. They decrease in number towards south and southwest of the basin. At Harisiddhi, Sunakothi and Lubhu, there are no clay free granular zones, and only thick layers of sticky clay are found.

Groundwater Conditions

Aquifer zones mostly confine to the central and northern parts of the basin (Fig. 1). The aquifer zones on the north lie between the depths of about 3-166 m below ground level. They are more or less continuous in the east-west direction along the foothills of Shivapuri range. Maximum thickness of a single aquifer in the northern part is 46 m. at Gokarna. It lies at a depth of 70-116 m below ground level.

Central part of the basin consists of only two aquifer zones. One of them is on the top and the second one is at the bottom. These two aquifers are separated by a thick column of sticky clay. The thickness of the top aquifer increases towards north and northeast up to 44 m while it is only 5 m thick in the central part. On the other hand, the thickness of bottom aquifer increases towards the central part from 17 m to 108 m.

The upper aquifers in the central part of the valley are in the form of lenses and layers. Some of these layers are pinching and bulging and in some places discontinuous. The bottom aquifer zone is almost continuous in east-west direction stretching from Tahachal to Bhaktapur.

Based on the position and hydrological properties, aquifers in the northern part and upper aquifers in the central part are classified as 'unconfined aquifers' while the bottom aquifer in the central part of the basin is classified as 'confined aquifer' (Fig. 2).

Unconfined Aquifer Zone

This zone lies north of Maharajganj and Boudha and West of Gokarna extending up to the western and northern foothills of the valley. Unconfined aquifers on the terraces in other parts of the valley which may have limited potentiality by virtue of the finer grain size of the sediments are not considered here.

In this area no rise of water level above the top of screen is observed. The depth of water level ranges from 11 m at Boudha to 25 m below ground level at Bansbari (Table 1). The water table is deep as this zone is located near the foot hills at higher elevations.

