Groundwater Management in NCT Delhi

Shashank Shekhar[1], Raja Ram Purohit[2] & Y. B. Kaushik[2]

[1] Asstt. Professor, Department of Earth Sciences, University of Delhi, Delhi-110007
[2] Scientist, Central Ground Water Board, Jamnagar House, Mansingh Road, New Delhi – 110011, India.
e-mail: shashankshekhar01@gmail.com, oicnd-cgwb@nic.in

Abstract

National Capital Territory of Delhi occupies an area of 1483 sq.km. with the population density of 9344 persons/sq.km. The projected population for year 2009 works out to be 176 lakhs and total water requirement for drinking and domestic purposes, 927 million gallons per day (MGD). The Delhi Jal Board (DJB) supplies 815 MGD (including around 100 MGD from groundwater). The deficit in drinking water supply works out to be 112 MGD. This deficit in drinking water supply of Delhi can be partially augmented through exploitation of groundwater resources. The groundwater availability in Delhi area is controlled by the hydrogeological conditions characterized by different geological formations. The major aquifers contributing to the groundwater are fine to medium sand of Older alluvium, medium to coarse sand of Newer alluvium along the Yamuna Flood Plain and the hard rock formations occupied by quartzite, inter-bedded with mica schist belonging to Delhi Super Group. The depth to water in the Delhi state varies greatly from 1.2 meter (in the Yamuna flood plain) to more than 64 meters (in the southern part of the Delhi Ridge) below ground level. The groundwater is declining in majority of the areas of Delhi on account of overexploitation of the resources. The rate of decline is as high as 1.7 to 2 meters/year in some areas (South & South west Dist.). Thus seven out of nine districts of Delhi are categorized as overexploited with respect to dynamic groundwater resources. The groundwater quality shows horizontal and vertical variation in space. The deeper aquifers are mostly underlain by saline water in alluvial areas. The extent of fluoride contamination in groundwater is also high in western part of Delhi in areas like Northwest, Southwest & West districts. The groundwater management aspects of Delhi emphasizes on augmentation of groundwater resources and improvement in groundwater quality through measures like rainwater harvesting and artificial recharge, conservation of groundwater by limiting withdrawal in overexploited areas and limited development of potential aquifers of Delhi to augment drinking water supply. The paper elaborates on groundwater scenario of Delhi and discusses the groundwater management aspects in detail.

1. Introduction:

The National Capital Territory (NCT) of Delhi occupies an area of 1483 Sq.km. lies between latitudes 28^{o} 24' 15'' and 28^{o} 53' 00''N and longitudes 76^{0} 50'24" and 77^{0} 20' 30" E. It is divided into 9 districts and 27 Tehsils/Sub-divisions. The population of the city is growing at a very fast pace and so is the urbanization of the city. This rapid urbanization is leading to population resource imbalance in the city. The city has limited surface water allocation for drinking purposes and the groundwater of the district is being widely extracted to meet the industrial, agricultural and domestic needs.

The projection of population figures of the census of 2001 of NCT Delhi for year 2009 comes out to be 176 lakhs. Thus the total water requirement for drinking and domestic purposes works out to be 927 MGD. The Delhi Jal Board (DJB) supplies 815 MGD (including around 100 MGD from groundwater). The deficit in drinking water supply works out to be 112 MGD. The groundwater resources of the district though over exploited, it can partially meet deficit in drinking water supply.

2. Geology

The basement and surface exposure of the hard rock in N.C.T Delhi is occupied by quartzite inter-bedded with mica schist belonging to Delhi Super Group. Unconsolidated sediments of Quaternary to Recent age unconformably overlie Delhi Super group. The quartzite is grey to brownish grey, massive to thinly bedded and structurally form a coaxially refolded regional anticline plunging towards north. The major planar structure strikes NE-SW with steep southeasterly dips. Quartzite occurs in the central and southern part of the area while the Quaternary sediments comprising Older and Newer Alluvium cover the rest of the area. The older Alluvium comprises silt, clay mixed with kankar in varying proportions. The Newer Alluvium mainly consists of un-oxidized sands, silt and clay occurring in the Yamuna flood plain. The thickness of alluvium on eastern and western side of the ridge is variable but west of the ridge it is generally thicker (>300m). The area is dissected by number of faults, fractures and shears, the trend of these varies from NNE-SSW to ENE-WSW.

