Available online at www.ewijst.org

ISSN: 0975-7112 (Print)
ISSN: 0975-7120 (Online)

Environ. We Int. J. Sci. Tech. 6 (2011) 71-76

Environment & We
An International
Journal of Science
& Technology

Sub-Soil Water Quality Studies Using Remote Sensing and Geographical Information System

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Abstract

Water is one of the most precious natural resources and its suitability depends upon soil texture and composition, crop type and irrigation system in addition to the chemical composition of the irrigation water. Underground water constitutes the main source of irrigation in many parts of Haryana. As per the hydrogeomorphology map, there is no scarcity of ground water potential in the study area, but underground water was found to be saline or saline-sodic prohibiting its use for drinking purpose and limitation for irrigating the crops. Satellite data of IRS-IB and IRS-IC in combination with ground data on 1:50,000 scale was used to study the sub-soil water quality and its distribution in old Gurgaon district (Presently Gurgaon and Mewat districts). The ground water quality maps were prepared by taking physiographic units as a base and water samples were collected from the running tube wells and supplemented by local enquires from farmers. It was seen that water quality is saline in most of the southern region of the district i.e., between Nuh to Firozpur-Jhirka and Punhana. After analyzing the water samples, it was found that 54.97% of the geographical area comes under good quality and 30.42% falls under saline water. Other classes like marginal, sodic and saline-sodic cover 12.58, 0.86 and 1.17 percent of the geographical area of the district, respectively.

Key words: Hydrogeomorphology, physiography, satellite data, ground water, marginal, saline, sodic.

Introduction

Improving the primary productivity to meet the ever increasing demand of basic necessities such as food, fuel and fodder is one of the prime objectives of any development plan. This calls for optimum utilization of the available land and water resources, their conservation and effective management. This needs detailed information on land and water resources, and agriculture in the region for meticulous planning of strategies and effective implementation.

Water is one of the most precious natural resources of the earth and is of utmost importance in every facet of human life. Although, water is a more dynamic renewable natural resource, its availability with good quality and proper quantity is of significant

importance. Underground water constitutes the main source of irrigation in many parts of Haryana. Remote sensing technology has come up as the new tool for these natural resources mapping and their management. S. Asadi, P. Vuppala, and M. Anji Reddy, 2007 also prepared ground water quality maps and evaluated groundwater quality in Municipal Corporation of Hyderabad (Zone-V), India using remote sensing and GIS techniques. Nayak et. al. 1995 reported that the amount of work can drastically be reduced using satellite data comparatively in large area, since the sampling points are restricted to different physiographic units. As per the hydrogeomorphology map, there is no scarcity of ground water potential in the study area, but underground water was found to be saline or saline-sodic prohibiting its use for drinking purpose and limitation for irrigating the crops. Edzer J. Pebesma and J. W. de Kwaadsteniet ,1997 also studied ground water quality and prepared maps based on the soil type and landuse of the area. These maps can be considered as a translation of point information obtained from the monitoring networks into information on spatial units, the size of which is used in regional groundwater models. The maps enable location-specific network optimization.

Study area

The study area is old Gurgaon district and presently includes Gurgaon and Mewat districts. It was one of the southern districts of Haryana and lies between $27^0$39' to $28^0$32' N latitude and $76^0$39'to 77^0 20' E longitude. The total area of the district is 2760 sq.kms.

The district comprises of hills on the one hand and depressions on the other, forming irregular and diverse nature of topography. Two ridges (i) Firojpur jhirka - Delhi ridge forms the western boundary and (ii) Delhi ridge forms the eastern boundary of the district. These hills are northern continuation of Aravalli hills. The north-western part of the district is covered with sanddunes lying in the direction of westernly and south western winds. The extension of the Aravalli hills and the presence of sanddunes collectively form the diverse physiography of the district.

The drainage of the district is typical of Arid and Semi-arid areas. It comprises of large depressions and seasonal streams. The rain water collected in these depressions is best suited to rabi crops and their drying up, they are best available for kharif crops. Sahibi and Indrani are two important seasonal streams of the district, which originate from the Aravallis.

The district has sub-tropical, continental monsoon climate. The normal annual rain fall in the district is 553 mm. It is increased towards east. About 77 % of the annual rain fall in the district is received during the monsoon months - July to September. On an average, there are 28 rainy days in the district.

Temperature starts rising in March. The mean daily maximum temperature is about 41^o C in the months of May and June. It may go up to 45^o on an individual day. During the winter the mean daily maximum temperature in January is 21^o C and the minimum is 7^oC. The annual potential evapotranspiration is 1600 to 1650 mm of which

690 - 775 mm occurs in kharif and 475 to 550 mm in rabi season.

