RECENT WATER QUALITY TRENDS IN GUADALUPE MOUNTAINS NATIONAL PARK, TEXAS

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ABSTRACT

Protection of the limited water resources in Guadalupe Mountains National Park is a primary concern of National Park Service managers. A two year sampling program at one spring and at four sites in McKittrick Canyon examined temperature, pH, nitrate-nitrogen, ortho-phosphate, sulfates, chlorides, dissolved oxygen, total hardness and calcium hardness. A non-parametric modification of the sign test, the Cox-Stewart test for trend, was used to evaluate changes in water quality parameters over time. There are some indications of trends in the data; however, these are not presently sufficiently consistent nor of sufficient magnitude to warrant modification of current management strategies.

Key Words - water quality, Guadalupe Mountains National Park, water quality trends

INTRODUCTION

The purpose of this study was to monitor various water quality parameters over time and to evaluate changes.

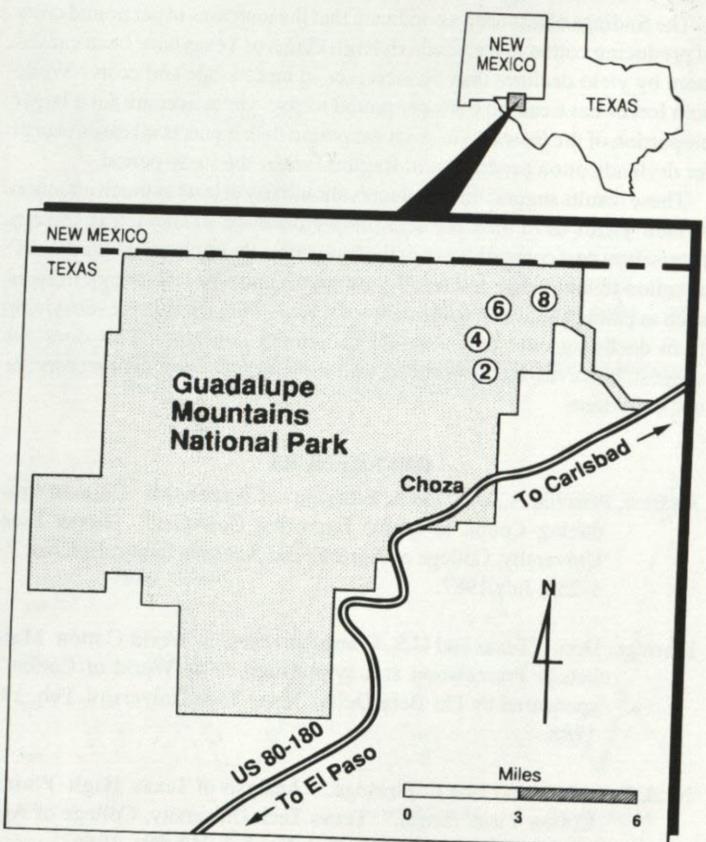

Figure 1. Study area and sample site locations

Located on the southern end of the Guadalupe Mountains in the Trans-Pecos region of Texas, the park is between El Paso, Texas, and Carlsbad, New Mexico (Fig. 1). The Guadalupe Mountains are composed largely of limestone, a remnant of the huge Capitan Barrier Reef. The mountains have the form of a 'V' with the apex pointing south and culminating abruptly in El Capitan, a prominent scarp face. The park contains within its boundaries the entire vegetative gamut from xeric desert shrub to mesic coniferous forest and includes animals as diverse as cottontails (Sylvilagus spp.), mountain lions (Felis concolor), porcupines (Erethrizon dorsatum) and elk (Cervus elaphus) (National Park Service, 1973).

Protection of the limited water resources in the park is a primary concern of National Park Service managers. With over 100,000 visitations annually, the impact of each person is important in the preservation of this unique ecosystem (National Park Service, 1975; 1978). Early accounts of water resources in the Guadalupe Mountains were made by Marcy (1859), Richardson (1904) and King (1948).

Numerous factors, including land use and the resultant interaction of runoff, affect water quality. The natural water quality and those elements which affect that quality require establishment in order for valid management decisions to be made. The park's water resources, primarily groundwater, reflect a strong relationship between their natural chemistry and the sedimentary geology of the area (Dasher, 1980; Dasher et al., 1981). The limestone substratum of the region is manifest in a well buffered calcium carbonate-magnesium carbonate system with bicarbonate the principal anion (Lind, 1979). Other geologic elements contributing to the natural system include sandstone, alluvial material, carbonate, and evaporative sediments (King, 1948).

A potentially significant input to the chemical character of the water resources of this area is the flow of dissolved solids from decomposition of organic material. Nutrient flow or output of dissolved solids from an ecosystem in streamflow is affected by catastrophic flood and erosion events. Brown (1980) suggested that, on a geologic time scale, such events may assume a significant importance. Events such as the 1969 or 1978 floods in McKittrick Canyon had a flushing effect on organic material which had accumulated during intervening years. Due to a lowering of available nutrients it seems that these disturbances may have lowered diversity in aquatic fauna populations (Lind, 1971).

