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RESEARCH ARTICLE

Arsenic pollution and associated human health hazards in Rupnagar district, Punjab, India

Gopal Krishan[1] · Srijita Ghosh[2] · Hardev Singh Virk[3]

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Abstract

The hydrosphere although covering almost 70% of the Earth contributes only 3% of fresh water out of which groundwater covers almost 98%. The presence of some unwanted substance in this limited natural resource causes pollution when the substance causes serious harm to human beings and to the total ecosystem in a way. Arsenic is such a pollutant that is most naturally released in groundwater and long-term exposure to As-rich groundwater causes skin lesions and often leads to different types of cancers in humans. Rupnagar district in the *Malwa* region of Punjab is situated alongside the river *Satluj* which is one of the five important tributaries of Indus. The lowest reported concentration of As in this district is 10 µg/L and the highest is 91 µg/L. The higher values of As (> 50 µg/L) that are above the permissible limit of IS 10500, 2004 in drinking water, are dominantly found in the western and south-western parts of the district. The average *hazard quotient (HQ)* indicates high risk for the consumers of the As-polluted groundwater in the district. The present study deals with the major cause of high arsenic (As) concentration in groundwater and its correlation with intensive agriculture in the Rupnagar district. Owing to the large size of the district, GIS techniques like ArcGIS 10.4.1 and QGIS 3.22.8 software were used for analysis in this study. The study reveals that high As concentration (> 50 µg/L) is mostly found in agricultural lands and moderate concentration of As (10–50 µg/L) in groundwater is distributed all over the district and are mostly reported from the urbanised areas. Overall, the water table shows a declining trend but no such decline is observed in the western and south-western parts of the district. As pollution in groundwater can also be caused due to water level decline owing to intensive agriculture and rapid water abstraction though As is naturally sourced in groundwater. A detailed study using the geochemical analysis of groundwater in the district can be effective in clearing out the scenario in the study area.

Keywords Groundwater · Arsenic · Malwa · Hazard quotient · GIS

Introduction

Groundwater is one of the most vital natural resources on earth. India is one of the major users of groundwater in the world with an average usage of 251 km^3/year (CGWB 2014). It is the most preferred source of water in Indian states due to its easy availability (CGWB 2020; Bonsor et al. 2017; MacDonald et al. 2016), cost-effective extraction and use and many such factors that has made it the most dependable one. Groundwater resource assessment for the year 2011 (CGWB 2014) states that total estimated annual availability of groundwater resources of the phreatic aquifers in India is 398×10^9 m^3 of which recharge from rainfall has a contribution of almost 70% and other sources like return flow from irrigation, seepage from surface water bodies contribute the rest. After the green revolution in 1960, India has witnessed a huge increase in agricultural productivity which goes at par with the increased need of water (Mundle and Sikdar 2019). Due to limitations in use of surface water and other factors, large abstraction of groundwater started after that very event and since then (MacAllister et al. 2022), use of groundwater in agricultural purposes has become its largest contribution in India. As per the estimates of the Government of India (CGWB 2014), almost 90% (222×10^9 m^3) of the total annual groundwater draft in India is due to irrigation.

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✉ Srijita Ghosh
srijitaghosh217@gmail.com

1 National Institute of Hydrology, Roorkee 247667, Uttarakhand, India

2 Presidency University, Kolkata 700073, West Bengal, India

3 SGGS World University, Fatehgarh Sahib, Punjab, India

Annual groundwater draft is very high in many parts, mainly in agriculture-based states like Punjab, Haryana and West Bengal (Saha and Ray 2018).

The economy of Punjab is based on agriculture (Gupta 2009). The state having only 1.54% of the total geographical area of India, contributes 27–40% paddy, 55–65% wheat and 18–25% cotton to a chunk of people all over India and outside and groundwater is the prime contributor in it (Baweja et al. 2017). The rotational pattern of paddy–wheat cultivation in Punjab has increased the agricultural water demand manifold (Vashisht 2008; Baweja et al. 2017) due to which water level decline in this state has become a major issue (Krishan et al. 2014; Chopra and Krishan 2014). The annual deficit of groundwater in Punjab is reported to be 14.31 BCM (Kumar et al. 2017; CGWB 2016). The water level is declining both spatially and temporally in Punjab at a rate of 33 cm/year in the northeast zone, 50 cm/year in the central part and 36 cm/year in the southwest (Baweja et al. 2017). The World Watch Institute has warned that if water level persists declining at this rate, groundwater in Punjab shall be over by 2025 (Baweja et al. 2017). High amounts of different unwanted elements specially the heavy metals in groundwater result due to this increased agricultural production resulting from use of agrochemicals, including plant nutrients and fertilisers (Virk 2019a). Arsenic (As) is one of such elements which is naturally released in groundwater but different anthropogenic activities enhance its effects (Mundle and Sikdar 2019). Arsenic was first detected in groundwater in the early 1990s in Bangladesh and West Bengal (Ahmed et al. 2004; Chakraborti et al. 2015) of India and it is now spread over almost every part in the south-eastern Asia (Kim et al. 2011). The Indus basin is reported to have aquifers that are over-exploited due to extensive agricultural activity (Nickson et al. 2005; Farooqi et al. 2007; Baig et al. 2009; MacDonald et al. 2016; Kumar and Singh 2019). High level of As in groundwater of Pakistan–Punjab is reported in many works (Bonsor et al. 2017; Brahman et al. 2013;) and high concentration of As in drinking water is mainly reported from the areas near Indus river and its tributaries Jhelum, Chenab, Ravi, Beas and Sutlej (Farooqi et al. 2007; Podgorski et al. 2017; Rasool et al. 2015; Javed et al. 2021; Krishan et al. 2021a). Rupnagar in Punjab is such a district which is traversed by river Sutlej and is reported to have one of the highest As concentrations in the state (Virk 2020). Hence, the major objective of the study is to correlate As concentration in this district with water level fluctuation and land use pattern to identify the probable source of high As and its relevance to the enhanced agricultural activity in the study area. Another purpose of this study is to make an assessment of the health hazard effects to consumers of this As-rich groundwater and to work out some feasible mitigation strategies for them.

Materials and methods

Study area

Rupnagar district falls between 30.757° to 31.438° North latitude and 76.316° to 76.736° East longitude (Fig. 1). The rock formations are distributed into two broad belts—outer and inner belts, formed of the upper and lower tertiary period. The rock formation of the upper Shiwaliks is composed of soft earth clay and boulder conglomerates and rocks of the middle Shiwaliks consist of massive sand rock

