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ORIGINAL ARTICLE

Groundwater quality analysis of quaternary aquifers in Jhajjar District, Haryana, India: Focus on groundwater fluoride and health implications

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Abstract Several types of health problems in Jhajjar district of Haryana state are prevailing owing to groundwater quality problems such as high concentration of fluoride, chloride, salinity, TDS, etc. The objective of this work was to assess the overall groundwater quality of the district based on Water Quality Index (WQI), and find out the factors leading to continuous deterioration in groundwater quality. The study demonstrates that groundwater quality of Jhajjar district is totally unsuitable for drinking purposes and is directly or indirectly influenced by geogenic factors. About 60–70% of the samples analysed show high fluoride content. Other parameters such as hardness, electrical conductivity, Total Dissolved Solids (TDS), and Chloride are also above the permissible limits. Hydrogeologically the study area belongs to Indo-Gangetic alluvial plains, which are dominated by clay-silt, clay and grey micaceous sand formations. Clay rich formations are rich in fluorine and other salts and their weathering is most probably causing the continuous escalation in the fluoride and salinity concentration in groundwater. Several in-situ and ex-situ measures have been suggested for remediation and to prevent further escalation of water quality problems that are needed imperatively for the sustainable development of water resources.

1. Introduction

Groundwater is the major source of water in India. About 80% of domestic water requirements in rural areas and 50% in urban areas are fulfilled by groundwater but owing to large population and over exploitation, water resources are depleting very rapidly [29]. In countries like India, where population exponentially increases [7], approximately 165 billion litres of water is required per day but the shortage of water resources leads to situation where 54% of India faces high to extremely high water stress conditions [27]. As per the Central Ground Water Board, the overall stage of groundwater development in the country is 62% [9]. Approximately 17% of the locations evaluated by CGWB are in the stage of over-exploitation, 3% critical, 10% semi-critical and 68% units are Safe. CGWB assesses the groundwater conditions based on stage of groundwater development for that area and is computed using the following formula:

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$$\text{Stage of groundwater development} = \frac{\text{Existing Gross Draft for all uses}}{\text{Net Annual Groundwater Availability}} \times 100$$

These values are more than 100% for the states of Delhi, Haryana, Punjab and Rajasthan; this signifies that the annual groundwater consumption is more than annual groundwater recharge in these states [8]. Besides depleting resource, another major issue with groundwater is declining quality in India. In 2015, World Resource Institute (WRI) measured water quality of India using India Water Tool (IWT 2.0) based on Bureau of Indian Standards (BIS) limits [6] and evaluated the IWT's 632 groundwater quality districts, and only 59 are found within BIS limits [27]. The previous reports and studies published also indicate the poor quality of groundwater throughout the country [10].

The quality of groundwater is contaminated mainly due to two reasons. One is addition of contaminants due to anthropogenic activities (called as anthropogenic contamination) and other is contamination due to the presence of natural minerals within the aquifer. There are several contaminates, such as Arsenic, fluoride, Chloride, Nitrate, Iron and Manganese, Uranium, Radon and Strontium, Chromium, and Selenium which are reported in groundwater due to geogenic contamination [9]. Amongst these, fluoride is the most widespread contamination in India [9]. The type of contamination is caused due to dissolution of soluble products of weathered rocks. The rocks are made up of minerals and chemical reactions such as weathering, dissolution, precipitation, ion exchange and various biological processes commonly take place below the surface release several ions and this cause natural contamination of groundwater. The degree of geogenic contamination in groundwater is highly dependent on the nature of the aquifers, climatic conditions, porosity of the soil and land use patterns [9,14,25,21].

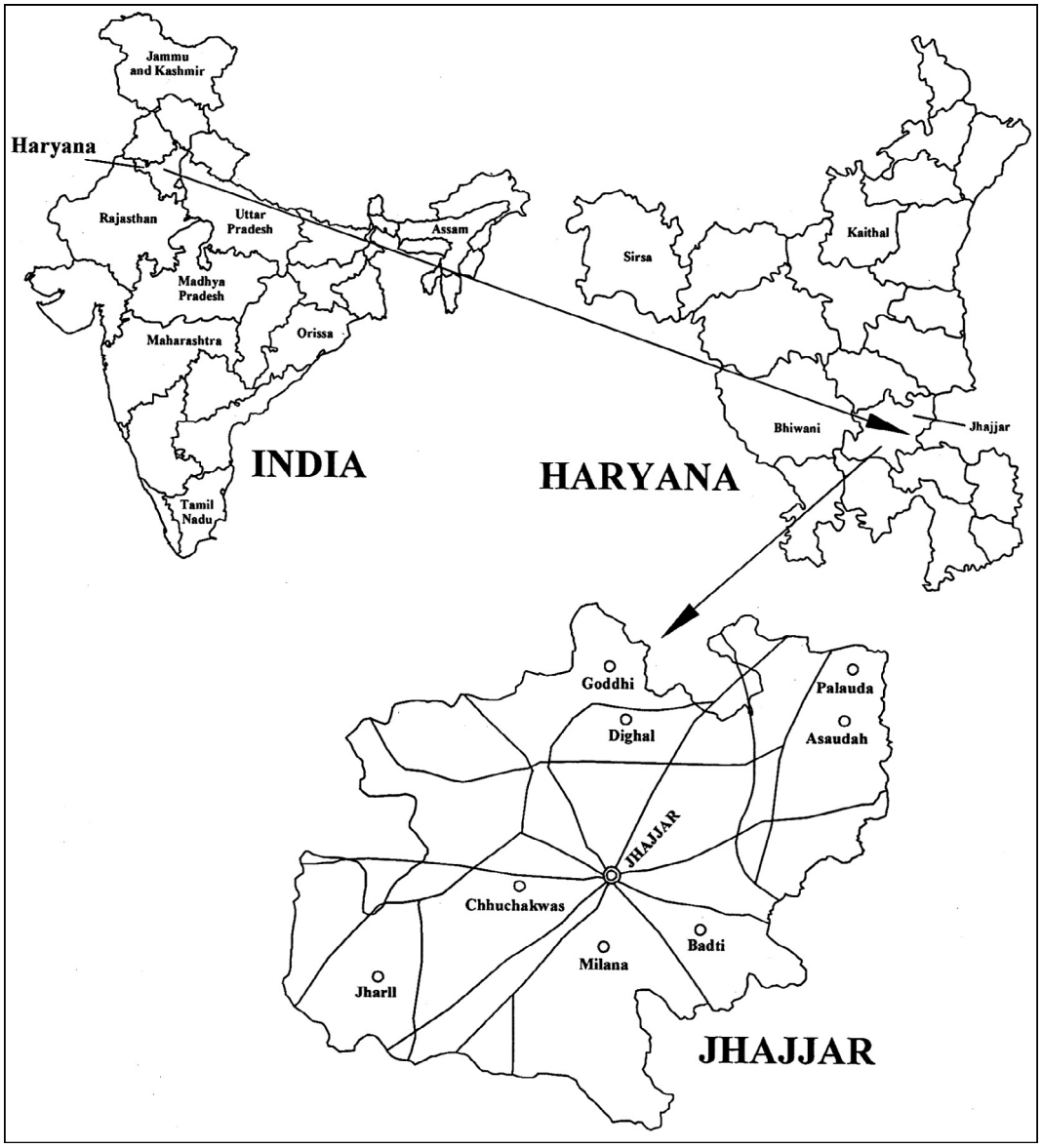

Figure 1 Location of Jhajjar district in Haryana, India.