Ground Water Characteristics of Kurukshetra District: A Review

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Abstract—*Ground Water is an essential and vital component of our life support system. The ground water resources are being utilized for irrigation, drinking and industrial purposes. Now there is growing concern on deterioration of ground water quality due to geogenic and anthropogenic activities. The quality of ground water has undergone a change to an extent that the use of such water could be hazardous. Increase in overall salinity of the ground water and presence of high concentrations of fluoride, nitrate, iron, arsenic, total hardness and few toxic metal ions have been noticed in large areas in several states of India. The contamination of ground water by heavy metals and pesticides has also assumed great significance during recent years due to their toxicity and accumulative behavior. A vast majority of groundwater quality problems present today are caused by contamination and by over-exploitation, or by combination of both. Elevated levels of total dissolved solids (salinity), nitrogen, and pesticides in ground water have been reported from arid areas under irrigation in Haryana. In this paper an attempt has been made to analyze the present scenario of ground water quality of Kurukshetra District. In Haryana Ground water contributes 95 % of the total need for agriculture. The stage of ground water development for the district is more than 166% and all its 5 blocks fall in over-exploited categories. That means that the ground water is under stress and the ground water level is declining. During the last 24 years the ground water level has declined in whole district and the decline is in the range of 7.5m to 20.64m. The depletion of levels and worsening of groundwater quality in general, can be attributed to over-exploitation of groundwater and excessive use of agrochemicals in addition to natural factors. Based on the analysis and data available from the Central Ground Water Board, the present study presents the possible negative impacts of deteriorating Ground Water Quality and its possible controlling measures. All the data available has been compared with Indian standards and WHO guidelines for drinking water.*

Keywords*: Ground Water Quality; Ground Water Control Board; Electrical Conductivity; Irrigation and Drinking water.*

1. INTRODUCTION

The quality of ground water is of great importance in determining the suitability of particular ground water for a certain use (public water supply, irrigation, industrial applications, power generation etc.). The quality of ground water is the resultant of all the processes and reactions that have acted on the water from the moment it condensed the atmosphere to the time it is discharged by a well. Therefore, the quality of ground water varies from place to place, with the depth of water table, and from season to season and is primarily governed by the extent and composition of dissolved solids present in it. A vast majority of ground water quality problems are caused by contamination, over-exploitation, or combination of the two. Most ground water quality problems are difficult to detect and hard to resolve. The solutions are usually very expensive, time consuming and not always effective. Ground water quality is slowly but surely declining everywhere. Ground water pollution is intrinsically difficult to detect, since problem may well be concealed below the surface and monitoring is costly, time consuming and somewhat hit-or-miss by nature. The wide range of contamination sources is one of the many factors contributing to the complexity of groundwater assessment. It is important to know the geochemistry of the chemical-soil-groundwater interactions in order to assess the fate and impact of pollutant discharged on to the ground.

Kurukshetra district falls in the north-east part of the Haryana State and is bounded by North latitudes 29053’00” and 30015’02” and East longitudes 76026’27” and 77007’57”. It falls in parts of Survey of India Toposheets nos. 53B and 53C covering an area of 1530 sq.km. The district covers 3.46% area of the State. The district is bordered by Karnal district in the south, Kaithal district in thesouth and south-west, Ambala in the north and Patiala in the north-west. The main townships are Kurukshetra, Shahabad, Babain, Ladwa and Pehowa. The towns are well connected by roads. Administratively the district comes under Ambala division and it has three tehsils, three sub-tehsils and five blocks. The tehsils are Thanesar, Pehowa and Shahabad and the blocks are Ladwa, Pehowa, Shahabad, Thanesar and Babain. The district is one of the most densely populated districts of the state. The total population of the district as per 2001 census is 825454. The population density is 540 persons per sq.km against the state average of 478 persons per sq.km. The eastern parts of the district falls in the Upper Jamuna Basin and western parts falls in Ghaggar basin. The river Markhanda provides the major drainage in the area. Irrigation in the district is done by surface water as well as ground water.

