WATER QUALITY OF STREAMFLOW FROM FORESTED WATERSHEDS ON SEDIMENTARY SOILS

by

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INTRODUCTION

In a recently completed "status-of-knowledge" assessment of watershed management in Arizona, it was found that little quantitative information exists to characterize water quality over the range of conditions on which ponderosa pine forests are located (Ffolliott and Thorud 1975). With many hydrologically important watersheds in ponderosa pine forests, this deficiency in water quality information is restricting with respect to the development of water resource policies and management strategies.

The limited water quality information currently available is based on experimental work that has been carried out on the Workman Creek, Castle Creek, and Beaver Creek Watersheds (Brown et al. 1975, Rich and Thompson 1974). However, as all of these watersheds are located on soils derived from basalt parent materials, specific knowledge of water quality from watersheds on sedimentary soils is non-existent. With sedimentary soils occurring on large proportions of the high water yielding river basins in Arizona, it is imperative that efforts be made to alleviate this deficiency in hydrologic information.

DESCRIPTION OF THE STUDY

To provide quantitative information on water quality of streamflow from ponderosa pine watersheds on sedimentary soils, an investigation has been initiated to determine chemical, physical, and bacteriological water quality parameters.[1/] Specifically, three areas are being explored: (1) the development of baseline information that is required to evaluate the hydrologic properties of these watersheds; (2) the empirical association of water quality parameters with land use patterns; and (3) the analyses of interactions among the water quality parameters that define the chemical, physical, and bacteriological quality of streamflow from these watersheds.

The purposes of this paper are to describe the baseline information on water quality of streamflow from ponderosa pine watersheds on sedimentary soils obtained to date, and to compare this information with EPA water quality standards.

Source data for this investigation are being collected on four watersheds, two with soil formed from parent material derived from sandstone (60 acres each), and two with soil formed from parent material derived from tertiary alluvium (20 and 30 acres). These watersheds are located near Heber in central Arizona. Uneven-aged stands of cutover ponderosa pine characterize the overstory, with Douglas-fir, white fir, Gambel oak, and alligator juniper as minor species.

Annual precipitation averages 25 inches on the four watersheds, with streamflow averaging 2 inches annually. The sandstone-derived soils are of the McVickers series, with fine sandy loam surface textures. Soils developed on tertiary alluvium are of the Overgaard series, with gravelly fine, sandy loam surface textures.

These watersheds have been instrumented and are being evaluated in cooperation with the Rocky Mountain Forest and Range Experiment Station (USDA Forest Service) to provide a basis for validation and refinement of natural resource response models.

Samples of water are collected at the mouths of the four watersheds at time of surface runoff. Collections are scheduled to coincide with weekly instrumentation maintenance, although samples are also collected during extreme or otherwise unusual hydrologic events. To supplement these source data, additional samples are being collected from an ungaged watershed in the immediate vicinity of the Heber watersheds.

The dissolved chemical constituents in each sample are being analyzed by the Soil and Water Testing Laboratory at the University of Arizona, Tucson. Constituents assessed include: calcium (Ca^{++}), magnesium (Mg^{++}), sodium (Na^{+}), chloride (Cl^{-}), sulfate ($SO_4^{=}$), carbonate ($CO_3^{=}$), bicarbonate (HCO_3^{-}), fluoride (F^{-}), nitrate (NO_3^{-}), total soluble salts, and hydrogen ion (pH).

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Concentrations of the major cations (Ca^{++}, Mg^{++}, and Na^{+}) were determined by using atomic absorption spectrophotometry. Alkalinity, described by CO_3^{-} and HCO_3^{-}, was measured by titrating with standard acid. Fluoride, sulfate, and chloride ion concentrations were determined by colorimeteric methods using an Autoanalyzer. Hydrogen ion concentration was measured by using a glass electrode.

Suspended sediment concentrations were measured by the Rocky Mountain Forest and Range Experiment Station by filtration.

RESULTS AND DISCUSSION

During the winters of 1973-74 and 1974-75, 30 water samples were collected to characterize chemical quality and 34 samples were obtained to determine physical quality. These water samples were taken from streamflows that originated, primarily, as snowmelt runoff. Bacteriological water quality parameters were not defined in these sampling periods.

No consistent differences were found in the chemical and physical water quality characteristics among the four watersheds sampled. Therefore, the data were grouped for further analysis.

The baseline water quality characteristics of the streamflow from the sedimentary watersheds evaluated are presented in Table 1. Also, these characteristics are compared with criteria for water quality proposed by the EPA in 1973.[2] Specifically, levels of acceptability for aquatic life, irrigation, and public water supply are considered.

Table 1. Comparison of water quality characteristics of the sedimentary watersheds with proposed EPA water quality levels of acceptability.

Constituent	Sedimentary Watersheds	Levels of Acceptability		
		Aquatic Life	Irrigation	Public Water
pH	6.60-8.10	6.0-9.0	4.5-9.0	5.0-9.0
Total Soluble Salts (mg/ℓ)	23.00-99.00	By Test	500-1000 sensitive crops, 2000-5000 tolerant crops	NP[a]
Bicarbonate (mg/ℓ)	14.60-44.00	NL[b]	NL	NL
Calcium (mg/ℓ)	3.00-10.00	NL	NL	NL
Carbonate (mg/ℓ)	0.00-0.00	NL	NL	NL
Chloride (mg/ℓ)	1.40-13.00	NL	NP	250
Fluoride (mg/ℓ)	0.02-0.16	NL	2.0	0.06-1.90[c]
Magnesium (mg/ℓ)	0.30-6.70	NL	NL	NL
Nitrate (mg/ℓ)	0.03-0.75	NL	No Max	45
Sodium (mg/ℓ)	1.00-5.00	NL	NP[d]	NP
Sulfate (mg/ℓ)	1.00-60.00	NL	NP[d]	250
Suspended Sediment (mg/ℓ)	3.00-181.60	80	NP	NP

[a] Not Prescribed (NP)

[b] Not Listed (NL)

[c] From Public Health Service Drinking Water Standards (1962) level dependent upon annual average of maximum daily air temperatures.

[d] Cannot be prescribed without consideration of other soil and water constituents.

2. These unpublished criteria were issued by the Environmental Protection Agency, Office of Water Programs, Washington, D.C., October 1973.

The importance of water in Arizona is well-known, and, as a result, a large investment of time, talent, and funds has been made over the years to assess the role of watershed management in the development of water resources. However, as mentioned above, little effort has been directed toward the evaluation of water quality, both in terms of existing watershed conditions and possible changes in conditions following the implementation of water yield improvement practices.

As demands for water resources increase, the quality standards that are associated with these resources will undoubtedly ascertain, in part, the ultimate allocation of water supplies among potential users. Therefore, baseline water quality information, as presented herein, is requisite to the synthesis of future water policies relating to the allocation of existing and, possibly, increased water yields from upland watersheds.

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