3. Hydrogeology

The ground water availability in the territory is controlled by the hydrogeological situation characterized by occurrence of alluvial formation and quartzite hard rocks. The NCT Delhi can be divided into following distinct hydrogeological units: Newer Alluvium - Yamuna flood plain deposits, Older Alluvium - Eastern and western sides of the ridge, Older Alluvium - Isolated and nearly closed Chattarpur alluvial basin and Quartzitic Formation - NNE-SSW trending Quartzitic Ridge.

The alluvial deposits are of Quaternary age. The newer alluvium belongs to recent age and is referred to the sediments deposited in the flood plains of Yamuna River. These sediments range in texture from clay/silt mixed with tiny mica flakes to medium/coarse sand and gravel. Newer alluvium, in general, is characterised by absence of kankar.

The older alluvium consists of sediments deposited as a result of past cycles of sedimentation of Pleistocene age and occurs extensively in the alluvial plains of the territory. This is comprised of inter bedded, lenticular and inter-fingering deposits of clay, silt and sand ranging in size from very fine to very coarse with occasional gravels. The kankar or secondary carbonates of lime occur with clay/silt deposits and sometimes as hard/compact pans. Older alluvium is predominantly clayey in nature in major parts of territory except the nearly closed alluvial basin of Chattarpur where the alluvial formation is derived from the weathered quartzites rocks.

The hard rock formations; mainly the Alwar quartzites of Delhi System exposed in the area belong to Pre-Cambrian age. The quartzites are pinkish to grey in colour, hard, compact, highly jointed/ fractured and weathered. These occur with interbeds of mica-schists and are intruded locally by pegmatites and quartz veins. The strike of these rocks varies northeast southwest to north-northeast south southwest with steep dips towards southeast and east except for some local variations due to folding. Quartzites are ferruginous and gritty types on weathering and subsequent disintegration give rise to coarse sand (Badarpur sands). Chemical weathering of deeper horizons is also common.

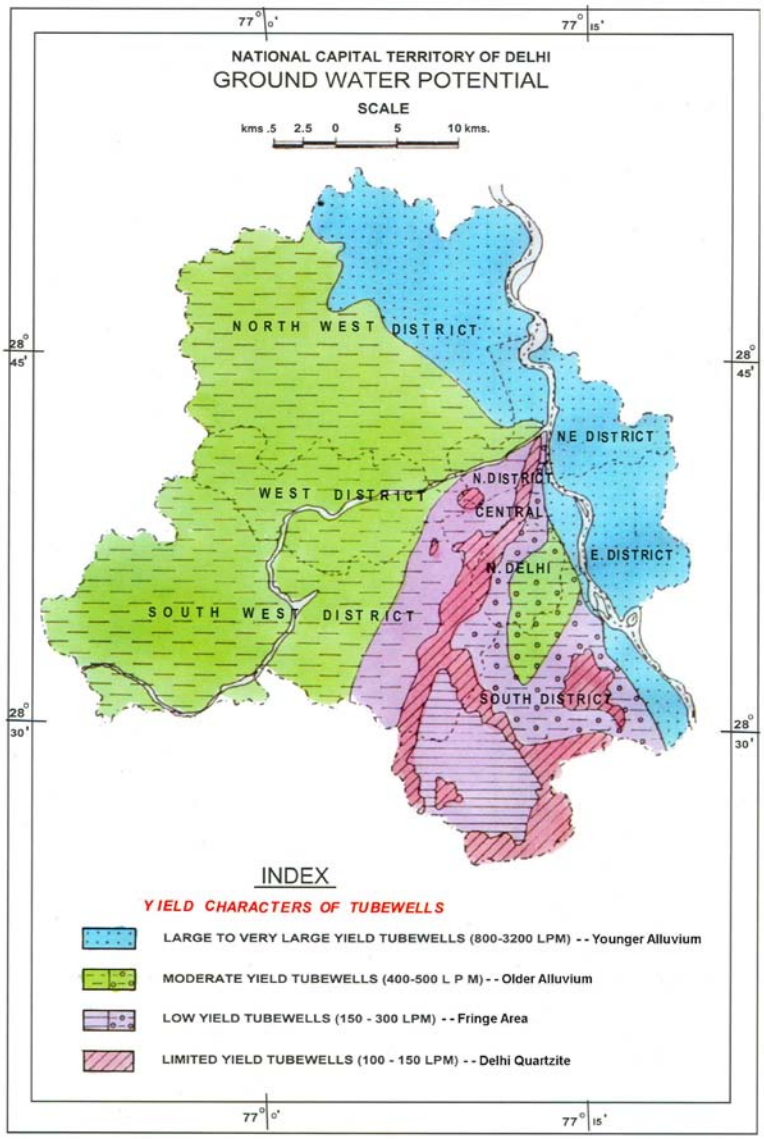
The formation wise details of ground water characteristics in NCT Delhi are given below (Table-1).

