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Ground water potential and quality of water in Sirsa district Haryana

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Abstract

The groundwater quality on both sides of the Ghaggar River was generally good, resulting in the installation of numerous tube wells in the belt along the river. The deep groundwater quality in the northern and extreme southern part of the SIC was quite poor. Rising groundwater levels in areas underlain with marginal to poor quality groundwater due to water losses from the irrigation system. Declining groundwater level in the good quality groundwater zones due to over exploitation. The shallow groundwater quality was good in about 28 %, marginal in 64 % and poor in 8 % of the district. Deep groundwater quality was good in 20 %, marginal in 16 % and poor in 64 % of the area. Shallow tube wells constructed in the district have discharge range between 300 and 1000 lpm with a drawdown of 1.0 to 3.5m. While deeper tube well/ bore wells constructed in Ghaggar basin tapping water bearing zone in depth range 100m to 260m yield 1500 to 3000 lpm with 5 to 17 m of draw down. The river Ghaggar has experienced a declining trend in the groundwater levels. The increase in the intensity of tube wells is mainly concentrated in the regions where groundwater is of relatively better quality. The number of tubewells per km^2 varies from as low as 2 in the Dabwali block to 5-10 in the Sirsa, Rania,Baragudha and Elenabad block.Varying water levels and ground water development are observed in Sirsa district, a large part of district Sirsa is suitable for Artificial Recharge on the basis of ground water development level. But it would be prudent to take Sirsa, Rania Dabwali, Ns Chopta and Ellenabad blocks of the district in priority as are of over-exploited category.

Keyword: Sirsa, Groundwater Quality, Tube well Ground water levels

Introduction

Water is needed to ensure food security, feed livestock, to conserve the biodiversity and environment, and take up industrial production. Increasing human population, over-exploitation of water resource, underground brackish water, inadequate supply of canal irrigation water and recurring aridity are major factors of acute water shortage. The ever-increasing difference between water availability and consumption is causing severe shortage of water in many fields. There is a growing concern all over the world but India is the most vulnerable because of the growing demand for rising population. Freshwater is the single most precious element for life on the earth. It is essential for satisfying basic human needs, health, food, energy and maintenance of regional and global ecosystems.

Although 70 per cent (%) of the world's surface is covered by water, only a fraction of that 2.5 % is fresh water. Out of the total fresh water, 68.7% is frozen in ice caps, 30% is stored underground and only 0.3% water is available on the surface of the earth (Anonymous, 2006). This leaves only less than 1 % of the world's freshwater resources accessible for human use. The available water is generally used for agriculture, industry and domestic purposes and is also needed for fishery production, hydro-power generation, transportation and maintaining biodiversity and ecological balance. The proportion of water used for agriculture and industries varies from country to country depending on the lifestyle, extent of industrial development and water use efficiency. The current water use in the world for various purposes i.e. agriculture (69%), industry (23%) and for domestic purpose (8%), whereas in the developing countries like India and Africa, alone water use for agriculture (80-90%), industrial (5-12%) and for domestic purpose (5-7%). This is reflecting on inefficient use of water in agriculture and poor investments in industrial development (Hedge, 2012). It may also be noted that the per capita water use in India will increase from the current level of 99 litres per day to 167 litres per day in 2050. The per capita water availability in the year 1951and 2001 was 5177 and 1820 m^3 per year when the total population was 361 million and 1027 million respectively, while the per capita water availability will further drop down to 1341 m^3 to 1140 m^3 in the year 2025 to 2050, respectively.

Canal irrigation is the second largest source of the irrigation in the country after tube well irrigation. The land area under irrigation has expanded from 22.6 m ha in 1950 to 87.3 m ha in 2006, with 52% area being irrigated by surface water through canal network. Unfortunately, the overall efficiency of canal irrigation system worldwide is very low which leads to poor utilization of irrigation potential. International Institute for Reclamation and Improvement (ILRI), Netherland reviewed the conveyance losses in irrigation supply schemes of different countries of the world and reported maximum conveyance loss of 60% in India and minimum in Philippines (13%).

