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ESTIMATION OF AQUIFER PARAMETERS IN THE WESTERN SIDE OF JAMUNA RIVER, BANGLADESH

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ABSTRACT Groundwater is very precious for human beings in various extent of life. The amount of it depends on the characters of the underlying aquifer, its extent and the frequency of discharge. Quantitative hydro-geological studies of aquifer parameters are important pre-requisites for scientific management of groundwater resources. Borehole litho logical data and static water level data can be used as an important source for hydro-geological investigation. In this research the litho logical data of 467 locations and static water level data of 59 locations have been collected, analyzed and interpreted for studying the hydro-geological properties of the eighteen upazilas of the study area. Various types of map of hydro-geological properties of subsurface formation have been prepared for the proper identification of groundwater occurrence, distribution and potentiality of the area. Porosity and specific yield are the two important properties of an aquifer material to identify the storage of the aquifer. The yield will determine the source of groundwater and the natural characteristics of the water bearing formation. The porosity of a rock or soils will measure the volume of void spaces in geological formations and the absorptive power of the material. The transmissivity determines the effectiveness of groundwater reservoir and its exploration. The hydraulic conductivity of a water saturated zone represents its average water transmitting property. The higher value of hydraulic conductivity indicates the higher recharge. The hydraulic diffusivity indicates the favorable condition for groundwater development. The radial distance represents suitable distance for well construction and exploration.

KEYWORDS : Groundwater, Aquifer parameter, Geological formations, Borehole, Porosity.

I. INTRODUCTION

Groundwater is not only the prime source of drinking water but also the main source of irrigation in the area studied. In dry season water level goes downward from the earth surface and then water scarcity is prominent in the proposed area due to over extraction of it. The increasing population has suddenly increased the demand for consumption of water. It does not cope with the increasing population and development activities. The large scale abstraction of groundwater for irrigation purpose without any pre-planned proper planning and adequate management is causing much environmental degradations. So an effective and efficient study is now essential for the conservation of groundwater in the proposed study area.

Aquifer parameter of subsurface formations plays an important role for groundwater occurrence, distribution and reservation. The formation parameters are very important for groundwater investigation and detection of its condition. Detection of the effective groundwater reservoir, measurement of the rate of propagation of groundwater, selection of suitable well-sites etc. are important for groundwater development. Hydraulic conductivity, transmissivity, hydraulic diffusivity and radius of influence are the measuring instruments for the identification and estimation of the hydro-geologic parameters. Those parameters have been estimated and presented in the form of shaded contour maps. The proper estimation of various types of aquifer parameter would definitely identify the actual feature of groundwater condition of the area investigated.

II. MATERIALS AND METHODS

Any fruitful research largely depends not only on the availability and quality of data but also the appropriate methodology. It is impossible to identify and estimate the invisible properties of subsurface formations. Because, it is far beyond of direct visual measurement and experiment. So present work has been conducted and completed through data acquisition from various relevant institutions. Analysis has been made on integrated hydro-geological approach. About 467 borehole litho log data and static water level data of 59 locations during the period of 1994-2014 have been analyzed for the measurement of aquifer parameters. Latitude, longitude and elevation data were collected through direct field investigation. Borehole data would provide valuable information of subsurface water bearing formations and help to estimate the other types of aquifer parameter of the studied area. All the maps have been generated using ArcGIS computer program.

III. DESCRIPTION OF THE STUDY AREA

The study area is composed with Pabna and Sirajgongonj districts (Fig.1). It is situated in the western side of the Jamuna river. The total area is 4869.42 sq.km and it is located in between 23°48´ and 24°47´ north latitudes and 89°00´ to 89°59´ east longitudes. It contains 18 upazilas which has been presented with groundwater measuring locations in Fig.2. The area is bounded by Padma river, Kusthia and Rajbari districts on the south; Jamuna river, Jamalpur, Tangail and Manikganj districts on the east; Natore district on the west and Bogra district on the north. The river Padma flows in the extreme boundary of the southern side of the study area and the river Jamuna flows in the extreme boundary in the eastern side of the area. Numerous swamp have been developed in the study area. Besides, there are a large number of beels here. The study area is located in the flood plains of the Ganges,the Brahmaputta and the Meghna river systems (Khan,2001).