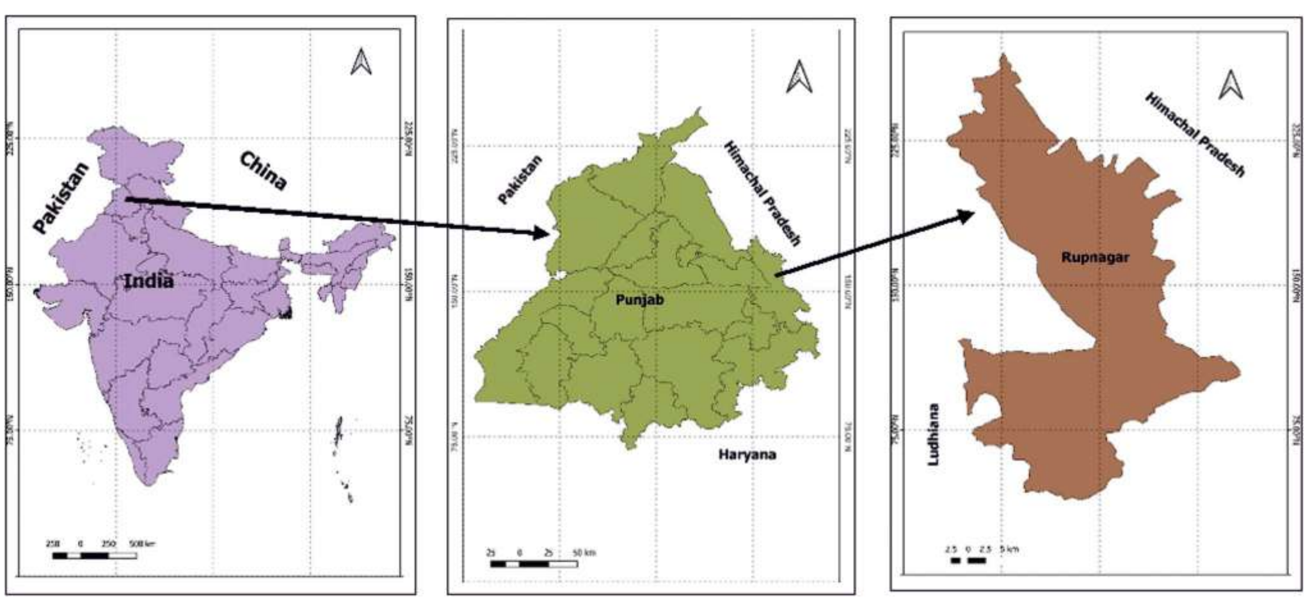


Fig. 1 Map of the study area

and clay beds whereas the lower Shiwaliks mainly consists of grey micaceous sand stones and slabs and are non-fossiliferous (Singh et al. 2010). The piedmont plain area consists of the alluvium that is derived from these Shiwaliks that is cut off by the seasonal rivulets or choes (Singh et al. 2010). Rupnagar District is overall characterized by its hot summers and cold winters. The average annual rainfall in district is 775.6 mm. The soil type in Rupnagar varies from loamy to silty clay loam except along the Satluj River where the soil is somewhat sandy (Singh et al. 2010). Aquifers in Rupnagar district are mainly alluvial in nature and are composed of heterogeneous complex mass of clays, silts, fine sands, coarse sands and gravels. Hydraulic conductivity of the aquifers ranges between 5 and 10 m/day and the specific yield has a range of 0.08–0.17 (Baweja et al. 2017).

Data collection

As concentration data used in this study were collected from the study area by the technical staff of DWSS (Department of Water Supply and Sanitation), Punjab (Virk 2019b). The collected samples were filtered and analysed in ICPMS in the DWSS Punjab state laboratory setup in Mohali, India and the As concentration data collected from this analysis were used in this study. Water level data of the pre-monsoon period from 2000 to 2016 in the study area was collected from Department of Agriculture and Farmers Welfare, Punjab.

Tools and software used

Geographic information system (GIS) is used as major tool in this study. GIS is system used for analysis and displaying geographically referenced information using data corresponding to a unique location. ArcGIS 10.4.1 and QGIS 3.22.8 are the two major GIS softwares used for preparing various maps of the study area. The coordinates of different locations in the study area were known using Google Earth pro software.

Obtaining elevation and land surface

Digital elevation model (DEM) is a 3-dimentional representation of elevation of a land surface excluding vegetation, buildings and other surface objects with respect to any reference datum plane. For this study, DEM with 30-m spatial resolution was prepared using Cartosat satellite imagery for India that is helpful for topographical studies. The required Cartosat images were downloaded from *Bhuvan portal* of *NRSC (National Remote Sensing Centre) – ISRO*. The images in form of raster layers were added in the QGIS project and merged and clipped to prepare the DEM of Rupnagar district.

Obtaining drainage map

A drainage map shows different rivers, their tributaries and distributaries flowing through a region. Drainage map of the study area was prepared using the DEM of Rupnagar with the help of QGIS software. The drainage map, along with the flowing streams, also shows *Strahler stream ordering*, *stream nodes* and *drainage basins* in the study area.

Geology characterization

Geology refers to the basic information regarding the rock types, mineral composition, soil characters and landforms of an area. Map of general geology of the study area was downloaded from *USGS portal* and was categorised with the help of QGIS software. This map is useful for studying the formation of the district according to their geologic age.

Land use and land cover map

Land use maps are the primary and basic fundamental data sources for proper land planning and management. Precise land use and land cover (LULC) maps are important to provide accurate information regarding proper utilisation and upgradation of lands on this Earth. With the new opportunities, LULC mapping has now become more accurate with the advent of *cloud computing platforms*, *time series feature extraction* techniques, *artificial intelligence* and *machine learning classifiers*. For preparing a LULC map, use of mono-temporal and mono-source satellite images is very important. For this study, *Sentinel-2 imager*y was used which can provide data with a high temporal resolution, short revisit time and rich spectral configuration. It has mainly six land monitoring bands (blue: 490 nm, green: 560 nm, red: 665 nm, NIR: 842 nm, SWIR1: 1910 nm and SWIR2: 2190 nm). Bands 2, 3, 4 and 8 were used for preparing the composite band in ArcGIS in this study. Supervised classification of 8 classes was prepared using numerous ground rectangle samples by which training sample was produced. Two different LULC maps were prepared for the two different seasons namely—the *Rabi* and *Kharif* seasons in Rupnagar using satellite imagery of February and October respectively.

Generating water level maps

Water level change has been mapped using pre-monsoon (June) data of 16 years from 2000 to 2016 in QGIS. Different colours have been used to define the different depths of water level. Contours have been drawn to reflect the change more precisely with time.

Health-risk assessment

Risk assessment is a function of the hazard and exposure and is defined as the process of estimating the probability of occurrence of any given magnitude of adverse health effects over a specified time period (Bortey-Sam et al. 2015). Risk level is represented in terms of a carcinogenic or non-carcinogenic health risk (USEPA 2009). The two principal toxicity risk factors are the slope factor (SF) used for carcinogenic risk characterization and the reference dose (RefD) used for non-carcinogen risk characterization (USEPA 1997, 1999). A health-risk assessment has been done in the study area on basis of calculation of average daily dose (ADD in mg/kg/day) of the As-rich water. ADD was calculated as per the formula (USEPA 1992) given below:

$$\mathrm{ADD} = \frac{\mathrm{C} \times \mathrm{IR} \times \mathrm{ED} \times \mathrm{EF}}{\mathrm{BW} \times \mathrm{AT}}$$

where,

C As concentration (mg/L) in groundwater

IR average daily intake rate which is assumed to be 2 L/day and 3.45 L/day for children and adults respectively (Apambire et al. 1997; Roychowdhury et al. 2003)

ED exposure duration which is assumed to be 10 years for children and 70 years for adults

EF exposure frequency which is 365 days/year

BW average body weight which is assumed to be 25 kg and 60 kg for children and adult respectively (USEPA 2009)

AT average time which is 25,550 days i.e. (70 × 365) days for adults and 3650 days, i.e. (10 × 365) days for children (Wongsasuluk et al. 2013; Roychowdhury et al. 2003)

The non-carcinogenic risk for the consumers of As-rich groundwater in the study area was calculated as hazard quotient (HQ). HQ is defined as the ratio of ADD and RefD where RefD for As is 3×10^{-4} mg/kg/day (USEPA 2015).

$$\mathrm{HQ} = \frac{\mathrm{ADD}}{\mathrm{RefD}}$$

HQ > 1 indicates potential non-carcinogenic health risk to the consumers whereas HQ < 1 is considered as safe for consumers of drinking water (USEPA 1992).