The canal irrigation efficiency in India is only 30–35% (Sanmuganathan and Bolton, 1988). About 71% of the irrigation water is lost in the whole process of its conveyance from head works to application in the field. The breakup of the losses is main and branch canal (15%), distributaries (7%), water courses (22%) and field losses (27%) (Navalwala, 1991). Therefore, we need to reduce the gap between potential and actual irrigated areas and save water for irrigating new areas by increasing irrigation efficiency of existing projects or reservoir or by constructing small water storage structure in the farmer‘s farm.

The Ghaggar, an important seasonal river in the district is a major drainage of the area. It enters the district near village Ranga (Block- Baragudha) and flows through the central part of the district (covering Sirsa, Rania, Ellenabad and part of Baragudha blocks) in south westerly direction but about 1.5 km downstream of Ottu Weir (renamed as Ch. Devi Lal Weir), it takes a sharp turn towards west and flows in the westerly direction. The river leaves the district a little to the south west of village Kariwali (block- Ellenabad) and enters Rajasthan & finally lost in the arid belt (thar desert) of Rajasthan. The river is dammed at Ottu from where two prominent canals namely northern ghaggar and southern ghaggar takes off. The river sometimes gets flooded during monsoon and causes extensive damage to crops and property. The total length of river ghaggar in the district is about 85 km. Besides, the area is also drained by the artificial drains, which are used during heavy rains by pumpage to the canals. In water-logged area, these artificial drains have also been proposed to combat with the water logging problems in the area.

In this study, we mainly focussed on the ground water study and its potential in the Sirsa district Haryana.

Material and Methods

Description of the study site

Sirsa, the north western most district of Haryana State with a total geographical area of 4277 sq. km is located between the latitudes of $29^0$13'N and $29^0$59'N and longitudes of $74^0$30'E and $75^0$7'E at an average elevation of 204 m above the mean sea level. Sirsa district was carved out of the Hisar district in 1975.

The Sirsa district is divided into seven administrative blocks i.e. Dabwali, Baragudha, Ellenabad, Rania, Sirsa, Odhan and NathusariChopta. The climate of Sirsa district can be classified as tropical desert, arid and hot which is mainly dry with very hot summer and cold winter except during monsoon season when moist air of oceanic origin penetrates into the district. The mean annual temperature is 25 ^{0}C. May and June are the hottest months with 30 years normal maximum temperature of 41-46 ^{0}C. January is the coldest month with a mean daily maximum temperature of 21 ^{0}C and a minimum 5 ^{0}C.

The mean annual rainfall is 300-350 mm out of which 80 % is received during monsoon months from July to September. Frost occurs occasionally during month of December and January. The average relative humidity is varied from 34.1 to 97.9 % and average wind speed is 0.45 to 3.96 m s^{-1}. The mean annual rainfall is 300-350 mm of which as much as 80 percent is received during monsoon months of July to September. Frost occurs occasionally during month of December-January. The average relative humidity is 34.1 to 97.9 % and average wind speed is 0.45 to 3.96 m s^{-1}. The study areas is shown in shown in Fig. 1

As per 2011 census the total population of the district is 1295114. Out of total population 683242 are males and 611872 are females. In Sirsa district rural population is settled in 321 villages and the rest of population is concentrated in five towns.There is no scheduled tribe population in the district, as no part of the district is under tribal area.

