Effect of Land Use Type on Shallow Groundwater Quality

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Abstract

Groundwater monitoring wells (about 70 wells) were extensively installed in 28 sites surrounding Lake Texoma, located on the border of Oklahoma and Texas, to assess the impact of geochemical stressors to shallow groundwater quality. The monitoring wells were classified into three groups (residential area, agricultural area, and oil field area) depending on their land uses. During a two-year period from 1999 to 2001 the monitoring wells were sampled every three months on a seasonal basis. Water quality assay consisted of 25 parameters including field parameters, nutrients, major ions, and trace elements. Occurrence and level of inorganics in groundwater samples were related to the land-use and temporal change.

Key words: Land use, Geochemical stressor, Ground water, Monitoring, Lake

1. Introduction

The deterioration of groundwater quality due to the human activities can lead to adverse effects on human health and ecosystem. Groundwater containing extraneous nutrients and harmful chemicals may also degrade surface water quality by underground streams flowing into the lake. Modelling groundwater contribution to the lake inflow showed that maximum 50% of input to the lakes was groundwater (Lampert and Sommers, 1997). Inflow of nutrients and harmful compounds by groundwater into the lakes may deteriorate water quality and affect sensitive eco-system within the interaction areas between groundwater and surface water (Burton and Greenberg, 2000).

The Ground Water and Ecosystems Restoration Division (GWERD) of National Risk Management Research Laboratory (NRMRL) in U.S. Environmental Protection Agency has installed about seventy monitoring wells surrounding a watershed lake to monitor the groundwater quality seeping into the lake. Groundwater quality along the shoreline of Lake

Texoma was monitored for two years from the Fall of 1999 to the Fall of 2001 to identify the presence of ecosystem stressors in aquifers that may contribute the quality of shallow groundwater. The objective of this study was to investigate the vulnerability of shallow groundwater quality to geochemical ecosystem stressors surrounding the lake.

2. Methods

Water quality parameters measured were field parameters (dissolved oxygen, redox potential, ferrous iron, pH, conductivity), inorganics (nitrate, nitrite, ammonia, orthophosphate, sulfate, chloride), dissolved methane, dissolved organic carbon (DOC), methyl tert-butyl ether (MTBE), BTEX compounds (benzene, toluene, ethylbenzene and xylenes), and a suite of metals. Parameter analyses were compared between wells and between three-month seasonal durations. Land use has an intimate relationship with quality of both surface and ground water. The monitoring wells were classified into three groups, residential area, agricultural area, and oil field area, to understand the effect of land use on groundwater quality.

Protocol guidelines for containers, preservatives and subsequent laboratory analyses are listed in EPA/600/R-98/128 (USEPA, 1988). Samples were collected for laboratory analyses for nitrate, nitrite, orthophosphate, ammonia, sulfate, chloride, dissolved methane, dissolved organic carbon (DOC), volatile organic carbons (VOC) and some metals. Samples for the analysis of VOCs were collected in 40-ml glass VOA vials with lead-lined septa and trisodium phosphate was uses as preservative (Kovacs and Kampbell, 1999). All samples collected were stored in a cooler with blue ice and delivered the same day to the analytical laboratory.

Descriptive statistical analysis was performed for major groundwater quality components using statistical softwares, SPSS SmartViewer for Windows V.11.0 (SPSS Inc. Chicago, IL, USA) and Origin Pro 7.0 (OriginLab® Corporation, Northampton, MA, USA). Differences between groups of monitoring wells were tested for statistical significance using nonparametric statistics. The Sapiro-Wilk's test was conducted to test the normality of data. Because the monitoring data was not normally distributed in this study, nonparametric ANOVA (Kruskal-Wallis test) was performed on the data set for different land uses. Median, the 50th percentile of a sample, was calculated to identify the central tendency of the contamination level of each parameter. The distribution of parameter concentrations was expressed as a statistical graph boxplot. Scatterplots and Pearson product moment correlation coefficient (r) was used to show associations between related parameters.

3. Results

Inorganic profiles of samples collected in different areas of the lake showed differences with respect to ferrous-iron, redox potential and nitrate concentrations. Fig. 1 shows the ranges of ferrous-iron and redox potential for agricultural and residential areas. The ferrous-iron range of agricultural area was much lower than that of residential area while the redox potential range of agricultural area was relatively higher than that of residential area. Fig. 2 shows that the range and mean concentration of nitrate for agricultural areas were smaller than those for residential areas. Therefore, groundwater of the agricultural area showed lower levels of ferrous iron and nitrate than the residential area. The results indicate that property of land use would affect quality of groundwater and may imply that geo-chemical activity of agricultural area would be more apparent than residential area.