The carcinogenic risk or cancer risk (CR) for the consumers of As-rich groundwater in the study area was calculated as the product of ADD and SF where the value of SF for oral carcinogenic As is 1.5 mg/kg/day (USEPA 2015).

$$\mathrm{CR} = \mathrm{ADD} \times \mathrm{SF}$$

$\mathrm{CR} > 1.00 \times 10^{-6}$ indicates higher possibilities of cancer cases with one case out of 1,000,000 individuals.

Result and discussion

Land use/land cover

LULC maps have been prepared based on 8 classes namely—*Agricultural land*, *dense forest*, *waterbodies*, *barren land*, *fallow land*, *urbanised area*, *hilly area* and *sediment*. LULC indicates that during Rabi season (mid-February), ~ 43.19% (~ 597.45 sq. km) of the total geographic area of Rupnagar district comes under agricultural land and ~ 15.63% (~ 216.27 km^2) area occupies barren land (Fig. 2a) whereas during Kharif season (end October), ~ 23.39% (~ 323.62 km^2) area of the total geographic area comes under agricultural land, barren land covers 25.29% (~ 349.82 km^2) area and 16.32% (~ 225.87 km^2) area is covered by fallow land (Fig. 2b). A study by Singh et al. (2010) indicates that there is a rapid increase of ~ 93.5 km^2 in the urbanised area during the time period of 1989 to 2006 in Rupnagar district which has most likely been occurred at the expense of decrease of ~ 89.61 km^2 area in the agricultural land. The study also reflects that the salt affected land in the study area has been increased by ~ 9.74 km^2 due to excessive use of fertilisers in the field of irrigation (Singh et al. 2010). This change in land use pattern is irreversible and affects the ecosystem hence needs to be regularly monitored using remote sensing techniques (Singh et al. 2010).

Arsenic concentration in drinking water

The As concentration in the study area ranges from 10 to 91 µg/L. Only one location with As concentration equal to 10 µg/L has been found in this area where groundwater is safe for drinking purpose as per IS 10500, 2004. As concentration between the acceptable limit and the permissible limit by IS 10500, 2004 (10–50 µg/L) are found to be spread all over the study area and are reported mainly from the urbanised area and a few from the agricultural land in the district. For the Rabi season, reported As concentration that are greater than 50 µg/L in the study area, falls in the agricultural land (Fig. 3a) where intensive cultivation of wheat, barley and other winter crops take place. For the kharif season, the locations with high As concentration comes mostly under fallow land (Fig. 3b) which substantiates that the LULC maps of the two different seasons are made

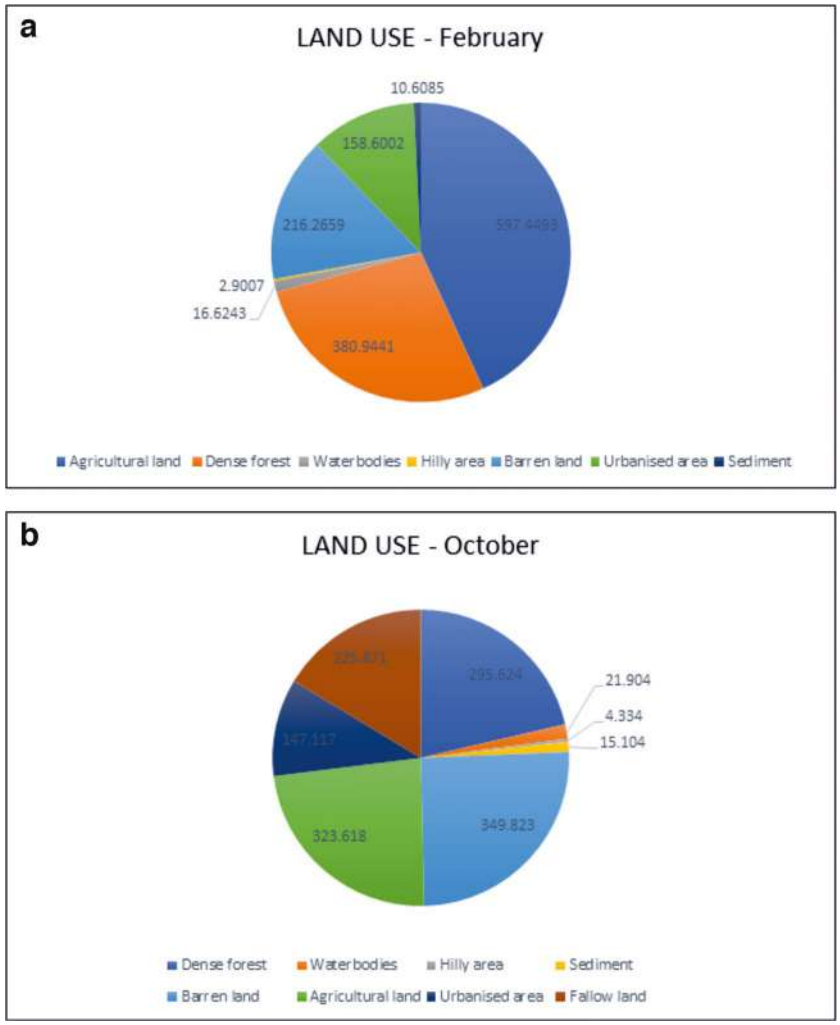


Fig. 2 **a** Maximum likelihood classification showing areas of different land use classes during the month of February which is the Rabi season. Values in the pie diagram indicate the corresponding areas (in sq. km) covered by each class. **b** Maximum likelihood classification showing areas of different land use classes during the month of October which is the Kharif season. Values in the pie diagram indicate the corresponding areas (in sq. km) covered by each class

properly. The mean As concentration in pre-monsoon season in this district is reported to be 192.22 µg/L in a recent study by Kaur and Paikaray (2021), which is way higher than the mean concentration reported from this study which is ~ 18 µg/L. The pre-monsoon As concentration ranges upto 1446 µg/L in this district (Kaur and Paikaray 2021). So, the trend of increasing As concentration with time is quite high in groundwater in this district.

Mechanism of As release in groundwater

Different studies reveal that application of phosphate fertiliser promotes competitive exchange of PO_4^{3-} with As. The PO_4^{3-} present in the fertiliser can readily substitute for As that is sorbed on mineral surfaces and soil water becomes As-rich. It is experimentally seen that As-polluted groundwater often contains 1–5 mg/L of PO_4^{3-} and putting As into solution by competitive exchange that is an equilibrium process with PO_4^{3-}, it is observed that this little amount of PO_4^{3-} is not capable of liberating more than a few µg/L of As. Hence, it cannot be responsible for the occurrence of groundwater containing tens to hundreds of µg/L as is commonly seen in alluvial and deltaic aquifers (Ravenscroft et al. 2001; Kent and Fox 2004).