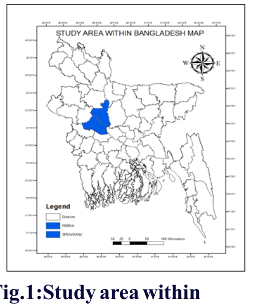

Fig.1:Study area within Bangladesh map.

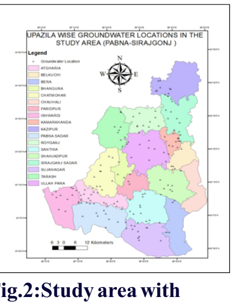

Fig.2:Study area with oundwater measuring locations.

IV. AQUIFER PARAMETERS ESTIMATION

(A)POROSITY

The porosity of a rock or soils is a measure of the volume of void spaces expressed as the ratio of the volume of interstices to the total volume. It determines the absorptive power of the material, In terms of groundwater supply, granular sedimentary deposits are of major importance for porosity. Porosities in these deposits depend on the shape and arrangement of individual particles, distribution by size, and degree of cementation and compaction.

Porosity of the aquifer materials of the study area have been estimated and a shaded contour map (Fig..3) of the distribution of average porosity has been prepared at an interval of 3% which ranges from 12%

to 39%. From the figure it is observed that the maximum area is covered by the range of average porosity of 27%-30%. The maximum range of porosity (36%-39%) is found in the south-eastern side of the study area which lies at Bera upazila under Pabna district. But this range is very little as compared to the entire area. The average porosity of 30% - 33% is found around 20% of the entire area. The range of porosity as 24%- 27% is found as a scattered manner in the study area. From the above discussion it can be concluded that the values of porosity are satisfactory for the abstraction of groundwater in the study area.

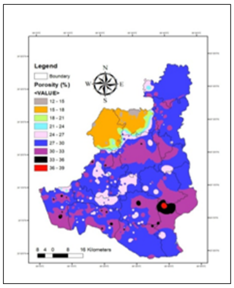

Fig.3: Representation of porosity in the study area.

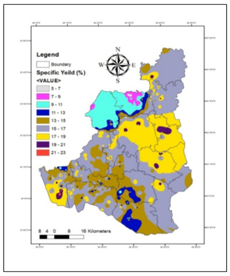

Fig: 4: Representation of specific yield in the study area.

(B) SPECIFIC YIELD

The term yield is applied to the maximum amount of water which can be obtained indefinitely from a well whereas production is the amount obtained from a limited time. The specific yield (S_y) is defined as the volume of water released by the downward movement of a unit distance. The portion that can be pumped out of a well and are that part of the water that would drain under the influence of gravity is measured by specific yield. Specific yield is also the storage capacity of a unit volume of material (Raughunath, 1987).

Specific yield is related to texture classes and within classes, depending upon the composition; the more sand in the sediments the higher the specific yield. The higher the clay content, lower the specific yield. The water bearing sand deposits of the study area has been encountered just below the upper clay layer. The specific yield of the study area has been estimated from the borehole and static water level data and a shaded contour map (Fig.4) of it has been prepared at an interval of 2%. From the contour map it is observed that the specific yield values change from 5% to 23%. The specific yield of 15% to 17% is found in the maximum portion of the study area. The specific yield values of 17% to 19% are observed in the middle-eastern side of the study area. There are some pockets of the range of 17% to 19% are identified in the south-western corner of the area. There is a trend of specific yield of 13%-15% which stars from the south-eastern side and ends to the western side of the area. A small portion having specific yield of 9% -11% is found in the north-western side of the area. Besides, there are some ranges of specific yield those are not evolved significantly. The analysis based on the lithology gives good estimates of specific yield and the overall values of specific yield of the study area is suitable and satisfactory for groundwater potentiality.

