

Assessment of groundwater contamination susceptibility based on water chemistry data - A review

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<Abstract>

Groundwater contamination susceptibility studies have many advantages in groundwater monitoring, management and future planning. Several methods have been developed and applied to the groundwater regime through out the world. However, each and every method has some limitations. In this study, a detailed review was carried out about the already existing methods for groundwater contamination susceptibility studies. Additionally, a new parameter called mineral dissolution factor is recommended for groundwater contamination susceptibility studies. This parameter is applied for groundwater contamination susceptibility studies in Namwon area, Korea. The result of this approach suggests that mineral dissolution parameter could overcome the limitations as observed in the earlier methods.

Key Words : Groundwater, susceptibility, mineral dissolution, Namwon, Korea

1. Introduction

The concept of groundwater susceptibility has been a useful tool in many risk assessment systems for groundwater pollution. It is an idea based on the fundamental concept "that some land areas are more susceptible to groundwater contamination than others" (Vrba and Zaporozec 1994). This approach is providing preliminary information and criteria for decision making in such areas as: designation of land use controls, delineation of monitoring networks and management of water resources in the context of regional planning as related to protection of groundwater quality (Bachmat and Collin 1990). Groundwater contamination susceptibility methods are classified into two major types: one is physical methods and the other is chemical methods. In the physical methods, DRASTIC is very familiar rank/score based method developed in USEPA by Aller et al., (1987). Similar index or score based systems were developed such as EPIK (Doerflinger et al. 1999), German method (Von Hoyer and Sofner 1998), GOD (Foster 1987), ISIS (Civita and De Regibus 1995), GIS

based method (Faye et al. 2004), SINTACS (Civita, 1994), AVI rating system (Van Stempvoort et al. 1993), AQUIPRO (Passero 1990), etc. Some of the researchers modified the drastic method and extended using other parameters.

The physical methods have a number of significant drawbacks: (1) Most of these vulnerability methods consider only vertical permeability and ignore possible contamination coming directly from streams and bypassing the soil and the unsaturated zone, which causes inaccurate assessments, (2) Data scarcity is another major problem in most of the vulnerability assessment methods, (3) Due to lack of knowledge in chemical and biological activity in the soil zone and the physical chemical character of percolating pollutants, all the methods are needed to validate by accurate field testing as well as groundwater quality data, (4) Results of these methods are validated only using nitrate and pesticides concentrations in groundwater (Aller et al 1987). Nitrate and organic compounds may be affected by chemical and biological activities, (6) Few methods are site specific like EPIK method. Further, some of the researchers identified some drawbacks during validation of the physical methods. Napolitano and Fabbri (1996) carried out a sensitivity analysis to evaluate a single parameter influence on the aquifer vulnerability assessment in Piana Campana region and concluded that all the seven DRASTIC parameters are important in assessing aquifer vulnerability. Gogu et al. (2003) compared five different methods and suggested that reducing the number of parameters is unsatisfactory and the various methods produce very different results at any given site. Few chemical methods are reported for groundwater contamination susceptibility studies: Contamination Index (Rapant et al. 1995), IAWQ (Index for Aquifer Water Quality) (Melloul and Collin 1998), etc. In the case of Contamination index method, it consider both the number of parameters exceeding the upper permissible limits or guide values of the potentially harmful elements, and the concentration exceeding these limit values. In IAWQ model, ratings of the chemical parameters are based on WHO or regional standard. However, weights of the parameters are decided like DRASTIC and validated by nitrate.

In the present study, groundwater susceptibility to contamination was determined by water chemistry data. In this approach, we assumed that highly mineralized water is less or no susceptible for contamination. Based on this concept, some ionic ratios were used to differentiate the mineral dissolution and anthropogenic contamination.

2. Implication for groundwater contamination susceptibility :

A case study in Namwon

Namwon is located in the western part of the Korean Peninsula. The groundwater in this area is susceptible to agricultural and urban pollution due to different land use pattern, especially agricultural activities. For this study, 279 groundwater samples were collected from 93 wells during March 2002, August 2002, and February 2003. Electrical conductivity (EC), pH, dissolved oxygen (DO), and temperature were measured directly in the field. Major ions, NO₃ and dissolved silica were analysed in the lab.

The results of the chemical analysis indicate that the water chemistry of this area is mainly controlled by mineral dissolution and anthropogenic activities. To identify and differentiate these

processes, the ratios such as $(TC-Cl)/Alkalinity$, $(Na+K)/(Cl+NO_3)$ and $(Ca+Mg)/Alkalinity$ were used. If the mineral dissolution is the dominating process, chloride corrected total cation ($TC-Cl$) is equal to alkalinity where as higher ratios indicate the contribution of other processes. The plot of $(Na+K)/(Cl+NO_3)$ versus $(Ca+Mg)/Alkalinity$ (Fig.1) shows two different reaction pathways. One is parallel to X axis and illustrates excess sodium and potassium over chloride and nitrate. Where as, the other parallel to Y axis define the excess calcium and magnesium over alkalinity. Excess calcium and magnesium over alkalinity might be derived from anthropogenic activities; where as excess sodium and potassium indicate dissolution of silicate minerals. Nitrate and chloride concentrations are also supporting our assumption. It clearly shows that highly mineralized groundwaters are less susceptible to pollution. Hence, ionic ratios related to mineral dissolution ($(Ca+Mg)/Alkalinity$, $(Na+K)/(Cl+NO_3)$, $(TC-Cl)/Alkalinity$) are very good tool for groundwater susceptible studies.

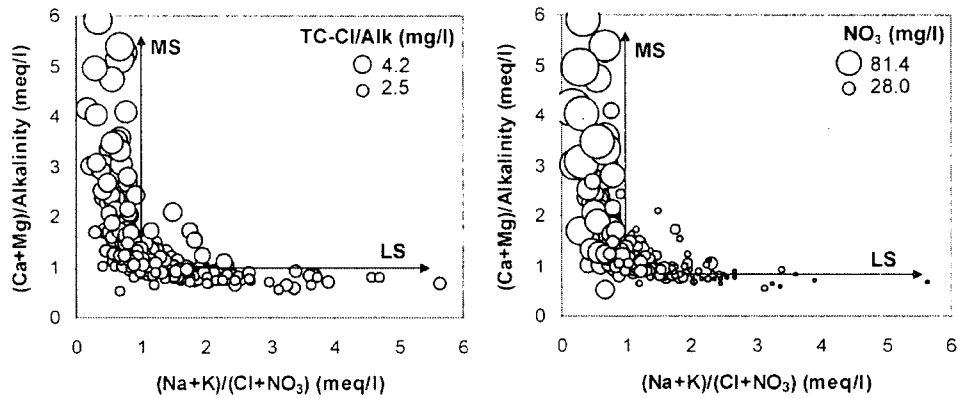


Fig. 1. Relation between ionic ratios and groundwater contamination susceptibility.

LS = Less susceptible wells, MS = More susceptible wells

3. Conclusion

Groundwater contamination susceptibility studies are useful tool for groundwater management and future planning. Several methods have been developed for this study and applied throughout the world. However, each method has some limitations. In this study, a detailed review was carried out about the already existing methods for groundwater contamination susceptibility studies. Additionally, a new parameter called mineral dissolution factor is recommended for groundwater contamination susceptibility studies. This parameter is applied for groundwater contamination susceptibility studies in Namwon area, Korea. The result of this approach suggested that mineral dissolution parameter is suitable for groundwater contamination susceptibility studies and it over comes the limitations as observed in the earlier methods.

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