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An Appraisal of Groundwater Recharge in Netrokona District

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Abstract : *A research work was conducted in Netrokona district to make an overall assessment of groundwater resource for its optimum utilization. The annual potential recharge was estimated by Well Hydrograph method and Sehgal's empirical method. By Well hydrograph method potential recharge was found in the range of 226 mm to 904 mm with an average recharge of 549 mm. By Segal's method the potential recharge varied from 532 mm to 779 mm with an average recharge of 689 mm. The difference between the two methods is minimum. Optimum well spacings were also estimated which ranged from 398m to 989m for various combination of well discharge and operation hours based on the peak-irrigation demand and available recharge.*

Introduction

Groundwater is extensively used as a reliable and dependable source of irrigation in Bangladesh. Now a days it is considered as one of the significant components of the natural resources of the country. About ninety percent of the total potable water is supplied by groundwater (Rashid et al., 1989).

Though Bangladesh is blessed with abundant groundwater resources but this resource is not unlimited. Most of the surface water bodies dry up in irrigation season. Therefore use of groundwater is increasing day by day at an accelerated rate. Its judicial utilization depends on reliable information of the aquifers. The future strategies should be established on the basis of extensive study on groundwater reserve. Groundwater is a renewable

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resource. Proper management of this resource requires knowledge of the factors governing the aquifer potentiality and its utilization strategies viz. recharge depletion characteristics of the basin, appropriate extraction technology and optimum well spacing. These all are equally important for any groundwater development project. If optimum technique of groundwater extraction based on the resources availability is not established and unplanned withdrawal is continued, the resulting effects may lead to a dangerous imbalance in the local geology in near future.

Well-planned development of groundwater resource is a complicated task, especially for hydro- geologically dissimilar regions. The available literatures on groundwater revealed that the aquifer systems are very heterogeneous over various regions of the country. A good number of research works were carried out in the past. Most of these works are confined in northwest region of the country. Very little work has so far been done on the northeastern region. In the context of the aforesaid situations Netrokona Sadar Upazila has been selected to justify the feasibility of groundwater development programme.

Recharge and depletion are the two key factors, which govern the dynamics of a groundwater system in a basin. The recharge process is governed by many factors, natural and man-made, which makes the process very complex. The recharge rate for different regions of Bangladesh were estimated by simplifying processes in various ways by many researches (UNDP, 1982; Karim, 1984; and MPO, 1984).

The average annual recharge of Bangladesh had been estimated to be 30 to 91 cm (Hyde 1979). MacDonald (1983) estimated groundwater recharge in the northwest and northeast regions of Bangladesh by the water Balance study. He determined wet and dry deep percolation ratios for 27 defined aquifer units from model calibrations of the study area. The wet deep percolation ratios were ranged from 1.5 to 3.3 mm/day. Nevertheless minimum recharge period during monsoon is assumed to be about 90 days; a minimum and maximum potential recharge might have been quantified on the basis of wet land deep percolation rates; and the use of the wet land deep percolation rates might be affected by the plough pan appearing beneath the agricultural land. The recharge rate established from the water balance model is obviously the annual recharge applicable to the calibration period (1978-81) only. In this water balance model the annual recharge rate was assumed to be far less than potential, because it did not take into account of all the rejected recharge. Pitman and Haque (1984) observed that the maximum exploitation of groundwater resources was determined by the mean annual potential recharge available. Bangladesh water Development Board (Karim,1984) applied ground water level fluctuation method for estimating thana-wise recharge covering major part of the country. Based on this method, the calculated annual recharge of different study areas varied from 50 mm to 700 mm per unit area with an average annual recharge of 320mm per unit area. It is stated that the entire potential recharge was both available for pumping, as it was subjected uncertainity and part of the annual potential recharge was lost before it could be used. Recently Ahmed et al. (1991) made a simple approach to assess groundwater recharge in Muktagacha aquifer under Mymensingh district where rainfall was considered as the single source of recharge. An empirical relation known as Sehgal's Method was used for calculating recharge. Accordingly an average recharge of 596 mm was estimated from an average annual rainfall of 2654 mm in the study area. Kabir (1993) estimated groundwater recharge for an unconfined aquifer situated within Jamuna flood plain in Tangail district using soil moisture balance method. Using this method the potential recharge of 201.07 cm was obtained from the total rainfall of 1077.57 cm during the period of January 1988 to May 1993, which was about 18.66% of the total rainfall. Again applying the groundwater level hydrograph analysis method and the Sehgal's empirical method the estimated recharge values were found to be 23.15% of rainfall respectively. There are no better national estimates than the MPO (Master Plan Organization) estimates (Matt MacDonald, 1991). MPO (1991) estimated usable recharge (75% of potential recharge) for Netrokona Sadar Thana as 617 mm.