Glaciers in the Himalayas naturally erode crystalline rocks to fine particles which are then carried downstream and mainly accumulate in the delta. During this process, grains get chemically weathered and gain a coating of *iron-oxyhydroxide* from the weathering of Fe-bearing minerals (Acharyya 2005; McArthur et al. 2018). The coating is patchy and thin because of the slow weathering and rapid transportation in the higher reaches of river. During downstream movement, the oxyhydroxides coatings strongly adsorb As and PO_4^{3-} from river water and are rapidly buried by later sedimentation. The hot, wet, climate of the delta is favourable for growth of vegetation (mainly swamp). The sediments contain bacteria which in presence of oxygen, use the organic matter as food for their growth. To do so, they need oxygen. The only source of oxygen is the sedimentary Fe-oxyhydroxide which is then reduced turning Fe (III) into

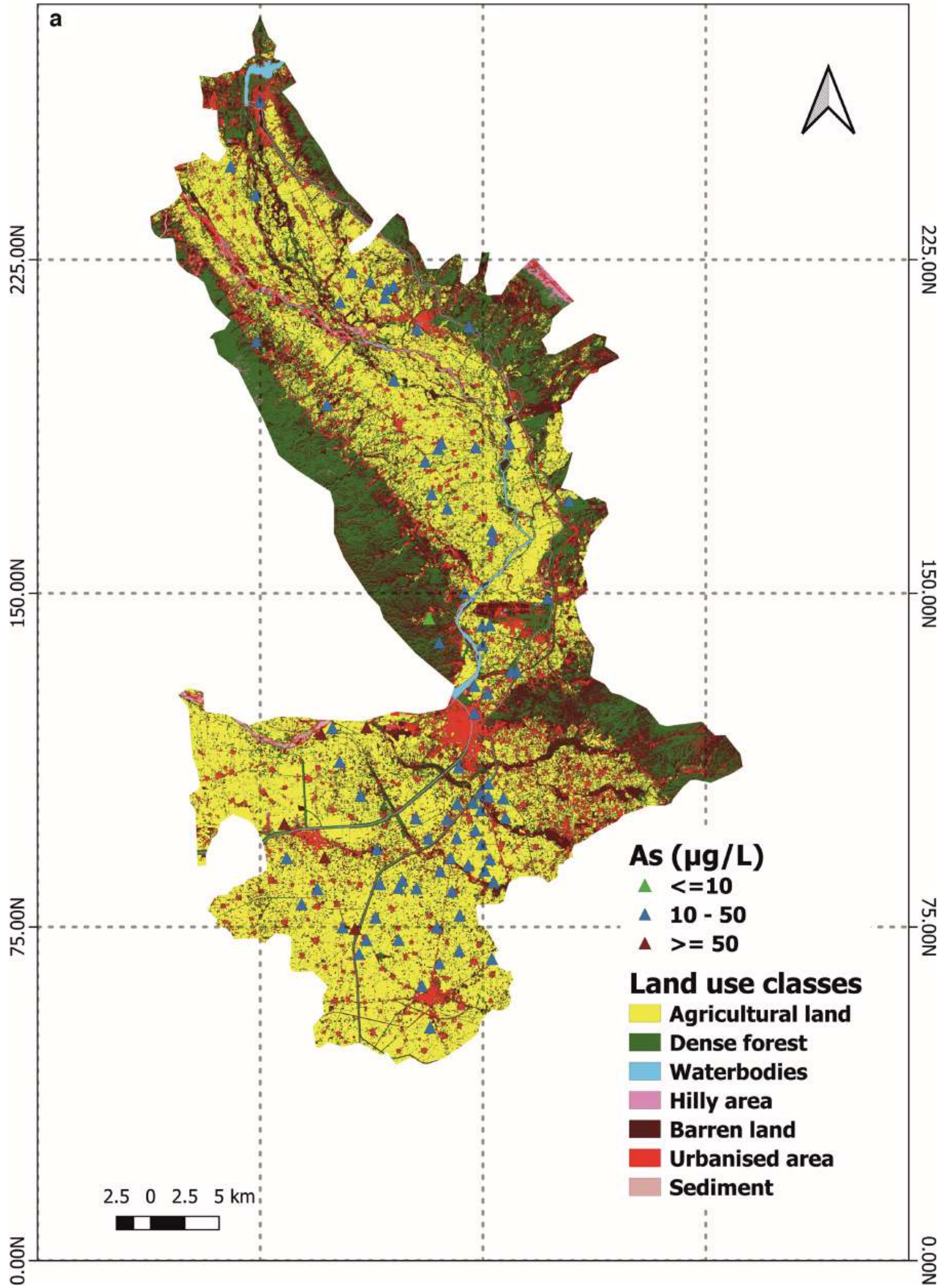


Fig. 3 **a** Locations (marked in triangles) with different As concentration shown in LULC map of Rabi season. **b** Locations (marked in triangles) with different As concentration shown in LULC map of Kharif season

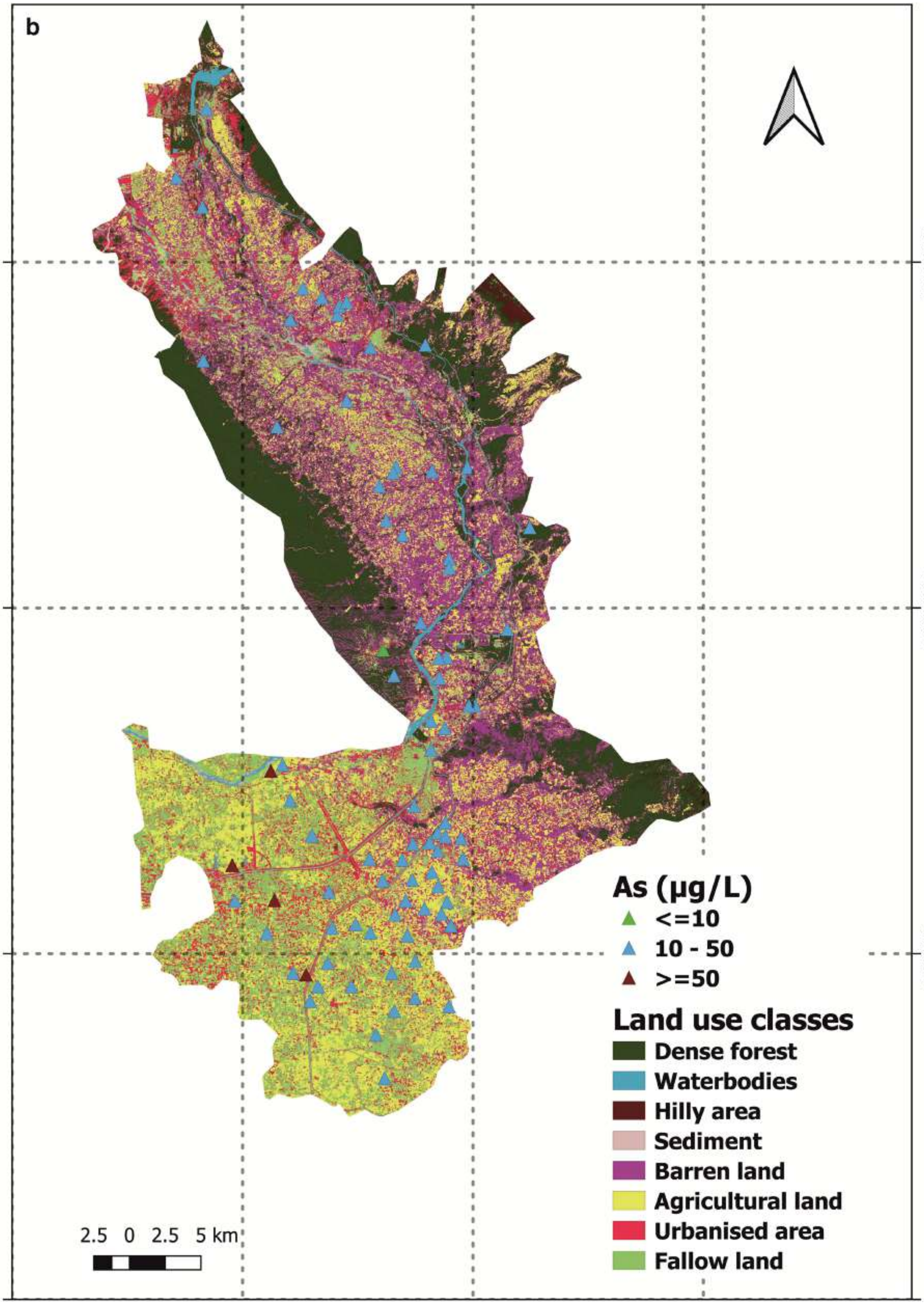


Fig. 3 (continued)

insoluble Fe (II). The As and PO_4^{3-} adsorbed to the Fe-oxy-hydroxides are released to groundwater along with Fe (II). Although the source of the organic matter driving reduction is still a matter of debate.

