ASSESSMENT OF GROUNDWATER QUALITY IN THE PATHRI RAO WATERSHED, HARIDWAR DISTRICT,INDIA[+]

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Abstract

The chemical analysis of twenty one groundwater samples have been carried out to explain the recharge sources of various aquifers, and aquifer-aquifer interaction in the Pathri Rao watershed Haridwar District, India. The chemical composition of groundwater collected from the shallow and deeper aquifer shows that the existence of two types of water. This indicates that there are different sources of recharge to the shallow and deeper aquifers in this region. The electrical conductivity (EC) values of shallow aquifer especially in the Bhabhar zone (Upper Piedmont) were high which also indicates that the shallow aquifers have recharge source other than deeper aquifers and the interconnection between shallow and deeper aquifer is poor to moderate in this region.

المستخلص

تم اجراء التحليل الكيميائي لواحد وعشرون عينة ماء لتوضيح مصادر التغذيه للمياه الجوفيه في الحد الفاصل لباثري راو في منطقة هريدوار، الهند. التركيب الكيميا ئي للمياه الجوفيه الماخوذه من الطبقات الحامله للمياه(الطبقات الضحله والطبقات الاعمق) تشير الى وجود نوعين من المياه الجوفيه وهذا يدل على وجود مصادر مختلفه لتغذية الطبقات الحامله للمياه في هذه المنطقه . الموصليه الكهربائيه للطبقات الضحله الحامله للمياه وخاصة في نطاق البهابر عاليه والتي تدل كذلك على ان مصدر تغذية المياه الضحله تختلف عن مصدر تغذية المياه العميقه وكذلك الاتصال بين الطبقات الحامله للمياه متوسط الى فقيرفي هذه المنطقه.

Introduction

Groundwater is one of the most widely distributed water resources of the earth. A significant portion of drinking water around the globe comes from groundwater, as it is believed to be safe and free from pathogenic bacteria and suspended matter.

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The evaluation of groundwater quality is an inseparable part of any groundwater evaluation studies. Groundwater during its flow in the geological formation comes in contact with various mineral deposits. Dissolution of various ions during its contact depends upon the chemical nature of water, concentration of species and the residence time of water in contact with these species. Therefore, a detailed study of water quality may provide geochemical history of groundwater.

The earlier work in the Pathri Rao has largely dealt with mapping of water table [1]and [2]; groundwater resource evaluation [3]; estimation of aquifer characteristics using pumping test data and grain size analysis [4] and [5]; subsurface studies using data of lithologs and electrical resistivity [7], [8], [9] and [10] and on groundwater balance [11]; recharge zone [12]. These studies, however, do not focus on the evaluation of groundwater quality and identification of recharge sources of various aquifers, and aquifer-aquifer interaction in study area.

Area of Study

The study area is located between 29° 50' 00" to 30° 11' 21" North and Longitude 77° 59' 19" to 78° 06' 21" East covering an area of approximately 44 square km Fig.(1). The area is well drained by a number of small seasonal rivers the notable ones being Pathri Rao. The area is bounded by Siwalik Hills towards the northeast from which most of the seasonal rivers are flowing towards southwest.

The hilly area is protected by Government as a forest reserve which is named the Rajaj National Park. As there is no regular agriculture in the hilly Terrain, big settlements or villages are not found in this forested area. The rainy season in area extends from June to September under the influence of south- west monsoon. The area also receives some rainfall during January and February from north- east monsoon. July and August are the main rainy-months. Normally, the rainfall ceases by the end of September. There is considerable variation in rainfall from year to year as well as from month to month in a year.

Objectives and Methodology

The objective of present study is to identify the recharge sources on the bases of water chemistry in complex geohydrological setup of the Bhabhar and Tarai tracts of Pathri Rao catchment, a typical watershed in the piedmont zone of Uttaranchal, India.