Since its authorization as a National Park by Public Law 89-667, 15 October 1969, several water quality studies have been conducted along the stream in McKittrick Canyon and at certain springs to establish baseline parameter values and to evaluate human impacts (Lind, 1971; 1979; Kelley, 1979; Dasher, 1980; Dasher et al., 1981; Fish and Dvoracek, 1980; Brothers and Fish, 1980; Fish, 1987). Lind (1971) suggested that a cesspool located near the Hunter line camp picnic area was contributing nitrate-nitrogen and orthophosphate to McKittrick Canyon Stream. After this facility was closed in 1970, Dasher (1980) concluded that the contribution was no longer significant. During his sampling Dasher (1980) found the highest nitrate-nitrogen and chloride levels for any of his McKittrick Canyon sites to be at the Pratt Lodge well. He inferred that this may have been due to the proximity of a cesspool located 180 feet from the well. Brothers and Fish (1980) conducted a tracer dye study involving the cesspool and well. They found no evidence of contamination but recommended subsequent monitoring because the cesspool did not meet design

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standards established by the Texas Department of Health Resources. Fish (1987) examined water quality parameters for five sample dates in each of four years (1979, 1980, 1981, 1982) and concluded that although there were some trends, concentrations were within expected natural ranges and values probably represented natural phenomena associated with normal fluctuations.

In 1987 park managers expressed a desire to reestablish water quality monitoring at selected sites in order to evaluate current trends.

METHODS

Parameters investigated were selected to provide general information on the quality of water for aquatic life and for a drinking water supply. They would also indicate possible pollution from human impacts. Water samples were collected monthly in one-quart polyethlene containers, and dissolved oxygen samples in 2 ounce glass stoppered bottles. Flow measurements were not recorded during sampling due to the remoteness of the sites and restrictions on placing permanent flow measuring devices in the park. To insure comparability all sampling was conducted during "normal base flow" conditions, avoiding particularly any runoff influenced flows. Normal base flow conditions for the spring were less than 20 gallons/minute and for the McKittrick Canyon Stream sites less than 900 gallons/minute.

Sampling sites included four locations on McKittrick Canyon Stream and Choza spring. All locations were identical to sites extensively documented by Dasher (1980) used in previous studies. Financial considerations precluded a comprehensive sampling of all previously studied locations and the collection of site specific visitor use data.

A Hach DR-EL/4 field analysis water quality test kit was employed for all sample testing. The kit uses visual and single-beam analytical spectrophotometer techniques for colorimetrically measuring concentrations of particular substances in water. Table 1 indicates the parameters of interest and the specific test procedure employed.

One of the first indications of differential usage impact would be a trend in parameter values over time. The Cox-Stuart test for trend (Daniel, 1978) was applied to appropriate parameters using data obtained from May 1987 through April 1989. This nonparametric statistical test is a modification of the sign test in which sequentially obtained values are paired and the sign of the difference is recorded. The data are said to display an upward trend if a sufficient number of the later observations are greater in magnitude than those of earlier observations. Likewise the data exhibit a downward trend if a sufficient number of the earlier observations tend to be larger than the later observations. The test can also be applied in a "flow" situation to indicate trend along the path of flow.

Table 1. Water quality analysis procedures.

Parameter	Test Procedure
Temperature C	Mercury thermometer -20 to 100 celsius
pH	*Wide range, 4-20, colorimetric spectrophotometer method
Nitrate-Nitrogen (ppm)	*High range, 0-30 ppm, cadimum reduction spectrophotometer method
Ortho-phosphate (ppm)	*Reactive phosphorus, 0-2 ppm, ascorbic acid spectrophotometer method
Sulfates (ppm)	*Sulfate, 0-150 ppm, turbidimetric spectrophotometer method
Chlorides (ppm)	*Chloride, 0-125 ppm, mercuric nitrate digital titration method
Dissolved Oxygen (ppm)	*Oxygen, 0-20 ppm, modified azide-winkler digital titration method
Total Hardness (ppm @ $CaCO_3$)	*Hardness, 0-250 ppm, EDTA digital titration method
Calcium Hardness (ppm @ $CaCO_3$)	*Calcium, 0-250 ppm, buret titration method

*Source: Hach Chemical Company, 1978. Methods manual Hach direct reading engineer's laboratory models DR-EL/1, DR-EL/3, DR-EL/4. Hach Chemical Company, Ames, Iowa.

RESULTS

Table 2 presents the means and ranges for the water quality parameters measured at each sampling location. Table 3 indicates the statistically significant outcomes for trend over time when the Cox-Stuart test was applied with the null hypothesis, Ho: There is no trend present in the data; versus the alternative hypothesis, Ha: There is either an upward trend or a downward trend. Assuming that a P value of 0.100 or less is sufficiently critical in this case, it appears, based on the number of tests performed for each parameter that there is a consistent indication of a downward trend for nitrate-nitrogen in the McKittrick Canyon Stream samples.

