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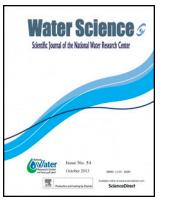

# Characterization of groundwater quality using water evaluation indices, multivariate statistics and geostatistics in central Bangladesh

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**Abstract**

This study investigates the groundwater quality in the Faridpur district of central Bangladesh based on preselected 60 sample points. Water evaluation indices and a number of statistical approaches such as multivariate statistics and geostatistics are applied to characterize water quality, which is a major factor for controlling the groundwater quality in term of drinking purposes. The study reveal that EC, TDS, $Ca^{2+}$, total As and Fe values of groundwater samples exceeded Bangladesh and international standards. Ground water quality index (GWQI) exhibited that about 47% of the samples were belonging to good quality water for drinking purposes. The heavy metal pollution index (HPI), degree of contamination ($C_d$), heavy metal evaluation index (HEI) reveal that most of the samples belong to low level of pollution. However, $C_d$ provide better alternative than other indices. Principle component analysis (PCA) suggests that groundwater quality is mainly related to geogenic (rock–water interaction) and anthropogenic source (agrogenic and domestic sewage) in the study area. Subsequently, the findings of cluster analysis (CA) and correlation matrix (CM) are also consistent with the PCA results. The spatial distributions of groundwater quality parameters are determined by geostatistical modeling. The exponential semivariagram model is validated as the best fitted models for most of the indices values. It is expected that outcomes of the study will provide insights for decision makers taking proper measures for groundwater quality management in central Bangladesh.


*Keywords:* Geostatistics; Hydrochemistry; Groundwater quality; Water indices; Central Bangladesh

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## 1. Introduction

Sustainable groundwater quality is important for drinking, irrigation and domestic purposes. Groundwater quality has become a major concern in Bangladesh (Shahidullah et al., 2000; Raihan and Alam, 2008; Bahar and Reza, 2010; Rahman et al., 2012a,b; Biswas et al., 2014). The central part of Bangladesh is facing the problem of declining groundwater quality due to several reasons such as shifting of river natural direction, improper management of water body, climatic variability and anthropogenic activities. Arsenic contamination and mobilization into groundwater also affect the water quality in central Bangladesh (BGS and DPHE, 2001).

However, heavy metals contamination is also of great concern on lives owing to their toxicity, persistence and bioaccumulation in central Bangladesh. Continuous monitoring and evaluation of the groundwater quality, thus helps to save lives and environment (McCutcheon et al., 1993; Meharg and Rahman, 2003; Islam et al., 2015). Islam et al. (2015) found that concentrations of Fe and Mn were found higher than other heavy metals in groundwater of Bangladesh. Although, groundwater pollution rate is not so high, groundwater is the only option for good quality water in Bangladesh. Accessibility of drinking water in Bangladesh has increased over the past decade, adverse impact of unsafe drinking water on health continues (WHO, 2004). Foster (1995) investigated that groundwater quality are posing great threat due to intensive use of natural resources and increased human activities (Fig. 1). Evaluation of groundwater quality is a complex process that undertaking numerous variables capable of causing various stresses on general groundwater quality. However, characterization of groundwater quality in central Bangladesh by using integrated appropriate methodologies is not yet to be carried out.

Therefore, this study has been designed to elaborately illustrate an integrated approach that includes drinking water indices, several pollution indices, multivariate statistics and geostatistics modeling to characterize the groundwater quality in the Faridpur district of central Bangladesh. Various researchers have tried to develop a wide range of WQIs for evaluation of groundwater quality; the choice of index depends on the groundwater input parameters and the desired results (Vasanthavigar et al., 2010; Singh et al., 2013; Tiwari et al., 2014; Shahid et al., 2014). For instant, water quality index (WQI) is an effective technique for assessing drinking water quality suitability in any area and to communicate the information on overall water quality. Heavy metal pollution index (HPI), heavy metal evaluation index (HEI) and degree of contamination ($C_d$) are used to evaluate the hazardous metal pollution in drinking water purposes (Prasad and Bose, 2001; Edet and Offiong, 2002). However, the WQI values have limitation, which cannot provide evidence of the pollution sources. The WQI values, thus have to be used together with heavy metal pollution index (HPI), heavy

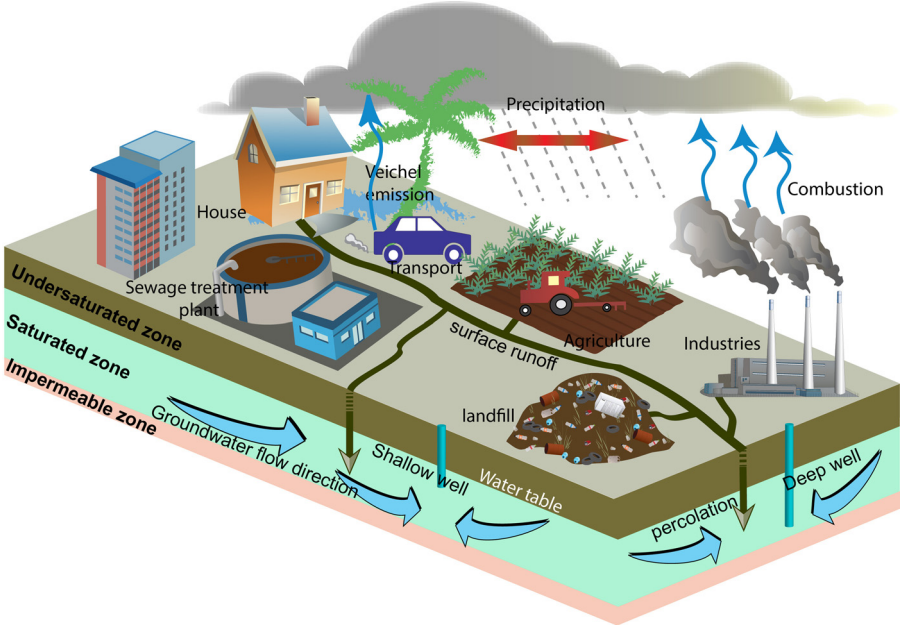


Fig. 1. Groundwater contamination depending on natural and anthropogenic activities.

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