THE EFFECT OF THE OPERATION OF THE FOSS DEMINERALIZATION PLANT ON THE CHEMICAL QUALITY OF THE WASHITA RIVER

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Foss Reservoir, the Washita River, and several of its tributaries were investigated from 1973 through 1976, to determine if brine discharged from the Foss Reservoir 3-MGD Demineralization Plant, near Clinton, Oklahoma, affected the Washita River. The analyses of periodic samples indicated that the concentrations of dissolved material in the river were significantly higher after January, 1975, when the brine discharge and regular releases from Foss Reservoir began.

INTRODUCTION

The Foss Reservoir 3-MGD Demineralization Plant (FDP) supplies fresh water to four western Oklahoma towns — Clinton, Cordell, Hobart and Bessie — by demineralizing water from Foss Reservoir using electrodialysis (1). Waste brine is discharged into the Washita River and water is released from Foss Reservoir to dilute the brine (2). The Oklahoma Water Resources Board investigated the chemical quality of the river before and after the brine discharge began to determine the effect of the brine on the river.

METHODOLOGY

Water samples were collected at 10 river and 12 tributary sites along 27 miles of the Washita River monthly for one year before and after the FDP became operational in January, 1975 (Figure 1). Each sample was taken, using a plastic bucket, from the stream's surface with care to exclude debris, stored in polyethylene containers, iced in

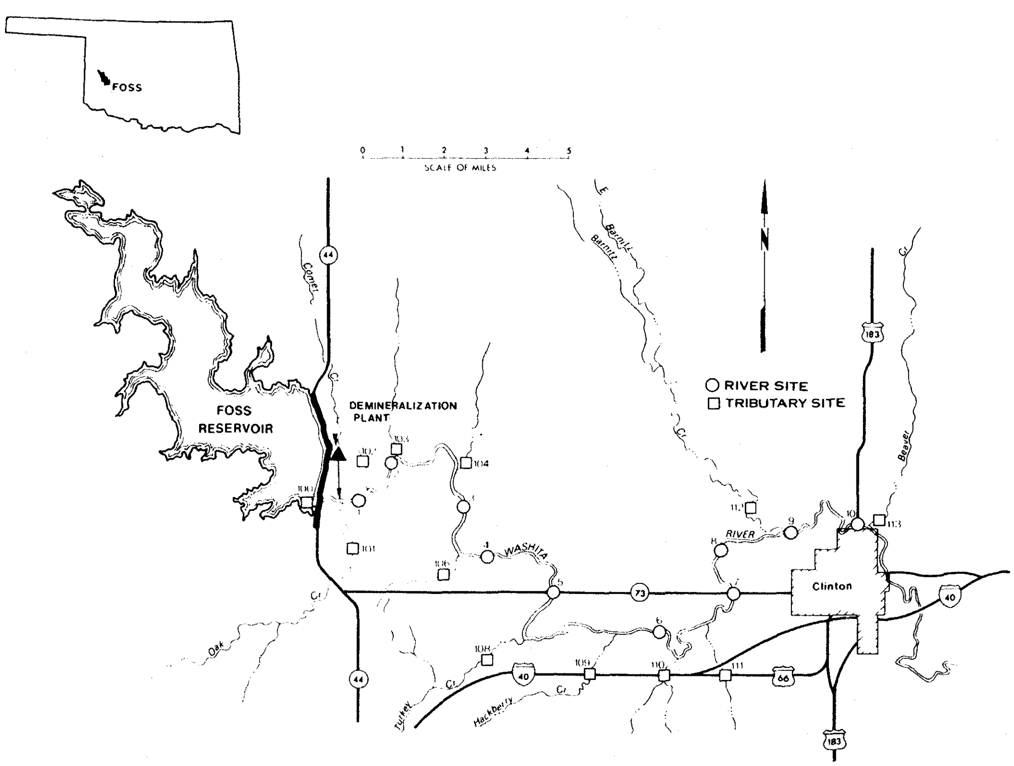

FIGURE 1. Region of the Washita River investigation.

the field, and kept refrigerated until analyzed (3). The samples were analyzed for total dissolved solids (TDS)), chloride, sulfate, hardness, alkalinity, and pH by methods suggested by the U.S. Environmental Protection Agency (3) and the American Public Health Association (4).

Washita River flow data were obtained from the U.S. Geological Survey (USGS), which maintains gaging stations on the river at sites 1 and 10 (Figure 1) corresponding to USGS sites 07324400 and 07325000 respectively (5). Rainfall data were obtained from the U.S. Bureau of Reclamation (USBR) and the U.S. Department of Commerce (6). Foss Reservoir release data were obtained from the USBR. All statistical procedures — calculation of means, standard deviations, F-tests and regression analyses — were conducted according to methods of Steele and Torrie (7) and Sokal and Rohlf (8, 9).