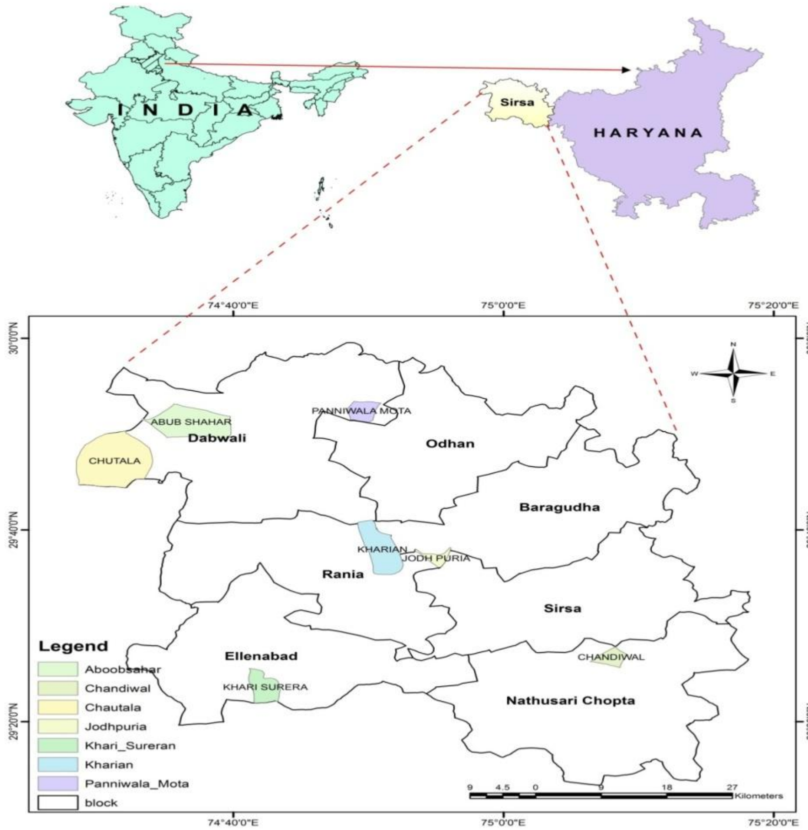


Fig. 1 Location map of the study areas of Sirsa district, Haryana

Methodology

The groundwater potential and quality data was collected from the Department of Central Ground Water Board, Faridabad. Data has been collected of groundwater potential i.e. net annual groundwater availability, existing gross ground water draft for irrigation, net groundwater availability for future irrigation development, groundwater level in different observation wells, monthly ground water table data depth in last one decade and groundwater quality i.e. pH, EC, etc.

Location: In the Sirsa district of jhajjar basin 11 exploratory boreholes down to a maximum depth of 306.71m were drilled to determine the aquifer parameters.

The transmissivity: Transmissivity is the rate of flow under a unit hydraulic gradient through a unit width of aquifer of given saturated thickness. The transmissivity of an aquifer is related to its hydraulic conductivity as follows:

T=Kb

Where T is transmissivity [L2/T] and b is aquifer thickness [L].

Hydraulic conductivity is a measure of a material's capacity to transmit water. It is defined as a constant of proportionality relating the specific discharge of a porous medium under a unit hydraulic gradient in Darcy's law:

ν=−Ki

Where ν is specific discharge [L/T], K is hydraulic conductivity [L/T] and i is hydraulic gradient [dimensionless]. Coefficient of permeability is another term for hydraulic conductivity.

Storability: The storability of a confined aquifer (or aquitard) is defined as the volume of water released from storage per unit surface area of the aquifer or aquitard per unit decline in hydraulic head. Storability is also known by the terms coefficient of storage and storage coefficient.

Pumping a well in a confined aquifer releases water from aquifer storage by two mechanisms: compression of the aquifer and expansion of water.

In a confined aquifer (or aquitard), storability is defined as

S=Ssb

Where S is storability [dimensionless], Ss is specific storage [L-1] and b is aquifer (or aquitard) thickness [L].

The typical storability of a confined aquifer, which varies with specific storage and aquifer thickness, ranges from 5×10-5 to 5×10-3 (Todd 1980). Storability in unconfined aquifers typically ranges from 0.1 to 0.3 (Lohman 1972).