Table-1 Summary of ground water characteristics in Different Geological formations in NCT Delhi

Sl.No.	Nature of Formation	Depth of the well	Discharge	Drawdown	Transmissivity/
		(mbgl)	m^3/hr	(m.)	(m^2/day)
1	Newer Alluvium	40 - 60	50-180	5.0 - 8	600-2000
2	Older Alluvium	30 - 60	20-60	6.0 - 24	130 - 403
3	Quartzite	50 - 150	02 - 10	6.0 - 30	05 - 135

The groundwater potential of the different formations in NCT Delhi is given as Fig.1.

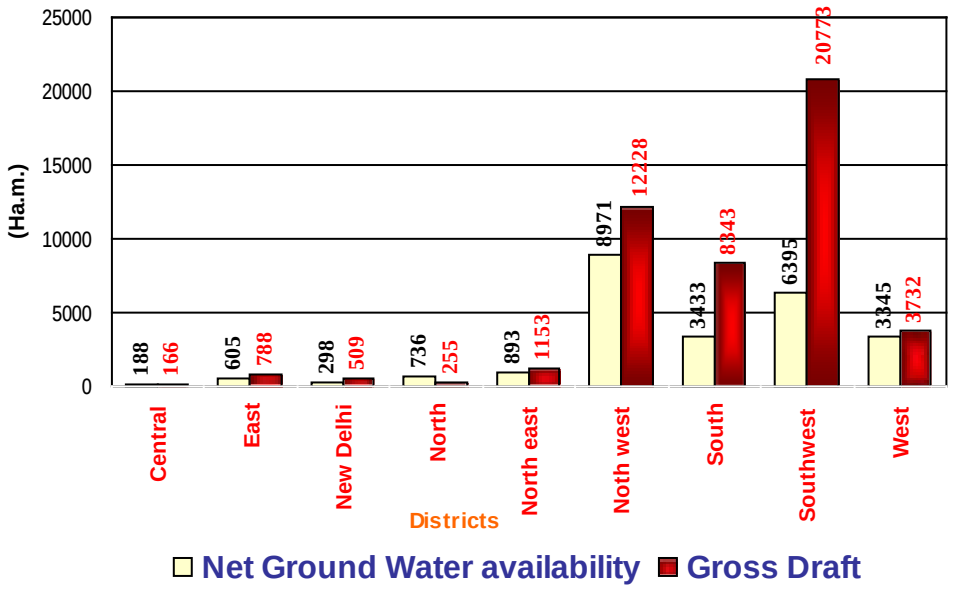
Fig. 1 Groundwater potential viz-a-viz geological formations