Virk (2020) reported that Majha districts of Punjab have comparatively high As concentration than the Malwa districts of Punjab. High concentration of arsenic in the study area is thought to have resulted from the weathering of mostly argillaceous material carried by river Satluj and its tributaries (Fig. 4) and organic matter associated with the fine-medium sands of these *Holocene alluvium (Quaternary sediments)* covering a major part of the study area as all of the reported high As-rich locations belong to quaternary sediments (Fig. 5). Reduction of iron oxyhydroxides in groundwater occurs only in anoxic condition, i.e. lacking both dissolved oxygen and dissolved nitrate (Gulens et al. 1979; Vogel et al 1981; Nickson et al. 2000), and this anoxic condition is a result of high organic activity in the study area. Anoxia usually takes place in stagnant or slowly moving groundwater like that in deltas and the alluvial plains of large rivers which is also significant in this case as the Indus basin is a poorly drained one (Ali et al. 2019). As organic matter is oxidised, the organic-N and organic-P in it are also released as NH_4 and additional PO_4^{3-} both of which are present in the groundwaters of the alluvial aquifers of Indus basin. The pre-monsoon pH condition of the study area is reported to be 6.78–7.57 which is near neutral (Kaur and Paikaray 2021) and indicates weak desorption ability of PO_4^{3-} towards As leading to release of As into the groundwater from soil through ligand exchange process (Oinam et al. 2010).

Correlation of As concentration with water level data

The changes in Water Level (WL) have become clear with the prepared WL map using 16 years pre-monsoon (June) data (Fig. 6a, b, c). The significant changes that can be inferred from these maps are as follows:

i. In the north-eastern part of the study area, an overall rising trend in WL is observed in this 16-year span. WL has increased from 2 m. in 2000 to 10 m in 2008 and has persisted to 10 m till 2016 in this part. Similar observations have been made by Krishan et al., (2021b) and Lapworth et al., (2015) in Bist Doab, Punjab and Krishan et al (2014) in Punjab.
ii. In the south-western part, WL is showing a slight increase from 4 m in 2000 to 6 m in 2016. This is a remarkable portion in the study area as high As concentrations (> 50 μg/L) are reported from this part and in LULC map, this area mainly comes under agricultural land. Hence, high As in groundwater in this area is not a result of water abstraction for agricultural use, instead it must be naturally released into groundwater or might have sourced from leaching of As-rich pesticides used in agricultural field which is yet to be confirmed. This negligible change in WL again substantiate the idea of formation of anoxic condition in stagnant or slowly moving groundwater leading to reductive dissolution of Fe-oxyhydroxides releasing As in groundwater. Lapworth et al (2017) also found high concentrations of heavy metals including arsenic in the groundwater of the Bist Doab area.
iii. A major change in WL is observed in the south-western part of the study area. WL contours infer an increase in WL from 12 m in 2000 to 18 m in 2008 which can be caused due to either continuous recharge of groundwater from any single source or multiple sources like rainfall, return flow from irrigation etc. or installation of new wells into the subsurface aquifer. WL in this area has interestingly dropped to as low as 2 m by 2016 owing to nothing but rapid abstraction of groundwater. Although no reported data of As concentration is available in this part of the study area, the direct correlation of As pollution with this rapid drawdown of WL cannot be done at this moment.

Human health risk due to consumption of As-rich water

The average daily dose, HQ and CR for the consumers of As-rich groundwater is listed in Table 1. The calculations suggest that the average HQ for children and adult consumers in the study area are 5.35 and 3.85 respectively. All the HQ values are greater than 1 which clearly infer that all the consumers of As-rich groundwater in the study area are at high potential of risk for developing non-carcinogenic adverse health effects on their bodies upon long-term consumption of As-rich groundwater and especially the children are at very high risk. The calculated cancer risk for both the children and adults are measurably high which are 2.41E-03 and 1.73E-03 respectively. The study by Kaur and Paikaray (2021) states that the average HQ for the consumers in this district is 14.48 μg/L. It can be clearly said that the As pollution in this district is becoming increasingly high with increasing population and corresponding water demand.

Conclusion and recommendations

In order to sustain agricultural production, groundwater resources of Punjab have already been over-exploited. Water level of the aquifers in the south-eastern part of the study area has faced a major decline in the 16 years from 2000 to 2016 which has become a prime concern in recent times. As concentration in groundwater in the study area does not