2. GEOMORPHOLOGY & SOIL TYPES

The area represents almost flat alluvial plain without any conspicuous topographical features. It forms a part of the vast Indo-Gangetic alluvial plains. The average elevation of the plain varies from 274 to 241 m above mean sea level. The general slope of the land is from north-east to south-west wards. The district falls in two basins i.e Upper-Ghaggar Basin and the Upper Yamuna Basin. A small portion in south-east part of the district falls in Upper Yamuna basin and the rest of the area falls in Upper Ghaggar basin. The district is devoid of any perennial river. The only river Markhanda flows in the north-western part of the district which originates in Nahan hills. Chautang, Khand and Omla nalas of local existence also drain the district. The entire district of Kurukshetra is covered by tropical arid brown soils. These soils are very pale brown in colour. They do not have well definedhorizons. In general these soils are deep and imperfectly drained. Thepermeability of these soils is low to moderate. These soils are mildly alkaline to strongly alkaline in reaction. The available moisture holding capacity of these soils is medium to high. These soils are medium to high in organic matter. Three soil types viz. sandy loam, loam and clay loam are commonly met within this group.

3. GROUND WATER SCENARIO

3.1 Hydrogeology

The area falls in the Upper Jamuna and Ghaggar Basins and the principal ground water reservoir in the area is unconsolidated alluvial deposits of Quaternary age. Ground water in near surface zone occurs under water table conditions and occurs under semi confined to confined conditions in deeper aquifers. Rainfall and seepage, canal networks and irrigation is the principal source of ground water recharge in the area.

Depth to water level (2006) in the district during pre-monsoon ranges between 15.66m bgl to 31.35 m bgl.The depth to water level is deeper in the north and central parts and shallow in south and south-western parts. The depth to water level during post monsoon ranges between 17.1m bgl to 34.72m bgl. The seasonal fluctuation varies between –4.32m to 0.21m. The water table elevation in the district varies between 242.75m and 220.03m above mean sea level. The elevation is higher in eastern parts of the district in Ladwa block and gradually decreases towards west in Pehowa block. In general the ground water flow direction is from east to west. The long term trend for 24 years shows that the water level is declining in the district at a rate between 0.98 to 1.16m/year.

3.2 Ground Water Resources

Ground Water Resources estimation of the district was done in 2004 for each individual block. Perusal of the Estimates reveals overall stage of ground water development in the district is of the order of 166%. The ground water development in all the blocks of the district has exceeded the available recharge and thus all the blocks have been categorized as over exploited. Ladwa and Pehowa blocks are showing 208 % and 180 % respectively. Shahabad block has least development of ground water among all blocks i.e. 118%. Net annual ground water availability of the district is 40439 ham and existing gross groundwater draft for all users is 66974 ham.

The block wise ground water resource potential in the district are as follows:-

Block	Net annual ground water availability	Existing gross water draft for irrigation	Existing gross ground water draft for domestic and industrial water supply	Existing gross ground water draft for all users	Allocation for domestic and industrial requiremen t supply up to next 25 years	Net ground water availability for future irrigation development	Stage of ground water development	Category of block
Babain	3411	5709	304	6013	294	-2592	176%	Over exploited
Ladwa	3981	8000	286	8286	284	-4303	208%	Over exploited
Pehowa	12959	22683	633	23316	888	-10612	180%	Over exploited
Shahbad	8692	9587	707	10293	662	-1556	118%	Over exploited
Thaneswar	11395	18217	849	19066	820	-7643	167%	Over exploited
Total	40439	64196	2778	66974	2949	-26706	166%	

Ground Water Quality (Irrigation and Drinking point of view)

Chemical data of ground water from shallow aquifer indicates that ground water is alkaline in nature (pH 7.05- 8.19) and is fresh to moderately saline. Generally it is suitable for drinking purposes except at eight locations where either fluoride or nitrate or heavy metal (Iron, lead and zinc) are beyond the permissible limits for safe drinking waters set by BIS 1991 &revised in 2007. These places are Dhurala (F=1.78 mg/l), Bodhni (F=1.94 mg/l), Ishaq (F=2.06mg/l & Fe=2.86 mg/l), Salpanikalan ($N0_2$=74 mg/l & Lead =0.20 mg/l), Jhansa ($N0_3$=105 mg/l, Hardness as $CaC0_3$=623 mg/l & Zn=15.38 mg/l), Yara (Fe=1.97 mg/l), Tatka (Fe=1.45 mg/l) and Mathana (Fe=1.68 mg/l). Among anions, bicarbonate is the dominant anion and among cations, either calcium or calcium and magnesium are dominant cations at most of places .The suitability of ground water for irrigational purposes is generally ascertained by considering salinity (EC), Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC). These parameters range from 395 to 1756 micromhos/cm. At 250C, 0.21 to 6.23 and –9.16 to 5.86 mill equivalentsrespectively. These water will neither cause salinity hazards nor sodium hazards when used for customary irrigation. Thus it can be concluded that ground water of the district is suitable for irrigation on well drained soils.