Table 2. Means and ranges of selected water quality parameters in Guadalupe Mountains National Park. Monthly samples from May 1987 through April 1989.

Parameter	Location				
	MK-2	MK-4	MK-6	MK-8	Choza
Temperature C	10.2 1.0-20.0	10.9 2.0-19.5	13.0 7.0-18.0	13.7 10.0-17.0	15.0 7.0-22.0
pH	8.0 6.7-8.9	8.1 7.7-8.7	8.0 7.7-8.6	7.8 6.5-8.6	8.2 7.7-8.8
Nitrate-Nitrogen (ppm)	0.28 0.00-1.10	0.29 0.00-1.10	0.42 0.00-1.50	0.42 0.00-1.80	0.23 0.00-0.90
Ortho-Phosphate (ppm)	0.05 0.00-0.25	0.08 0.00-0.50	0.07 0.01-0.22	0.05 0.00-0.18	0.05 0.00-0.14
Sulfate (ppm)	10.8 4.0-17.0	9.4 5.0-12.5	9.0 6.0-12.0	10.8 6.0-17.0	14.8 8.0-19.0
Chlorides (ppm)	3.6 0.0-16.0	3.5 0.0-20.0	3.6 0.0-22.0	3.2 0.9-8.0	3.8 0.00-17.0
Dissolved Oxygen (ppm)	8.1 4.0-11.9	8.0 3.2-15.2	9.0 4.5-20.4	7.0 3.0-9.4	8.0 4.0-10.6
Total Hardness (ppm @ $CaCO_3$)	254 223-330	260 249-287	268 254-290	271 256-292	268 243-290
Calcium Hardness (ppm @ $CaCO_3$)	138 120-160	156 140-180	173 140-210	170 140-190	161 140-180

Table 3. Cox-Stuart trend results over time at selected locations in Guadalupe Mountains National Park. (Significant outcomes P< 0.10; direction of trend)

Parameter	Location				
	MK-2	MK-4	MK-6	MK-8	Choza
Temperature					
pH					
Nitrate-Nitrogen	—	—	—	—	
Ortho-Phosphate					
Sulfate			++		—
Chlorides					
Dissolved Oxygen					
Total Hardness					
Calcium Hardness					

A second set of Cox-Stuart tests was performed to test for trend in parameter values along the flow path in McKittrick Canyon. The tests were performed for the appropriate parameters by pairing the following sites: 2-6 and 4-8. Table 4 indicates the results of the testing by showing the trend for statistically significant results of the test.

Table 4. Cox-Stuart trend results along flow path in McKittrick Canyon. (Significant outcomes P< 0.10; direction of trend)

Parameter	Location Pair	
	MK-2 vs MK-6	MK-4 vs MK-8
Temperature		
pH		—
Nitrate-Nitrogen		++
Ortho-Phosphate		—
Sulfate	—	
Chlorides		
Dissolved Oxygen		
Total Hardness	++	++
Calcium Hardness	++	++

DISCUSSION AND CONCLUSIONS

Fish (1987) noted a downward trend for sulfates and nitrate-nitrogen; and, an upward trend for chlorides for various time intervals from 1979 to 1982. In the current study, chloride values did not display consistent trends; sulfate values appeared to be trending upward only at sample site six in McKittrick Canyon and downward at Choza spring; all of the sample sites in McKittrick Canyon indicated a downward trend in nitrate-nitrogen values. Both Dasher (1980) and Fish (1987) discussed a trend for a general increase in the parameters of total hardness and calcium hardness along the flow path in McKittrick Canyon which is evident in the current study. Fish (1987) also found a downward trend in sulfate values between sites two and six and an upward trend in nitrate-nitrogen between sites four and eight.

Based upon the data obtained in this study, it appears that there are minimal detrimental impacts on the water quality parameters studied in Guadalupe Mountains National Park as a result of current recreational use patterns and intensities. Major trends occurring in the data along the flow path in McKittrick Canyon are probably an indication of normally expected chemical changes rather than being a result of the trend in visitor use intensity which also occurs along the flow path.

Concentrations of nitrate-nitrogen, because of its close association to life processes, are likely to be influenced by the activities of plants and animals. In this study a general downward trend was found which has a favorable connotation in terms of quality. However, it should also be noted that the nitrate-nitrogen concentrations are generally low and well within limits for human consumption. The majority of the values obtained are similar to concentrations normally associated with rainwater [(0.20 ppm), Riffenburg, 1925] therefore it does not seem appropriate to place an undue emphasis on the trend indication at this time.

While there are some indications of trend over time and along the flow path in McKittrick Canyon Stream, these are not presently sufficiently consistent nor of sufficient magnitude and direction to warrant modification of management strategies.

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