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Research Paper Geology

Hydrogeologic Settings of the North and South Brahmaputra Plains in Upper Assam: A Comparative Study

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ABSTRACT

A comparative study of the hydrogeologic characteristics of the water bearing formations occurring in the North and South Brahmaputra Plains in Assam, comprising parts of Dhemaji and Lakhimpur districts in the North Bank, and Dibrugarh and Tinsukia districts in the South Bank areas, has been carried out. The unconsolidated alluvial sediments are primarily composed of sands of various grade and gravel with minor amount of silt and clay. Thickness of granular zones mostly varies from 80% to 100% and 63% to 92%.in the North and South Brahmaputra Plains respectively. In the northern plains, ground water mostly occurs under unconfined to semi-confined conditions, while the single aquifer zone in southern plains gets locally dissipated into multiple aquifer zones forming semi-confined to confined aquifers.

Keywords : Alluvial sediment, Granular zone, Aquifer, Assam

Introduction

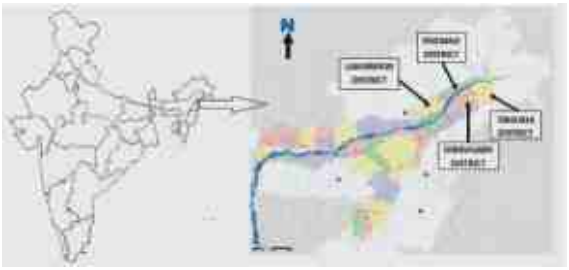
Ground water is an essential and vital component of our life support system. Assam is one of the rich states of the country in term of the ground water development potentiality. The entire Brahmaputra valley, covering more than 70 per cent of the total geographical area of the state, contains prolific aquifer system comprised of unconfined, semi-confined and confined aquifers. The conditions under which ground water occurs may vary widely depending on the nature and type of aquifers, lithologic and textural characteristics of the of the water bearing formations, local as well as regional geologic setting (which may include topographic, geomorphic, structural factors among others), the influence of and the possible relationship with surface water bodies. For these varied reasons, the hydrogeologic setting or the conditions of occurrence of ground water within the same hydrogeologic province (e.g. the Brahmaputra valley) may locally vary from area to area or from region to region.

The objective of the present study is to carry out a comparative study of the hydrogeologic settings in terms of lithologic characteristics of the water bearing formations, nature and extension of the aquifers and the hydraulic characteristics of the shallow aquifer zones occurring in the North Brahmaputra Plains with that of the shallow aquifer zones occurring in the South Brahmaputra Plains. In the present case, the comparative study is confined only to parts of the Dhemaji and Lakhimpur districts in the North Bank while it is confined to parts of the Dibrugarh and Tinsukia districts in the South Bank areas of the Brahmaputra in Upper Assam (Fig. 1).

Materials and Methods

The relevant topographic maps of the above stated two areas (83 I and 83 M series of maps in 1:50,000 scale) have been studied. Available hydrogeological data like lithologic logs of deep tube wells and pumping test (APT) data of a few deep water wells pertaining to the above areas have been collected from different government organizations engaged in exploration and development of ground water in the area. Various types of graphs, maps, sections, figures and diagrams have been prepared and analyzed in the laboratory by following suitable and accepted methods. During well inventory, soil samples have also been collected for determination of soil textural characteristics. Aquifer characteristics have been determined following widely accepted methods suggested by Theis, Jacob, Boulton and Walton.

Fig. 1: Location map of the North and South Brahmaputra Plains in Assam



Results and Discussion

Geomorphic units of the North Brahmaputra Plains are: flood plain, younger alluvial plain, older alluvial plain, Piedmont plain and hilly terrains. While all other units are fairly well developed in the southern plains, the Piedmont plain is conspicuously absent in that area. Study of the hydrogeologic Properties of soils in the North Brahmaputra plains indicates that the soils mostly belong to 'Sand' to 'Loamy Sand' type. Effective size (d10) varies from 0.010 mm (medium silt) to 0.077 mm (very fine sand). Sorting Coefficient (Sc) value ranges from 1.15 (well sorted) to 2.44 (poorly sorted). Uniformity Coefficient (Cu) value varies from 1.23 (uniformly graded) to as high as 6.67 (non-uniformly graded). In the South Brahmaputra Plains, soils mostly belong to 'Sand' type. Effective size (d10) varies from 0.050 mm to 0.185 mm. Sorting Coefficient (Sc) values range from 1.07 to 1.90 (well sorted to moderately well sorted) and Uniformity Coefficient (Cu) value varies from 1.20 (uniformly graded) to 3.25 (non-uniformly graded).

