The Controls to the Variation in Depth to Fresh/Saline Interface in the Groundwater of Southwest District, NCT, Delhi – A Case Study

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Abstract: The hydrogeology of the southwest district of National Capital Territory (NCT) Delhi is challenging on the account of the fact that the quality of groundwater in the district shows horizontal and vertical variation with respect to salinity The present paper tries to study the variation in the depth to fresh (electrical conductivity equal to or below 1500-2000 micro siemens per cm)/saline (electrical conductivity above 1500-2000 micro siemens per cm) water interface of the district and locate the factors controlling the variation in the depth to fresh/saline interface in the groundwater of the district The map showing variation in the depth to fresh/saline interface in the groundwater of the district was studied vis-à-vis geology and cultural practices in the district, in order to identify the factors controlling the variation in the depth to fresh/saline water interface in the groundwater of the district

Keywords: Hydrogeology, Groundwater, Salinity zone, Delhi area

Introduction

The Southwest district of NCT Delhi has been notified by the Central Ground Water Authority (CGWA) of India for regulated development of the groundwater resources The step was taken on account of the rapid decline in the water levels of the district and because of the fact that a major part of the groundwater resource available in the district is of poor quality The hydrogeology of the district is challenging on account of the fact that the quality of groundwater in the district shows horizontal and vertical variation with respect to salinity The groundwater for the purpose of drinking has been considered to have electrical conductivity equal to or below 1500-2000 micro siemens per cm The present paper tries to locate the factors controlling the variation in the depth to fresh/saline interface in the groundwater of the district In the perspective of hydrogeology, the district has simple geology comprising of Alwar quartzites in the east and fluvioaeolian deposits in the rest of the district (Fig 1) The borehole data of Central Ground Water Board (CGWB) shows alternation of fluvial bands with aeolian bands in sporadic manner The sediments are mostly silt with medium to fine sand and clay The depth to bedrock data indicates towards steep subsurface escarpment on the western side of the Delhi ridge (Alwar Quartzites) exposed in the district, thereby hinting at the presence of a fault on the western side of the hard rock exposure A map (Fig 2) showing variation in the depth to fresh/saline interface in the different regions of the district was prepared with the help of database at Central Ground Water Board and field survey carried out during year 2002-03 The map has been studied with respect to the hydrogeology of the district in order to find out the factors controlling the variation in the depth to fresh/saline interface in the groundwater of the district

The Fresh Saline Water Interface

The map showing the variation in the depth to the fresh/saline interface of the district (Fig 2) shows that except a few isolated locations in the hard rock, almost everywhere throughout the logged and drilled depth fresh water is reported The depth to fresh/saline water interface is maximum in the regions just adjacent to the hard rock areas based on the general behaviour of interface, exploration data and the field observation The depth to fresh/saline water interface decreases from east to west and becomes minimum in the range of 10 to 15 m below ground level in the zone passing near to Amberhai, Pochanpur and Bamnoli It also shows a decreasing trend towards NW direction and the depth to fresh/ saline water interface reaches in the lowest range of 5 to 10 m below groundwater level around sector 3 of Dwarka To the west of the above mentioned zone, towards Najafgarh drain, the depth to fresh/ saline water interface increases at a steeper rate reaching its maximum of 30 to 40 m below ground level in the regions along the Najafgarh drain To the west of the Najafgarh drain there are three patches in the depressions defined by 210 m amsl contour to the west of Kair, to the north of Ojwah and Daulatpur (Fig 1) where the depth to fresh/saline water