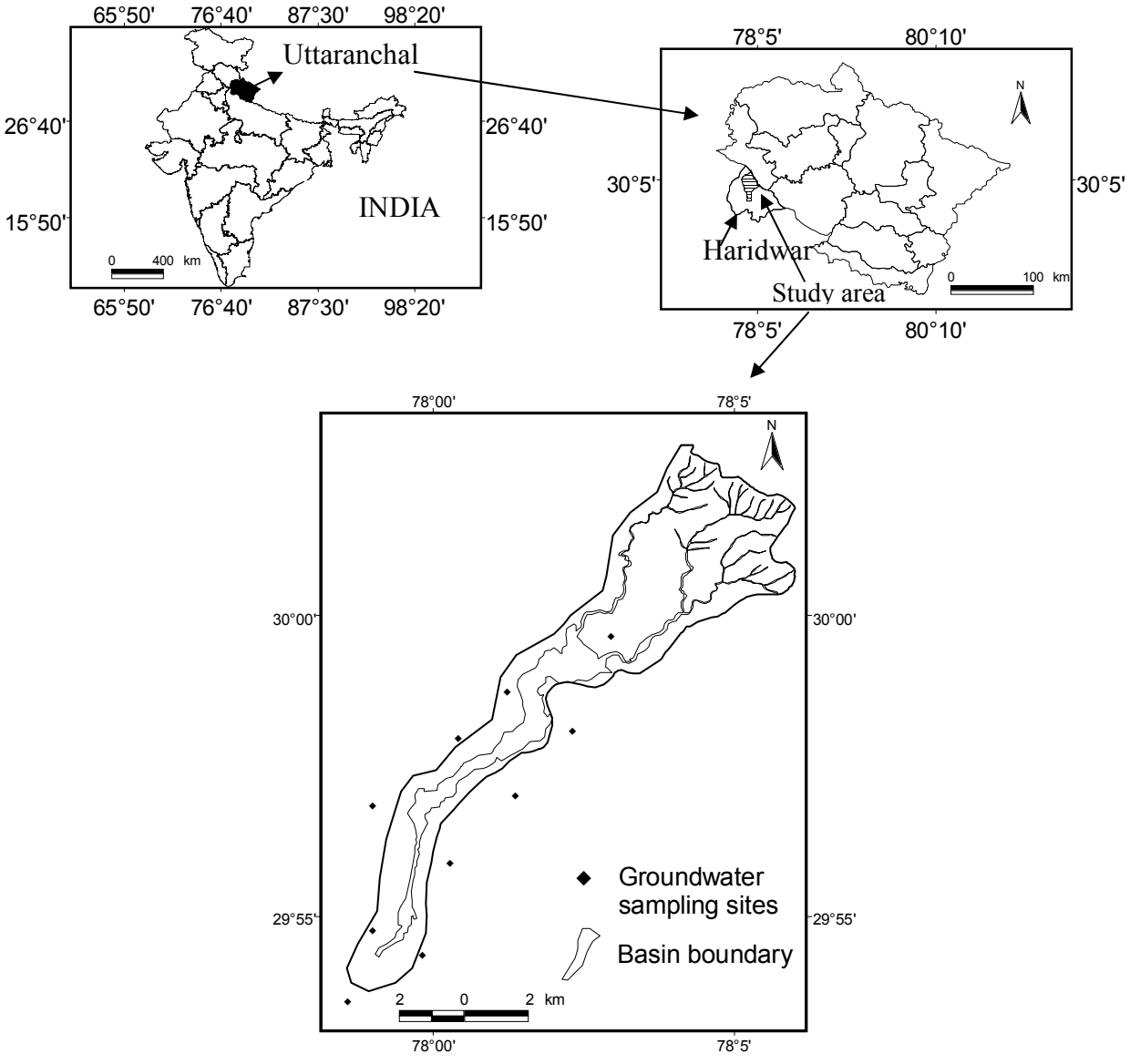

Fig.1: Location map of the study area

To meet these objectives the following techniques and data products have been used:

- Image processing software ERDAS [13] is used to enhance LISS III image for interpretation of the hydrogeological features, which in turn are digitized using a GIS software (Arc View 3.1) from which thematic maps of, geology, hydrogeomorphology, are prepared.
- Twenty one water samples have been collected from the shallow and deep aquifers at eleven selected sites during premonsoon season of 2002. The locations of these samples are shown in Fig(.1.) About 9 groundwater samples have been collected from the shallow aquifer (6m to 11 m depth) and 12 samples from deeper aquifer (12- 100m depth). Cations and anions in addition to other physical parameters such as PH, TDS and EC have been measured in all water samples collected. Cations (Ca^{++}, Na^{++}, and K^{++}) have been analyzed by flame photometer, Mg^{++} in EDTA titration method, $HCO3^{--}$ and Cl^{-} analyzed by H2SO4 and AgNO3 titration method, respectively. The measured values are summarized in Table 1.

- Hydrochemical facies or hydrochemicla zoneation for the present investigation has been carried out by plotting percentage reacting values of major ions in Pipers (1944) trillnear diagrams Fig.(2). Trillinear (Hill piper) which adds to the original two triangles, is a diamond shaped area in which two points (percentage epm values of major cations and anions) plotted with triangles are projected into diamond and plotted as a single point for the representation of overall characteristics of water.

Table.1: Major cation , anion concentration and Physical parameters. [S-Shallow, D- Deeper r]

S. No	*Depth*	*PH*	*EC*	*TDS*	Ca^{++}	Mg^{++}	Na^{++}	K^{+}	Cl^{-}	SO_4^{--}	CO_3^{-}	$HCO3^{-}$
1	**D**	**8.3**	**488**	**320**	**40.05**	**31.58**	**17.10**	**1.60**	**5.00**	**67.90**	**33.00**	**192.17**
2	**S**	**9.1**	**788**	**520**	**67.08**	**37.66**	**41.70**	**9.80**	**24.99**	**69.95**	**63.01**	**268.42**
3	**D**	**8.7**	**575**	**380**	**28.03**	**38.87**	**35.60**	**3.40**	**3.75**	**67.90**	**39.01**	**256.22**
4	**S**	**8.2**	**522**	**346**	**55.07**	**21.87**	**10.50**	**3.20**	**12.50**	**74.07**	**24.00**	**170.81**
5	**D**	**8.5**	**465**	**350**	**40.05**	**28.55**	**13.50**	**2.00**	**5.00**	**67.90**	**24.00**	**179.96**
6	**S**	**8.2**	**995**	**658**	**100.12**	**18.83**	**45.10**	**3.30**	**81.22**	**189.29**	**36.00**	**125.06**
7	**D**	**8.3**	**915**	**602**	**96.12**	**27.33**	**19.80**	**2.00**	**106.22**	**205.75**	**12.00**	**164.71**
8	**S**	**8.8**	**375**	**248**	**29.03**	**12.76**	**9.90**	**22.70**	**12.50**	**65.84**	**18.00**	**94.56**
9	**D**	**8.5**	**372**	**245**	**47.06**	**11.54**	**6.90**	**1.30**	**3.75**	**43.21**	**39.01**	**100.66**
10	**S**	**8.2**	**868**	**573**	**85.00**	**27.33**	**35.40**	**1.80**	**44.99**	**96.70**	**18.00**	**280.62**
11	**D**	**9.1**	**553**	**365**	**33.04**	**25.51**	**33.00**	**2.90**	**29.99**	**88.47**	**27.00**	**161.66**
12	**S**	**8.3**	**1990**	**1320**	**137.16**	**35.23**	**86.90**	**78.50**	**231.18**	**316.85**	**9.00**	**103.71**
13	**D**	**8.8**	**453**	**298**	**53.06**	**12.76**	**10.20**	**1.10**	**16.24**	**63.78**	**33.00**	**137.26**
14	**S**	**9.4**	**353**	**233**	**29.03**	**15.18**	**17.70**	**3.00**	**10.00**	**61.73**	**30.00**	**125.06**
15	**D**	**9.3**	**352**	**232**	**25.03**	**17.61**	**15.30**	**2.90**	**6.25**	**69.95**	**27.00**	**149.46**
16	**S**	**8.8**	**503**	**335**	**62.07**	**9.72**	**4.40**	**1.50**	**6.25**	**98.76**	**33.00**	**167.76**
17	**D**	**8.7**	**418**	**276**	**46.06**	**14.58**	**6.10**	**1.20**	**8.75**	**57.61**	**21.00**	**134.21**
18	**S**	**8.6**	**515**	**339**	**36.04**	**10.93**	**10.70**	**48.80**	**21.24**	**49.38**	**18.00**	**118.11**
.19	**D**	**9.3**	**693**	**458**	**71.09**	**19.44**	**10.70**	**12.90**	**37.49**	**67.90**	**36.00**	**128.11**
20	**D**	**8.7**	**346**	**227**	**40.07**	**8.50**	**11.00**	**1.10**	**7.50**	**59.67**	**15.00**	**152.51**
21	**D**	**8.8**	**450**	**299**	**53.16**	**12.78**	**10.28**	**1.11**	**16.25**	**63.79**	**33.01**	**137.27**