The subsurface geologic settings of the two areas represented by the North and South Brahmaputra Plains are distinctly different from each other. The subsurface geology has been deciphered from the information obtained from exploratory bore holes drilled by the CGWB (NER), DGM (Assam) and other deep tube wells installed by the PHED and Irrigation Department, Government of Assam. Lithologic logs of 11 and 16 bore holes have been utilized to prepare panel diagrams respectively for the eastern and western parts of the North Brahmaputra Plains showing the thickness and extent of the shallow aquifer granular zones comprised mostly of sand and gravel. Similarly, lithologic logs of 11 bore holes have been utilized to prepare the panel diagram for the South Brahmaputra Plains.

In the North Brahmaputra Plains, unconsolidated alluvial sediments are primarily composed of sands of various grade and gravel with minor amount of silt and clay. A gravel horizon persistently occurs throughout the lower levels of the area. Depth to the gravel bed generally increases from piedmont zone to alluvial plain (Fig. 2). Up to the drilled depth, the thickness of the granular zones in this area mostly varies from 80% to 100%. In the South Brahmaputra Plains, the unconsolidated alluvial sediments are primarily composed of sands of various grades with occasional gravels. A surface clay layer of varying thickness is consistently present throughout the study area. Considerably thick homogeneous sand beds are present in certain locations. Increase in percentage of fie grained materials has given rise to multiple potential aquifer zones (Fig. 3). Up to the drilled depth, the thickness of the granular zones in this area mostly varies from 63% to 92%.

Fig. 2: Panel diagrams showing nature and extent of aquifer zones in the North Brahmaputra Plains, Assam

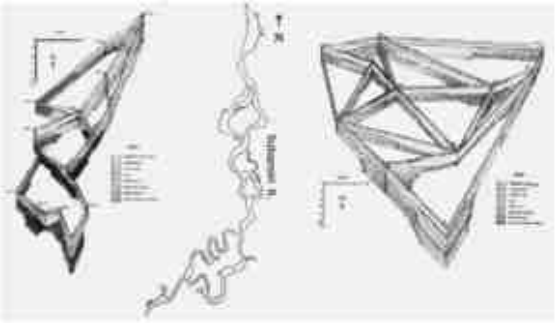
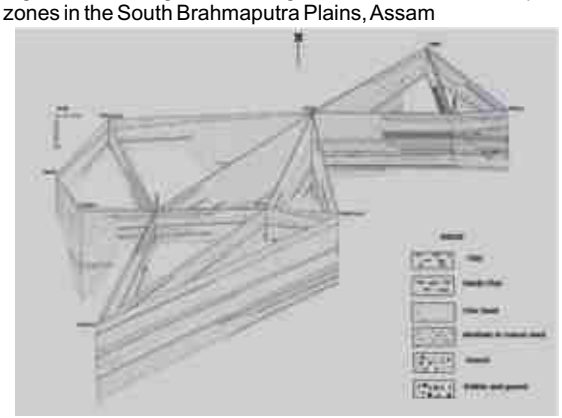


Fig. 3: Panel diagram showing nature and extent of aquifer zones in the South Brahmaputra Plains, Assam



Study of the hydrogeologic characteristics of aquifers in the North and south Brahmaputra plains reveals many contrasting features. The summarized hydrogeologic characteristics of the aquifer zones of the North and South Brahmaputra Plains are presented in Table 1.

Table 1: Summarized hydrogeologic characteristics of aquifers

North Brahmaputra Plains	South Brahmaputra Plains
1. The shallow aquifer zone is primarily composed of fine to coarse grained sand, gravel with minor amount of silt and clay	1. Below a surface clay layer varying thickness, a shallow aquifer zone comprising of a sand y formation is continuously present throughout the area.
2. Characterized by the presence of a single aquifer system where ground water mostly occurs under unconfined to semi - confined conditions.	2. Locally at some places the single aquifer zones of considerable thickness (more than 110 m) gets dissipated into multiple aquifer zones due to increase in finer materials like silt and clay.
3. In general, the amount of finer materials such as silt and clay in the aquifer zones decrease from north to south in the eastern part and from west to east in the western part of the area.	3. There is a hydraulic continuity between the aquifers of the northern, western and central parts of the area. However, in the eastern and south - western parts, there is limited hyd raulic continuity between the different aquifers.

