



Major ion chemistry of the ground water at the Khoda Village, Ghaziabad, India



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ABSTRACT

The ground water quality in and around the Khoda village, Ghaziabad, India, has been evaluated for sustainability and its suitability for drinking, domestic and irrigation purposes. A total of 184 ground water samples were collected from India Mark II hand-pumps during pre-monsoon (March 2011) and post-monsoon (October 2010) periods, respectively. All the samples were analyzed for 29 physicochemical water quality parameters. According to the Soltan's classification, the majority of the samples were normal sulfate, normal bicarbonate and normal chloride types, respectively, during pre- and post-monsoon seasons. Base-exchange, meteoric genesis, Langelier saturation and Ryznar stability indices were also estimated. The total ionic dominance (meq/L) pattern follows the order $\text{Na}^+ > \text{HCO}_3^- > \text{Cl}^- > \text{Mg}^{2+} > \text{SO}_4^{2-} > \text{Ca}^{2+}$. Piper trilinear and Chadha's rectangular diagrams indicated that alkali metals ($\text{Na}^+ + \text{K}^+$) exceed alkaline earth metals ($\text{Ca}^{2+} + \text{Mg}^{2+}$) and anions of strong acids ($\text{SO}_4^{2-} + \text{Cl}^-$) dominate over anions of weak acids ($\text{HCO}_3^- + \text{CO}_3^{2-}$), suggesting that this water is of the $\text{Na}^+ - \text{Cl}^-$ and Na_2SO_4 types. Ground water suitability for irrigation was assessed using electrical conductivity and percent sodium, the US Salinity Laboratory's diagram, residual sodium carbonate (RSC), salinity index, chlorinity index, sodicity index, Kelly's Index and magnesium hazard.

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1. Introduction

Ground water is a significant water source in many parts of India, especially in semiarid and arid regions (Adhikary et al., 2010). Drastic population increases, land (agricultural and industrial) use applications and increasing water supply demand have limited the quality and quantity of Indian ground water resources. Urban aquifers are the only natural resource for drinking water supply but they are often considered less relevant for the drinking water supply. This leads towards drinking water scarcity and increasing pollution which reduces potability (Dixit et al., 2005). Once aquifer contamination occurs from agricultural, industrial and urban development, it can persist for hundreds of years because of very slow water movement in aquifers (Jerry, 1986). Ground water chemistry determines its use for domestic, irrigation and industrial purposes. This mandates investigations of aquifer quality of the study area.

About 50% of the total irrigated area in India is dependent upon ground water (CWC, 2000) and ~60% of irrigated food production depends on ground water wells (Shah et al., 2000). Ground water for drinking purposes is generally evaluated by comparing its quality with drinking water standards established by national and international bodies. Ground water

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sustainability is threatened by poor understanding about the risks of depletion and quality deterioration, both for irrigation and potable purposes. Intensive farming together with the lack of indigenous water quality chemical characterization among farmers, absence of policies encouraging sustainable water use in rural areas intensifies the problem. If ground water sustainability is defined as the “development and use of ground water in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social consequences (Alley et al., 1999), then unsustainable resource use is leading to lowering of water table, reduction in river flows and serious pollution levels of both ground and surface waters after 30–40 years of intensive farming in the Indo-gangetic plains (Garduño et al., 2011; Singh et al., 2006, 2012).

The main objective of this study, a component of long term program to sensitize farmers and policy makers towards sustainable use of ground water, was to evaluate the ground water quality in and around Khoda village of Ghaziabad District, Uttar Pradesh, to find its suitability for drinking, domestic and irrigation purposes. Ghaziabad is very densely populated urbanized district. Its urban population is nearly three times that of the state's average, due to rapid industrialization over the last two decades (Waheed, 2008). A review of Ghaziabad's ground water quality literature has not been fully attempted (Singh et al., 2012). Furthermore, the aquifers in the alluvial region in the northern Indo-gangetic planes are more prone to anthropogenic contamination because of its dense population and intensive agricultural and industrial activities. An adequate anthropogenic ground water pollution data base of this alluvial region is needed, which should include domestic, industrial as well as agricultural activities.

Anthropogenic activities have altered ground water quality around the Khoda, a village with over 18907 households and a population of ~99,506. Khoda lies adjacent to a Ghazipur solid waste dumping site, where contaminants may leach into the ground, percolate and alter the ground water quality (Mor et al., 2006) [Fig. 1]. Therefore, this area's water quality must be defined before use for drinking, agricultural and industrial purposes. Herein, attempts are made to ascertain this ground water's quality for sustainability. This detailed investigation reports the major ion chemistry and identifies hydrochemical processes responsible for ground water protection and its seasonal variations. Ground water samples were collected during post-monsoon (2010) and pre-monsoon (2011) seasons from the Khoda village region of the Ghaziabad district. The Piper, Chadha and US Salinity Laboratory (USSL) classifications were used to evaluate ground water hydrochemical characteristics. The sodium absorption ratio (SAR), %Na and RSC were also determined to define this water's suitability for irrigation. Ground water was classified according to the variations discussed above. Various options for sustainable use of water resources have also been discussed.

2. Materials and methods

2.1. Study area

The study area of Khoda village region lies between 28°36' to 28°38' N latitude and 77°20' to 77°21' E longitude (Fig. 1) with an area of ~9 km² and is located ~15 km from Ghaziabad city (Census, 2001). Ghaziabad is a planned industrial city in Uttar Pradesh, lying on the Grand Trunk road about 2.5 km from the Hindon river, between 28°40' to 28°67' N latitude and 77°25' to 77°42' E longitude (Fig. 1). It is bound on the north by the Meerut district, on the south by Bulandshahar and Gautambudh Nagar, on the south-west by Delhi and on the east by the Jyotibaphule Nagar district. Moreover, being in close vicinity to the national capital and several other big townships, urban and industrial waste disposal sites exist in the region.

Ghaziabad district is a monotonous flat plain cleft by the Hindon and Kali rivers and their tributaries. The fertile plain is dotted with barren patches of flat land having kankar pan at shallow depths and alkaline soil on the surface spread as white sheet. It may be categorized into (i) low lands or Khadar in the east and west of the Ganga and Yamuna rivers, (ii) the area lying in between the Ganga and Kali rivers (iii) the Doab region of Kali and Hindon rivers and (iv) the area lying in between the Hindon and Yamuna rivers (Waheed, 2008). The district lies in the sub-tropical division of deciduous vegetation and does not have expanses of natural forests. Scattered forests do occur in the low land (Khadar) around the Ganga and lower and upper Ganga canal (Waheed, 2008). Besides Ganga, Yamuna and Hindon rivers, there are some small rain-fed rivers including the Kali River. Ghazipur's landfill site which is very near to village Khoda, spreads over an area of ~70 acres (NIC, 2014).

Three tier aquifer system has been identified in the area. The first aquifer system extends to 125–200 metres below ground level (mbgl) while the second aquifer system exists between 170 and 350 mbgl. The third aquifer system extends to 350–450 mbgl (Singh et al., 2014; Verma, 2008–2009). The upper aquifer is the main source of water supply to the dug wells and shallow tube wells. The sub-soil water table depth in this area is ~10–15 m below ground level and the seasonal variation is about 5 m (Singh et al., 2014).

2.2. Sampling and analytical procedure

2.2.1. Sampling

Ground water samples from India Mark-II hand-pumps (#1–6, 8–17, 20–47, 49–92) and submersible pumps (#7, 18, 19 and 48) were collected after preflushing for 10–15 min in order to remove the stagnant water and to ensure that the ground

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