Modeling Cations in a Contaminant Plume in Groundwater

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A computer program was created using MATLAB to simulate the sorption and transport of major cations in a contaminant plume in groundwater. The results show that we can predict the fate of these interactive cations along a flow line. The model can be used to evaluate possible sources of nitrate with its accompanying cations, although the retardation of strongly sorbed cations prevents them from moving with the same speed as nitrate.

Groundwater is the only source for drinking water in Suffolk County. So, water quality control is a major concern. In recent years, the groundwater in some areas of Suffolk County has been found to be susceptible to nitrate contamination. Waste water from septic tank/cesspool systems and leachate from lawn fertilizer are considered to be the major sources of nitrate in Suffolk County groundwater. So identifying the sources of nitrate-rich contaminant plumes is the subject of interest.

Based on previous geochemical analysis of the groundwater on Long Island (Munster, 2004, and Bleifuss, et al), we think there is a possibility we can use cation as well as anion concentrations in contaminated groundwater to determine the sources of the contaminants whether lawn fertilizer or sewage .
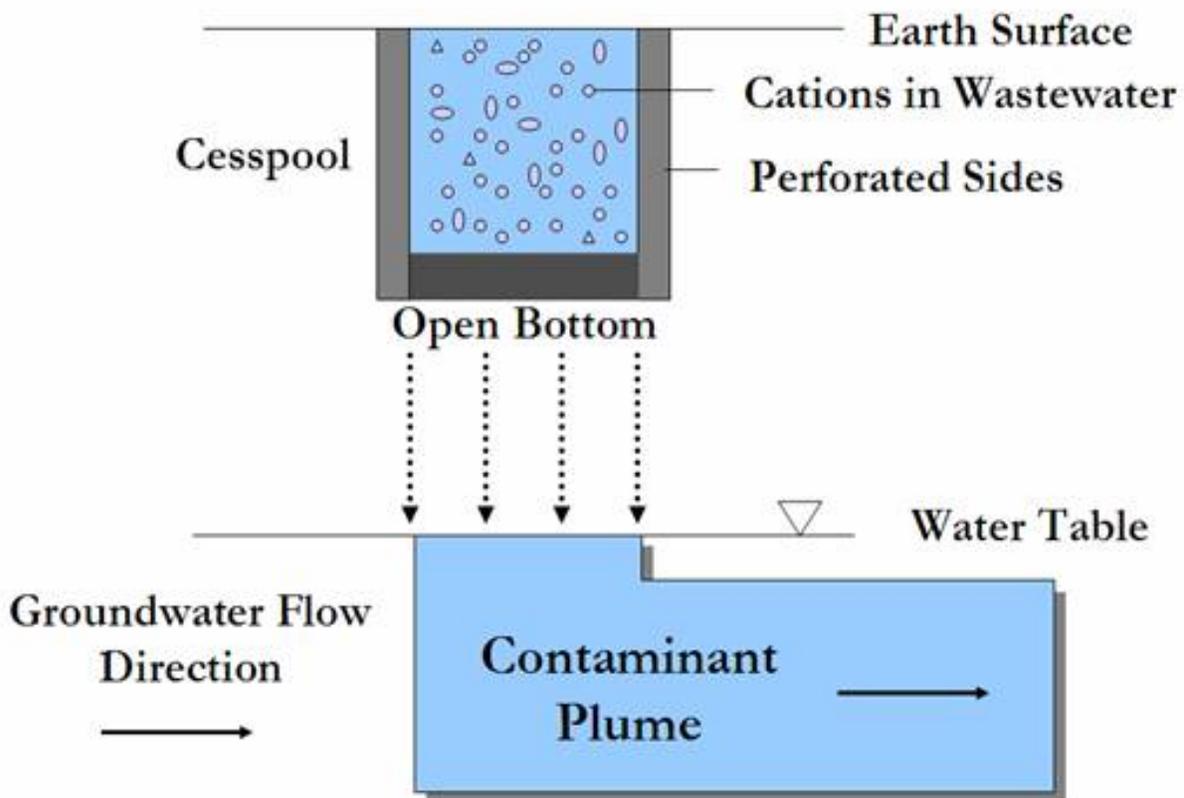
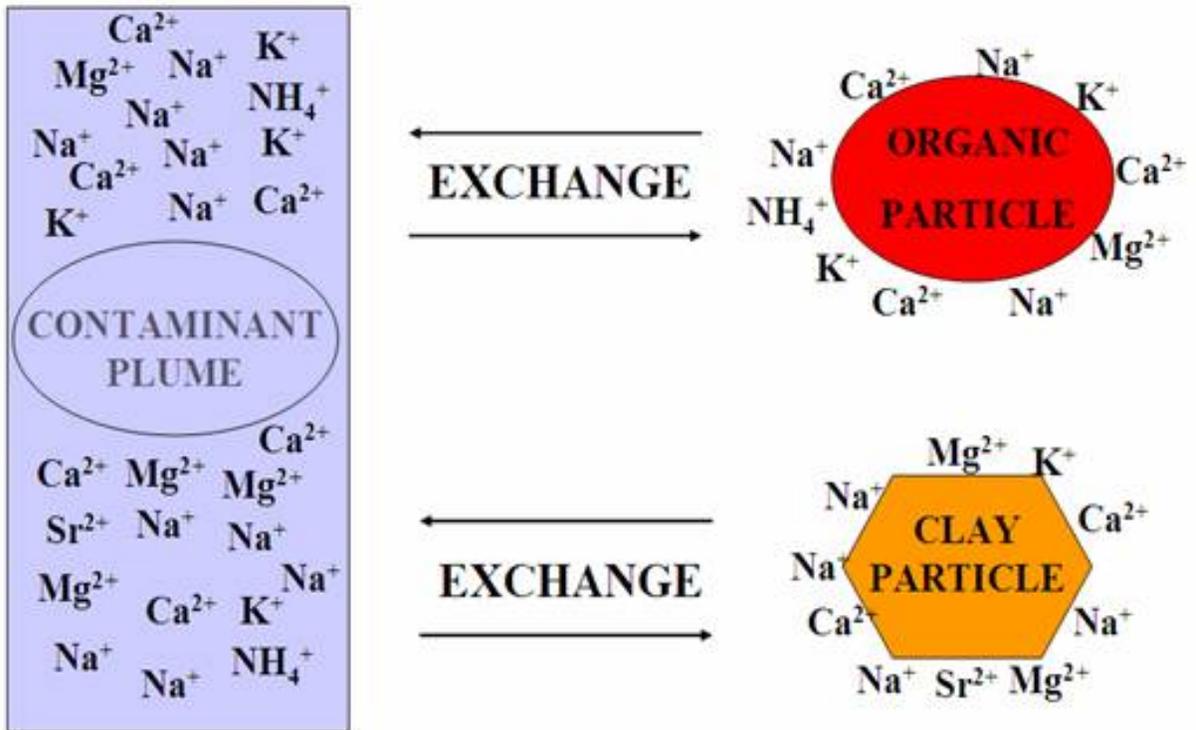**Fig 1. Transport of a contaminant plume from a cesspool**