Specific storage is the volume of water that a unit volume of aquifer (or aquitard) releases from storage under a unit decline in head. Specific storage is related to the compressibility of water and the aquifer (or aquitard) as follows:

$Ss=\rho g(\alpha+ne\beta)$

Where ρ is mass density of water [M/L3], g is gravitational acceleration (= 9.8 m/sec2) [L/T2], α is aquifer (or aquitard) compressibility [T2L/M], ne is effective porosity [dimensionless], and β is compressibility of water (= 4.4×10-10 m sec2/kg or Pa-1) [T2L/M].

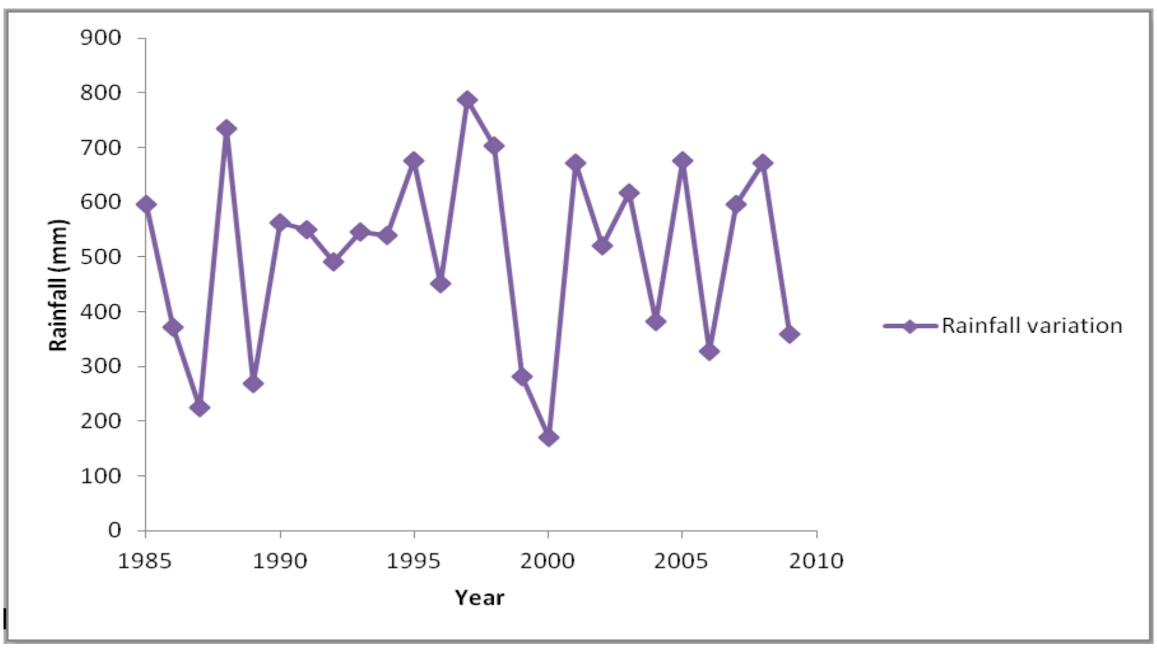
Result and Discussion

Climate and Rainfall

The climate of the area is characterised by its dryness, extremes of temperature and scanty rainfall. The mean daily maximum temperature during May and June, which is the hottest period, varies from 41 to 46 ^{0}C. On individual days, during the hot period, it may rise up to about 49 ^{0}C. Hot winds, with low relative humidity, often causes dust storms during the hot season. January is generally the coldest month with a mean daily maximum temperature of 21^{0}C and a minimum 5 ^{0}C. During the months of December and January, occasional fogs reside in the area. An agricultural year may be divided into four distinct seasons: the hot dry season from March to June, hot rainy (monsoon) season from July to September, post- monsoon season from October to November and cold season from December to February. The reference evapotranspiration in SIC is 4 to 5 times as large as the amount of rainfall. On an average SIC receives 300-550 mm of rainfall. This amount is not only insufficient but ishighly erratic both in quantity and distribution. Successful crop production without supplemental irrigation is hardly possible even in the rainy season. About 80 % of the annual normal rainfall occurs during the monsoon months of July to September. On an average, thearea has 20 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year. Sometimes a large amount of the total rainfall is sometimes received in a few heavy storms, causing temporary ponding of fields of crops, particularly in the low lying areas. In the past, when farmers used to rely mainly on rainfall, it was a common practice to store and conserve as much of the rainfall as possible. However, with the development and operation of the canal irrigation system, the practice of in situ conservation of rain water receives less and less attention. The meteorological data, including minimum and maximum temperature, relative humidity, vapour pressure in the morning and evening, sunshine hours, wind speed and rainfall were collected from a meteorological station installed at ICAR-Cotton Research Institute in Sirsa (Dam and Malik, 2003).

Rainfall pattern