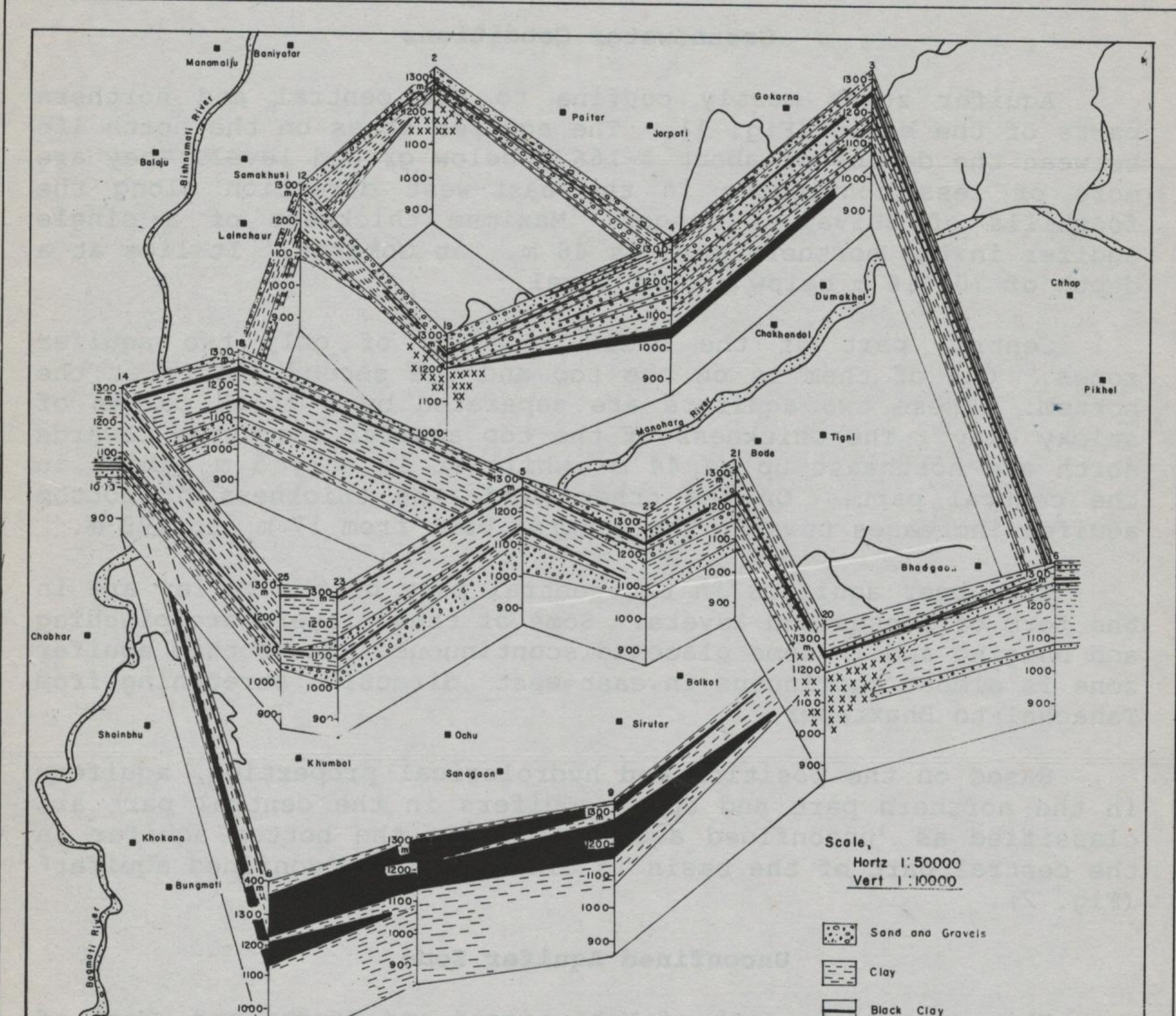

Fig. 1 Fence Diagram of Sediment Distribution in the Kathmandu Valley

Well No.	Location	Total Depth (m)	Screen Position (m,bgl)	Total Thickness (m)	Depth of aquifer (m,bgl)	Shallow Wat.Level (bgl,m)	Piez. Surface (m,msl)	Piez.Head (Avail.d., m)	Discharge l/s	Discharge m^3/hr	Drawdown (m)	Specific capacity m^3/day/m	Max. Yield (m^3/day)	Transmissibility m^2/day	Hydraulic conductivity (m/day)	Storage coeff.
BH_2	Bansbari	79.25	-	21.33	45.72	-	-	-	-	-	-	-	-	-	-	-
BH_3	Nayapati	241.40	53.04-65.50 101.19-116.19	27.46	53.04	9.80	1332	43.24	7.36	26.50	-	-	-	-	-	-
BH_4	Gokarna	305.10	67.97-78.33 93.57-115.43	32.22	67.97	0.00	1335	67.97	3.15	11.34	-	-	-	-	-	-
BH_{13}	Tahachal	314.00	209.49-241.0	68.19	209.49	0.00	1294	209.49	-	-	-	-	-	-		
BH_{16}	Lagantol	376.00	283-286 311-355 361-367	53.00	283.06	0.00	1295	283.00	3.78	13.60	60.00	5.44	1539.50	-	-	-
BH_{17}	Singhadurbar	273.71	-	56.70	61.56	0.00	1293	61.56	1.00	3.60	15.00	5.76	350.58	-	-	-
BH_{19}	Pashupatinath	113.38	92.35-109.11	16.76	92.35	18.91	1291	73.44	6.30	22.70	100.00	5.44	400.00	-	-	-
BH_{20}	Katunge	160.00	77.75-160.00	82.25	77.75	7.01	1334	70.74	-	-	99.06	-	-	-	-	-
BH_{22}	Sanuthimi	278.28	60.66-142.95 210.62-273.25	144.92	60.66	-	1290	-	-	-	-	-	-	-	-	-
BH_{23}	Patan	304.19	165.20-191.28 252.98-304.19	77.21	165.23	20.00	1286	145.23	5.04	18.10	9.00	48.38	7026.22	-	-	-
BH_{24}	Shantabhaban	60.04	41.45-60.04	18.59	41.45	-	-	-	0.05	0.20	-	-	-	-	-	-
BH_{25}	Surendrabhawan	136.12	112.47-137.09	24.62	112.47	-	-	-	0.038	0.14	-	-	-	28.00	1468.80*10-3	-
WHO_1(27)	Boudha	160.50	2.50-17.75 105-124.50	34.75	2.50	14.00	1315	-	10.80	39.00	-	-	-	493.00	1270.08*10-2	-
WHO_3(28)	Bansbari	112.20	7.20-87.20	80.00	720	25.00	1320	-	8.10	29.16	6.70	104.50	-	196.00	2851.20*10-3	2.43*10-3
WHO_5(29)	Bode, Thimi	141.90	18.5-73.0 103-123	39.50	18.50	17.68	1315	0.82	12.20	44.00	8.93	118.03	96.76	301.00	7516.80*10-3	8.60*10-4
WHO_6(30)	Gokarna	129.50	17.25-49.25 66.75-105.00	70.25	17.25	19.00	1317	-	10.72	36.62	8.20	113.00	-	175.00	1209.60*10-2	-
Ni_1(31)	Monohara	300.00	235-300	65.00	235.00	7.15	1303	227.85	44.02	158.50	-	528.40	120396.00	114.00	1753.80*10-3	-
Ni_{12}(32)	Chobhar	91.00	61-91	30.00	61.00	1.50	1288	59.50	2.03	7.30	-	113.57	6757.41	96.00	3200.00*10-3	-
Ni_7(33)	Hotel Soltee	305.00	27.5-244.00 270.5-275.00 278.0-297.00	60.00	207.50	6.75	1303	200.75	39.39	144.00	-	127.34	25563.50	150.00	2500.00*10-3	-