4. Dynamic Groundwater Resources of NCT Delhi

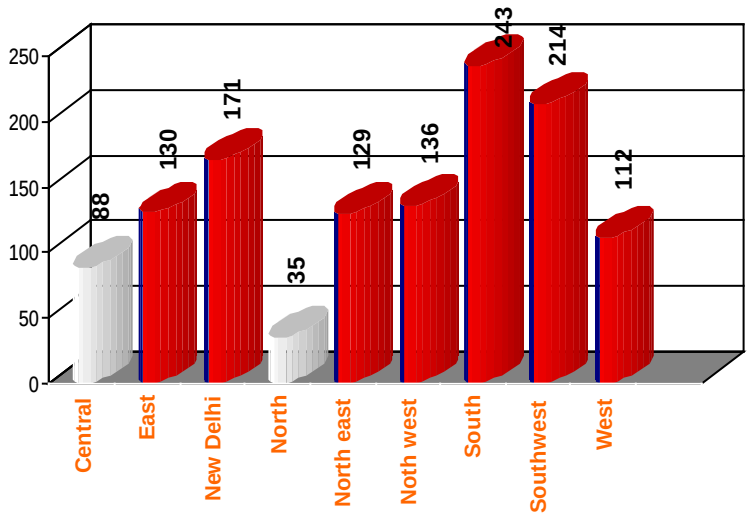
The complex situations of ground water occurrence in different formations, presence of saline ground water at varying depth in the aquifers and growing urbanization influences availability of ground water in different parts of NCT of Delhi.
Central Ground Water Board estimated the annual replenishable ground water resources in NCT Delhi as 29710 hectare meter (Ha m) and the net ground water availability of NCT Delhi as 28156 ham. District wise net groundwater availability and gross groundwater draft is shown in Fig 2. The annual ground draft for NCT Delhi (as on 2004) is 47945 ham. of which 20002 ha.m is for irrigation use, 21506 ham is for domestic use, 2137 ham by farmhouses and around 4300 ham for industrial uses.

Fig. 2 Annual Net Groundwater Availability and Annual Gross Groundwater draft (ha m)



The stage of groundwater development in NCT Delhi is shown as bar graph with Figure-5. The figure clearly shows that out of nine districts of NCT Delhi, seven districts are overexploited.

Fig.3 Stage of Ground Water Development



5. Groundwater Quality

Chemical quality of ground water in NCT Delhi varies with depth and space. Brackish ground water mainly exists at shallow depths in Northwest, West and Southwest districts with minor patches in North and Central districts.