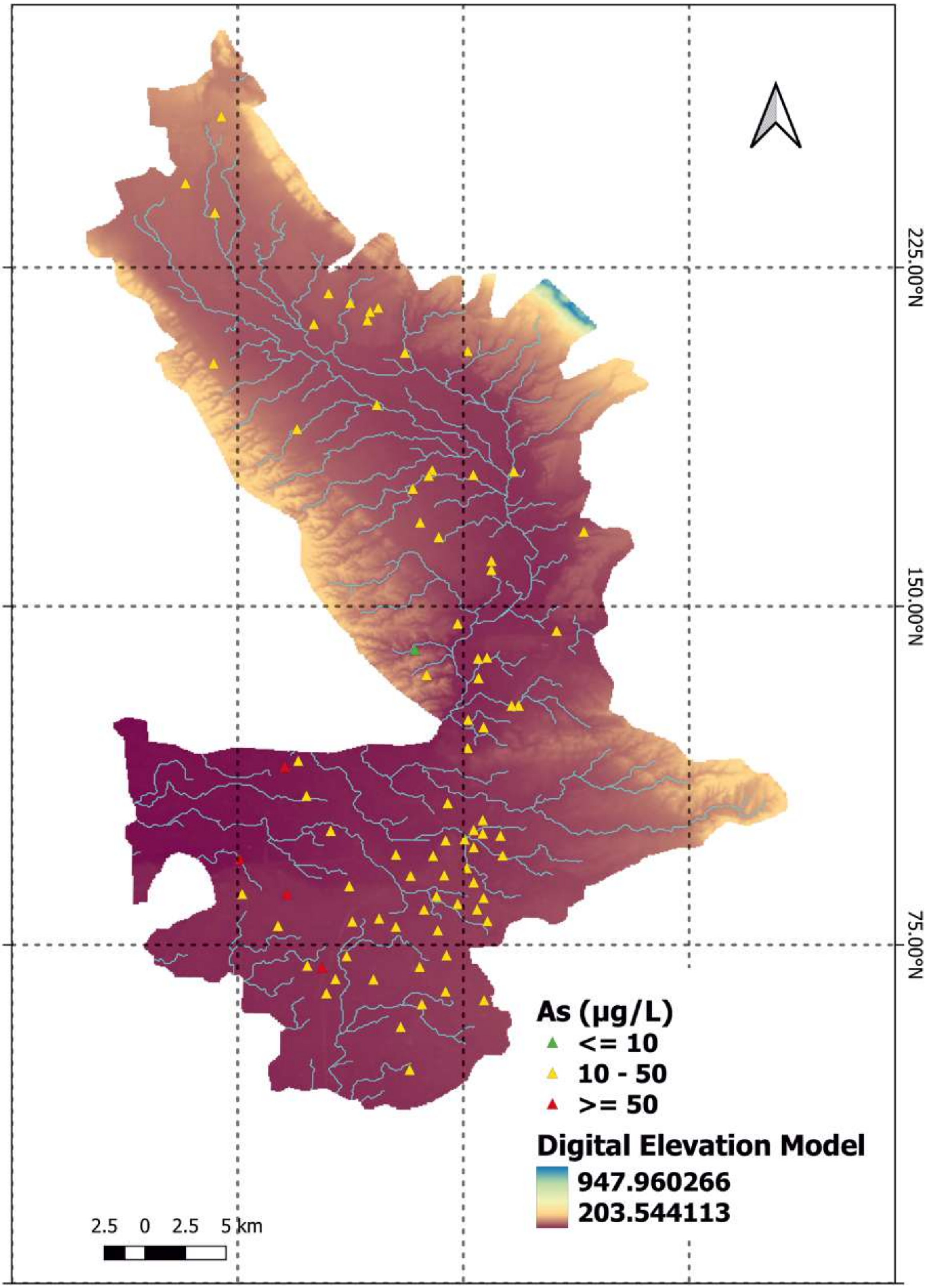


Fig. 4 Locations (marked in triangles) with different As concentration shown in drainage map of Rupnagar

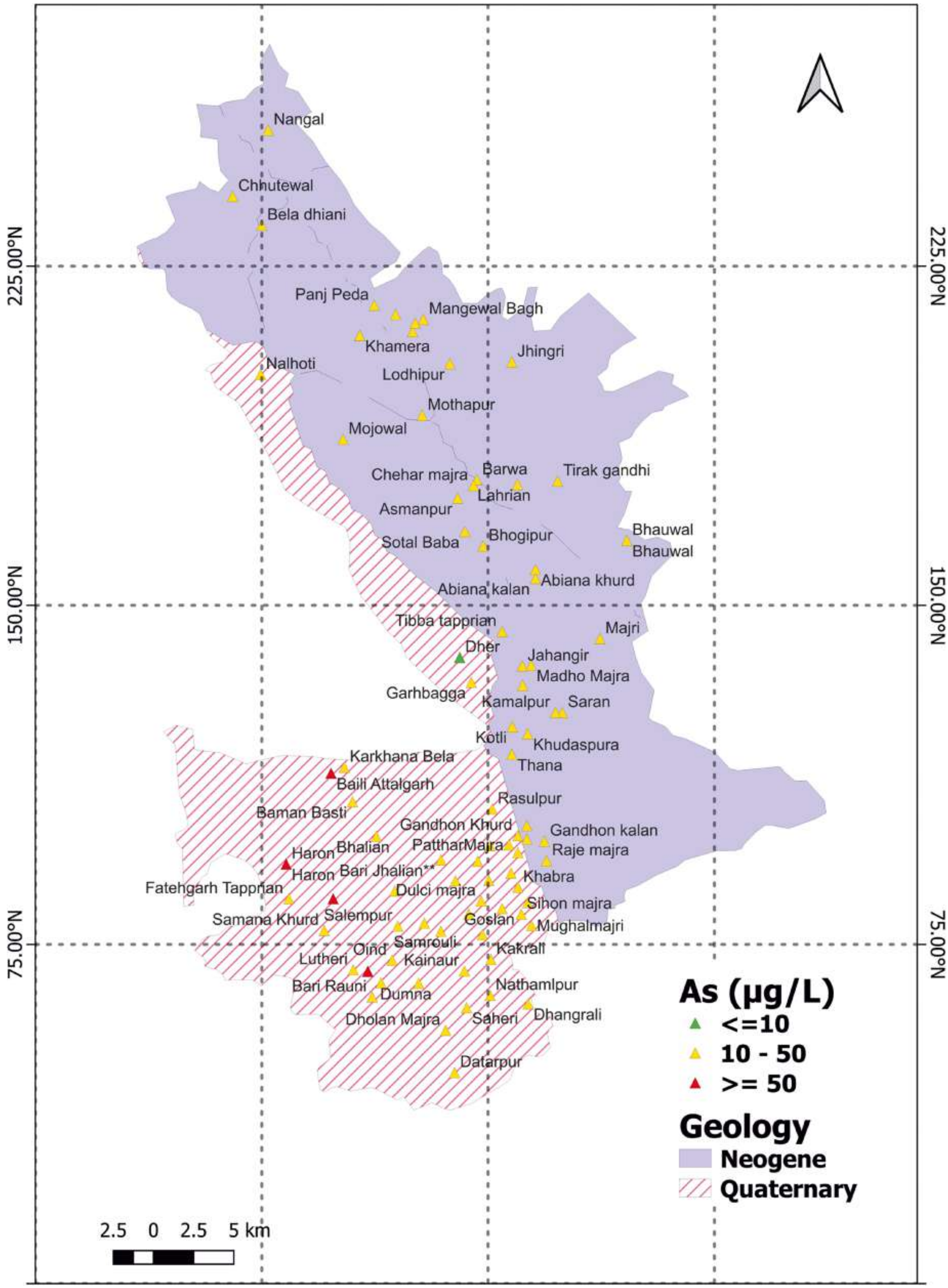


Fig. 5 Locations (marked in triangles) with different As concentration shown in geology map of Rupnagar