Hazardous pollutants of concern, their permissible limits and remedy methods:-

I. Electrical Conductivity (salinity)

II. Chloride

III. Fluoride (>1.5 mg/litre)

IV. Iron (>1.0 mg/litre)

V. Arsenic (>0.05 mg/litre)

VI. Nitrate (>45 mg/litre)

1 Electrical conductivity (salinity)

Salinity is the saltiness or dissolved salt contents of a water body.Salinity always exists in ground water but in variable amounts. It is mostly influenced by aquifer material, solubility of minerals, duration of contact and factors such as the permeability of soil, drainage facilities, quantity of rainfall and above all, the climate of the area. BIS has recommended a drinking water standard for total dissolved solids a limit of 500mg/l (corresponding to about EC of 750 µS/cm at 250C) that can be extended to a TDS of 2000mg/l (corresponding to about 3000 µS/cm at 250C) in case of no alternate source. Water having TDS more than 2000 mg/litre are not suitable for drinking uses. The gradual rise of ground water levels with time has resulted in water logging and heavy evaporation in semi-arid regions lead to salinity problem in command areas. Salinity level in the district is more than permissible in ladwa ,pehowa and shahbad area rendering ground water unfit for use(CGWB,2006).

2 Chloride

Chloride is present in all natural waters, mostly at low concentrations. It is highly soluble in water and moves freely with water through soil and rock. In ground water the chloride content is mostly below 250 mg/l except in cases where inland salinity is prevalent and in coastal areas.BIS (Bureau of Indian Standard) have recommended a desirable limit of 250 mg /l of chloride in drinking water; this concentration limit can be extended to 1000 mg/l of chloride in case no alternative source of water with desirable concentration is available. However ground water having concentration of chloride more than 1000 mg /l are not suitable for drinking purposes.Chloride content of Kurukshetra district is within permissible limits only in some villages , most of the district has excess chloride content.

3 Fluoride

Fluorine is a fairly common element but it does not occur in the elemental state in nature because of its high reactivity. Fluorine is the most electronegative and reactive of all elements that occur naturally within many type of rock. It exists in the form of fluorides in a number of minerals of which fluorspar, cryolite, fluorite and fluorapatite are the most common. Fluorite (CaF_2) is a common fluoride mineral. Most of the fluoride found in groundwater is naturally occurring from the breakdown of rocks and soils or weathering and deposition of atmospheric particles. Most of the fluorides are sparingly soluble and are present in ground water in small amounts. The occurrence of fluoride in natural water is affected by the type of rocks, climatic conditions, nature of hydrogeological strata and time of contact between rock and the circulating ground water. Presence of other ions, particularly bicarbonate and calcium ions also affects the concentration of fluoride in ground water.It is well known that small amounts of fluoride (less than 1.0 mg/l)have proven to be beneficial in reducing tooth decay.However, high concentrations such as 1.5 mg/l of F and above have resulted in staining of tooth enamel while at still higher levels of fluoride ranging between 5.0 and 10 mg/l, further pathological changes such as stiffness of the back and difficulty in performing natural movements may take place. BIS has recommended an upper desirable limit of 1.0 mg/l of Fas desirable concentration of fluoride in drinking water, which can be extended to 1.5 mg/l of F in case no alternative source of water is available. Water having fluoride concentration of more than 1.5 mg/l are not suitable for drinking purposes. In Haryana 11 no. of districts are affected from excessive fluoride content which are Rewari, Faridabad, Karnal, Sonipat, Jind, Gurgaon, Mohindergarh, Rohtak, Kurukshetra, Kaithal, and Bhiwani. Kurukshetra district is not worse affected but amount of fluoride is in excess in areas in proximity to Yamunanagar district.