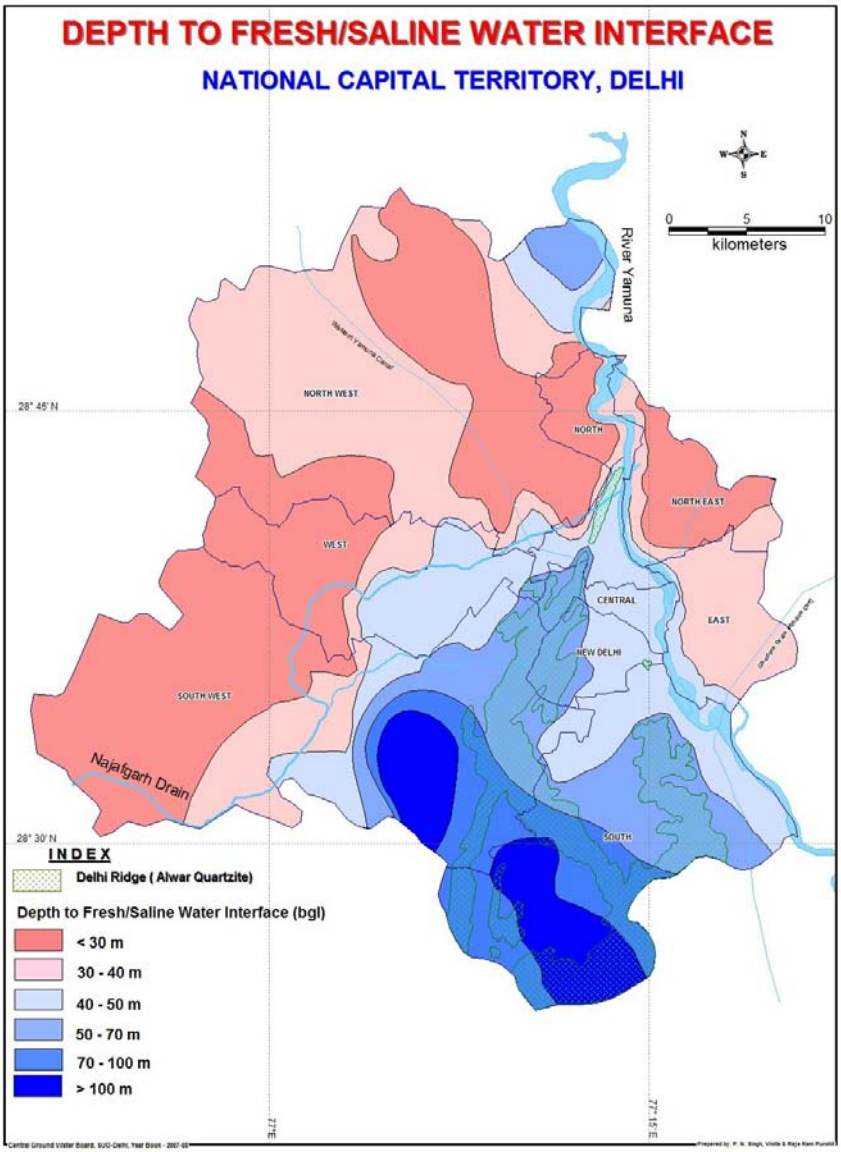
In alluvial formations, the quality of ground water deteriorates with depth, which is variable in different areas. The ground water is fresh at all depths in the areas around the ridge falling in Central, New Delhi, South and Southwest districts and also Chattarpur basin. In the areas west of the ridge, in general, the thickness of fresh water aquifers decreases towards northwest, the thickness of fresh water zones is limited in most parts of west and southwest. In the flood plains of Yamuna, in general, fresh water aquifers exist down to 30-70 m. The fluoride contamination in groundwater has been noticed in samples of groundwater collected from south west district and West districts. The high fluoride levels are mostly found in areas where groundwater is brackish to saline in nature. The nitrate concentration in groundwater has been reported mostly from areas where domestic effluent is discharged in to open unlined drains. The high nitrate concentrations are mainly from point source of contamination.

6. Depth to Fresh Saline Interface in Ground Water of NCT Delhi

The depth to fresh saline water interface in ground water of NCT Delhi (Fig.4) is found at maximum depth in Part of Chattarpur Basin and the in the area adjacent to Delhi Ridge near Samalkha and Bijbasan. In general the greater depth in Fresh/Saline interface is found in areas fringing Delhi Ridge. Furthermore the younger alluvium of Yamuna flood plain and coarser alluvium adjacent to Delhi ridge has depth to fresh saline interface 40m below ground level. In general in other parts of NCT Delhi as indicated on the map, depth to fresh water interface is found either below 30 m bgl or in the range of 30 to 40mbgl. The spatial distribution of fresh ground water in controlled by natural factors. The younger alluvium of Yamuna Flood Plain having higher Hydraulic conductivity and continuous source of fresh water from the perennial river has accumulated fresh water thickness in the aquifer in the range of 30 to 50 m. The Delhi Ridge in general has fresh Ground Water at all explored depth. The area adjacent to the ridge receive continuous recharge fro Delhi ridge and has high lateral permeability on account of faults and coarser nature of sediment (weathered Quartzite)

The growing demand of portable ground water has led to rapid depletion in ground water levels of the areas where the fresh saline water interface is at greater depth. Fig.5. It is apart from the figure that nearly 1.5m per year decline in ground water is observed in Chattarpur basin and adjacent areas which incidentally also has maximum fresh water thickness. In other potential fresh water areas of Delhi, the annual rate of decline is nearly 1m per year. It is to be noted that minimal decline in ground water level is observed in areas where saline water is found at shallow level (Fig.5). The Yamuna flood plain of NCT Delhi is the only potential area where possibility of recharge to compensate ground water abstraction exist, while in other fresh water areas either there is dense habitation or the formation (Alwar Quartzite) characteristics limits ground water recharge. Thus the level of exploitation in Yamuna Flood plain will not be same as the Alwar quartzite.

