Nitrate and Phosphate Content of Ground and Surface Waters of the White River Drainage, Northwest Nebraska

Charles E. Baker
Union College Environmental Education Center

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Charles E. Baker
Biology Department, Chadron State College; present address: Union College Environmental Education Center, Rte 2, Middlesboro, Kentucky 40965

ABSTRACT: Selected stream and ground water sites in the White River Drainage Basin were sampled for phosphate and nitrate content. The sampling procedure was designed to elucidate the impact of each tributary drainage area on water quality of the White River.

Concentration of nitrates found in surface waters was 5.7 $\mp$ 1.75 ppm($\bar{x}$ $\pm$ sd), while that of phosphates was 0.67 $\pm$ 0.33 ppm. Ground water contained higher concentrations of both contaminants, 8.81 $\pm$ 0.66 ppm for nitrates and 0.82 $\pm$ 0.20 ppm for phosphates. The White River increased in nitrate content at each downstream sampling site. Values ranged from 4.4 ppm near the headwaters to 7.7 ppm at the farthest point sampled downstream.

The highest nitrate concentration found in any stream sampled was 9.9 ppm, and the highest in ground water was 25.7 ppm. According to some authorities, these concentrations, especially the latter, are high enough to induce cyanosis due to methemoglobinemia if consumed by infants.

INTRODUCTION

A major area of concern during the hydrologic decade (1965-1975) has been the cultural eutrophication of slow-moving and standing bodies of water. Cultural, or man-caused, eutrophication may be induced when nutrients which usually are limiting to an aquatic ecosystem are elevated to excessive levels.

Under such conditions, certain organisms, notably algae, grow and die at an accelerated rate. Eventually, through decomposition processes, most of the available oxygen in the habitat is expended. As a result, other organisms may die off, thus upsetting the ecosystem balance.

These algal blooms make water unfit for recreation by creating obstacles for swimmers and boaters. Foul odors often accompany dense growths of algae, further damaging the aesthetic features of an affected area.

An element which can accelerate eutrophication, but which usually is in short supply in natural aquatic ecosystems, is phosphorus. The activities of modern society, however, have resulted in copious amounts of phosphorus being added to our waterways. The element is released in the form of phosphates from laundry waste water, industrial effluents, and rural runoff.

Nitrogen, principally as nitrate, also can contribute to cultural eutrophication, since the scarcity of this element often is a limiting factor in aquatic productivity. It is believed by some that nitrogen is even more important than phosphorus in causing eutrophication (Pletcher, 1972). The primary sources of nitrate appear to be agricultural fertilizers and animal (including human) wastes.

With a significant proportion of U.S. lakes showing signs of cultural eutrophication (Crossland and McCaull, 1972), it is imperative that exact sources of these contaminating nutrients be identified across the country. Further, it is important that the stability of concentration of nitrates and phosphates in the environment be investigated.

It was the purpose of the present study to obtain baseline data on phosphate and nitrate concentrations in ground and surface waters of the White River Drainage Basin in Dawes County, Nebraska. The drainage area investigated is situated immediately north of the Nebraska National Forest (Pine Ridge Area), and has been described fully by Cassells (1972). It is anticipated that the present study will open opportunities for future investigations in which the sources of contamination can be mapped and modeled in this area.

METHODS AND MATERIALS

Water samples were taken from selected tributaries of the White River near the point at which feeder streams empty. This sampling procedure was designed to elucidate the impact of each tributary drainage area on water quality of the White River. The river itself was sampled below the point at which each tributary merges. Two replicate samples were taken on each of two sampling visits to each site, yielding a total of four separate measurements on each stream. In most cases, the two sampling times were at least one week apart, and all samples were taken during July and August of 1971.

Ground water was sampled by extracting water from selected wells located over the drainage basin. Only one visit was made to each well, with two replicate samples taken. The sampling pattern for both wells and streams is included in Figure 1.

