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Effects of Monitor Well Purging Technique on Selected Chemical Properties of Surficial Groundwater

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Evaluation of groundwater quality is generally conducted by analysis of a representative sample collected by installation of monitoring wells (Nielsen 1991; Wilson 1995). Drinking water wells have been used for preliminary assessment and to determine the potential of groundwater contamination. However, the information on the construction details, i.e., depth of well, depth of casing, etc., are not always available for the drinking water wells. Furthermore, drinking water wells generally extend multiple aquifers and often contain large pore volume, therefore, require pumping large quantity of water to dispose the stagnant water in the well prior to sampling for analysis. Due to the above limitations, confirmation of groundwater contamination often requires installation of monitoring wells for sampling groundwater to analyze the concentration of the contaminant in question. The principle behind sampling monitor wells is to ensure that the sample collected is representative of the area, unlike sampling a drinking water well which represents stagnant water. The properties of water can vary considerably in stagnant water as compared to those of the water in the aquifer in its natural state.

To ensure collection of sample representative of the groundwater, the monitoring well is purged to dispose the stagnant water. There are no set standards on the number of well volumes to be disposed prior to collection of the groundwater samples from the monitoring wells (EPA 1985). Likewise, standard guidelines by the American Public Health Association (APHA 1992) simply recommend collection of water samples after pumping the well long enough to ensure that the sample collected was representative of the groundwater. Those guidelines do not specify the number of well volumes to be purged. However, the environmental agencies at the state level recommend variable standards with regard to the number of well volumes to be purged for sampling the monitoring wells. To ensure that the samples adequately represent the groundwater, the following guidelines are generally adapted as standard operation procedures (Gibb et al. 1981; Schuller et al. 1981): 1) measure the pH and electrical conductivity (EC) of water for each well volume and then collect the sample when the pH and EC

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values were stabilized, or 2) if the pH and conductivity measurements are not done in the field, purge four to six well volumes prior to collection of the sample.

Stabilization of groundwater properties is an indication that the sample collected is representative of the groundwater in that location. This evaluation is important for all groundwater monitoring studies for assessing the degree of contamination. The objective of this study was to examine the changes in chemical properties of groundwater, i.e., pH, electrical conductivity, and concentrations of nitrate, chloride, potassium, and sulfate, sampled from monitoring wells before purging and after purging each well volume for a total of five well volumes. The stabilization of the chemical properties of groundwater is the basis to decide the number of well volumes to be purged prior to routine sampling of the wells for evaluation of contaminant concentrations.

MATERIALS AND METHODS

This study was conducted in a citrus grove with 36-yr-old Valencia orange trees on Rough Lemon rootstock planted in an Astatula fine sand (Hyperthermic, uncoated, Typic Quartzipsamments) in Highlands County, FL. The study site consisted of two blocks of 33 ha each with different N management programs. Each block consisted of 52 rows of trees (7.62 m between the rows) with 172 trees per row at a spacing of 4.57 m. Four monitoring wells were installed in each of the two blocks; two wells per row, which are spaced 175.3 m apart. The spacings between the two wells within a row were 167 and 203 m in Block 1, and 207 and 257 m in Block 2. The screened portion of the monitor wells were installed 2.0 m into the surficial aquifer. The depth of Vadose zone varied from 1 to 6.4 m depending on the surface topography within the field.

Sampling of water at bi-weekly intervals began 4 wk after installation. During each sampling, the depth of water table was measured using an electronic indicator meter. The volume of water in the well was calculated. A tygon tube was lowered to the bottom of the well and the well was purged at a rate of 5 mL per min, using a peristaltic pump (Cole-Parmer Instrument Co; Vernon Hills, IL). A 20 mL sample was taken at the beginning of each purge volume. A final water sample was taken after purging five well volumes. The pump tubing was cleaned by pumping 250 mL each of 2% HCl followed by distilled water between each well sampling, to avoid cross contamination. Water samples were stored in a cooler with ice and transported to the laboratory. Concentrations of anions were determined using Ion Chromatograph (DX 100, Dionex Corporation, Sunnyvale, CA). The instrument was calibrated using three points standards obtained from the Dionex Corporation (Sunnyvale, CA). The samples were analyzed within 24 hr of sample collection to satisfy the sample holding time requirement for determination of concentration of nitrate (U.S. EPA 1991). The pH and electrical conductivity (EC) were determined using a pH/ion conductivity meter (Accumet Model 50, Fisher Scientific Co.). Ionic strength (I in mol L^{-1}) was calculated by the following relationship: I = 0.0013 EC, where EC is electrical conductivity in S m^{-1} (Alva et al. 1991; Griffin and Jurinak 1973).