Though conceptually sound the major failing of MPO's investigation of potential recharge has been the failure to calibrate the result against field data of abstraction and ground water levels. The required proper well spacing for Barind area was calculated by Reza M.S (1991) from a equation modified from the relationship given by Chowdhury (1978).

By studying the above literatures it might be concluded that the detailed aquifer study in northeastern region is very few. Though some investigations were done on aquifer properties but those all are rough estimation. Accurate recharge rates for the aquifer must be estimated before groundwater resource utilization. With a view to this, a research was undertaken for estimating groundwater recharge of Netrokona Sadar Upazila. The objective of this research is to assess groundwater recharge by well hydrograph method for the study area and to verify the estimated recharge with the results obtained from Sehgal's method. Another objective is to recommend optimum well spacings between different tube wells in the study area.

Methodology

Groundwater recharge is the amount of water, which enters into the aquifer. It is often defined as the amount of water, which remains available for often long term abstraction. Ground water recharge of an area is usually estimated by the following Methods.

1. Water balance method.
2. Analysis of ground water level fluctuations.
3. Field experiments.
4. Mathematical modeling.
5. Other empirical methods.

1. Well Hydrograph Method: Analysis of ground water level fluctuation is the most easiest method and reliable to some extent. Therefore this method was used in this study to determine the annual recharge. In this method the annual fluctuation (maximum) in ground water is multiplied by specific yield of the aquifer as shown below:

R=▲H*S (Twort et. al., 1974)

Where, R= Annual Recharge,

▲H= Annual fluctuation of static water level (maximum)

S = Specific yield.

1.a) Determination of Annual fluctuation of static water level (▲.H)

The monthly static groundwater level is monitored by BADC (Bangladesh Agricultural Development Corporation) in 10 deep tubewells at the representative locations of the study area. From 1986 to 1995 i.e. ten years data have been collected from BADC office. From these data minimum annual fluctuation of static water level have been calculated by deducting the minimum from the maximum water level. Thus ten year annual fluctuations have been determined for the ten selected DTWs, which are shown in Table.1.

Table.1: Annual Groundwater level Fluctuations (maximum) at Ten Representative places in Netrokona Sadar Upazila for 10 years (1986—1995)

Annual Fluctuations (m)

Well No.	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	6.00	7.20	7.85	7.54	3.63	4.88	7.01	4.60	6.10	6.70
6	5.88	9.05	8.57	8.27	3.80	5.46	8.70	5.80	7.70	7.60
7	6.05	8.47	8.79	8.69	3.17	4.82	9.15	5.65	8.10	7.10
11	6.11	7.26	7.78	9.25	3.43	5.46	8.41	4.90	5.50	6.60
15	5.67	8.46	8.34	8.60	4.25	5.65	9.05	5.75	7.80	7.10
21	6.15	9.62	11.30	9.23	2.85	5.62	7.53	4.45	6.58	6.10
25	6.00	7.85	8.44	8.01	3.70	5.68	7.74	6.00	7.90	7.00
39	6.12	7.75	8.12	9.03	2.83	4.67	7.25	4.75	6.00	6.90
53	5.94	7.93	8.58	10.00	4.34	5.97	9.95	6.20	8.80	7.30
68	6.15	8.35	9.37	10.15	4.20	5.39	7.48	6.10	7.85	7.00

1.b) Determination of specific yield

In the present study specific yield of the aquifer has been estimated by lithological analysis of 52 bore log data collected from BADC. The hydrological laboratory of the United States Geological Survey (USGS) in Denver, Colorado, under the direction of A1 Johnson had under- taken a research study on the specific yield of unconsolidated materials based on litho logical analysis. The results of this work are shown in Table.2.