Some of the options available for removal of fluoride from drinking water are:

1. Adsorption(Activated Alumina)

2. Ion Exchange

3. Nalgonda Technique

4. Membrane (Reverse Osmosis)

5.Electro dialysis

4 Iron

Iron is a common constituent in soil and ground water. It is present in water either as soluble ferrous iron or the insoluble ferric iron.. The concentration of iron in natural water is controlled by both physico chemical and microbiological factors. In aqueous solution iron is subject to hydrolysis and iron hydroxides are formed during these reactions, especially the ferric form having very low solubility. The reaction of iron in aqueous solution is affected by redox potential and pH of the solution. In natural water, pH mostly ranges from 5 to 9 and as such is not low enough to prevent hydrolysis under oxidizing conditions. Practically all the iron is precipitated as hydroxides. This ferric hydroxide may exist in colloidal suspensions in the range of 5 to 8. Organic rich water particularly those with hemic acid, can contain dissolved iron over a large range of redox conditions. Organic compounds present in water consume dissolved oxygen which lowers the pH of water because of production of CO_2.The permissible Iron concentration in ground water is less than 1.0 mg/litre as per the BIS Standard for drinking water.In Haryana following districts havingexcess of iron in ground waterare Ambala, Bhiwani, Faridabad, Fatehabad, Gurgaon, Hissar, Jhajjar, Jind, Kaithal, Karnal, Kurukshetra, Mahendragarh, Panipat, Rohtak, Sirsa, Sonepat, Yamuna Nagar. Mostly all the sub-tehsils of Kurukshetra District are affected with excess of iron.

The remedial methods available for removing Iron from drinking water are-

i) Chemical Oxidation

ii) Aeration

iii) Ion exchange method

5 ARSENIC

Arsenic is a naturally occurring trace element found in rocks, soils and the water in contact with them. Arsenic has been recognized as a toxic element and is considered a human health hazard. As per the BIS Standard for drinking water, the maximum permissible limit of Arsenic concentration in ground water is 0.01 mg/l.Arsenic and its compounds are widely used in pigments, as insecticides and herbicides, as an alloy in metals and chemical warfare agents.Arsenic is a metalloid. The common valancy of arsenic in unpolluted ground water of geogenic origin are +III & +V as hydrolysis species. The dissociation constant of As (III) and As (V) acids are quite different .The fact that dominant dissolved species are either uncharged or negatively charged suggests that adsorption and ion exchange will cause little retardation as these species are transported along ground water flow path. Organic arsenic compounds such as methyl arsenic acid and dimethyl arsenic acid are not common in ground water. No region in district have critical arsenic levels.

The remedial options available for getting Arsenic free water are

1. Development of ground water from Arsenic free aquifers
2. Piped water supply from surface water sources.
3. Dilution of ground water with surface water.
4. Treatment of ground water for removal of arsenic using adsorption (Activated alumina /Granulated ferric hydrated oxide) or precipitation and coagulation technique.
5. Rain water harvesting.

6 NITRATE

Nitrate is a naturally occurring compound that is formed in the soil when nitrogen and oxygen combine. The primary source of all nitrates is atmospheric nitrogen gas. This is converted into organic nitrogen by some plants by a process called nitrogen fixation. Dissolved Nitrogen in the form of Nitrate is the most common contaminant of ground water. Nitrate in ground water generally originates from non-point sources such as leaching of chemical fertilizers & animal manure, ground water pollution from septic and sewage discharges etc. .

As per the BIS Standard for drinking water the maximum desirable limit of Nitrate concentration in ground water is 45 mg/l with no relaxation. Though Nitrate is considered relatively non-toxic, a high nitrate concentration in drinking water is an environmental health concern arising from increased risks of matheomoglobinemia particularly to infants. Adults can tolerate little higher concentrations. The specified limits are not to be exceeded in public water supply. Districts affected are Ambala, Bhiwani, Faridabad, Fatehabad, Gurgaon, Hissar, Jhajjar, Jind, Kaithal, Karnal, Kurukshetra, Mahendragarh, Panchkula, Panipat, Rewari, Rohtak, Sirsa, Sonepat, Yamuna Nagar.

The remedial methods available for removing Nitrate from drinking water are-

1. Reverse Osmosis
2. Ion Exchange
3. Bio remediation
4. Blending

Factors Affecting Ground Water Pollution:

The extent of ground water pollution depends on the following factors:

1. Rain Fall Pattern,
2. Depth of Water Table,
3. Distance from the Source of Contamination, and
4. Soil Properties such as Texture, Structure and Filtration Rate.