(C) SPECIFIC RETENTION

The quantity of water retained by the material against the pull of gravity is termed as the specific retention. The specific retention is the amount of water held between the grains due to molecular attraction. Therefore, the amount of this water will depend upon the total interstitial surface in the rock. If the total interstitial surface is more, the specific retention will be more and vice versa. Now, if the effective size of the grains decreases, the surface area between the interstices will increase leading to more specific retention. It, In fine soils like clay, the specific retention would be more, and in large particle soils like coarse gravels, the specific retention would be small.

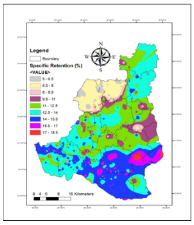

Fig.5: Distribution of specific retention of the study area.

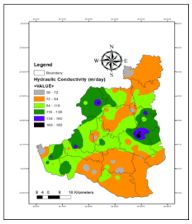

Fig.6: Distribution of conductivity in the study area.

The specific retention has been estimated from the litho logic data and a shaded contour map has been prepared at an interval of 1.5% as shown in Fig.5. The highest value ranges from 17% -18.5% is found as a pocket in the south-eastern side of the study area, but this range covers no significant area. The lowest range of specific retention of 6.5%-8% is found in the north-western side of the study area. From the figure it is observed that a trend extended from north-east to south-west corner having the specific retention of 11%-12.5%. The specific retention of 12.5% to 14% has attained a significant area in discrete manner. The value of specific retention of 14% -15.5% has also a significant area. Besides, there are some pockets of the lower values of specific retention distributed in a scattered form. The areas containing the lower specific retention indicate the suitable regions for groundwater exploitation and the highest values of specific retention are not suitable for better exploitation of groundwater.

(D) ***HYDRAULIC CONDUCTIVITY***

The hydraulic conductivity of a water saturated zone represents its average water transmitting property which depends mainly on the number and diameter of the pores present. A shaded contour map of hydraulic conductivity has been prepared from the estimated values using the borehole litholog data as shown in the Fig.6. The hydraulic conductivity of the study area has been classified into six groups depending upon its magnitudes. It ranges from 50 m/day to 182m/day. The highest values of hydraulic conductivity 160m/day to 182m/day are found in the mid eastern portion and northwestern portion of the study area. But these are distributed as some pockets and are not the significant in quantity. The northeastern and the southeastern parts of the investigated area have the values of hydraulic conductivity of 72m/day to 94m/day. There is a trend of hydraulic conductivity of 94m/day to 116m/day which extends from the southwestern corner to the northeastern corner of the study area. Some pockets of 116m/day to 138m/day are found in a scattered way. Some pockets of the lower values are also found in the area studied. The higher value of hydraulic conductivity indicates the higher recharge area of the investigated area and vice versa.

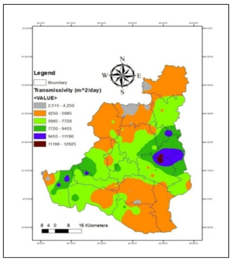

Fig.7: Distribution of transmissivity in the area.

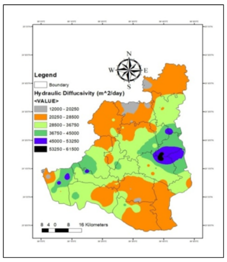

Fig.8: Distribution of hydraulic diffusivity in the area

(E) TRANSMISSIVITY

Transmissivity is the product of mean aquifer thickness and mean aquifer permeability. Decreasing aquifer thickness will cause a decrease in transmissvity for the same type of sand and lowered mean permeability caused by train towards fine or poorly sorted sands will have the same effect. Steep gradients on the transmissivity map are generally a combination of both aquifer thickness and lithological changes.

The value of transmissivity in the study area has been estimated from the borehole information. In the present study, transmissivity of water in the saturated formation i.e., below the water table only has been taken into account considering the thickness of the layer of different grain size and the corresponding hydraulic conductivity in different layers have been calculated. Then the transmissivity of the geologic formation of the area have been estimated. The transmissivity value in the study area has been estimated and presented in the form of a shaded contour map at an interval of 1735m^2/day as shown in Fig.7. The figure illustrates a high contrast of tranmissivity over the area, which ranges from 2515m^2/day to 129500m^2/day. In most of the areas, the value of transmissivity covers 5985m^2/day to 7720m^2/day. From the contour map it is observed that the mid-eastern region of the study area have the highest value of transmissivity of 9455m^2/day to 12925m^2/day. The area having the transmissivity of 7720m^2/day to 9455 m^2/day is found around the highest value of transmissivity. Besides, there are some pockets of the highest value of transmissivity are also found in the area studied. The values of transmissivity show that the studied area is suitable for groundwater exploration.