Hydraulic characteristics of an aquifer are generally evaluated in terms of its two basic inherent characteristics its ability to store and its ability to transmit water. Porosity and permeability are the two basic parameters by which storage and transmitting capacities of an aquifer can be quantitatively determined. Transimissivity (T) and Storativity (S) are two other important parameters by which the transmitting and storage capacities for an entire saturated thickness of an aquifer or a group of aquifers can be determined. In the present study, although the basic hydraulic characteristics of aquifers, i.e. porosity and permeability were not determined in the field as well as in the laboratory, the other two hydraulic characteristics viz. transmissivity and storativity are, however, determined by analyzing the pumping test data of a few exploratory boreholes constructed by the C.G.W.B. The permeability (K) of the aquifer zone was determined from the total saturated thickness tapped and the transmissivity value.There are various methods for evaluation of pumping test data, the applicability of which is based on the nature of the aquifer (whether confined, semi-confine or unconfined). The nature of the aquifer, on the other hand, influences the response of the aquifer to pumping which can be determined by analyzing the graph obtained by plotting the drawdown versus time data on a log-log or semi-log graph papers of suitable scale. Hence, a number of methods such as Theis Method, Jacob's Method, Chow's Method, Walton's Method, Boulton's Method, Theis Recovery Method etc. have been developed by different workers for analyzing the pumping test data. A few such methods which are used for analysis of pumping test data obtained from different types of aquifers are shown in Table 2.

Table 2 : Applicability of different methods used for analysis of pump test data

Sl No.	Name of methods used for pumping test analysis	Aquifer type	Condition of Ground water flow	Minimum No. of Observation well needed
1	Theis Method	Confined	Non-steady state	1 (one)
2	Jacob Method	Confined	Non-steady state	-
	(i) Time-drawdown	Confined	Non-steady state	1 (one)
	(ii) Distance-drawdown	Confined	Non-steady state	3 (three)
3	Chow's Method	Confined	Non-steady state	1 (one)
4	Walton's Method	Semi-confined	Non-steady state	1 (one)
5	Boulton's Method	Unconfined	Non-steady state	1 (one)
6	Theis Recovery Method	Confined	Non-steady state	Not needed

Aquifer performance tests were carried out in exploratory boreholes at Ujjalpur, Bahadurchuk and Machkhowa in the North Brahmaputra Plains. Similar tests were also conducted at exploratory boreholes at Madhakali, Lepetkata and Hapjan in the South Brahmaputra Plains. The results obtained are presented in Table 3.

Le 3: Comparative statement of hydraulic characteristics of aquifer

North Brahmaputra Plains				South Brahmaputra Plains			
Well Location	T m2/day	S	K m/day	Well Location	T m2/day	S	K m/day
UJJALPUR	6461	1.12 x 10-3	200.16	MADHAKALI	4827	-	29.83
BAHADUR- CHUK	3881	5.66 x 10-4	47.3	LEPETKATA	8063	2.61x 10-3	34.92
MACH-KHOWA	1187	1.77 x 10-3	37.7	HAPJAN	5991	7.37 x 10-4	41.35

Conclusion:

From the present study it has been observed that the drilled depths of most of the wells in the North Brahmaputra plains are far less as compared to that in the South Brahmaputra plains. Because of the presence of the bouldery formation at shallow depths, it is somewhat difficult to carry out drilling in that area by following conventional rotary drilling method. Change of drilling method would be necessary for continuing further drilling into the deeper formations. In spite of that limitation, aquifers in the shallow zones of North Brahmaputra plains, which are unconfined to semi-confined in nature, are found to contain favourable hydraulic characteristics to give fairly good yield. Aquifers in the South Brahmaputra plains, on the other hand, have great overall thickness. But, the increase in the percentage of finer particles has given rise to multiple aquifers of different thickness at various depths. Although the hydraulic characteristics of the aquifers of this region are not as good as in the North Brahmaputra plains, the greater thickness of the aquifer zones has compensated that shortcoming.

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