Source of Contamination in Ground Water: Underground sources of drinking water, especially in outskirts of larger cities and villages are highly polluted. Ground water is threatened with pollution from the following sources:

1. Domestic Wastes:

2. Industrial Wastes:

3. Agricultural Wastes:

4. Run off from Urban Areas:

5. Soluble Effluents

Harmful Effects on Men

a) Polluted ground water is the major cause for the spread of epidemics and chronic diseases in man. It causes typhoid, jaundice, dysentery, diarrhea, tuberculosis and hepatitis. b) Water contaminated by fibers i.e. asbestos causes fatal diseases like asbestosis and lung cancer.c) Ground water in excessive rainfall areas contain iron in toxic amounts as much as 20 mg/L. In deep tube wells, iron exists as ferrous ion which on taking out rapidly changes to light yellow orange colour due to oxidation and precipitation as ferric hydroxide. d) The woolen industries contribute large amounts of toxic metals such as Hg, Ni, Cu, Cr, Fe, and cyanides to ground water causing skin and stomach diseases in man.

Harmful Effects on Soil

a) The use of polluted ground water for irrigating agricultural fields severely damages crop and decreases grain production. b) Polluted water acutely affects soil fertility by killing bacteria and soil microorganisms. c) Contaminated ground water increases alkalinity in the soils. d) Ground water pollution affects plant metabolism severely and disturbs the whole ecosystem.

4. GROUND WATER RELATED ISSUES & PROBLEMS

In the district, the main issues of concern related to ground water is the depleting ground water resources which is being reflected through the declining ground water level. The analysis of long term water levels in the district shows the rate of decline of water level is in the range of 0.38m/yr. to 1.16m/yr. This water level decline is a reflection of over development of ground water in the district which is also revealed by the Resource Estimate in the district which brings out that all the blocks are over exploited.

5. GROUND WATER MANAGEMENT STRATEGY

The stage of ground water development for the district is 166% and all the five blocks fall in over-exploited categories. That means that the ground water is under stress and the ground water level is declining. There is no scope for further ground water development. Only measures should be taken to reduce on the dependence on ground water and to enhance the ground water resources.

Water Conservation & Artificial Recharge

There are 163 tanks /ponds in the Kurukshetra district which act both as water conservation and recharge structures. Their block wise distribution and recharge to ground water is as follows.-

Name of block	**No of tan k/p ond**	**Average water spread area(ha)**		**No of days water is available**		**Recharge in ha-m. During**	
		monso on	**Non monso on**	**monso on**	**Non monso on**	**monso on**	**Non monso on**
Ladwa	31	44.95	21	120	200	7.7636	6.048
Babain	14	44.95	21	120	200	7.7636	6.048
Shahbad	15	22.2	11	120	200	3.8361 6	3.168
Thanes war	49	69.6	30	120	200	12.026 8	8.64
Pehowa	54	78	38	120	200	13.478 4	10.944

The stage of ground water development for the district is 166% that means the net annual withdrawal is more than the net annual recharge. During the last 24 years the ground water level has declined in the whole district and the decline is in the range of 7.5m to 20.64m. So there is a need to take measures to arrest the decline of ground water level and artificial recharge to ground water is one of such measures. Whole of the district is suitable for artificial recharge to ground water. Excess rain water in agricultural field, surplus canal water and rooftop rain water can be injected to ground water system. Recharging shafts and injection wells are recharging structures suitable for the district.

6. CONCLUSIONS AND RECOMMENDATIONS

As ground water conditions are not satisfactory in the district, water level is depleting and quality is also deteriorating and not cheap options are available for pollution removal. But precautionary methods can help save ground water quality and natural and artificial recharge enhances its status. Central Ground Water Board has executed three artificial recharge to ground water schemes in the district. (i)On the Markhanda river bed at Shahabad two lateral trenches of 50m long with five injection wells were constructed to inject river flow. The depth of injection wells is around 30m. (ii) Two recharge shafts and two injection wells were constructed near Brahma Sarover, Kurukshetra to inject the pumped out water of the sarover. (iii) In the villages Kirmich and Samaspur six recharge shafts in each village were constructed to inject the water from the depressions.

1. The stage of ground water development for the district at present is 166% and all the blocks fall under over-exploited category which leads to constant decline of water level over last 24 years. So no further ground water development is recommended.
2. The contribution of surface water to irrigation in the district is very less. Measures should be made to increase the canal water supply for irrigation.
3. Change in cropping pattern is recommended to reduce the heavy pumping of ground water.
4. Ground water pumping from deep aquifers is recommended to reduce stress on the shallow aquifers.
5. Ground water pumping for supplies should be shifted to the active flood plains all along the river Markhanda.
6. The construction of roof top rainwater harvesting and artificial recharge to ground water structure.

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