National Symposium on Hydrology
Dec.16-18,1987, N.I.H., Roorkee

CLASSIFICATION OF UNDERGROUND WATER - A HYDROGEOLOGIC APPROACH

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ABSTRACT

Underground water occurs in various types of unconsolidated and semi-consolidated formations (Porous Media) and consolidated formations (Fissured Media). Three major units in the hydrogeologic stratification have been identified. A 5-tier classification of underground water is also proposed to assist in diverse requisitions for the exploitation of various water types and its role in civil engineering works in India.

INTRODUCTION

Classification systems of underground water can be numerous. Underground waters can be classified in terms of origin, composition, temperature, mode of occurrence, hydro-dynamic parameters, lithologic characters and their age. Any classification; mainly based on the mode of occurrence, head and flow type and characteristics of ground water regime; is considered valuable for the purposes of groundwater exploitation and assessing the role of underground water in civil constructions. Hence an attempt has been made to present an acceptable classification of underground water under the prevailing geological conditions in India and discuss about the units in the hydrogeologic stratification.

MAJOR UNITS IN THE HYDROGEOLOGIC STRATIFICATION AND THEIR SIGNIFICANCE

Alternating lithologies in a vertical geologic section, such as found in Indo-gangetic and coastal alluvial belt and other intra-cratonic sedimentary basins (Ghosh, 1987), can be water bearing and non-water bearing as well. Hence dividing the sequences of loose and poorly consolidated sediment (alluvial belt), semi-consolidated sediments (Mesozoic and Tertiary formations) or the consolidated formations like igneous, metamorphic rocks; forming either stratified porous reservoirs or with pores, fracture voidage; is not considered of any practical significance by the author unless the accepted hydrogeologic units such as the aquifer, aquifer system and hydrogeologic complex are identified.

Considering the prevailing geologic setting and hydrogeologic regime in India, it is seen that underground water reservoirs occur under confined unpressed condition and confined pressed condition. While identifying the aquifer types it is essential, therefore, to find out the thickness of aquifer which may not be greater than that of a stratigraphic stage or series. Since an aquifer is an hydrodynamic entity and has its free or piezometric surface, it may also not be necessarily limited to a certain stratigraphic unit. Hence an aquifer may constitute one or several water bearing strata

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of similar or different geologic ages, lithologic character and infiltration capacity. It may thus be a single or multi-layered aquifer (Fig.1). An aquifer system is characterised by its location of its recharge area, area of head generation and discharge area. Hence thickness of an aquifer system may correspond to a stratigraphic stage, suite, group, series or part of a system. It thus becomes a regionally and vertically continuous water bearing sequence bounded at the top and bottom with continuous impervious formation which almost eliminates hydraulic communication with adjacent aquifer system (Fig.2). Each aquifer system thus constitutes a specific hydrodynamic and hydrogeochemical features essential for identifying an aquifer system. An aquifer system, therefore, includes several aquifers of variable continuity where lthe magnitude of ground water pressure head may change vertically depending upon the degree of hydraulic communication between the individual aquifers. Piedmont areas along the outer himalaya and wide intermontane valleys, cuestas of the sedimentary belt of the shield area are common occurrrences of aquifer systems.

A hydrogeologic complex is considered an assemblage of aquifer systems which are regionally continuous throughout the artesian basin. Hence it may be defined by structural stages or combination of structural units which are controlled by geologic evaluation of the artesian basin. Thus it differs in the extent of water circulation, the features characteristic of groundwater formation and their palaeohydrogeologic history. The thickness of a hydro-geologic complex correspond to that of a system or combination of systems. Beas syncline in Punjab North-west himalaya (Fig.3) is one such classic example of a hydrogeologic complex.

The aquifers, the aquifer systems and the hydro-geologic complexes are distinguishable in sections composed of soft sedimentary rocks like the Mesozoic and Tertiary sediments of the peninsular India, the Siwaliks of the himalaya and the poorly consolidated sediments of the alluvial belt. They are often indistinguishable in the well cemented sedimentary rocks like the Cuddapah and Vindhyan formations of the peninsular India, the lesser himalayan sedimentary belt and the metamorphic, igneous rocks of the crystalline belt forming the ground water reservoirs of fractured and karstic types. Irregular fracture distribution and diverse lithology in lateral and vertical sections are typical of such rocks. It may be emphasized here that a horizon or a layer which is regionally continuous as a geologic unit may not be necessarily an aquifer in terms of hydro-geology even though it may have proved to be water bearing in isolated zones since there may not be any hydraulic communication between separate water bearing zones. Such identification of units in the hydro-geologic stratification helps in the assessment of groundwater conditions and their role in civil engineering works.