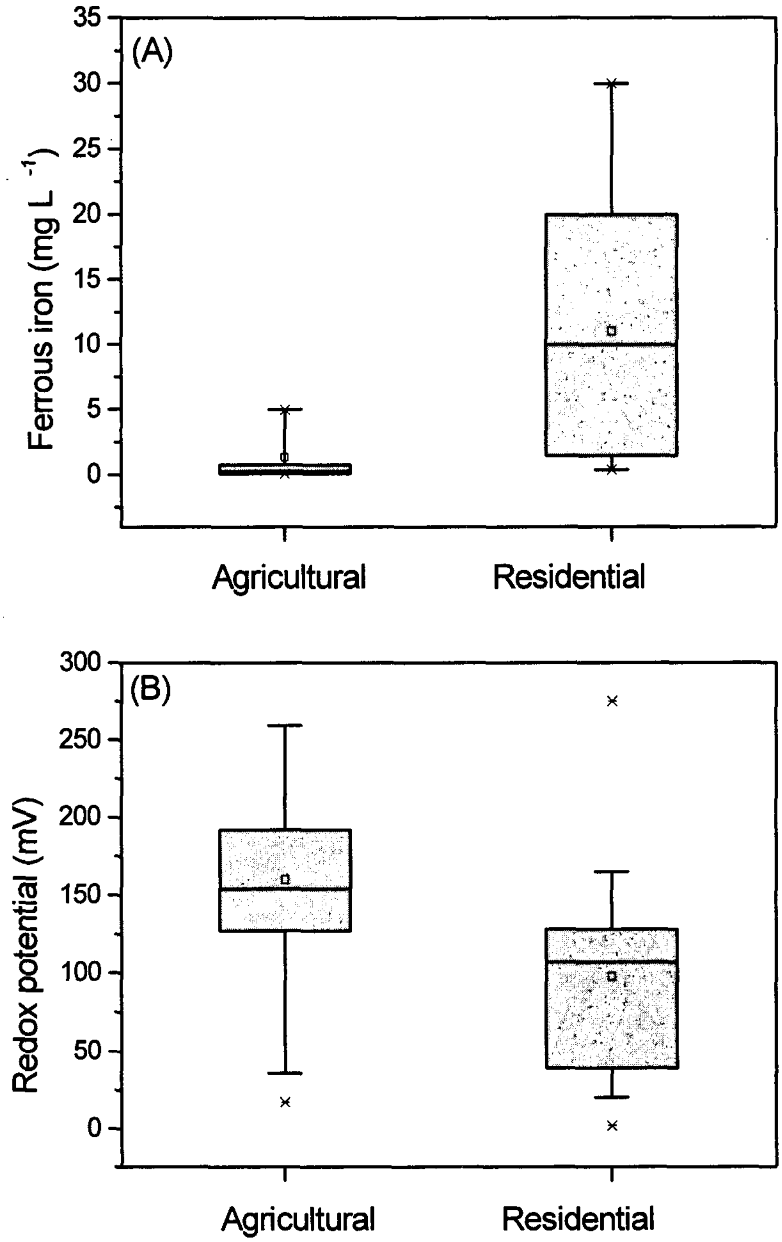

Fig 1. Boxplots showing the distributions of (A) ferrous iron and (B) redox potential for groundwater of residential and agricultural areas. Box ranges from 25% percentile to 75% percentile.