Water was taken from streams by lowering a polyethylene bucket from traversing bridges, and transferring the water to 100-ml polyethylene bottles. All vessels were rinsed thoroughly with distilled water and with water from the stream being sampled before the actual sample was introduced. The use of detergents for cleaning sampling ware was avoided entirely because of the danger of contamination by constituent phosphates. Sampling of wells was conducted similarly except that water was drawn directly from spouts leading to the ground water.

Samples were sealed tightly, placed in an ice chest, and transported immediately to the laboratory. Analysis was performed quickly to prevent decomposition, settling, and adsorption of the subject nutrients.

Analysis was performed using a Delta System Model 260 Water Analyzer, which measures specific color reactions by photoelectric principles. Nitrate samples were prepared using a brucine sulfanilic acid-sulfuric acid procedure to produce color change, and phosphate samples were prepared with an annomium molybdate-stannous chloride method. Meter readings were translated to real values by means of calibration graphs provided with the analyzer. To avoid contamination, analytical glassware was cleaned with a dichromate solution and rinsed with distilled water.

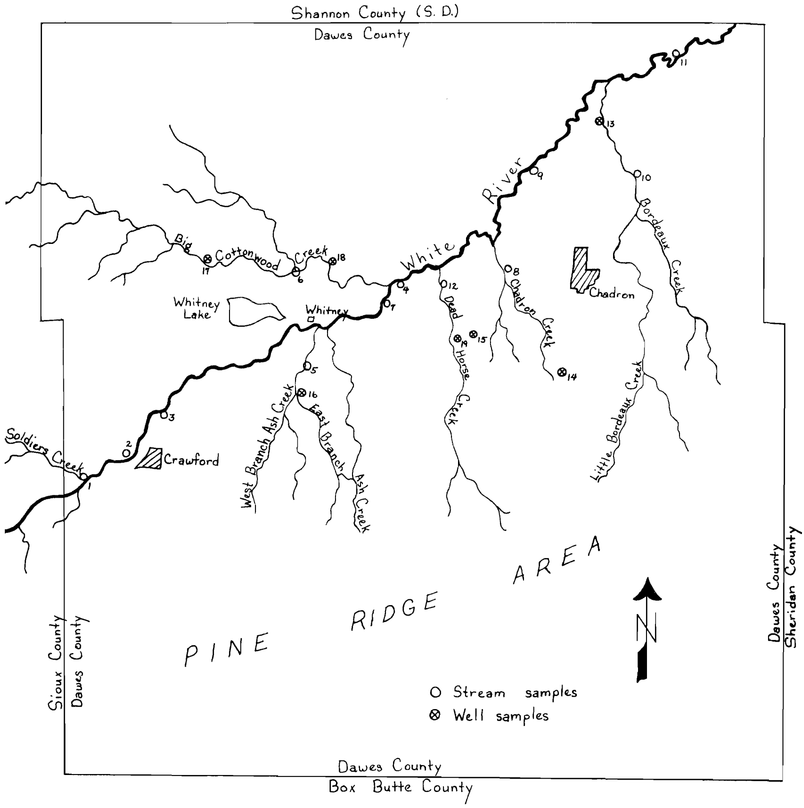

Figure 1. White River Drainage Basin in Northwest Nebraska. Streams and well sites sampled for nitrates and phosphates are indicated. See Table I-III for site identification.

RESULTS AND DISCUSSION

Individual values (ppm) for each sampling site and replicates are provided in Tables I-III. It is noted from the tables that only one sampling was made at Chadron Creek because the stream dried up after the first visit. Consequently, it was decided to sample Dead Horse Creek to compensate for loss of data in that area, and this stream was sampled on two successive days.