Water table contours have been drawn with respect to mean sea level (Fig. 2). These contours are observed to fall towards south following the general topographic gradient. It shows that the flow direction of the groundwater is from the northern parts to the southern part of the valley.

In this region the pumping discharge of the tubewells ranges from 81/s at Bansbari to about 11 l/s at Boudha and Gokarna (Table 1). Specific capacity of the tubewells for this area ranges from 73 to 78.501 pm/m of drawdown.

Confined Aquifer Zone

This zone lies south of Maharajganj and Boudha and west of Bode and extends up to the western and southern boundaries of the valley.

The piezometric surface in the confined aquifer area is observed to decrease in elevation towards the centre of the valley (Fig. 2) conforming to the topographic gradient. Thus it shows that the flow directions of the groundwater in the confined aquifers are from the periphery towards the middle part of the basin converging at the centre.

The piezometric head (rise of water level above the uppermost screen) ranges from 0.82 m to 283 m. The minimum piezometric head is measured in between Bode and Thimi and the maximum is at Lagantol (Table 1).

The piezometric head of the aquifers is observed to increase from the periphery towards the centre of the valley (Fig. 3). However the pattern of piezometric head variation as depicted in the figure may be misleading since the depths of tubewells and the depths of aquifers tapped in different parts are not same. Therefore the piezometric head is plotted against the depth of aquifers (Fig. 4). The piezometric head is observed to increase with the depth of the aquifer which is in conformity with the hydraulic principle.

The pumping discharge of the tubewells in this region ranges from 2 l/s at Chobhar to 44 l/s at Manohara whereas the free flow discharge ranges from 0.5 l/s at Kirtipur to 4 l/s at Lagantol (Table 1).