The area receives the mean annual rainfall 300-350 mm. of which as much as 80% is received during monsoon months of July to September. During winter the probability (at 75% chance) of getting rain is 282 mm, which is lesser than mean annual rainfall. Past 15 years data shows that there is a probability of drought occurrence in once in every two years. The recurrence interval at 50%, 75% and 90% chance of occurrence of normal rainfall. The conclusion shows the probability of getting average annual rainfall (300- 350 mm) is at 50% chance. Probability (P) and Recurrence Interval (RI) of annual one-day maximum runoff series based on 15 years of data (N).(Dam and Malik, 2003). Rainfall occurrence from years 1985 to 2010 is shown in Fig. 2



Groundwater

The geological formations are unconsolidated alluvial deposits of Quaternary age. The alluvial deposits comprises of sand, silt, clay associated with kankar. Fine to medium grained sand horizon forms the potential aquifer in the area. The major source of recharge to ground water in the area is inflow of ground water from north eastern and northern parts, rainfall, seepage from canals, return seepage through irrigation and percolation from surface water bodies. The area has both unconfined and confined aquifers. In general the unconfined aquifers occur down to 60 m depth below ground level in the district. The alluvium acts as ground water reservoir and principal aquifer material comprises fine to medium sand and sand mixed with kankar (Khanet. al, 2006). This aquifer is either in the form of isolated lenses of sand embedded in clay beds or well-connected granular zones that have a pinching and swelling disposition and are quite extensive in nature.

The ground water in unconfined condition is abstracted through hand pumps and shallow tube wells where as in deep and confined aquifer through medium and deep tube wells (Todd, 1959). The thickness of the alluvium deposit varies from 200 to 300 m. The thickness of alluvial formation increases towards northwest. Perusal of the data of the exploratory tube well drilled in Ghaggar Basin indicate that tube wells tapping water bearing zone with in 100 to 200 m depth yield 1500 lpm to 3000 lpm for draw down of 5 to 17 m. Aquifer parameters viztransmissivity (T), storability (S), hydraulic conductivity (K) and yield (discharge) of the test well have been determined on the basis of Aquifer Performance Test (APT) conducted on exploratory wells. In the area, 11 exploratory boreholes down to a maximum depth of 306.71m were drilled to determine the aquifer parameters. The yield (discharge) of the test well ranges from 120 lpm to 3000 lpm with a drawdown of 3.66m to 17.47m. The transmissivity value of the aquifers ranged from 327 m2/day to 2600 m2/day. The hydraulic conductivity ranged from 5.83m to 83 m/day. The value of the storage coefficient worked out to be between 0.638x10-3 and 27x10-3. Shallow tube wells constructed in the district have discharge range between 300 and 1000 lpm with a drawdown of 1.0 to 3.5m. Whereas, perusal of data of deeper tube well/ bore wells constructed in Ghaggar basin tapping water bearing zone in depth range 100m to 260m yield 1500 to 3000 lpm with 5 to 17 m of draw down. Hence it can be said that tube wells constructed in vicinity of Ghaggar river has enormous groundwater potential (Srivastava and Poonia 2010; Shrivastava et.al. 2013; Lapworth et al 2014).