(F) HYDRAULIC DIFFUSIVITY

The ratio of transmissivity to the coefficient of storage of an aquifer is defined as its hydraulic diffusivity (Karanth,1990). This parameter determines the time that is needed for a given head change to occur in an aquifer as a response to a great change in head at another point. It is remarkable that hydraulic diffusivity is directly related to the transmissivity.

The hydraulic diffusivity has been estimated using the parameters T and S and has been presented in Fig.8. Since the aquifer of the study area is unconfined in nature, so the value of storage coefficient S is considered as 0.21, The hydraulic diffusivity varies from12000m^2/day to 61500m^2/day. The hydraulic diffusivity of the southeastern part and the northwestern part of the study area are small and the highest value is observed in the eastern part of the study area. A trend of hydraulic diffusivity of 28500m^2/day to 36750m^2/day is observed in the study area which extends from the north-eastern corner to the south-western corner. Actually this parameter indicates the regions having higher values are comparatively favorable for groundwater development due to smaller head change.

(G) RADIUS OF INFLUENCE

If water is pumped at a constant rate from the well, a gradient in the water table towards the well is created which results in a depressing form of the water table. In a homogeneous and isotropic medium, the resulting conical shape of the water table around the well due to radial flow of water into it is known as cone of depression. Pumping wells should be spaced far apart so that their cones of depression will not overlap over each other resulting in the reduction of their yields and /or increased drawdown. To avoid well inference the wells should be spaced beyond their radius of influence. If two or more wells are constructed in such a way that they are near to each other and their cones of depression intersects, they are said to be interfere. Such mutual interference of wells decrease the discharge of the interfering wells (Garg,2004).The radial distance from the centre of well to the limit where the drawdown is zero is called radius of the influence. Usually, the radius of influence (R) ranges up to 300m for unconfined aquifer.

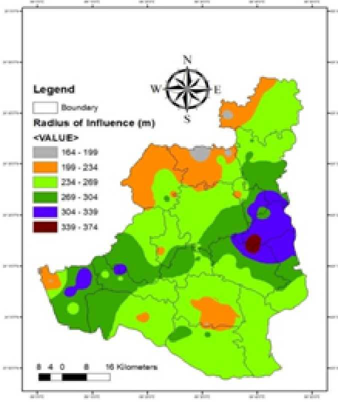

Fig.9: Radius of influence of the pumping wells in the study area.

A contour map of radius of influence is prepared depending upon the values of storage coefficient (S) and the transmissivity (T) as shown in Fig.9. As the aquifer of the study area is unconfined in nature, so the storage coefficient S is chosen as 0.21. From the figure it is observed that the value of radius of influence of the study area ranges from 164m to 374m which is very near to the prescribed value. The most of the part of the study area has the radius of influence of 234m-269m. Some portions of the study area have the radius of influence as 199m-234m which is very negligible as compared to the entire area. The rest parts of the study area have the values of radius of influence of 269m-374m. From the observation it can be concluded that the overall study area is suitable for well construction and exploration of groundwater except some small regions.

V. CONCLUSION

Borehole litho logical data and static water level data have been processed and analyzed to estimate the hydro-geological parameters of the subsurface formations of the study area. From the analysis it is clearly observed that various parameters have the values within the recognized limit. The overall thickness of the composite sand formation is suitable for groundwater potentiality. No other impermeable layer is found below the sandy formation. Basically, the study area is unconfined in nature. Porosity, specific yield, specific retention, hydraulic conductivity, transmissivity, hydraulic diffusivity, radius of influence of the study area have been measured and presented in the form of contour maps using the available program. From all the maps it is very clear that the hydro-geologic subsurface properties of the investigated area are favorable for groundwater abstraction.

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