Specific capacity of these tubewells varies from 3.75 to 366.5 lpm/m of drawdown. The lowest values are observed in the

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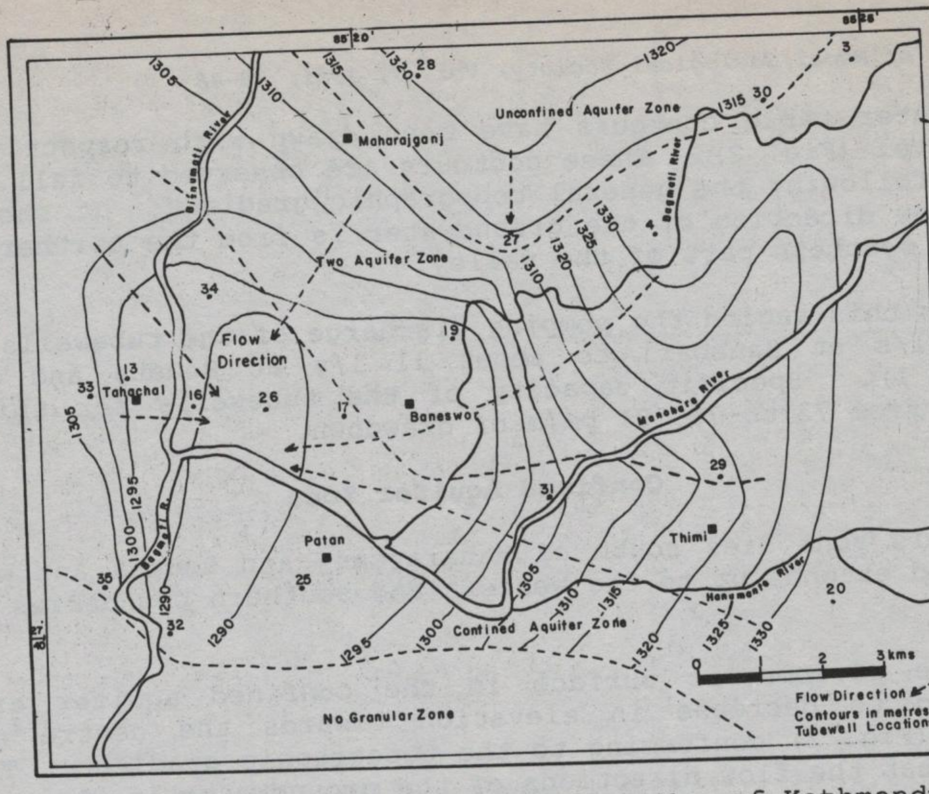

Fig. 2 Water Table/Piezometric Surface Map of Kathmandu Valley (Contours in metres above msl)