CLASSIFICATION OF UNDERGROUND WATER

Complexity and variability of the underground water occurrences in India present a number of difficulties in their classification. Available data on flow type, head type, geologic

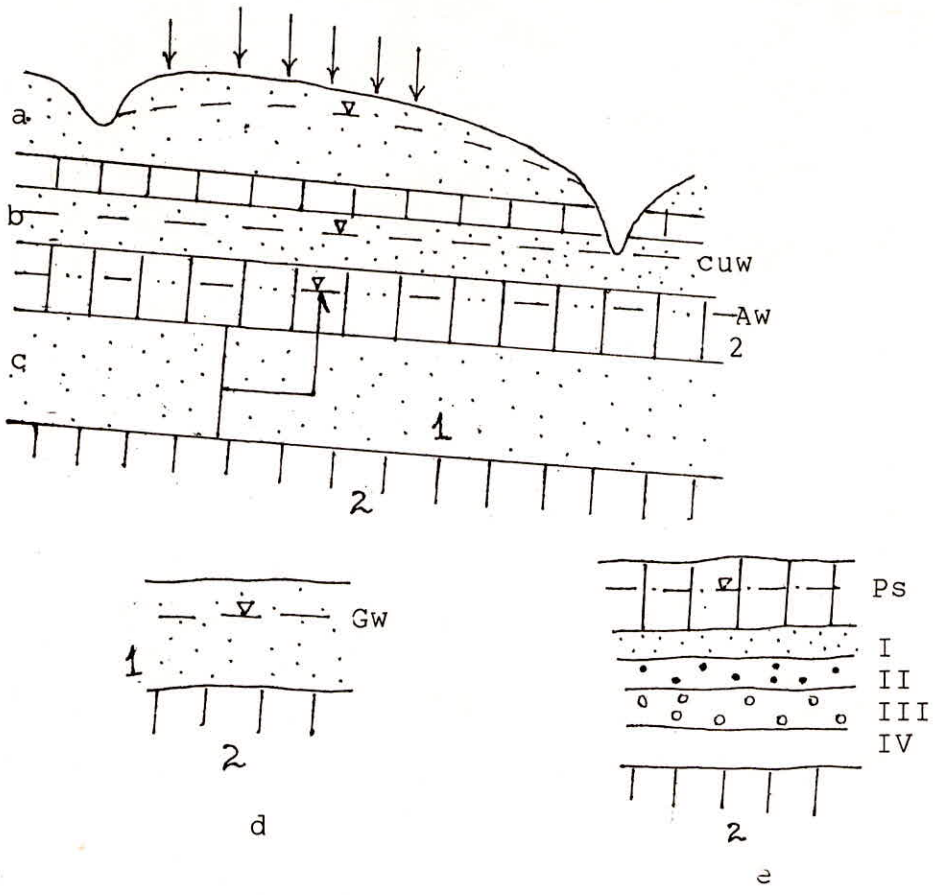

Fig 1. Geologic occurrence of aquifers and their structures

1. Sandy aquifers in different mode of occurrence and hydrogeologic regime, 2. Impervious rocks.

a. ground water, b. confined unpressed water, c. confined pressed water (artesian water).

Gw groundwater level, cuw confined unpressed water level, Aw artesian water level.

arrows show near horizontal movement of water. vertical arrow shows head of water.

d. single layer aquifer, e. multi-layered aquifer.

I-IV different types of water bearing horizons.

arrows on top of the figure show precipitation.