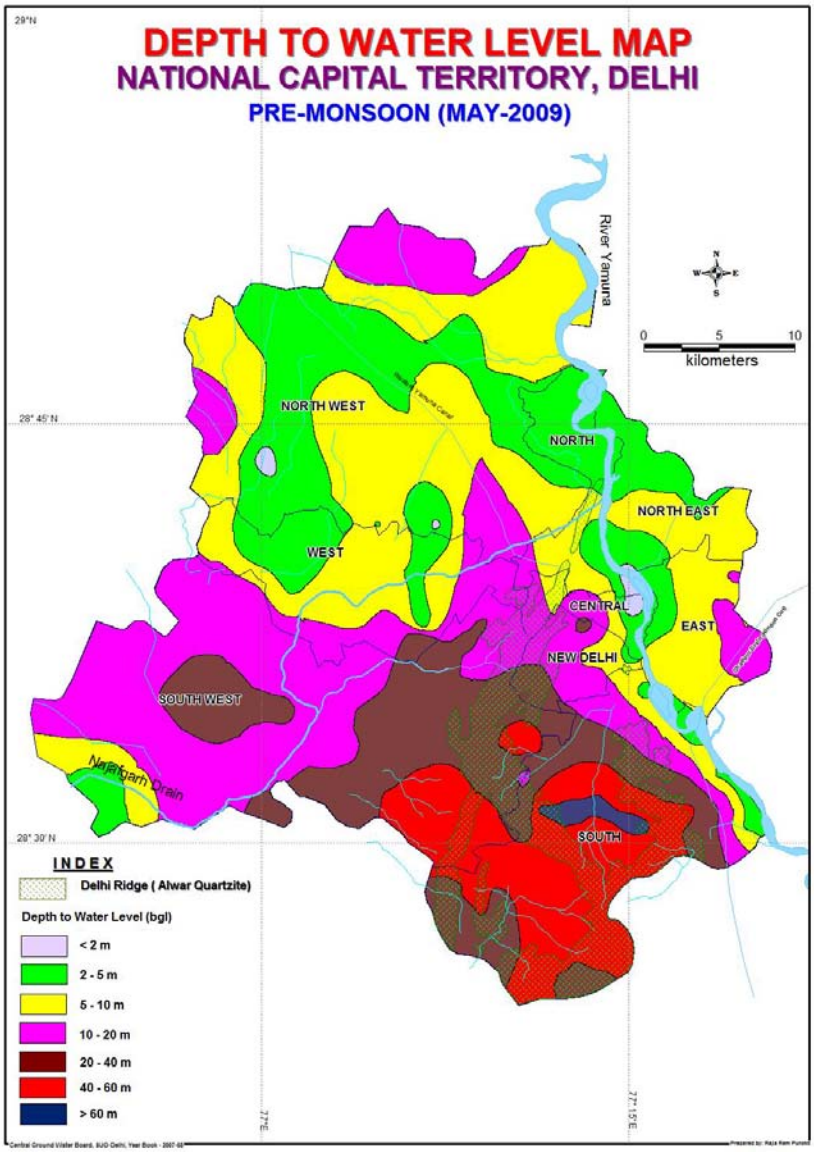
Fig.4 Depth to Fresh/Saline Water Interface, NCT-Delhi