Table. 2: Values of specific yield after U.S.G.S. Hydrologic Lab provisional Values

Material	Specific Yield (%)	Material	Specific Yield (%)
Clay	1	Fine San	26
Silty Clay	2	Medium Sand	35
Sandy Clay	3	Coarse Sand	33
Clay Silt	5	Sand (Undifferentiated)	32
Silt	7	Fine Gravel	25
Clay-Sand	7	Medium Grave	20
Sandy Silt	14	Coarse Gravel	14
Silty Sand	20		

The specific yield of any volume of geologic material can be obtained by summing up the specific yield values of all unit volumes it contains. Since nearly all such zones include various types of materials with different specific yield, it is necessary to weigh each material according to the proportion of the entire volume. This method was used to calculate specific yield value of the investigated area. The results of lithological analysis done from 52 bore log of BADC were used as base. In the present study the specific yield values were determined for the soil strata of the water table fluctuation zone.

2. Sehgal's Method

Another empirical method was used to estimate and verify annual recharge amount in the present study viz. Sehgal's empirical mathematical model (1973). It is expressed by the following equation.

$$R = 2.5(P - 16)^{0.5}$$

Where, R= Annual Potential Recharge (inch)
P= Annual Rainfall (inch)

Here 10 years monthly rainfall data have been collected from Bangladesh Water Development Board recorded at the Station No. 123 Netrokona.

3. Determination of optimum and safe well spacing

3.a) Well spacings based on peak irrigation demand

The spacing of tube wells must consider the peak irrigation requirement to irrigate all the areas within a well field. Aside from the maximum water requirement, well spacing is controlled by well discharge and period of pumping. The required proper well spacings were calculated from the following equation (Reza, 1978) modified from the relationship given by (Chowdhury, 1978).

$$R = 60 \times \sqrt{\frac{Q.tp.Dp}{Wp}} \quad \text{------------------------------} \quad (1)$$

Where, R= well spacing in meters,

Q= well discharge in lit/sec,

tp= period of pumping in hours/day,

Wp= peak water requirement in mm/week or month; and

Dp= number of days/week or month, depending on Wp.

3.b) Well spacings based on available recharge

Spacing of tubewells in the overall ground water development of an area may be controlled by the amount of recharge to the ground water reservoir. The annual recharge to ground water must not exceed the total extraction. The relation of well spacing to recharge, well discharge and period of pumping is described by the following equation (Chowdhury, 1978).

$$R = 60 \times \sqrt{\frac{Q.t.N}{Rg}} \quad \text{------------------------------(2)}$$

Where, R= well spacing in meters
t = period of pumping in days/ year
Rg =ground water recharge in mm/year
N= Number of operating hours/day
Q= tube well Capacity in litre/sec.

4. Results and Discussion

Annual potential recharge: Annual potential recharge has been estimated in the investigated area by two methods viz:

i. Ground water level hydrograph analysis method and *ii.* Sehgal's empirical method. In well- hydrograph method, the fluctuation of ground water levels were multiplied by specific yield of the aquifer. Recharge was calculated at ten representative places of Netrokona Sadar Upazila for the past ten years (1986-1995) shown in Table 3. Specific yield was estimated for the study area as 8% on an average by using U.S. geological provisional lab-values (Heath. 1984) as shown in table 4. The annual recharge amount was found to vary from 226mm to 904 mm. Year wise average value of recharge varied from 290 mm to 710 mm and the 10 years average recharge was found to be 549 mm. The higher recharge was observed in the northern part of the study area and lower recharge in the southern portion. The annual recharge was found to be 8 to 22 percent of total annual rainfall. Using Sehgal's empirical method, the annual potential recharge was estimated ranging from 532 to 779 mm for different years and 11 years average recharge was 689 mm (Table.5). According to this empirical method 18% to 24% of total rainfall was found to occur as recharge to the aquifer. Sehgal's method gave almost similar result in comparison to the Well hydrograph method.