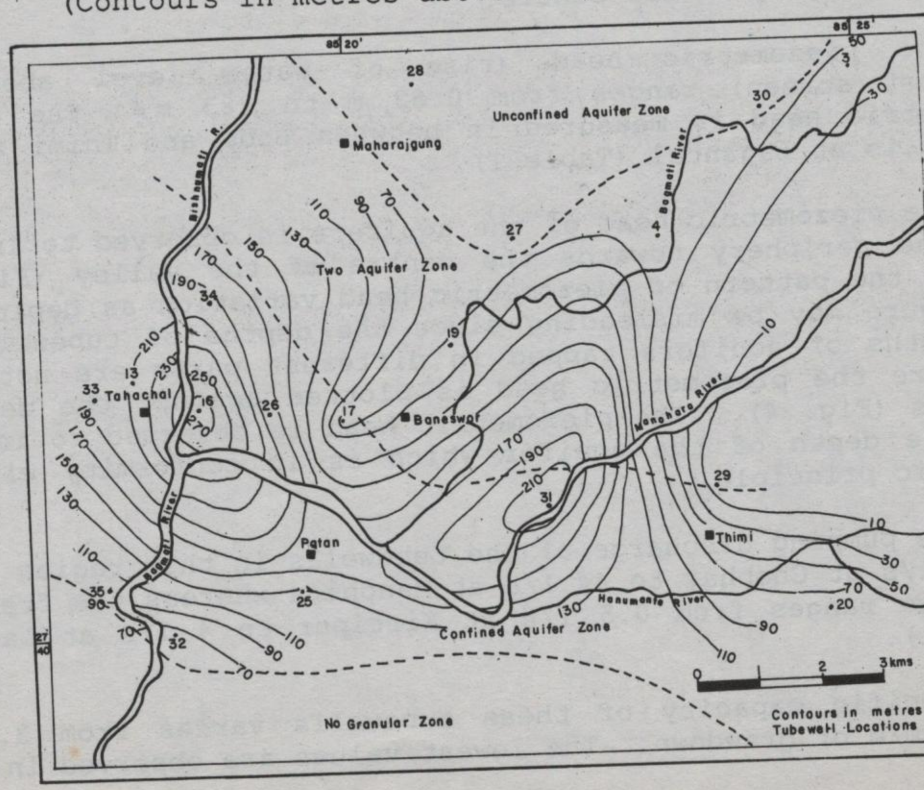

Fig. 3 Piezometric Head Variation in Kathmandu Valley

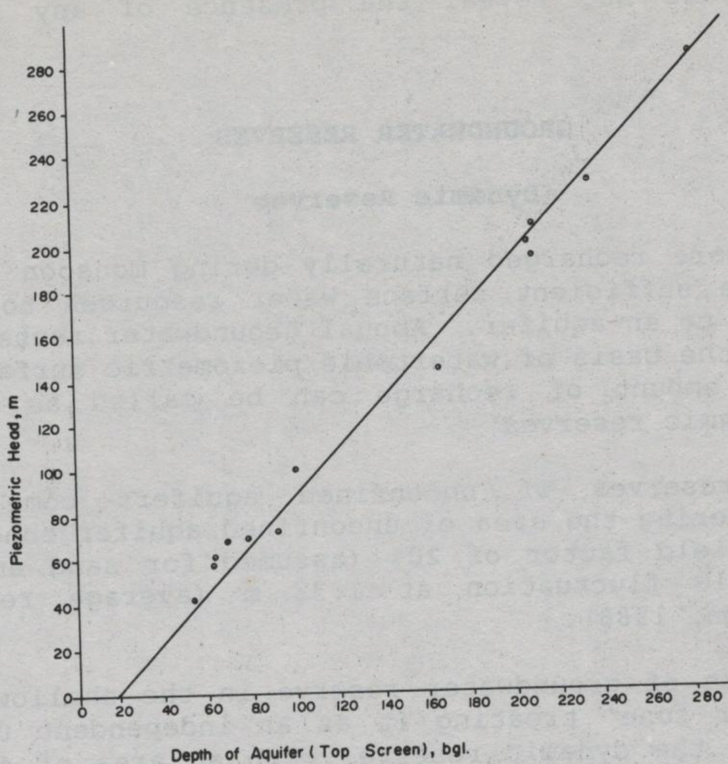

Fig. 4 Piezometric Head vs Depth of Aquifer Tapped, Kathmandu Valley

central part of the valley. Higher values are recorded in the peripheral zone close to the foot hills such as Manohara, Tahachal and Chobhar where the granular zones are thick and more coarse.

Two Aquifer Zones

The area between Manohara and Bishnumati rivers has been classified as interbedded aquifers and treated as an unconfined aquifer zone (Anon, 1988). In this area, the shallow aquifer is also tapped along with deep aquifers. In fact, the shallow aquifers of this zone could have been exploited through shallow tubewells separately. However it is essential to find out the hydraulic continuity and leakage between the two. It is expected that the leakage would be very negligible since the interlaying clay layers are described as sticky and hence impermeable.

No Aquifer Zone

No clay free granular zones were observed up to the drilling depths around Sunakothi, Harisidhi, and Lubhu. Electrical logging also did not reveal the presence of any significant aquifer zones.