Materials and Method

Three seasons (Rabi, Kharif and Zaid) IRS-1B LISS-II and IRS-1C LISS-III, geo-coded FCC (spectral bands 2, 3 & 4) in combination with ground information and Survey of India Topographical Sheets viz. 53D/11, 53D/14, 53D/15, 53D/16, 54A/13, 54A/14, 53H/2, 53H/3, 53H/4, 54E/1, 54E/2, 54E/5 was used to study the sub-soil water quality and its distribution in the Gurgaon district.

The physiographic regions, which have been found to have a bearing on the water quality of the area, were delineated. A detailed ground water quality survey was also conducted. Ground water samples from operational tube wells representing different physiographic units were collected and boundaries on the maps were extrapolated locally based on physiographic units. The ground water quality maps were prepared by taking soil mapping units as a base and water samples were collected from the running tube wells and supplemented by local enquires from farmers. The analysis of water samples for various constituents was undertaken following the methods outlined by Richards (1954). The water quality was judged as per the criteria laid down by CCS, Haryana Agricultural University Hisar as shown in Table-1.

Table1Water quality classification criteria for irrigation in agriculture.

Quality class	Electrical Conductivity (dSm^{-1})	Sodium Adsorption Ratio $(mmole/l)^{½}$	Residual Sodium Carbonate (meL^{-1})
Good	<2	<10	Usually <2.5
Marginal	2-4	<10	<2.5
Saline	>4	<10	Absent
Sodic	<4	>10	<>2.5
Saline- Sodic	>4	>10	<>2.5

Results and Discussion

The collected water samples were classified into five different quality classes as shown in Table-2 after analyzing their chemical properties. The ground water quality map of the study area is shown in Fig.1.

Good

The good quality waters having Electrical Conductivity (E.C.) less than 2 dSm^{-1} Sodium Adsorption Ratio (SAR) less than 10 and Residual Sodium Carbonate (RSC) less than 2.5 are very less in the Gurgaon district. This quality of water is mostly found in pediment zone i.e. near the hills. It may be due to the reason that the soils are light

textured having very high percolation rate. So, during rainy season, recharging takes place due to light texture of soils. The another pocket of these waters was also observed around Around Gurgaon, Badshapur, Ghahalka, Faruknagar, Patodi, Taj Nagar, Mokalwas, Taoru, Jaurasi and Madarka villages. The areal extent of these waters is 1517.15 sq.km which is 54.97 percent of the total geographical area. The total area under various categories is shown in table 2

Table 2 Area under different water quality classes.

Category	Area in Sq. Km.	Percent Geographical area
Good	1,517.15	54.97
Marginal	347.24	12.58
Saline	839.54	30.42
Sodic	23.83	0.86
Saline-Sodic	32.28	1.17

Marginal

These are the waters having E.C. between 2- 4 dSm^{-1} and SAR less than 10. These waters are fit for irrigation in light texture soils. These are found mainly around Siwari, Karaula, Khor, Sherpur and Mahanli, Pathauri, Rawas and Ghaggar etc. and on western side of Ferozpur Jhirka. These waters cover an area of 347.24 sq. km in the Gurgaon district.

Saline

Groundwater salinisation is a major groundwater contamination issue and can be caused by different processes, such as seawater intrusion, agrochemical pollution, geogenic contamination and irrigation-induced salinisation (Ellen Milnes, 2011). This is the major class of water quality in the southern part of the district. This quality of water occurs in the intermontane basin formed by two series of Precambrian hills. The high salt contents in underground waters in this landscape can be attributed to mineralization of ground water, as it forms a closed basin with no output. The salts might have accumulated over a period of time. However, the possible extension of sea arm (Creek) in earlier times in this region can also not be ruled out. The sea water must have been trapped when the sea receded back. These waters occur near Waziarpur, Siwari, Karula, Nuh, Nagina Bhadas, Sikrawa, Punahana, Hathin, Pingawar, Gangwani, and Malab etc. These waters are unfit for irrigation due to high amount of salts. However, after sufficient dilution with canal waters, these waters can be used for irrigation purposes. The continuous use of these waters should be avoided. These waters cover an area of 839.54sq.km which is 30.42 percent of the geographical area of the district.