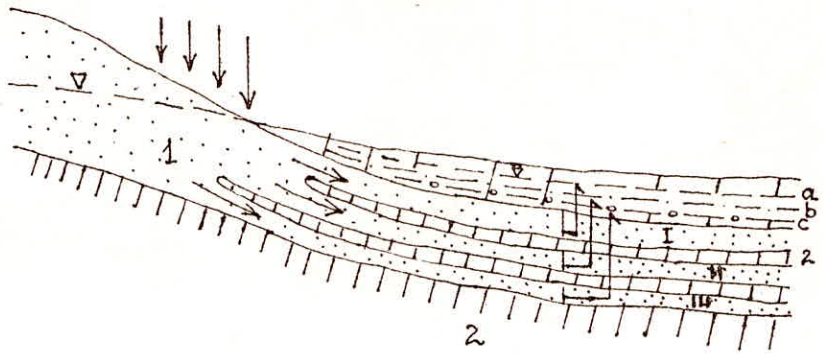

Fig 2. Geologic structure of an aquifer system

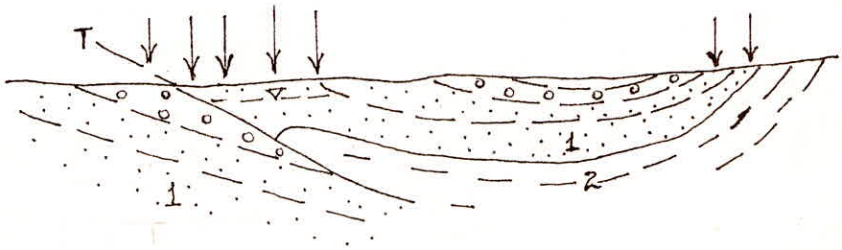

Fig 3. Hydro-geologic complex in Beas Syncline, Siwalik hills

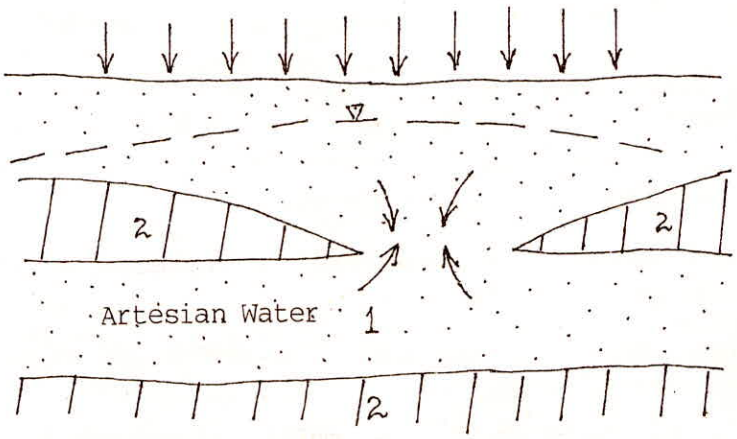

Fig 4. Hydraulic communication between groundwater and artesian water

1. Permeable rocks, 2. Impermeable rocks

a,b,c isopotential levels for the aquifers in Fig 2.

arrows within the aquifers show movement of water and arrows on top of the figures show precipitation.

Table : 1 : Classification of Underground Water

Type of Underground Water	Origin	Type of Head of Water	Type of Flow	Geologic setting and Water Regime	Relationship between Recharge Area and Area of Occurrence	Composition	Utilisation
1. Water in the zone of aeration (soil water, vadose water and swampy water).	Atmospheric (usually due to infiltration).	Generally unpressed to descending.	Laminar	1. Near surface and regolith cover zones, surface structural units, temporary water.	Coincident (water found close to ground water).	Generally Fresh (may also be locally saline).	In agriculture and local use.
2. Ground water	-do-	-do- (sometimes local head).	-do-	2. Near surface porous sediments and sedimentary layers, water level shifts with infiltration.	Generally Coincident (shallow water).	-do-	Mainly water supply.
3. Artesian Water	-do-	Ascending pressed water due to hydrostatic head.	Laminar in loose and porous rock and sometimes turbulent in fractured rock.	3. Sedimentary basins under confined conditions, water level shifts with head transmission.	Non-coincident (usually deep-seated).	-do-	-do-
4. Karst Water	-do-	Generally descending unpressed water, also sometimes pressed.	Mainly Turbulent.	4. Calcareous and Leachable Rocks	Nearly coincident (shallow water).	Fresh, Hard water.	-do-
5. Water in Fractured Zones.	Atmospheric and Juveline.	Ascending pressed water due to head.	Mainly Turbulent.	5. Jointed and Fractured Rock, Fault zones, etc.	Non-coincident (usually deep-seated).	Fresh and sometimes saline.	-do-

setting, relationship between recharge area and area of occurrences lead us to present a 5-tier classification of underground water (Table 1). In the scheme proposed by the author it would be able to assess the economic utilisation of underground water.

From the table above, it would be seen that the aquifers are of least regional continuity. On the otherhand the aquifer systems and the hydro-geologic complexes are of regional character such as the artesian basin distributed in synclises, depressions and troughs, foredeep area and intermontane troughs, grabens and tectonic fracture zones. Hence identification of recharge area, type of underground water basin, and discharge area is essential for the development of underground water system and evaluating its role in civil engineering. Underground water mainly contributes towards instability of slopes, open and underground cavities, foundation of civil structures due to pore and joint water pressure. Problems also occur due to poor sanitary characteristic of underground water in jointed rock (with no impermeable barrier) and artesian water having hydraulic communication with groundwater in areas where overlying impervious layer is either eroded away or grade into permeable facies (Fig.4). In such cases the artesian water is either replenished or discharged.

CONCLUSIONS

The proposed classification of underground water suggests the need for preparing a hydro-geologic zonation map of India. Basic units in this zonation map can be : artesian basins or artesian systems and folded regions. Geologic setting for such a purpose can be classified as : craton (platform) and foredeep, large intermontane depressions, folded mountains and fissures in igneous and metamorphic rocks.

ACKNOWLEDGEMENT

The author extends his grateful thanks and gratitude to Prof S.K.Singh, Head of the Geology Department, Lucknow University, for providing encouragement, support and facilities in the preparation of this manuscript.

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