In surface water analysis, two visits were made to each site, and two samples were taken per visit. Data were not numerous enough for valid

TABLE I
NITRATE CONCENTRATIONS (PPM) IN SURFACE WATER OF THE WHITE RIVER DRAINAGE BASIN, SUMMER OF 1971

sample	site*	rep-la**	rep-lb	rep-2a	rep-2b	$\bar{x} \pm s$
1	Soldiers Cr.	4.4	3.5	3.5	3.5	3.8 ± 0.31
2	White R., pre-Crawford					
2	White R., pre-Crawford	4.4	4.4	4.0	4.4	4.3 ± 0.16
3	White R., post-Crawford	4.4	4.9	4.4	5.3	4.8 ± 0.17
4	White R., post-Big Cottonwood	7.1	6.2	4.4	4.4	5.5 ± 1.54
5	Ash Cr., Hgwy 20	6.2	6.2	6.2	5.3	6.0 ± 0.31
6	Big Cottonwood Cr., pre-Whitney	4.0	3.5	4.4	4.4	4.1 ± 0.47
7	White R., post-Whitney	6.7	6.7	4.4	4.4	5.5 ± 1.57
8	Chadron Cr., Hgwy 20	5.8	5.8	----	----	5.8 ± 0
9	White R., Hgwy 385	7.5	7.8	6.2	6.2	6.4 ± 0.13
10	Bordeaux Cr., no. of Chadron	4.4	5.3	4.9	4.4	4.8 ± 0.16
11	White R., post-Bordeaux Cr.	8.9	7.5	7.1	7.1	7.7 ± 0.78
12	Dead Horse Cr., Hgwy 20	9.8	11.1	9.3	9.3	9.9 ± 0.79

* See map for site location by sample number.

** Each site sampled twice, with two replicates (rep) each sampling.

TABLE II
PHOSPHATE CONCENTRATIONS (PPM) IN SURFACE WATER OF THE WHITE RIVER DRAINAGE BASIN, SUMMER OF 1971

sample	site*	rep-la**	rep-lb	rep-2a	rep-2b	$\bar{x} \pm s$
1	Soldiers Co.	0.35	0.25	0.50	0.85	0.49 ± 0.27
2	White R., pre-Crawford	1.55	1.55	1.20	0.15	1.12 ± 0.61
3	White R., post-Crawford	0.20	0.65	0.45	0.95	0.57 ± 0.20
4	White R., post-Big Cottonwood	0.70	0.50	0.35	0.45	0.50 ± 0.14
5	Ash Cr., Hgwy 20	1.30	0.55	0.35	0.35	0.64 ± 0.41
6	Big Cottonwood Cr., pre-Whitney	0.30	0.55	0.20	0.15	0.31 ± 0.17
7	White R., post-Whitney	0.40	0.55	0.70	0.10	0.44 ± 0.06
8	Chadron Cr., Hgwy 20	0.75	1.10	------	------	0.93 ± 0.24
9	White R., Hgwy 385	0.80	0.85	0.60	0.65	0.73 ± 0.14
10	Bordeaux Cr., no. of Chadron	0.45	0.55	0.55	0.25	0.45 ± 0.07
11	White R., post-Bordeaux Cr.	1.35	0.75	0.75	0.75	0.90 ± 0.21
12	Dead Horse Cr., Hgwy 20	1.10	1.25	0.65	0.80	0.96 ± 0.33

* See map for site location by sample number.

** Each site sampled twice, with two replicates (rep) each sampling.

TABLE III
NITRATE AND PHOSPHATE CONCENTRATIONS OF GROUND WATER (WELL WATER) OF THE WHITE RIVER DRAINAGE BASIN, SUMMER OF 1971.

		Nitrates (ppm)			Phosphates (ppm)		
sample	site*	rep-A**	rep-B	$\bar{x} \pm s$	rep-A	rep-B	$\bar{x} \pm s$
13	Redfern Ranch	4.4	3.5	4.0 ± 0.62	1.05	1.35	1.20 ± 0.21
14	Rary Farm	4.9	4.9	4.9 ± 0	1.15	1.15	1.15 ± 0
15	Wohlers Farm	10.6	11.5	11.1 ± 0.62	0.50	0.70	0.60 ± 0.14
16	Haynes Farm	4.4	4.4	4.4 ± 0	0.75	0.95	0.85 ± 0.14
17	Campbell Ranch	25.7	25.7	25.7 ± 0	1.05	0.45	0.75 ± 0.42
18	Fox Farm	8.9	8.0	8.4 ± 0.62	0.55	0.55	0.55 ± 0
19	Nixon Farm	4.0	3.5	3.8 ± 0.32	0.55	0.50	0.53 ± 0.04

* See map for site location by sample number.