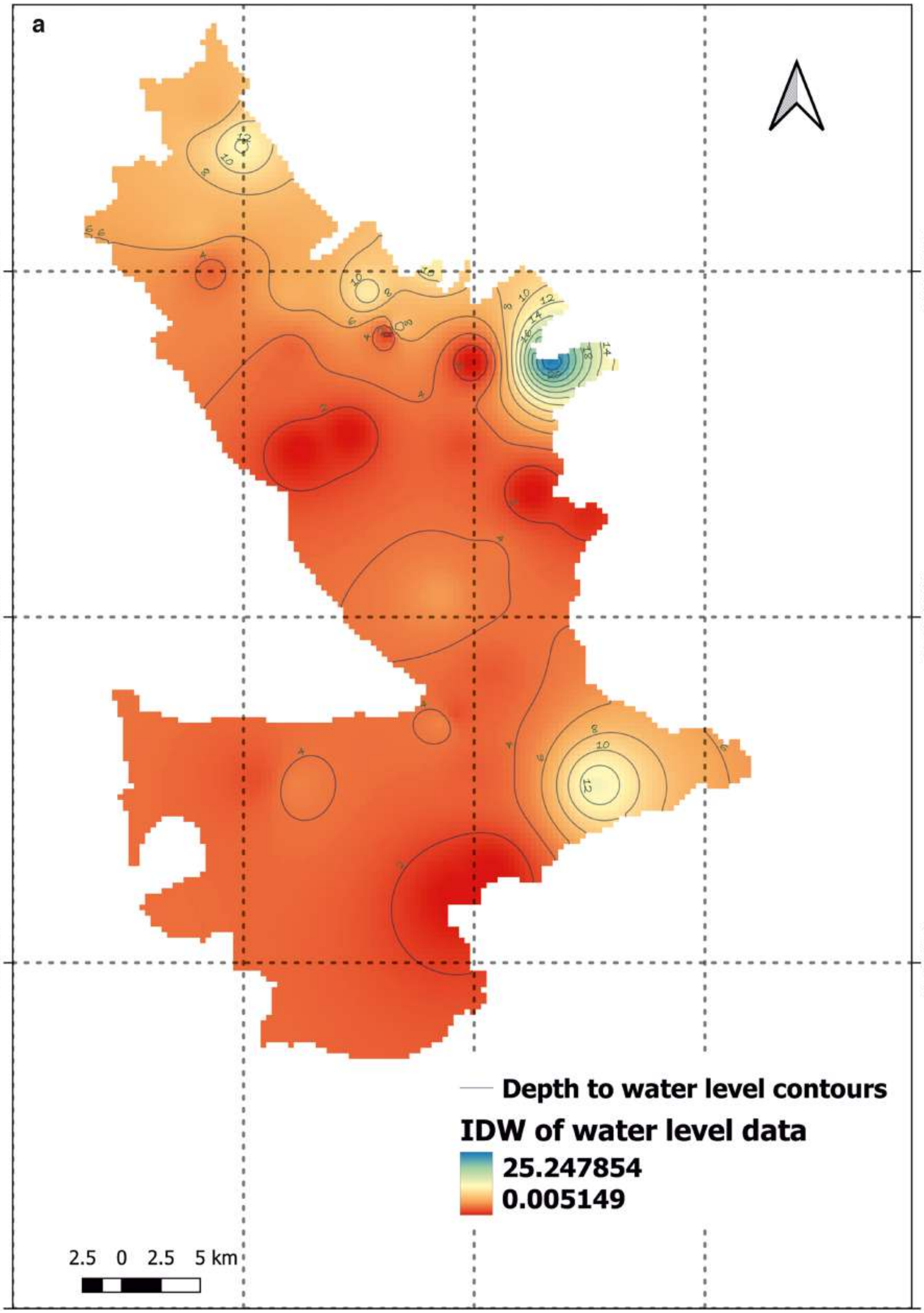
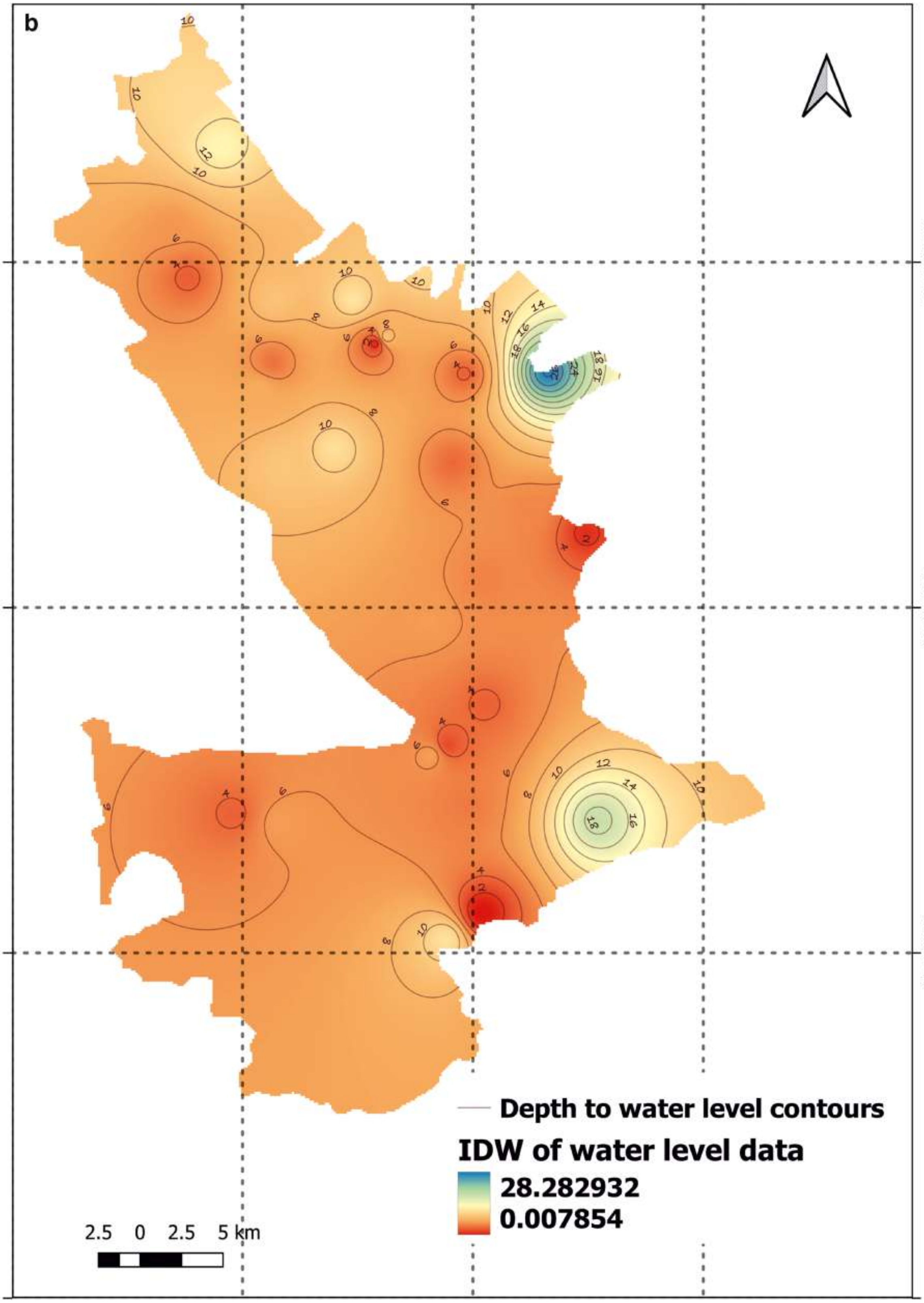


Fig. 6 **a** Water level map of Rupnagar of year 2000. **b** Water Level map of Rupnagar of year 2008. **c** Water level map of Rupnagar of year 2016