**Figure 2 Cation exchange between a contaminant plume and sediments**

Table 1 Composition of initial groundwater and sewage in plume (Munster, 2004)

	Ca ppm	K ppm	Mg ppm	Na ppm
Sewage	20.87	10.85	5.08	43.04
Rain as initial Groundwater	0.32	0.28	0.22	1.56

In the model the plume consists of multiple sequential cells. Sorption is the main reaction of cations in groundwater. Before the contaminant plume enters the vadose zone, the cations in groundwater are equilibrated with those on the sediment surface. The cations in the contaminant plume come to equilibrium with the sediments in each cell before entering the next cell. Chemical exchange interactions are calculated simultaneously for the cations involved in each cell. The cells represent a portion of the flow path. They do not have an actual volume. The number of cells determines the resolution of the cation compositions in the plume. The larger the number of cells the more precisely the changes in composition within the plume can be determined.
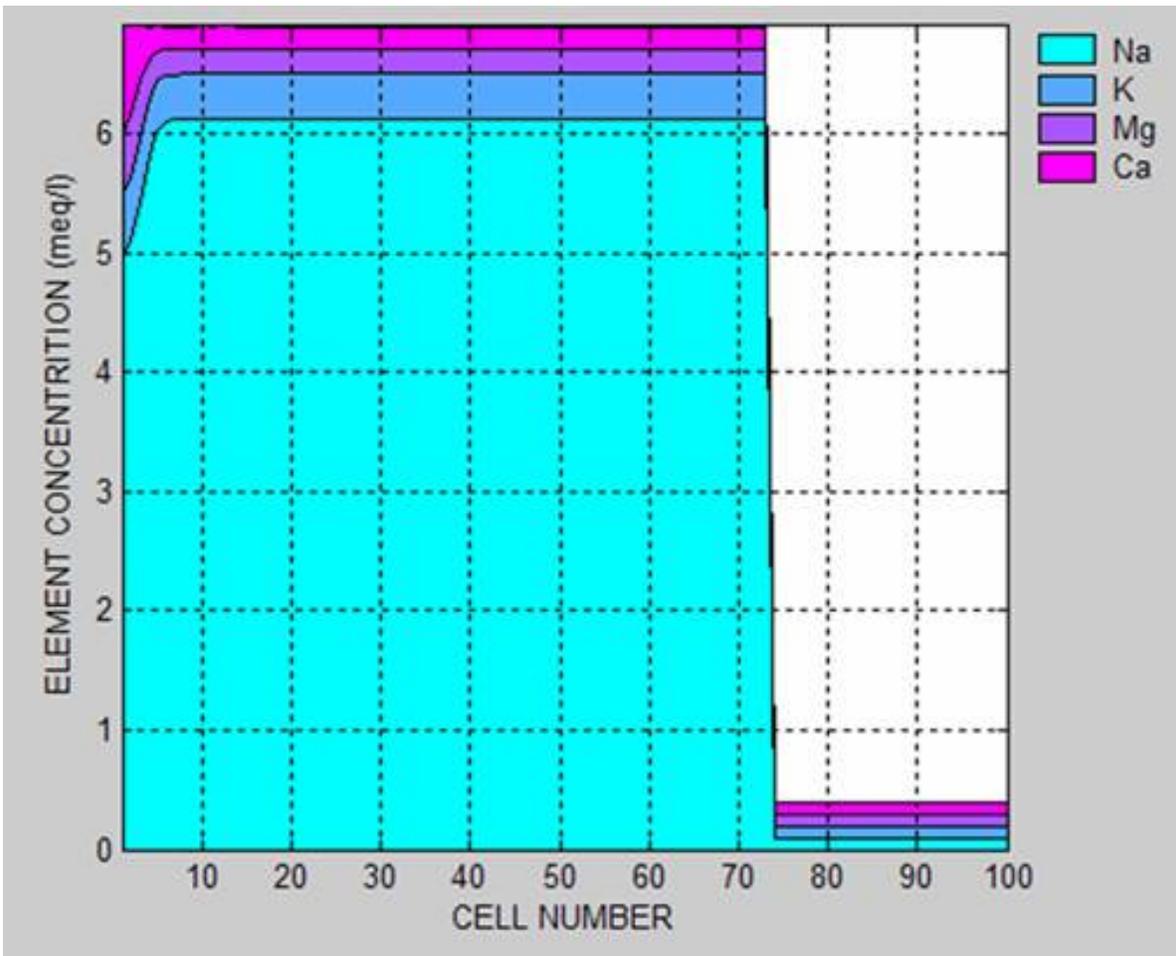
Figure 3. Concentration of cations within a plume after sewage first enters the system and has traveled 73% of the way through a plume with 100 cells. The composition of the front of the plume is controlled by the composition of cations sorbed from the initial groundwater and released during reaction of the sewage with the sediments.
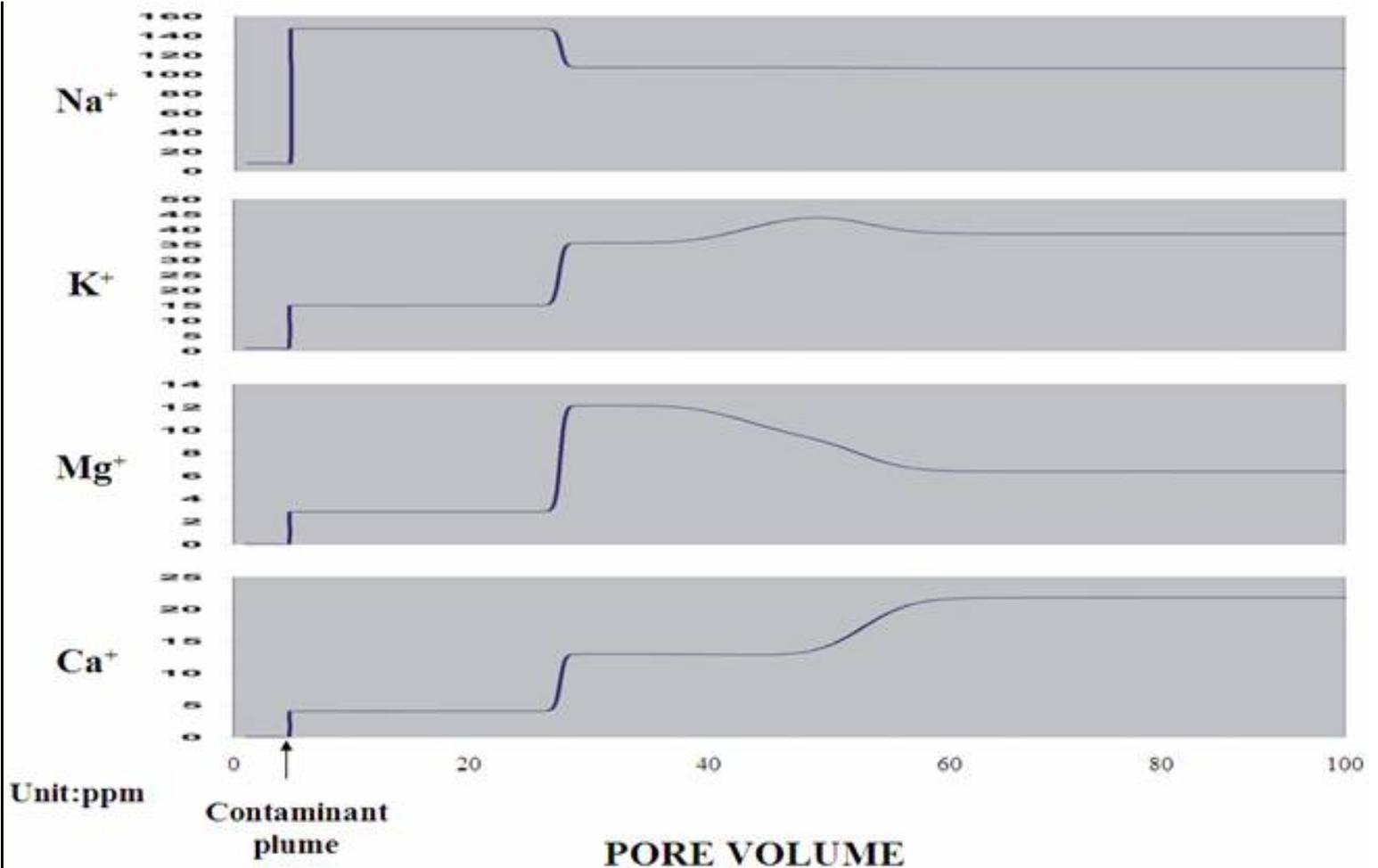
Fig. 4 Cation concentration at the front of a sewage plume from a cess pool. The contaminant plume enters the flow path at 5 pore volumes. The cation concentration of the plume immediately has the concentration of the original sewage but does not have the cation composition of the sewage.

The composition of the initial groundwater and the sewage plume are given in Table 1. The porosity is 30% and the cation exchange capacitiy is 1 milliequivalent per 100 grams of sediment (Boguslavsky, 2000). The graph in Fig. 3 shows the concentration in a sewage plume shortly after the sewage enters the plume. The graphs in figure 4 show how the concentration of cations at the front of the plume with increasing numbers of pore volumes of fluid passing through the plume. The concentration of cations along the path of the plume is that of groundwater until the front of the sewage plume arrives (see position of arrow labeled contaminant plume). The model assumes that the anions in the contaminant plume are conservative and travel at the same rate as the groundwater. As a result the front of the contaminant plume is shown by a sharp increase in both the anion and cation concentrations. However, while the proportion of anions is the same as that in the contaminant plume the proportion of the cations is not that of the contaminant plume but is controlled by the proportion of cations that are sorbed on the sediment particles from the initial groundwater. Eventually the cations in the contaminant plume will displace all of the initial groundwater cations on the particles and the proportion of cations in the plume will be the same as the original contaminant. In this case it requires 60 pore volumes before the composition of the plume has the cation composition of the sewage.

References Cited

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