** Each site sampled once, with two replicate (rep) samples taken.

statistical evaluation, but by inspection, replicate samples did not appear to differ significantly for nitrates nor for phosphates. However, there did appear to be differences between sampling visits for both contaminants. These observations suggest reproducibility of the analytical procedure, and that the decision was warranted to sample each stream twice to reveal temporal fluctuations. The data thus indicate that it is important to conduct periodic sampling on streams to account for fluctuations which may occur even more widely on a seasonal basis.

The decision to sample ground water only once was based on the assumption that fluctuations in nitrate and phosphate concentrations would not vary significantly during the study period. However, future studies should attempt to clarify this assumption by sampling at least on a seasonal basis.

Mean concentration (with standard deviation) of nitrates in surface waters tested was 5.7 ± 1.75 ppm, while that of phosphates was 0.67 ± 0.33 ppm. Ground water mean values were, for nitrates, 8.81 ± 0.66 ppm, and for phosphates, 0.80 ± 0.20 ppm. Mean values do not reflect the unusually high concentrations found in some of the sampling sites (Tables I-III), but they do indicate that both of these contaminants are more concentrated in ground water than in surface water.

The Wohlers Farm site (no. 15), for example, had a nitrate concentration of 11.1 ppm, and Dead Horse Creek, which flows through that property, had the highest nitrate content of any stream sampled (9.9 ppm). Attention also should be directed to the extremely high nitrate concentration found on the Campbell Ranch (25.7 ppm), site no. 17.

It has been indicated that some danger exists in the consumption of water with high levels of nitrates. According to the U. S. Geological Survey (Rainwater and Thatcher, 1960) water containing more than 10 ppm nitrates should not be fed to infants because of the danger of cyanosis due to methemoglobinemia. The stomachs of infants are not as acid as those of adults, allowing bacteria which normally inhabit the lower tract to live in the stomach. These bacteria convert nitrate to nitrite which reacts with hemoglobin to form methemoglobin, thus decreasing the capacity of the blood to transport oxygen. Certain types of brain damage can occur as a result of methemoglobinemia (Engberg, 1967).

Still, the nitrate concentration on the Campbell Ranch is well below the so-called safe limit (45 ppm) set by the federal government (Partsch, 1971). Whether this level is actually safe for human consumption is open to question, but concentrations of this order could conceivably contribute to cultural eutrophication in some situations. Therefore, the sources and dynamics of nitrate pollution on the Wohlers Farm and the Campbell Ranch need to be elucidated so that corrective and preventive measures can be implemented.

The date (Table 1) indicate a definite increase in nitrate concentration of the White River as it flows downstream. Mean values taken at sample sites, beginning near the headwaters and progressing downstream, were 4.4, 4.8, 5.5, 5.5, 6.4, and 7.7 ppm.

Concentrations of phosphates found in waters of the White River drainage do not constitute cause for alarm as regards ill effects from human consumption. However, the mean concentration (0.67 ppm) of all surface waters tested probably is great enough to induce algal blooms in still or slow-moving bodies of water (Wagner, 1971). Therefore, if streams of this drainage basin are dammed, rapid eutrophication could result.

Dawes County is a sparsely populated, predominantly agricultural region, and therefore, the contaminating nitrates and phosphates likely come from application of fertilizers and deposition of animal wastes. Continued monitoring of ground and surface water, at least on an annual basis, is recommended to determine whether levels of these contaminants are stable or are increasing in the White River Basin.

ACKNOWLEDGEMENT

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