GROUNDWATER RESERVES

Dynamic Reserves

Aquifers are recharged naturally during monsoon period and when there are sufficient surface water resources to percolate through ground to an aquifer. Annual groundwater recharge can be calculated on the basis of watertable/piezometric surface fluctuation. This amount of recharge can be called as 'perennial yield' or 'dynamic reserves'

Dynamic reserves of unconfined aquifers come to 2.13 Mm^3/year considering the area of unconfined aquifer zone as 8 sq. km, specific yield factor of 20% (assumed for sand and gravel) and water table fluctuation at 1.33 m (average recorded at Sundarijal, Anon, 1988).

An estimate of groundwater reserve in the shallow aquifers of 'Two aquifer zone' treating it as an independent unit shows 2.4 Mm^3/year as the dynamic reserve, with an area of 42 sq. km, specific yield factor of 20%, and average water table fluctuation at Bansbari as 0.29 m (Anon, 1988).

Perennial yield in the case of confined aquifers is governed by the rate of flow through the aquifer when the recharge area is located at some distance from the pumping area. In the case of Kathmandu Valley this concept may not be appropriate since the recharge area is close to the pumping areas. Therefore perennial (dynamic) reserves in the study area is calculated on the basis of piezometric surface fluctuation. This reserve comes to 0.08 Mm^3/year falling over an area of 107 sq.km., average storage coefficient of 1.64×10^{-3} and piezometric surface fluctuation at 0.47 m. (recorded at Panipokhari, Anon, 1988).

Thus the total dynamic reserves of the Kathmandu Valley is 4.61 Mm^3/yr i.e. 12630 Mm^3/day.

These estimates can be refined and improved with the collection of more data on water table/piezometric surface fluctuations, specific yield and storage coefficient values.

Static Reserves

Static reserve is the total groundwater reserve found in the confined aquifers which is not renewable. These reserves are equal to the total amount of groundwater that can be exploited by lowering the piezometric head down to the top of the aquifer.

Total static reserve is estimated as 21.60 Mm^3 considering the area of confined aquifer and average storage coefficient as mentioned above and the average available drawdown as 123.21 m.

This reserve is naturally not a renewable reserve. Hence the use of this groundwater reserve would be allowed only under unavoidable circumstances on the basis of socio-economic justification and with efforts to replenish it when exploited. However, the effects of such over exploitation such as land subsidence are to be studied.

The maximum perennial yield from the basin can be achieved by exploiting all possible methods of harnessing the water resources i.e. increasing the recharge through natural and artificial methods.

STATE OF DEMAND AND SUPPLY

Total water demand of the Kathmandu valley is 106,000 m^3/day Whereas, total quantity of water now supplied is only 83,000 m^3/day and there is a deficit of 23,000 m^3/day (Anon, 1986). Out of the total quantity supplied, 25, 500 m3/day of water is from ground water sources and the remaining quantity is from surface and other minor sources, (Anon, 1988).

As per the above calculation, the total dynamic reserve (perennial yield) of groundwater of the Kathmandu Valley is only 12,630 m^3/day. Thus there is already overdrafting situation of groundwater. This has been manifested in the declining trends of water levels in the tubewells by 0.5 to 20 m as well as decrease in discharge in some tubewells by 72 to 2630 m^3/day (Anon, 1988).

Future Situation

The projected water demand of the Kathmandu Valley by 2001 is 272,000 m^3/day (WSSC, Anon 1986). The expected surface water supply by 2001 is same as before i.e. 40,000 m^3/day and balance to be made from groundwater will be 232,000 m^3/day. When there has been already overdrafting conditions of groundwater reserve in the Kathmandu Valley, further exploitation is cautioned. Even the total groundwater reserves available in the kathmandu Valley (dynamic and static reserves put together) comes to only 71,965 m^3/day. If this much of groundwater is extracted to meet the immediate needs of the people, steps should be taken to increase the groundwater recharge to balance the overdraft conditions gradually in a systematic way. Basin management along with artificial recharge methods of groundwater are therefore imminent in the present circumstances.

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