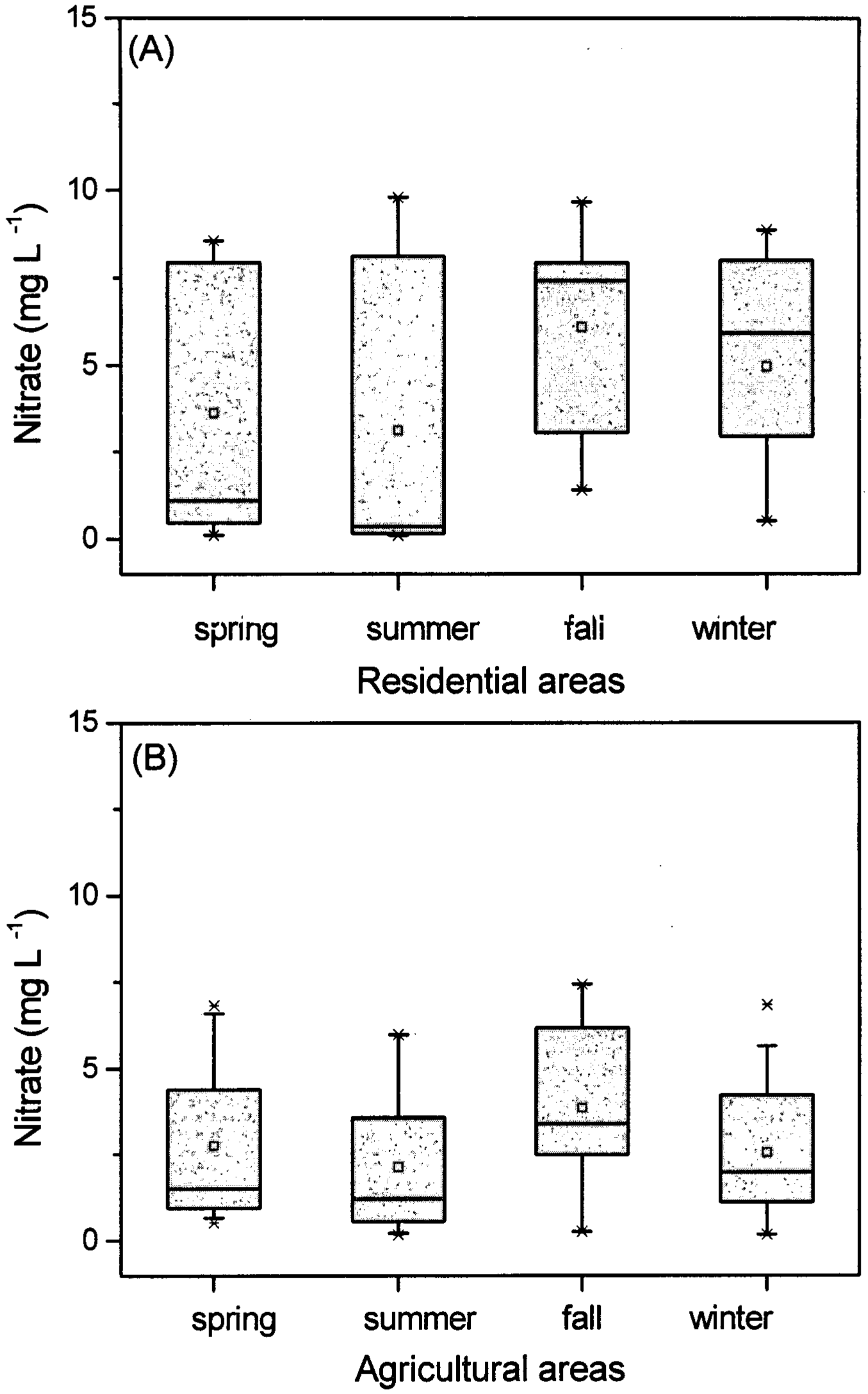

Fig 2. Boxplots showing the distributions of nitrate in groundwater for (A) residential and (B) agricultural areas on seasonal basis. Box ranges from 25% percentile to 75% percentile.

4. Conclusions

The monitoring well assessment did provide an understanding of groundwater quality in the Lake Texoma watershed as related to geochemical stressors. Occurrence and level of inorganics in groundwater samples were closely related to the land-use and temporal change. Inorganic profiles of samples collected in different areas of the lake showed differences with respect to ferrous-iron, redox potential and nitrate concentrations. Groundwater of the agricultural area showed lower levels of ferrous iron and nitrate than the residential area. The summer season data revealed more distinct differences in inorganic profiles of the two land-use groundwater samples. Groundwater of the agricultural area showed lower levels of ferrous iron and nitrate than the residential area, especially for summer season. The results imply importance of plant roots and its growth in nitrate and ferrous iron leaching groundwater. Nitrate of the residential area groundwater would be influenced by septic tank leaks and rainfall infiltration into the ground. Groundwater under oil production fields was higher in chloride, sodium, salinity, and conductivity, due to oil field brine, which is contained in the wastewater from oil well drilling. Overall, the shallow groundwater quality appeared to respond to regional geochemical stressors.

5. References

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