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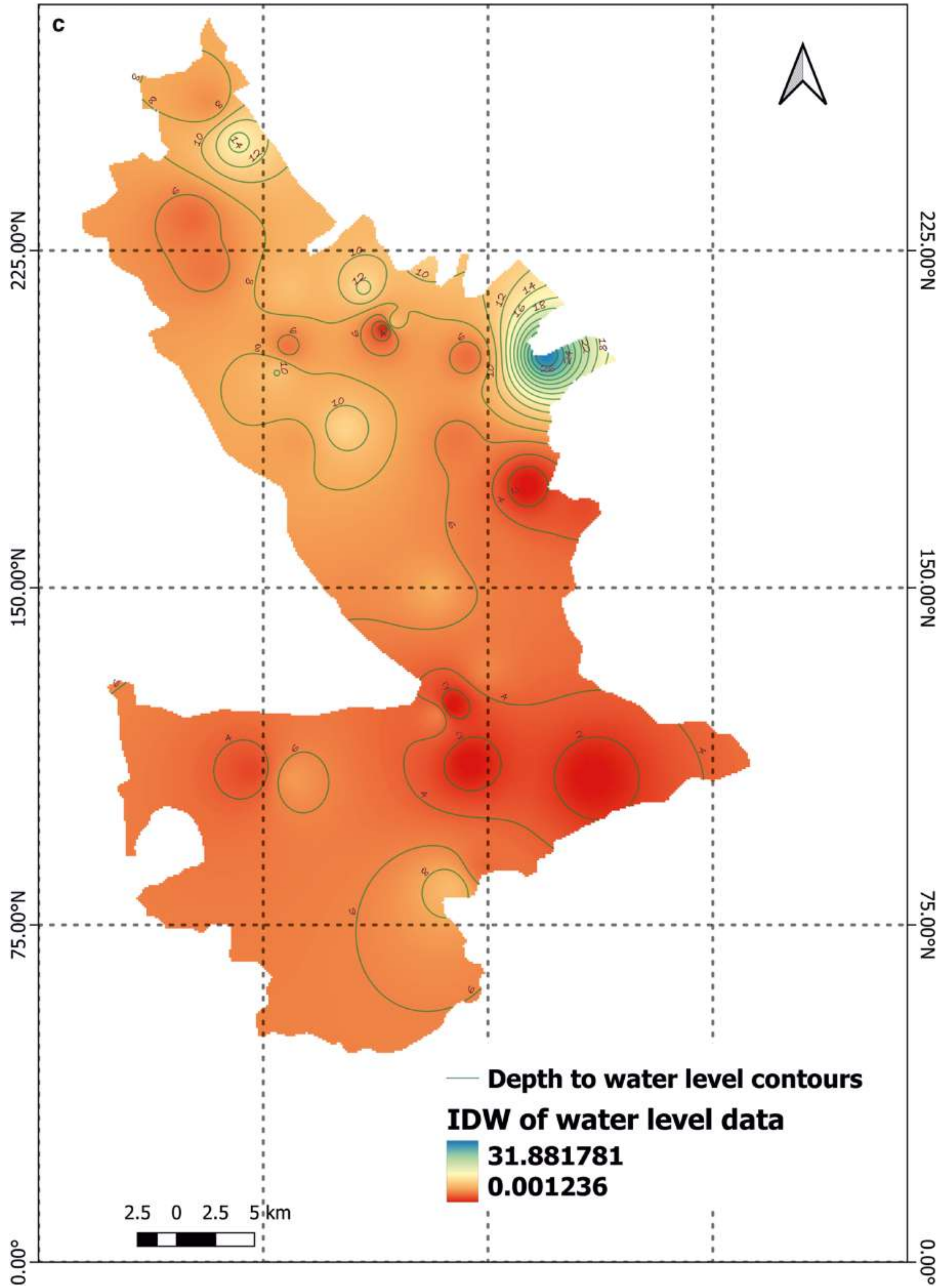

Fig. 6 (continued)

Table 1 Health-risk assessment on basis of ADD, HQ and CR

	ADD minimum, maximum and average (mg/kg/day)	HQ minimum, maximum and average	CR minimum, maximum and average
Children	8E-04, 7.28E-03,1.61E-03	2.67, 24.27, 5.35	1.2E-03, 1.09E-02, 2.41E-03
Adult	5.75E-04, 5.23E-03, 1.15E-03	1.92, 17.44, 3.85	8.63E-04, 7.85E-03, 1.73E-03

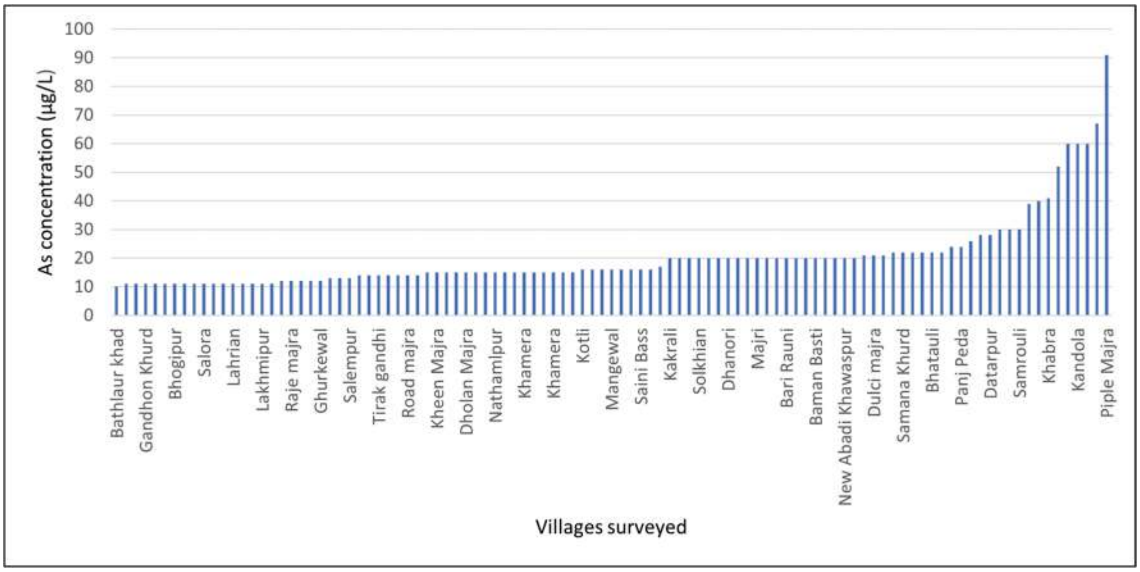

Fig. 7 Bar diagram showing arsenic concentration in Rupnagar district

vary uniformly with depth. As concentration of 11 µg/L is reported from a depth of 200 m, whereas high As concentration of 67 µg/L is reported from a depth of only 37 m in the study area (supplementary data table). Although a large portion of the study area is agricultural land, no direct correlation of high As concentration in groundwater with agricultural activity has been observed in the highly As-polluted south-western part and other parts too. So, high As in this district is assumed to be caused due to natural mechanism as no signature of anthropogenic impact has been observed here. Detailed geochemical study including assessment of PO_4^{3-} content in the sediment in this area needs to be performed for better understanding of the exact source of this high concentration of As in groundwater. Health-risk assessment for As indicates high potential of carcinogenic as well as non-carcinogenic risk for the consumers especially the children who are regularly using this As-rich groundwater for drinking purpose. Based on As concentrations in groundwater, Piple Majra village is at the highest risk among all the villages studied in this district (Fig. 7). Hence, proper mitigation strategies are required to be taken up immediately to ensure safe drinking water and lower the HQ for the consumers in the study area. As is well distributed in this district. So, the only way to secure potable groundwater for the consumers is As-removal technique with combined *oxidation, coprecipitation and adsorption* methods. Mass awareness is necessary step in this regard. *Artificial recharge* is also very important in order to conserve water and increase the recharge of the aquifers. Moreover, there should be operation enforcement of groundwater legislation laws and the farmers should be involved in cultivation of less water-consuming crops using proper agricultural planning.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11356-023-27247-z.

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Author contribution Gopal Krishan is responsible for conceptualization of this paper and helping the corresponding author for its planning and execution. Srijita Ghosh focused on writing this paper and analysis of the data using statistical and modelling techniques. Hardev Singh Virk is responsible for collection and curation of data used in the paper and its revision. All authors have worked as a team in planning its execution.

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Data availability The data used in this paper has been made available by Department of Water Supply and Sanitation (DWSS), Govt. of Punjab, from its Regional Water Testing Laboratory (RWTL) based in Phase II, Mohali (Punjab).

Declarations

I have not submitted my manuscript to a preprintserver before submitting it to Environmental Science and Pollution Research.

Ethical approval Not applicable.

Consent to participate All the authors give their consent to participate equally in this endeavour.

Consent to publish All of the authors give their consent to publish this work.

Competing interests The authors declare no competing interests.

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