EFFECTS OF HYDROGEOLOGIC CONDITIONS ON GROUNDWATER CONTAMINATION OF CVOCS IN THE NORTH COAST KARST AQUIFER OF PUERTO RICO

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Abstract

The karst system of northern Puerto Rico is the most productive aquifer of the island. It serves freshwater to industrial, domestic and agricultural purposes, and contributes to the ecological integrity of the region. The same characteristics that make this a highly productive aquifer, make it vulnerable to contamination of groundwater. Of particular importance is contamination with volatile organic compounds (CVOCs), which have been related to preterm birth problems. A great extent of CVOC contamination has been seen in the North Coast of Puerto Rico since the 1970s. The main purposes of this study are (1) to relate the water quality of wells and springs with the hydrogeological conditions in the north coast limestone aquifer of Puerto Rico, and (2) to make a statistical analysis of the historical groundwater contamination in that area. To achieve objectives, groundwater samples are collected from wells and springs during dry and wet seasons. Results show that trichloroethylene (TCE), tetrachloroethylene (PCE) and chloroform (TCM) are frequently detected in groundwater samples. A historical analysis of contamination in the north coast of Puerto Rico shows a high capacity of the aquifer to store and release contaminants. Future work will focus on the statistical analysis of the historical groundwater contamination data to understand the behavior of the contaminants in different hydrologic conditions.

1. Background and Significance

• Karst groundwater systems are highly productive and provide an important source of fresh water for human consumption and ecological integrity.
• The same characteristics that make karst aquifers highly productive, make them highly vulnerable to contamination (Figure 1) and could serve as an important route of contamination exposures.

2. Objectives

• Analyze the temporal and spatial variations of the contamination of groundwater in that area.

3. Methodology

• Hydrologic Data Collection:
  - Daily precipitation collected from NOAA rented station (Manatí 2E).
  - Groundwater levels collected from USGS (Figure 3).
• Field Sampling and Laboratory Analysis:
  - Groundwater wells and springs were sampled from the Toe Bajo-to-Arecibo study area in northern Puerto Rico (Figure 4).
  - Two "dry" season sampling schedules (Season 1: March 2011 and Season 3- March 2012).
  - Two "wet" season schedules (Season 2-October 2011 and Season 4- October 2012).
• Analyzed for CVOCs using GC/ECD and common ions using ICP-OES. Chromatography.
• Tap water samples are collected throughout the year from human subject volunteers in the study area (Figure 5).

4. Preliminary Results

• Total sites sampled:
  - Groundwater: 11 sites in Season 1, 11 sites in Seasons 2 and 3 and 4.
  - Tap water: 77 sites (34/77 completed data).
• CVOCs were detected in Groundwater in the Toa Baja-to-Aguadilla area (Figure 6a) and Tap water (Figure 6b).
• Groundwater: Trichloroethylene (TCE), Tetrachloroethylene (PCE), and Chloroform (TCM).
• Water levels in wells are affected by the seasons and respond to precipitation.

5. Preliminary Results (cont.)

• Detection of CVOCs in groundwater trend to increase during wet season, with higher detection rate of TCE, PCE, and TCM compared to other seasons (Figure 7).

6. Discussion

• Groundwater levels in study area (Figure 8) respond to the changes in precipitation (Figure 9).
• Seasonal changes in groundwater levels are higher at the sites near the coastline, and may be attributed to the hydrological processes of the region. Seasonal changes in groundwater levels are also observed in the sites far from the coastline.

7. Conclusions

• Water levels in wells are affected by the seasons and respond to precipitation.
• Changes in CVOCs and nitrate detection during wet and dry seasons are under investigation, but are associated with the amount of water entering and flushing the system.
• Tap water also show high increases in CVOCs contamination during wet season, indicating a relation to groundwater contamination.

8. Future Work

• Study the historical groundwater contamination in the area and investigate the relation to the hydrologic conditions.
• Establish the relation of the behavior of the groundwater levels historically to assess the response changes in the amount of water moving through the system.

9. References

• Mazzanti, L. and S. Forand. 2012. Adverse birth outcomes and maternal exposure to trichloroethylene. Environmental Health Perspectives 120, no. 7: 980-986.