7. Water levels if NCT Delhi:

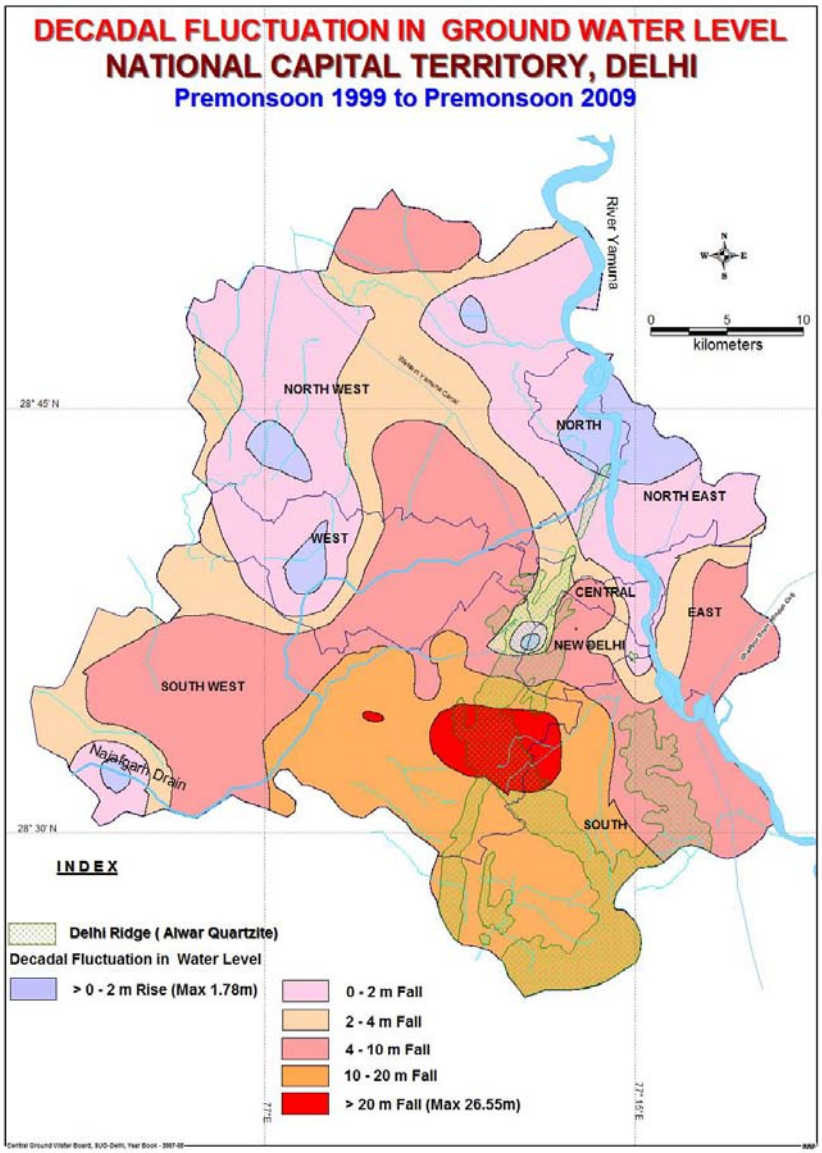
The Depth to water level recorded in NCT Delhi as on date ranges from 1.20 to 67.73 mbgl. The deeper water levels are mostly found in south and south west districts of NCT Delhi, while the shallower water levels are found in central, northern and eastern part of Delhi (Fig.5) .The CGWB data shows that nearly 50% wells of south district shows depth to water level more than 40 meters below ground level (mbgl) and nearly 35% wells show depth to water level in the range of 20 to 40 meters below ground level. In New Delhi and South-West district 56% and 46% wells respectively shows depth to water level in the range of 10 to 20 mbgl. In Central, East and North west districts 50%, 77% and 31% monitoring stations respectively have depth to water level in the range of 5-10mbgl. While in East, North, North East, North West, and West district 22%, 85%, 100%, 34% and 44% monitoring stations respectively have depth to water level in the range of 2 to 5 mbgl. The Yamuna flood plain in NCT Delhi also has depth to water level in the range of 2-5 mbgl.

Fig.5 Depth to Water Level Map, NCT Delhi



The decadal premonsoon water level data shows that nearly 95% monitoring stations shows decline in water level in the range of 0.08 to more than 20 meters as compared with 10 year mean of May water level. The maximum fall have taken place in district of South and South-West (i.e. 11.01 to 26.55m), (Fig.6).

Fig.6 Decadal Fluctuation in Ground Water Level, NCT Delhi



8. Ground Water Management Strategy

The ground water resources of 7 districts of NCT, Delhi are over-exploited with stage of development reaching to even 243% in south district. Moreover, the presence of saline aquifers below a depth of 30 to 40 m further limits the development of ground water resources. Thus the complex ground water regime of NCT, Delhi needs scientific planning to make the ground water resources as sustainable supplement source of water supply in NCT, Delhi. The groundwater management strategy in NCT Delhi should emphasize on the limited development of potential aquifers of Delhi and augmentation to the groundwater resources of Delhi by rainwater harvesting and artificial recharge to the groundwater. The groundwater management strategy under different headings is described below.