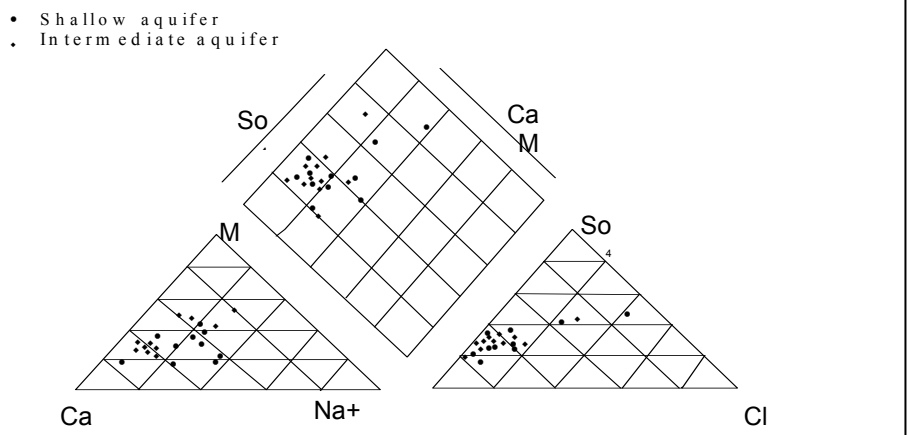

Fig. 2: Pieper diagram showing the chemical composition of Groundwater from shallow and deeper aquifer in the study area

Geology and Hydrogeomorphology of the Study Area

Geologically the study area compriss Siwalik rocks and alluvial deposits [3]. Towards north, the Siwalik sedimentary rocks are composed of indurate to compacted clastic sediments exposed in Haridwar district and represent an over 6000 m thick sequence, consisting of interbedded mudstones, sandstones, conglomerates and subordinate marls [14]. The formation occurring to south of the Siwaliks is alluvial fan deposits of recent age. The alluvial fan deposits are made up of assorted sands and gravel associated with occasional clays [15], [16] and [17]. After necessary ground checking and correlation with the existing literature, the geologic units are mapped using GIS to prepare thematic map for geology of the area (Fig. 3).

