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Spatially-distributed influence of agro-environmental factors governing nitrate fate and transport in an irrigated stream-aquifer system

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Introduction

This data set contains results from field monitoring of nitrate concentrations in the Lower Arkansas River Valley in southeastern Colorado for the period 2006-2009. The data is contained in the text document:

Field Monitoring of Nitrate Concentrations

Groundwater and surface water samples were gathered from several locations in the study region during ten sampling events conducted over the period 2006 – 2009 for use in estimating C_{NO_3-N}. Depicted in Figure 1 are 100 groundwater monitoring wells and 15 surface water monitoring points. Initially, to avoid bias in their placement, well locations were selected using a stratified random sampling technique. Adjustments then were made to comply with landowner permission and preferences. Additional wells were installed later to fill in data gaps over the study regions. Monitoring wells were drilled with a truck-mounted auger to depths that ranged from 1.5 to 11.9 m from ground surface, with an average of 4.2 m. The wells were cased with a 0.064-m diameter PVC pipe with slots of $4.07 \cdot 10^{-4}$ m width over the entire length of the PVC pipe below the water table. This yielded a slotted density of $6.56 \cdot 10^{-3}$ m^2 per lineal m along each pipe. Low-flow sampling techniques described in Gates et al (2009) were used to extract filtered samples from 52 routinely-monitored wells distributed over the region. Extensive non-routine (aperiodic) sampling was conducted in about 37 additional wells during a sampling event in June 2008. Peristaltic pumps were used to gather filtered water samples (Gates et al 2009) at ten locations along the Arkansas River and at five locations in tributaries feeding the river. Samples were transported on ice to Ward Laboratories Inc. in Kearney, Nebraska and analyzed for C_{NO_3-N} using Method 353.2 in APHA (1992).

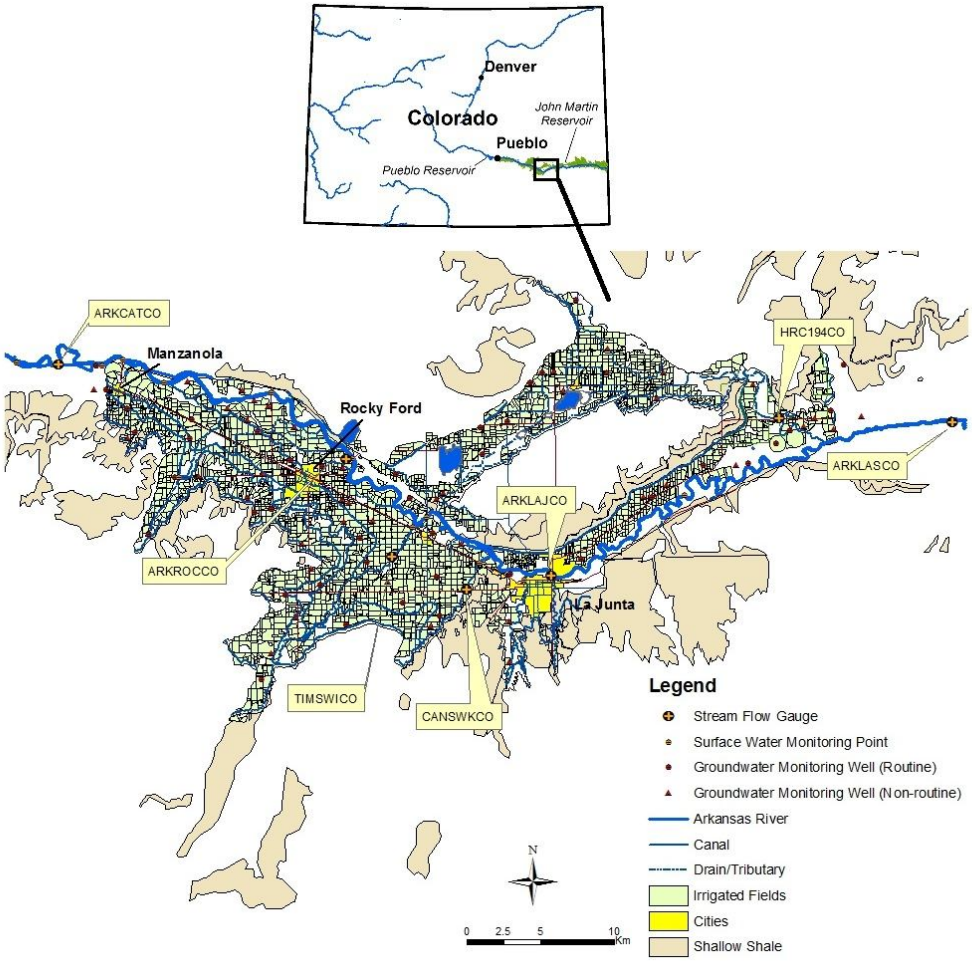


Figure 1. The study region in the Lower Arkansas River Valley in southeastern Colorado.