Groundwater quality - Groundwater quality is a major issue in the utilization of groundwater in the area. Keeping in mind the potential salinity hazard of irrigation water, the groundwater has

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been classified into three broad categories: good (ECgw< 2 dS m-1), marginal (ECgw 2-6 dS m-1) and poor (ECgw> 6 dS m-1), where ECgw is the electrical conductivity of groundwater. Sometimes, the marginal quality groundwater is further referred to as sub marginal (ECgw 2-4 dS m-1) or marginal (ECgw 4-6 dS m-1) quality water. The groundwater quality on both sides of the Ghaggar River was generally good, resulting in the installation of numerous tube wells in the belt along the river. The deep groundwater quality in the northern and extreme southern part of the SIC was quite poor (Furlong et al, 2011). However, over the years a relatively better quality water layer has developed over the saline groundwater. This prompted farmers in these areas to install shallow tube wells. Generally speaking, the shallow groundwater has a better quality than the deep groundwater. The shallow groundwater quality was good in about 28 %, marginal in 64 % and poor in 8 % of the Sirsa district(HSMITC,2001),. On the other hand deep groundwater quality was good in 20 %, marginal in 16 % and poor in 64 % of the area. In some cases, high residual sodium carbonate (RSC > 2.5 meq/l) is also observed in the groundwater. Use of this water requires the application of gypsum to prevent sodification of fine-textured soils.

Fig. 3 Mapping of Ground water in Sirsa

Groundwater depths - Over the years, major portion of the Sirsa district has experienced rise in groundwater levels. The average groundwater level in the Sirsa district has risen from 18 m below the ground surface in 1974 to about 10 m in June 2000. However, certain areas, particularly along the river Ghaggar have experienced a declining trend in the groundwater levels (Boels et. al, 1996). In general, the rising trend in groundwater levels was observed in the areas underlain with the poor to marginal quality groundwater and the declining trend in the areas underlain with good quality groundwater. The rising groundwater levels are mainly caused by lack of extraction of groundwater with marginal quality, seepage from the canal irrigation system, occasional heavy rainfall events and insufficient natural drainage. The declining groundwater levels are mainly due to over exploitation of good quality groundwater for the wheat-rice crop rotation. The long term groundwater level trend shows that the average rate of groundwater rise slows down. Between 1974 and 1984 the average rise in Sirsa district amounted 0.63 m y-1, while between 1990 and 2000 the average rise amounted 0.09 m y-1 only. In June 2000, prior to the monsoon period, the groundwater levels in Sirsa district ranged from less than 3 to more than 25 m below soil surface (Fig.4).

