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Evaluation of onsite sewage treatment and disposal systems in shallow karst terrain

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ABSTRACT

Two conventional onsite sewage treatment and disposal systems (OSTDSs) at Manatee Springs State Park, Florida, USA, were studied to assess their impact on groundwater quality in a shallow karst environment. Sulfur hexafluoride (SF_6) and fluorescein were used as tracers to establish connections between the drainfields and monitoring wells. Elevated nutrients were found in all wells where significant concentrations of both tracers were observed, with the mean of the highest nitrate (NO_3) concentration observed at each well being 47.8 ± 14.9 ($n = 11$) mg/L NO_3-N. The most elevated nutrient concentrations were found directly in the flow path of the effluent. Fecal coliform densities above 10 colony-forming units (cfu)/100 mL were observed in wells with the most rapid connection to the drainfield. The proximity and connectivity of the 0.4–4 m thick sandy surficial soils and the underlying karst aquifer allow rapid contaminant transport and limit the ability of conventional OSTDSs to attenuate NO_3.

1. Introduction

Onsite sewage treatment and disposal systems (OSTDSs) are an important part of Florida's wastewater infrastructure, serving about a quarter of the state's households and the 300,000 new arrivals per year (Social Science Data Analysis Network, undated; DOH, 2007). The proportion of homes served by OSTDS units is much higher in the rapidly growing, formerly rural areas of central and north Florida. In these areas, karst features, such as large springs, sinkholes, and caves, have formed in shallow limestone layers. These karst features have been shown to rapidly transport contaminants to and in the underlying groundwater (e.g. Price, 1988; Paul et al., 2000; Dillon et al., 1999, 2000).

Springs in most areas, except in national forests, have experienced degradation in water quality, particularly exhibiting elevated nitrogen concentrations (Florida Springs Task Force, 2006). While other sources such as fertilizer use, stormwater runoff, atmospheric deposition, and wastewater treatment plant discharge also contribute to water quality problems, the effects of conventional onsite sewage systems, consisting of a septic tank with a drainfield, have become of concern. The EPA has stated that "alternative systems may be necessary in karst areas" (EPA, 2006). In Florida, nutrient reduction is required for permanent onsite systems installed in the Florida Keys, where limestone is at the surface, lots are small, and allowable discharge methods include well injection (64E-6 Florida Administrative Code). In other karst areas of Florida, a larger drainfield is required when discontinuous limestone is encountered during site evaluation (DOH, 1999).

The objective of this study was to investigate the transport of septic tank effluent in shallow karst terrain covered by a sand layer, focusing on two goals. The first goal of this study was to examine the "connectivity" between the overlying

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sandy soil and the underlying karst aquifer. Two chemical tracers, SF_6 and fluorescein dye, were used to evaluate the subsurface flow pathways of the septic effluent and to unequivocally determine if the septic drainfield located above the karst and monitoring wells located within the karst aquifer are connected. The second goal of the study was to evaluate the conventional septic tank and drainfield method of OSTDSs in karst areas to determine if adequate removal of pathogen indicators and nutrients is being accomplished. Impacts of the septic drainfields on the surrounding groundwater quality were examined by comparing tracer and nutrient concentrations.

2. Methods

2.1. Site selection and description

The two study sites, Hickory and Magnolia, are located in wooded campgrounds within the Manatee Springs State Park on the lower Suwannee River (Fig. 1). Manatee Springs is a first-magnitude spring fed by an extensive cave system. Measured discharges have ranged between 3.1 and 6.7 m^3/s, and recent total NO_3 concentrations range between 1.7 and 2.0 mg/L NO_3-N (Scott et al., 2002; Florida Springs Task Force, 2006). The park had the advantages of being relatively isolated from outside sources of groundwater pollution, guaranteed access throughout the study, septic systems that were continuously in use, and the availability of local hydrologic data from the Suwannee River Water Management District.

The Lower Suwannee River Basin is part of Florida's karst area, where limestone, in this case Ocala limestone, has been dissolved to form solution channels (conduits), sinkholes, and springs. The lower Suwannee River is listed on Florida's impaired water list for elevated nutrient concentrations. Nitrogen and phosphorus are listed as co-limiting nutrients (DEP, 2002). Basin-wide, the contribution of OSTDS-derived NO_3 has been estimated to be less than 10% compared to other, largely agricultural, sources (Katz et al., 1999; DEP,

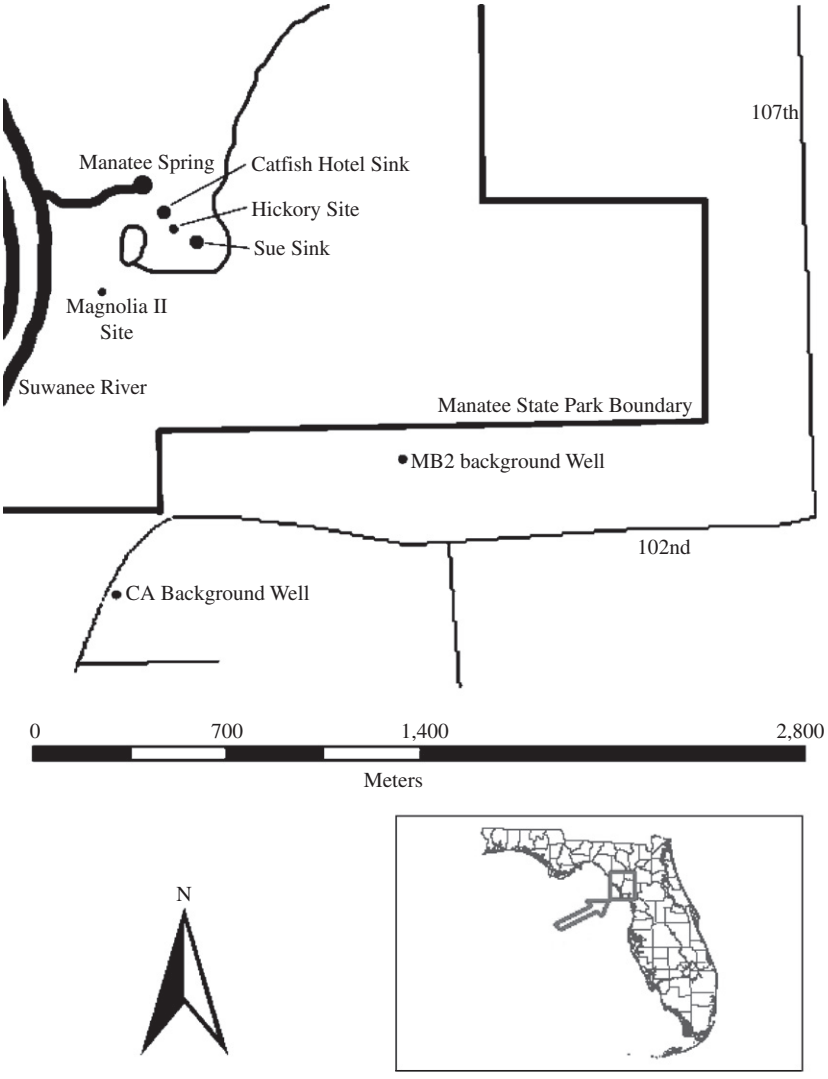

Fig. 1 – Map of study site. The two sites of study were the Magnolia II campground and the Hickory campground. The location of the site in the state of Florida, USA, is shown at the bottom of the figure.