Histograms in Figure 2 depict the distribution of C_{NO_3-N} values in water samples taken from groundwater monitoring wells over 2006 – 2009. Summary statistics across the sampled groundwater monitoring wells for each of the sampling events are summarized in Table 1. The 85th percentile values were at or in excess of the 10 mg/L (85th percentile) EPA drinking water standard for the first three sample trips. The maximum measured value was 66 mg/L.

Histograms of C_{NO_3-N} in the Arkansas River samples and in the tributary samples gathered over 2006 – 2009 are shown in Figure 3. The mean for the samples gathered from the ten sites along the reach of the Arkansas River was 1.53 mg/L and of the mean for samples from tributaries was 1.95 mg/L. The annual median values of the Arkansas River samples were 0.95, 1.20, 1.10, and 2.20 mg/L for each of the successive years within the period 2006 - 2009, compared to the Colorado interim standard of 2 mg/L (CDPHE 2012) for total N concentration (C_{NO_3-N} + C_{NO_2-N} + C_{NH_4-N}) in warm rivers and streams. The concentration of C_{NO_3-N} exceeded 2 mg/L in about 25% of the samples gathered in the river over this period and exceeded 2.5 mg/L in about 12% of the samples, signifying the growing concern about N pollution in the river. The median value of C_{NO_3-N} over 16 samples taken from Timpas Creek, a tributary of the Arkansas

River, was 1.85 mg/L. About 44% of all samples taken from the four sampled tributaries exceeded 2 mg/L. Analysis of 22 river samples and 15 tributary samples in 2013 revealed that C_{NO_3-N} made up greater than 80% of total dissolved N in the river and about 76% of total dissolved N in the tributaries.

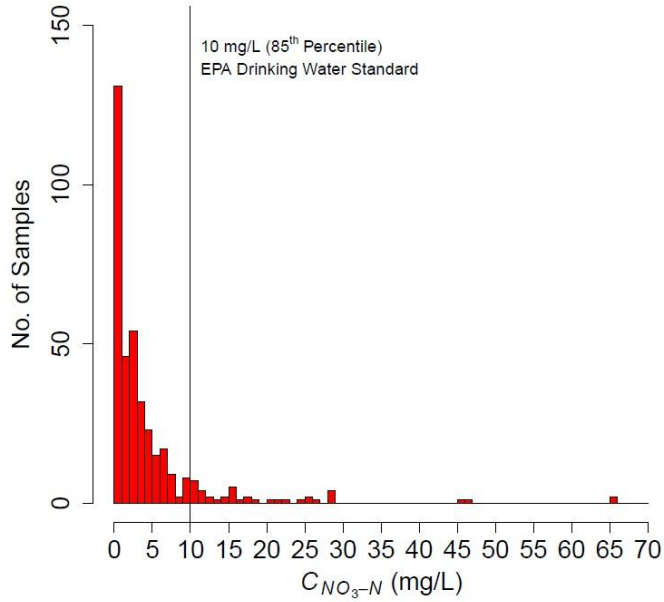
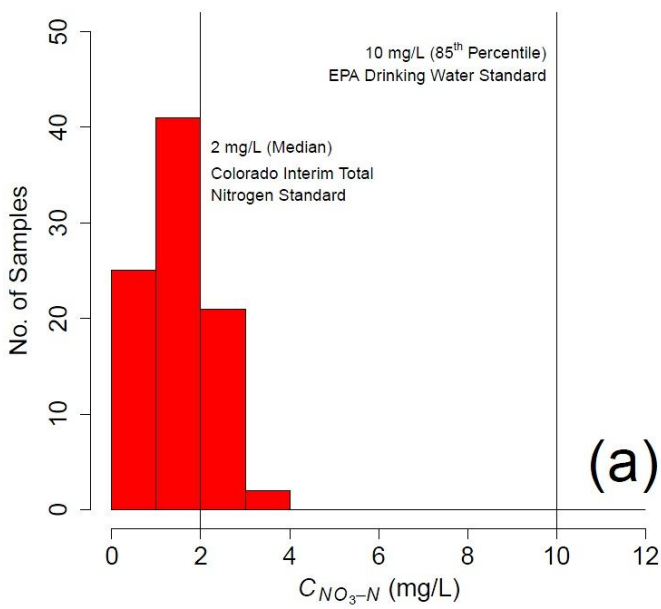


Figure 2. Frequency histogram of C_{NO_3-N} values in water samples (routine and nonroutine) taken from groundwater monitoring wells in the study region over 2006 – 2009.