RESULTS AND DISCUSSION

Water pH and electrical conductivity (EC) measurements are generally used as a measure of stabilization of water properties. Among the monitoring wells evaluated in this study, pH of stagnant water varied from 5.0 to 7.0 (Fig. 1). There was a significant reduction in pH after pumping one well volume as compared to that of the stagnant water in all monitoring wells. Pumping the subsequent five well volumes did not influence the water pH. Therefore, it appears that water properties stabilized after purging the stagnant water. This was true with respect to concentrations of NO_3^-, SO_4^{2-} and Cl in these wells (Fig. 1 and Table 1). The concentration of NO_3^- was significantly lower in the stagnant water as compared to that in the water drawn from the surrounding soil during purging subsequent well volumes. The magnitude of this difference varied between the wells. The lower NO_3^- concentration in the stagnant water as compared to that in the water drawn from the soil after pumping the stagnant water is due to greater potential for denitrification in the former as compared to the latter sample (Paramasivam 1997, unpublished data). The denitrification potential is greatly dependent on localized soil properties, i.e., extent of anaerobic conditions, the number and activity of denitritiers, and the presence of available carbon source for denitrifiers activity. In contrast to the NO_3^- concentration, the SO_4^{2-} concentration was significantly greater in the stagnant water as compared to that in the water after purging the stagnant water, in three out of four wells evaluated in this study. Similar to NO_3^- concentration, the SO_4^{2-} concentration did not change for the subsequent five well volumes. The Cl^- concentration in general was greater in the stagnant water as compared to that in the subsequent five well volume water. However, this difference was significant in one out of four wells sampled in this study. The concentration of K generally showed no definite trend with respect to purging various well volumes, except in one well (Table 1). This was expected considering that K does not undergo chemical transformation in the groundwater which could affect its concentration in the stagnant water in the well as compared to that in the surrounding soil area. Furthermore, unlike the concentrations of NO_3^- or SO_4^{2-}, the concentration of K was very similar between the wells within the site. This again suggests that the local variations in soil properties have greater effects on the concentration of NO_3^- and SO_4^{2-} as compared to that of K.

This study demonstrated that significant changes in groundwater properties (i.e., pH, ionic strength, concentrations of NO_3^-, Cl^-, and SO_4^{2-}) occur between the stagnant water in the monitor well and the fresh water withdrawn from the soil after pumping one well volume. Subsequent pumping of five additional well volumes had minimal effects on the water properties. Accordingly, under the conditions of this experiment, the concentration of NO_3-N in the sample