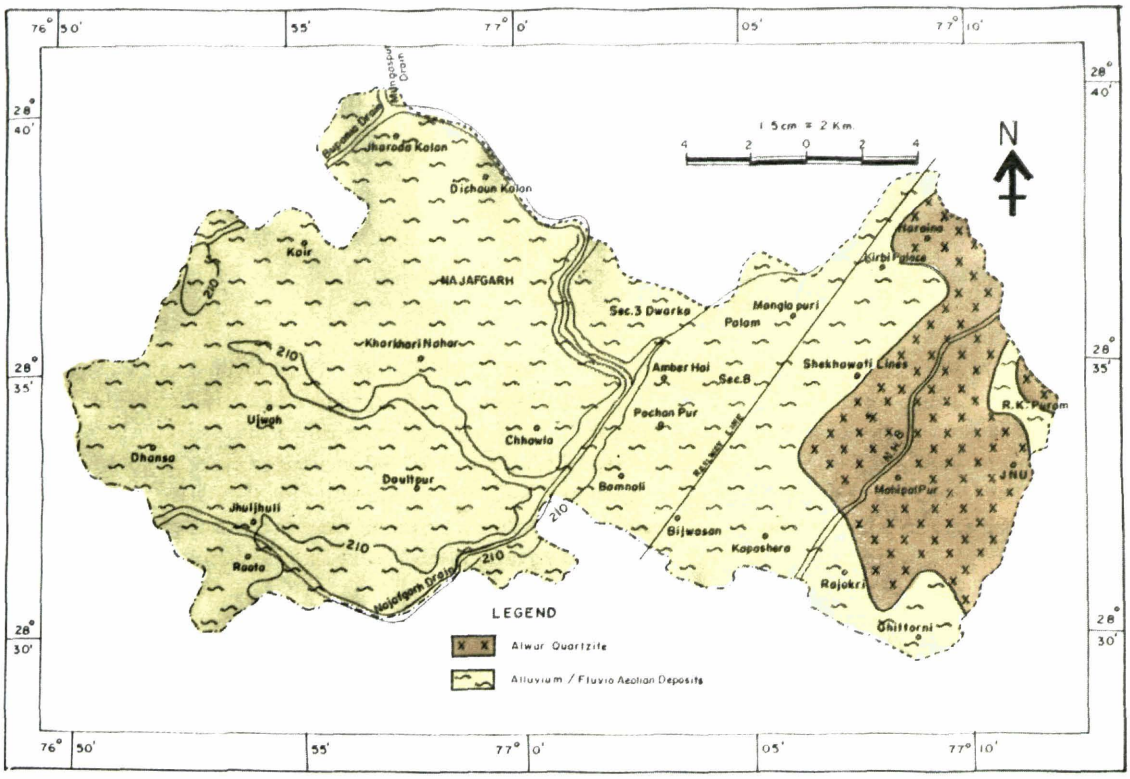

Fig.1. Geology of Southwest District, NCT, Delhi.

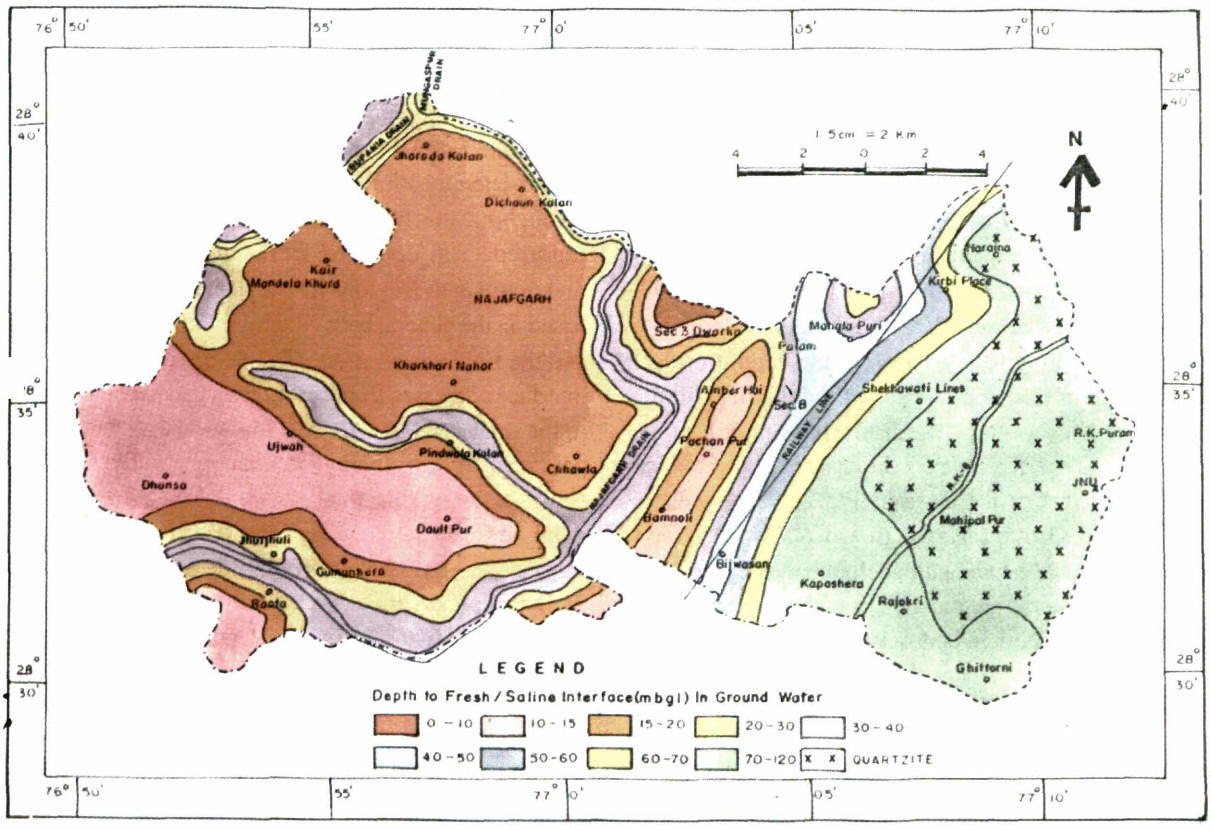

Fig.2. Depth to Fresh/Saline interface (G.W.), Southwest District, NCT, Delhi.