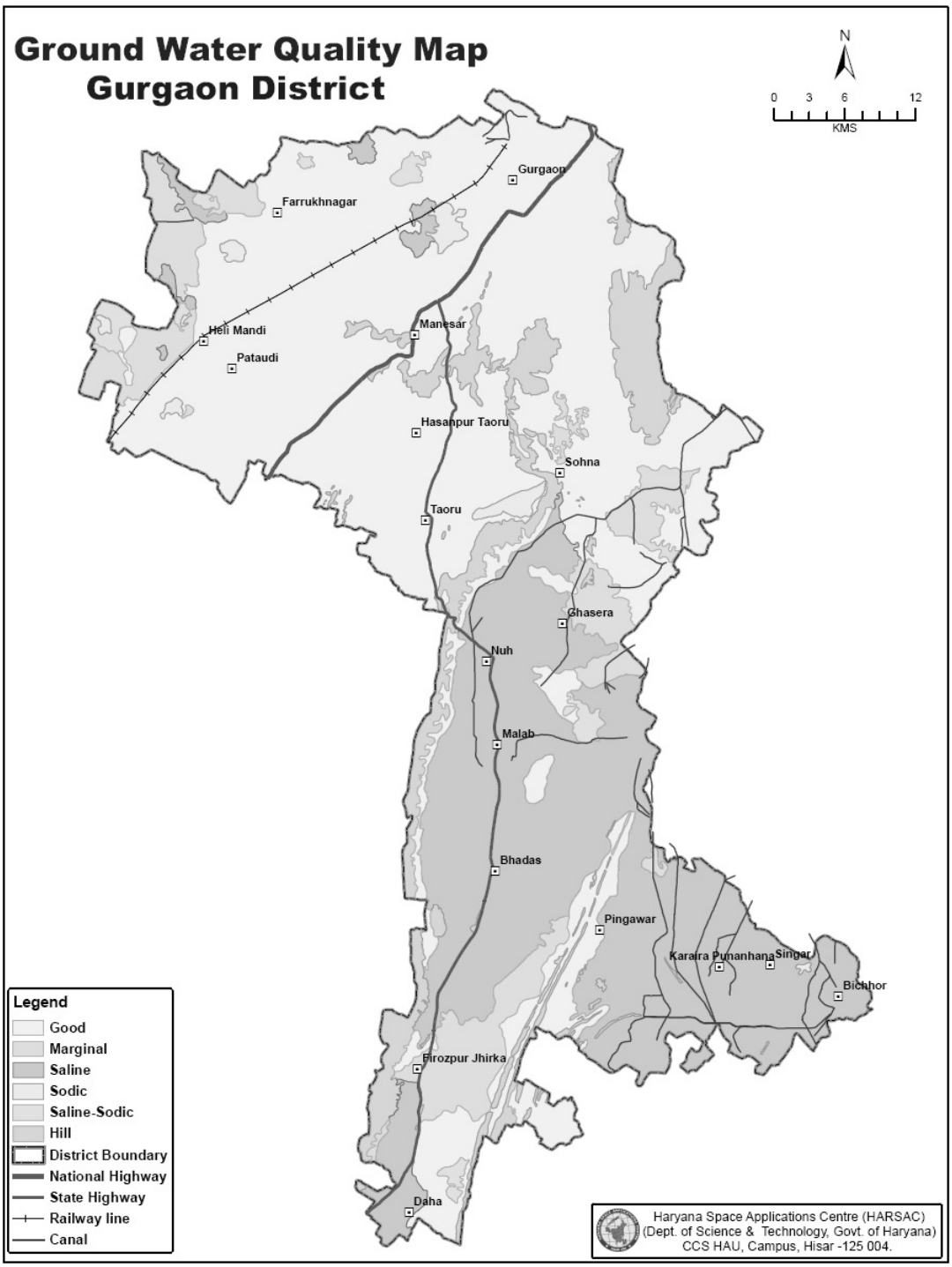

Fig. 1. Ground water quality map of the study area

Sodic

These are the waters having high content of sodium ion. The concentrating of carbonates and bicarbonate an ions is also important in these waters because these effect the precipitation of calcium and magnesium cations thereby resulting in excessive

sodicity. The indiscriminate use of these underground waters is expected to build excessive sodium in soil solution and on exchange complex. To use these type of waters, the recommended doses of gypsum need to be applied alongwith irrigation waters. These waters occur very less in the study area and cover only 23.83 sq.km in the Gurgaon district.

Saline – Sodic

The waters which have high EC and SAR are classified for this category. These waters found in very few pockets in the Mewat region. These are found near Kheraki majra, Faruknagar, Nurgarh, the southern portion of Firojpur Jhirka near Ajam Village and around Ujina village in the Nuh block. They occur only in 32.28 sq.km. These waters are also unfit for irrigation. The direct use of these waters should also be avoided.

Conclusions

It was seen that water quality is saline in most of the southern region of the district i.e., between Nuh to Firozpur-Jhirka and Punhana. After analyzing the water samples, it was found that 54.97% of the geographical area comes under good quality and 30.42% falls under saline water. Other classes like marginal, sodic and saline-sodic cover 12.58, 0.86 and 1.17 percent of the geographical area of the district, respectively.

Authors' contribution: Dr. R. S. Hooda *(Chief Scientist), contributed in project planning and final editing of the manuscript****; Dr. V. S. Arya*** *(Sr. Scientist 'SG'), contributed in project planning, preparation, wrote, GIS studies and corresponding author of manuscript;* ***Dr. Sultan Singh*** *(Sr. Scientist), contributed in collecting and analyzing samples;* ***Dr. G.S.Rao*** *(Assistant Scientist), contributed in collecting and analyzing water samples.*

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