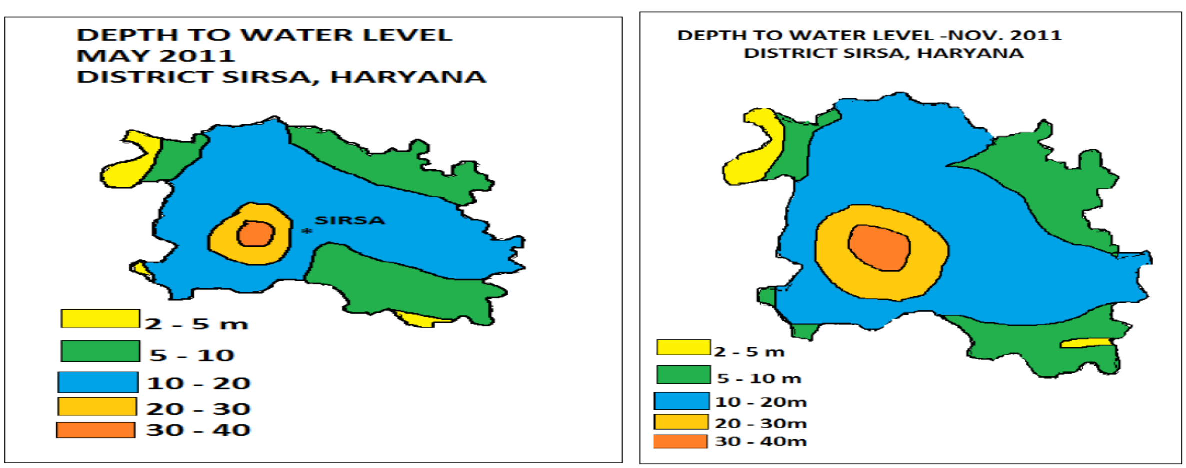

Fig. 4 Water level in Sirsa

Ground water resources - The blockwise ground water resource potential in the district has been assessed as per GEC-97in year 2009. Out of seven blocks five blocks namely Rania, Sirsa, NsChopta, Dabwali and Ellenabad are over exploited. Baragugha block is Critical and Odhan block is Semi-Critical as per resource assessment year 2009.The stage of ground water development ranges between 98% (Baragudha) to 256% (Raina) in the district. The net ground water availability in the district is 754.52 MCM. The net ground water draft is 1164.10 MCM. District shows an overall 154% ground water development.

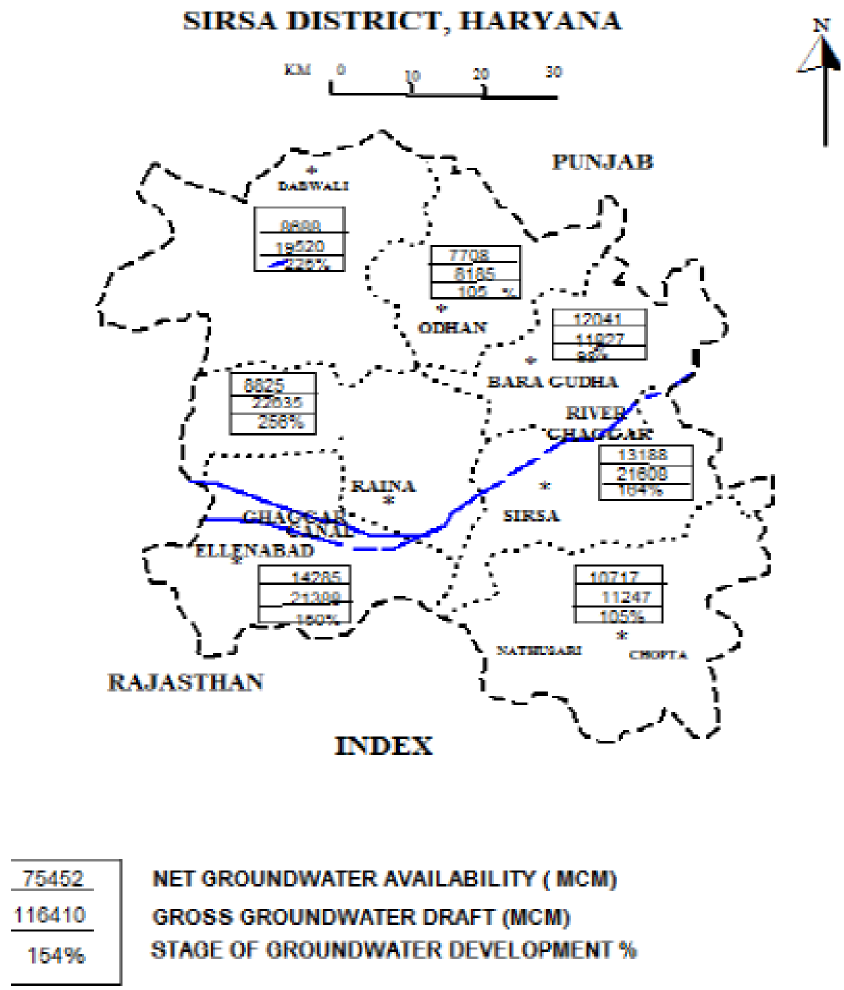

Fig. 5 Groundwater development potential and categorisation of blocks in District Sirsa