Table 3: Annual Recharge (mm) at Ten Representative places of Netrokona Sadar Upazila for 10 Years (1986-1995) obtained from groundwater level fluctuation method.

	Annual Recharge (mm)									
Well No.	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
1	480	576	628	603	290	390	561	368	488	536
6	470	724	686	662	304	437	696	464	616	608
7	484	678	703	695	254	386	732	452	648	568
11	489	581	622	740	274	445	673	392	440	528
15	454	677	667	688	340	452	724	460	624	568
21	492	770	904	738	228	450	602	356	526	488
25	480	628	675	641	296	454	619	480	632	560
39	490	620	650	722	226	374	580	380	480	552
53	475	634	686	800	347	478	796	496	704	584
68	492	668	750	812	336	431	598	488	628	560
Average	**481**	**656**	**647**	**710**	**290**	**430**	**658**	**434**	**579**	**555**

*** Specific yield = 8 percent**

Table 4: Estimation of specific yield obtained from 52 Bore logs data for different location.

WN	SY	WN	SY	WN	SY	WN	SY	WN	SY	WN	SY
1	3	11	20	29	14	38	14	6	11	4/K	11
9	13	20	11	30	4	39	15	48	14	3/K	3
12	10	21	14	31	6	40	15	49	9	2/K	8
13	14	22	14	32	8	41	15	50	22	72	3
14	2	23	2	33	8	42	5	51	2	5/K	9
15	2	24	2	34	2	44	15	52	7	D1	2
16	5	25	20	35	2	45	2	53	14	D2	2
17	2	26	11	36	6	46	7	69	3		
18	2	27	14	37	8	47	2	57	4		

Average Specific Yield = 8 percent

(Here, WN is Well No. and SY is Specific Yield (%)

Table 5: Potential Recharge (mm) estimated by Sehgal's Method.

Year	Annual Rainfall	Recharge	Recharge in percent of annual rainfall
1985	2189	532	24
1986	3098	654	21
1987	3664	685	20
1988	4243	781	18
1989	3475	694	20
1990	3630	715	20
1991	4234	779	18
1992	3426	692	20
1993	4081	764	19
1994	2491	575	23
1995	3500	700	20
Average	**3430 mm**	**689 mm**	**20 %**

Optimum and Safe Well Spacing: An attempt was made to find a more or less proper well spacing in the investigated area on the basis of some parameters viz: well discharge, period of pumping, peak water requirement and ground water recharge. Well spacings were calculated by using the equation no. 1 & equation no. 2. Table.6 shows the results. For different tubewell capacities and different operating hours the optimum well spacings among tubewells have been recommended in the present study which varied from 398 m to 989 m. These spacings could be maintained in the study area reliably.

Table.6: Proposed well spacing between tubewells (m)

Tube well capacities		Based on peak irrigation requirement operation hours					Based on available recharge
L/S	Qusec	8	10	12	16	20	8
56.6	2.0	625	699	766	885	989	563
42.5	1.5	542	606	663	766	857	487
28.3	1.0	442	444	542	625	699	398

* Peak irrigation requirement 500 mm (MPO, 1991)

Conclusion

In this study ground water recharge was estimated from ground water fluctuation using well hydrograph method and was verified by Sehgal's empirical method. The estimated recharge can be used reliably in any groundwater development programme for Netrokona district. For the purpose of actual recharge estimation some other method should be adopted like field measurement using Lysimeter study and nuclear techniques. In addition, computer-based simulation methods may be applied for higher precision. The recommended well spacings are very important during the installation of tube wells. It may check uncontrolled installation of tube wells and hence conservation of the environment would be enhanced. The investigation revealed that the study area is highly potential for ground water abstraction. But recharge mechanism is a dynamic process. Therefore, results obtained from this study can be considered as informative, but should not always be used as the absolute information for the entire location of the study area without further verification.

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