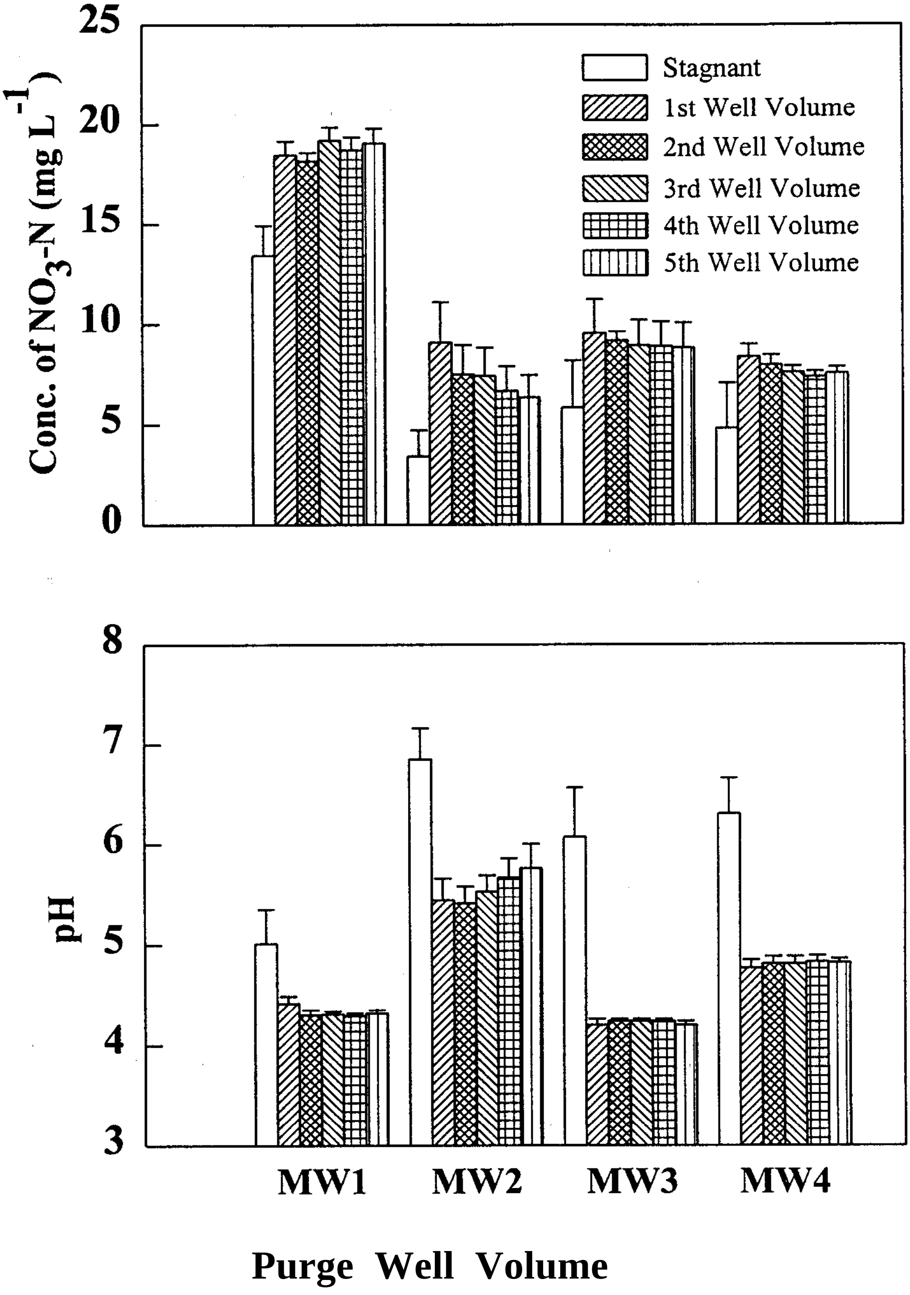

Figure 1. Changes in pH and concentration of NO_3-N in groundwater sampled without purging (stagnant water) and after purging each well volume for a total of five well volumes. The histograms represent the mean of eight sampling events and the vertical line at the top of histogram is the standard error of the mean

Table 1. Mean and standard error (SE) values for ionic strength and concentrations of chloride, potassium, and sulfate in groundwater samples before and after purging

Monitor well no.	Purge vol.	N	Ionic strength		Chloride		Potassium		Sulfate	
			Mean	SE	Mean	SE	Mean	SE	Mean	SE
			----mM----		---------------------mg L^{-1}	--------------------				
MW1	0	8	7.4	0.1	16.4	0.5	15.6	1.0	192.4	5.3
	1	8	7.2	0.1	15.4	0.9	21.6	3.2	168.6	6.9
	2	8	7.2	0.2	10.9	0.7	19.8	2.5	166.2	6.6
	3	8	7.3	0.2	15.6	0.8	19.5	1.5	166.5	6.9
	4	8	7.2	0.2	15.7	0.8	20.5	2.4	164.1	5.2
	5	8	7.3	0.3	16.0	0.9	18.6	1.5	164.8	5.8
MW2	0	8	6.3	0.9	17.2	2.5	22.6	2.6	141.6	37.5
	1	8	5.6	0.8	14.9	2.7	18.0	1.4	132.2	21.0
	2	8	5.3	0.6	14.0	2.0	18.6	1.9	122.8	16.7
	3	8	5.2	0.6	13.9	1.8	19.4	1.9	121.0	15.5
	4	8	5.1	0.5	13.7	1.7	20.2	3.0	117.1	14.6
	5	8	5.0	0.5	13.5	1.5	18.2	1.7	116.1	14.0
MW3	0	8	5.3	0.2	26.4	4.8	17.5	3.9	111.3	8.1
	1	8	5.0	0.3	20.2	3.9	15.8	2.5	91.8	3.1
	2	8	5.0	0.3	19.5	3.5	14.2	2.4	92.5	2.7
	3	8	5.0	0.3	19.3	3.4	17.8	4.0	93.2	2.5
	4	8	4.9	0.3	18.6	3.2	13.3	1.6	92.2	1.8
	5	8	5.0	0.3	19.6	3.8	13.0	1.2	92.6	2.7
MW4	0	8	6.7	0.3	30.7	3.0	16.7	3.1	148.9	5.7
	1	8	5.6	0.3	23.1	2.2	15.4	2.4	120.1	9.1
	2	8	5.8	0.3	23.4	2.4	14.0	2.4	125.0	8.5
	3	8	5.5	0.2	22.7	2.1	15.0	1.5	122.2	8.2
	4	8	5.7	0.2	22.9	2.0	18.9	3.0	124.2	7.3
	5	8	5.7	0.2	22.9	2.0	15.8	2.0	124.3	6.9

taken after purging the stagnant water in the well may represent the NO_3-N status in the surficial aquifer. Therefore, pumping five well volumes as recommended in the standard operation procedure was not necessary to stabilize the properties of water. However, the purging requirement may vary substantially depending on the site specific properties of the soil as well as the groundwater and also dependent on the nature of the pollutant of interest. We recommend that monitoring well purging evaluation be conducted as a first step in all groundwater monitoring studies. If the purging evaluation study shows that the groundwater properties are stabilized by purging well volumes fewer than the generally recommended four to six well volumes, the duration of sampling could be shortened and more wells could be sampled within a given period of time.

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