Groundwater use - Groundwater use is implemented in two ways. The State Government operates deep direct irrigation and augmentation tubewells and farmers operate shallow tubewells. The augmentation tubewells supply water to canals. A major portion of groundwater use takes place through farmers owned shallow tubewells (CGWB 2013). The number of tubewells increased from 8,217 in the year 1976 to about 32,000 in the year 2000. This shows the farmers interest to use groundwater for irrigation. However, the increase in the intensity of tubewells is mainly concentrated in the regions where groundwater is of relatively better quality. The number of tubewells per km2 varies from as low as 2 in the Dabwali block to 5-10 in the Sirsa, Rania,Baragudha and Elenabad block.

Table 1. GROUND WATER RESOURCES OF SIRSA DISTRICT, HARYANA

Assessment Unit/Block	Net Annual Ground water Availability (Ham)	Existing Gross Ground water Draft for Irrigation (Ham)	Existing Gross GW Draft for Domestic &Industrial water supply (Ham)	Existing Gross Ground water Draft for all uses (Ham)	Allocation Domestic industrial uptonext 25years (Ham)	Net GW availability for future irrigation development (Ham)	Stage of Ground water Development	Category of the Block
Baragudha	12041	11761	66	11827	79	201	98	Critical
Dabwali	8088	19478	42	19520	42	-10832	225	OE
Ellenabad	14285	21233	155	21388	155	-7103	150	OE
NSChopta	10717	11191	56	11247	56	-530	105	OE
Odhan	7708	8145	40	8185	40	-477	106	Semi-Critical
Rania	8825	22498	137	22635	137	-13810	256	OE
Sirsa	13188	21328	280	21608	280	-8420	164	OE
Total	75452	115634	776	116410	789	-40971	154	OE

In India, groundwater development is classified into three categories (white, grey and dark) depending on the extent of groundwater exploitation. In category white the level of exploitation is below 65% of the annual utilizable groundwater potential. In category grey this precentage ranges from 65% to 85%. In category dark the percentage of exploitation exceeds 85%. In Sirsa district, the level of groundwater exploitation varies from about 14 % in the Dabwali block to more than 154 % in the Ellenabad block. Accordingly to the level of groundwater exploitation, the Ellenabad block belongs to the ‘dark’ category and needs either to decrease the groundwater pumping or increase the groundwater recharge. The Rania block belongs to the ‘grey’ category. On the other hand, all the other blocks (Dabwali, NathusariChopta, Baragudha, Odhan and Sirsa) belong to the ‘white’ category. These blocks require more attention to arrest the rising groundwater levels.

Conclusion

The intensive study on the ground water and its potential in Sirsa district Haryana suggested that the level of water table is quite below in the district and the nature of fresh water is not so good. In most of the studied places, the quality of water was minimal standard. Study also concludes that the exploitation of water is quite high and most of the area had more than 65% of exploitation. The recommendation after study is that artificial recharge to ground water should be taken up in the urban and rural area to avert the further lowering of ground water level since natural recharge to the aquifer system is not adequate to support such ground water withdrawal. A detailed geophysical study is required for the delineation of phreatic aquifers in the district. Effective water management and selecting most suitable cost effective crop pattern suitable for irrigation including salt tolerant crops. The modern methods of irrigation like sprinkler, drip irrigation and other microirrigation methods should be used. The peoples of Sirsa district to be educated regarding consequences of heavy withdrawal of ground water and need for its effective and economic use. The ground water exploration should be taken in flood plains ofriver Ghaggar. Micro level ground water regulation and protection studied may be carried out for overcome the pollutant like fluoride in groundwater.

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