Based on hydrogeological characteristics, the area is classified into four geomorphic units. The geomorphic boundaries are digitized on the enhanced image through GIS and generated hydrogeomorphological map which is shown in Fig. (4). The Upper Piedmont zone also known as Bhabhar, bordering the Siwalik hill comprises unconsolidated coarse material. From groundwater point of view this belt

provides an excellent hydrogeological setup for recharge and infiltration. The Lower Piedmont (also known as Tarai) is separated from the Bhabhar by the spring line along their junction. This zone is composed of coarse-grained sand and clays with gravel. Flood plains form the youngest geomorphic unit and

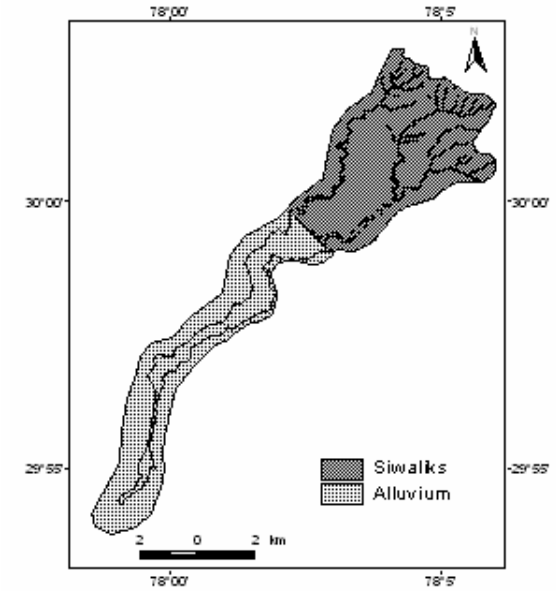

Fig. 3: Geological map

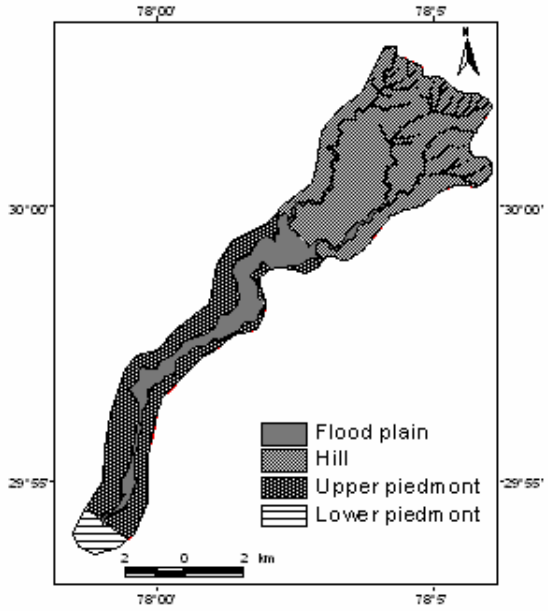

Fig. 4: Hydrogeomorphological map

include various landforms formed by fluvial action i.e. sandbars, channel bars, and meander scars. These are characterized by very gentle slope and consist of sub rounded to rounded fragments of sand, silt and clays.

Hydro-chemical Facies

Hydrochemical facies or hydrochemicla zoneation for the present investigation has been carried out by plotting percentage reacting values of major ions in Pipers (1944) Trillnear diagrams. The block wise data on the hydrochemical facies of groundwater in the study area has been presented in Trilinear diagrams Fig(. 2). This diagram shows 90% of groundwater in the study area belongs to Ca^{++} –HCO_3^- type with significant portion of Mg^{2+}. At few places which are getting additional recharge, the groundwater belongs to So_4^{--}- Cl^-.

Conclusion

The evaluation of groundwater quality has been carried out to explain the recharge sources of various aquifers, and aquifer-aquifer interaction in the Pathri Rao

watershed Haridwar District, India. The Piper diagram shows that there are different water types in the study area which indicat that there are different recharge sources. These findings are supported by the Electrical Conductivity (EC) data of groundwater which show an increase in the shallow aquifers. The increasing in EC indicates that the shallow aquifers have recharge source other than deeper aquifers and the interconnection between shallow and deeper aquifer is poor to moderate in this region.

Recommendations

Recharge source cannot be completed without understanding of stable isotopes. This may be more reliable to do with the help of stable isotope study which is commonly used to determine the elevation of recharge for particular groundwater.

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