9. Scope of the Limited Groundwater Development of the Potential Aquifers in Delhi:

i) *The Yamuna Flood Plain aquifers*:

Yamuna Active Flood Plain Aquifer System occupies an area of 97 Sq.km and stretches about 35 Km along river Yamuna. The total thickness of Newer Alluvium varies between 45 to 55 m. Aquifer system in Newer Alluvium is unconfined with depth to water level occurring at shallow depths of 3 to 7 m bgl and can sustain the tube wells with yields ranging from 1400 to 2800 lpm. A preliminary estimate by Central Ground Water Board says that the Yamuna flood plain has exploitation potential of nearly 85MGD, out of which the CGWB has created groundwater potential of 45 MGD by installing tube wells in the different sectors of the Yamuna flood plain.

ii) *The brackish water aquifers of Delhi*:

Ground water over-development has not only resulted in depletion of fresh ground water resources but also paved way for gradual invasion of brackish water into fresh water aquifers. Thus it has become imminent to explore the brackish water areas located within shallow/water logged areas to promote the scientific management and proper planning for exploitation of brackish water which is the only effective controlling method of spreading brackish water front. At present about 670 Sq. Km of area has brackish water at shallow depths which can be developed to be utilized for domestic uses other than drinking purpose. This apart from reducing the fresh water consumption will also result into arresting spreading of brackish water. CGWB estimated that the development of brackish water aquifers will yield about 80 MGD of water. This brackish water can be used for providing the dual water supply system, where the same pipe lines can be used to supply fresh water as well as brackish water for domestic uses at pre-determined hours of supply. The brackish water can also be mixed with fresh water to bring the elements under permissible limits as per drinking water standards.

iii) The aquifers of Dwarka Township

It is proposed that limited development of groundwater resources in some of the identified potential areas of the Dwarka Township can be taken up. The three following pockets (topographical depressions) have been identified for the withdrawal of fresh water: a) Gummenhera depression b) Pochanpur depression c) Kakraula depression. The fresh water supply can be supplemented by marginal fresh quality of water through a battery of tube wells within the township.

iv) The fresh groundwater aquifers of East Delhi

The east Delhi consisting of two districts occupies about 8.3% of total area of NCT Delhi and about 23% of population resides in East Delhi. The district is underlain by newer alluvium consisting of predominantly sand mixed with gravel and little amount of silt and clay up to a depth of about 30-40 meters followed by older alluvium. Depth to fresh/saline water interface in this area is about 40 to 45 m bgl. Depth to ground water levels in this area varies from 5 to 8 m bgl. CGWB estimated that about 4-5 MGD of fresh water can be extracted from aquifers of east Delhi.

10. Rainwater Harvesting and Artificial Recharge to Groundwater:

The rapidly declining water level of Delhi is attributed mainly due to rampant urbanization and enhanced groundwater withdrawal and reduction in the available open space for recharge to groundwater. The situation can be improved by adopting rainwater harvesting and artificial recharge to groundwater measures. The Master plan for rainwater harvesting and artificial recharge of NCT Delhi estimated that nearly 440 MCM of rainwater can be harvested annually in Delhi and utilized for artificial recharge to groundwater. The artificial recharge to groundwater can be taken up by adopting

different measures like rainwater harvesting at the level of individuals, at the level of colonies and by the institutions. The Central Groundwater Board of NCT Delhi has taken up the leadership of spearheading rainwater harvesting in NCT Delhi. The rainwater harvesting effort by CGWB in JNU and IIT campuses resulted in to rise in water level to the tune of about 2 to 3 meters in vicinity of the area where the project was implemented. Similar rainwater harvesting effort in President Estate resulted in the rise of water level in the range of 1 to 4 meters in the vicinity of the areas where the project was implemented.

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