interface is found in the range of 30 to 40 m below ground level. Just adjacent to and along the above mentioned zone along the Najafgarh drain, the depressions and along the Bupania drain there is a zone having depth to fresh/saline interface in the range of 20 to 30 m below ground level (Fig.2). In the regions to the west of Najafgarh drain, the northern part comprising of localities like Jharoda Kalan, Dichao Kalan, Najafgarh, Kair, Kharkhari Nahar and Chhawla have depth to fresh/saline interface in the range of 15 to 20 m below ground level. In the southern part of the above mentioned region, there is a zone comprising of depth to fresh/saline water interface in the range of 10 to 15 m below ground level comprising of localities like Dhansa, Daulatpur etc. To the south of Raota, there is a zone having depth to fresh/saline water interface in the range of 10 to 15 m below ground level. To the east of Najafgarh drain from the area having lowest depth to fresh/saline water interface, moving in SE and East direction towards the hard rock area, the depth to fresh/ saline water interface increases gradually reaching its maximum value on the fringes of the hard rock. The depth to fresh/ saline water interface also increases at a steeper rate in NW and West directions towards Najafgarh drain. To the west of Najafgarh drain the depth to fresh/ saline water interface increases towards the depression and the drain.

The Controls on the Variation in the Depth to Fresh/Saline Interface in the Groundwater of the District

The fresh/saline water interface is a hydrostatic pressure surface under dynamic equilibrium. The factors contributing to the dynamic elements of the interface are:

i. Groundwater draft through the groundwater abstraction structures.
ii. The volume and intensity of the rainfall.
iii. The volume of water flowing through the surface water bodies.
iv. The variation in the hydraulic conductivity/ permeability of the subsurface formations.
v. The infiltration capacity of the sub surface formations and in a nutshell the overall recharge to the groundwater.

As of today, the freshwater pockets and lenses along the Najafgarh drain and to the west of it has hydrogeologic setting somewhat similar to the fresh/ saline interface setting of island hydrogeology. The increase in groundwater draft in the freshwater areas leads to the reduction in the volume of the fresh water and the fresh/ saline water interface rises up. Based on volume of recharge to the groundwater by surface runoff of rain water and the water flowing through the drains, the interface migration receeds down gradient of the hydrostatic pressure surface during post-monsoon times. The long term behaviour of the groundwater level shows a declining trend in the major part of the area thus contributing to the decrease in the volume of fresh water. This has contributed to the overall rise in fresh/saline water interface of the area over a period of time. In the regional perspective of the current district the fresh/ saline interface can be broadly studied under the following subheadings:

The Fresh/Saline Interface in the Groundwater along and Adjacent to the Depressions Controlled by 210 m amsl Contour

The cause for the increase in depth to fresh/saline water interface towards these depressions is on account of maximum surface runoff during rainy seasons towards these depressions. Thus leading to greater retention time of the rain water in these localities, thereby enhancing natural groundwater recharge. Coupled with the above factor, these depressions are also in close vicinity of drains carrying voluminous amount of water, contributing to additional groundwater infiltration recharge. All along the Najafgarh drain and its tributaries, the effects of the recharge from the water being carried by drain is evident in the form of greater depth to fresh /saline water interface.

The Fresh/Saline Interface in the Groundwater Adjacent to the Hard Rock Areas

As mentioned earlier, the regions adjacent to the hard rock are traversed by faults, this along with the existing formation accounts for higher permeability of the ground water zones there. There is also continuous surface runoff from the adjacent higher elevation hard rock areas towards these areas during rainy season. Along with this the dynamic groundwater of the region have steeper gradient with water flowing into and out of the region more frequently. The above mentioned factors working in synergy contributes towards greater depth to fresh/ saline interface in this region.

Other Areas of the District

The other areas mentioned above refer to the areas having depth to fresh/saline water interface in the shallower range. They generally have surface topography such that the surface runoff is away from these localities. They are also away from recharge sources like drain and depression. The major controlling factors besides the above mentioned one is the predominance of finer sediments in the subsurface geology of the area having very low

permeability The low permeability of the formations inhibits continuous movement of groundwater The greater residence time of ground water within finer sediments and improper flushing leads to gradual accumulation of salts by dissolution

Summary and Conclusions

The depth to fresh/saline water interface in the groundwater of southwest district, NCT Delhi shows defined pattern of variation Factors like groundwater draft, rainfall, surface runoff, and more specifically the infiltration capacity and permeability of the formation controls behaviour of the interface The interface occurs at deeper level along and adjacent to the depressions on account of greater surface runoff and retention time of rain water into these depressions coupled with additional infiltration from the water flowing through drains aligned along the depressions Similarly the interface is deeper on the margin of hard rock exposures in the area, which is supposed to be a fault zone This is because of higher permeability of the formation along the hard rock exposure, continuous surface runoff from the higher elevation hard rock areas and steep hydraulic gradient transverse to the hard rock exposure These factors in conjunction lead to continuous flushing of the groundwater In other areas of the district, the depth to fresh/saline groundwater interface is at shallower range This is on account of the fact that topography is such that maximum surface runoff is away from these localities, the localities are away from major recharge sources like depressions and drains and the subsurface formation is predominantly finer sediments Moreover the present groundwater draft in these localities is more than the post-monsoon freshwater infiltration into the subsurface There is future scope for ascertaining hydraulic parameters of individual beds and evaluate migration of saline boundary in space and time

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