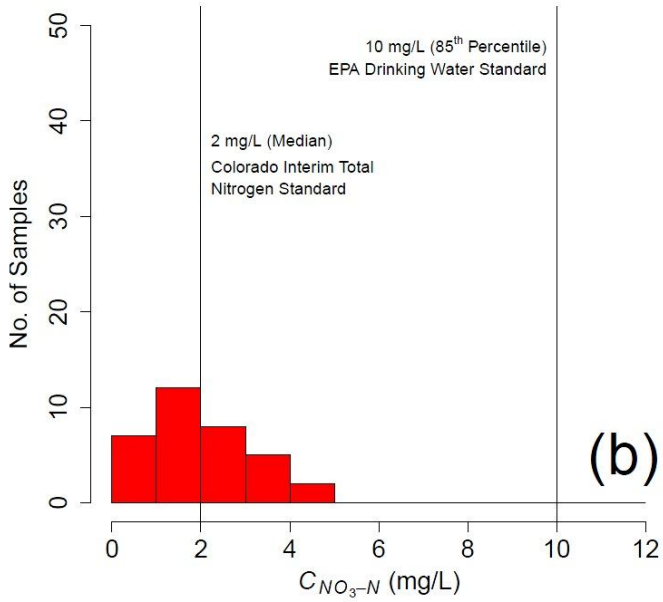


Figure 3. Frequency histogram of C_{NO_3-N} values in water samples (routine and nonroutine) taken from (a) the Arkansas River and (b) selected tributaries over 2006 – 2009.

Table 1. Summary statistics of C_{NO_3-N} in samples from groundwater monitoring wells in the study region for each sampling event.

Sampling Event Number	Event Dates	Number of Sites Visited	Number of Sites Sampled	Mean (mg/L)	CV	Minimum (mg/L)	Maximum (mg/L)	15th Percentile (mg/L)	85th Percentile (mg/L)
1	6/17/2006 to 6/20/2006	50	30	7.27	1.41	0.2	46.9	0.60	12.35
2	5/22/2007 to 5/24/2007	49	41	6.09	2.11	0.1	66.0	0.10	9.80
3	10/6/2007 to 10/11/2007	48	35	6.60	1.80	0.1	66.0	1.01	9.97
4	3/17/2008 to 3/22/2008	44	30	5.15	1.35	0.1	28.1	0.34	7.53
5 (Routine)	6/21/2008 to 6/26/2008	45	39	3.08	1.29	0.1	21.8	0.17	5.24
5 (Non-routine)	6/21/2008 to 6/26/2008	37	34	2.81	1.13	0.1	15.3	0.20	4.91
6	8/14/2008 to 8/15/2008	46	39	3.36	1.22	0.1	20.8	0.17	6.50
7	1/15/2009 to 1/17/2009	46	30	3.86	1.53	0.1	28.4	0.20	7.23
8	5/13/2009 to 5/14/2009	47	34	3.71	1.25	0.1	19.0	0.20	5.73
9	7/21/2009 to 7/23/2009	50	32	3.14	1.36	0.1	17.9	0.10	5.66
10	11/19/2009 to 11/20/2009	52	32	3.79	1.46	0.1	24.3	0.10	6.41

Locations of stream gauges in the Arkansas River and selected tributaries, operated by the Colorado Division of Water Resources and the United States Geological Survey, are shown in Figure 1. As described in Bailey et al (2014), flows and, in some cases, specific conductance measured at these stations were used in conjunction with sampled C_{NO_3-N} data in a mass-balance approach to estimate unaccounted-for rates of NO_3 mass loading to the Arkansas River over the study period. These loading rates averaged about 540 kg/day along the river reach within the study region over 2006 - 2009. They were interpreted as primarily derived from groundwater returns to the stream system and were used in calibrating the UZF-RT3D model employed here.

References

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