RESULTS AND DISCUSSION

The quantity of rainfall was not significantly different at Clinton or Foss Reservoir after the FDP became operational (6). The TDS, sulfate, alkalinity, and pH in the tributaries were not significantly different after brine discharge began, but chloride and hardness were higher (Table 1). The concentrations of TDS, chloride, sulfate, and hardness were higher in the brine than in the river, whereas the alkalinity and pH were considerably lower (Table 2).

The contribution of dissolved material from Foss Reservoir was statistically significant. After construction of the reservoir in 1961, the chloride concentration in the reservoir increased 2 mg/*l*/year (Figure 2, r = 0.98) and the sulfate concentration increased 33 mg/*l*/year Figure 3, r = 0.92).
From 1961 until January, 1975, releases

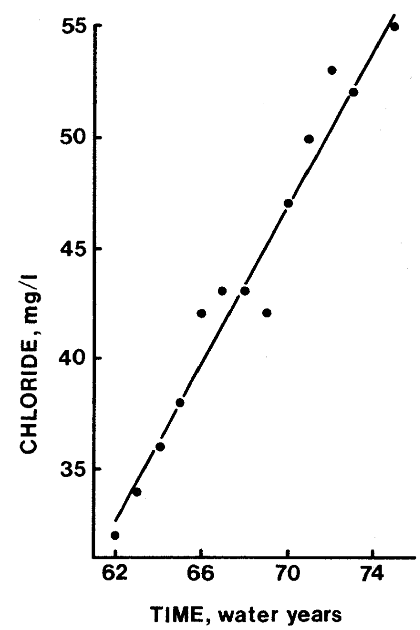

FIGURE 2. Chloride concentration in Foss Reservoir since its construction (5).

TABLE 1. *Comparison of tributaries before and after the FDP became operational.*

Parameter	Mean[a] before	Mean[a] after	% change	F[b]
TDS	1172	1731	−2.3	0.176 ns
Chloride	30	42	+39.1	39.013***
Sulfate	904	813	−10.1	2.408 ns
Hardness, as $CaCO_3$	1147	1408	+22.8	15.035***
Alkalinity, as $CaCO_3$	282	278	−1.2	0.133 ns
pH, standard units	8.0	7.9	−0.3	0.063 ns

[a]All values in mg/*l* unless otherwise indicated.
[b]*** indicates P < 0.001
ns indicates not significant

TABLE 2. *Chemical quality of the Washita River water before and after the FDP became operational. Characteristics for the FDP brince are included for comparison.*

Parameter	Washita River before (Mean)[a]	Washita River after (Mean)[a]	% Change	F[b]	FDP Brine (Mean)[a]
TDS	843	1394	+65.3	87.1***	4023
Chloride	17	41	+145.0	195.0***	144
Sulfate	360	616	+71.1	47.5***	2132
Hardness, as $CaCO_3$	564	1106	+96.3	126.8***	1941
Alkalinity, as $CaCO_3$	300	296	−1.3	6.7**	4
pH, standard units	7.9	8.0	+0.8	2.2 ns	4.1

[a]All values in mg/*l* unless otherwise indicated.
[b]*** indicates P < 0.001
** indicates P < 0.01
ns indicates not significant

from the reservoir were infrequent, i.e., during the first sampling phase the only release was 33,000 m^3 during August, 1973. Since the FDP became operational, approximately 17,000 m^3/day have been released continuously. The TDS in the reservoir was higher than in the river before FDP became operational ($P < 0.001$). After the brine discharge and regular releases from the reservoir began, the TDS in the river and reservoir were not significantly different.

The results of chemical analyses of the river samples (Figs. 4, 5, 6, 7, 8 and 9) illustrate the consistent increases of TDS, chloride, sulfate and hardness concentra-

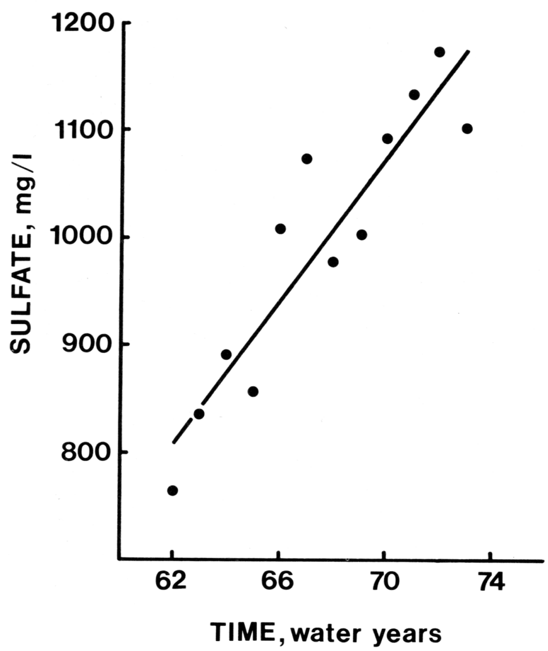

FIGURE 3. Sulfate concentration in Foss Reservoir since its construction (5).

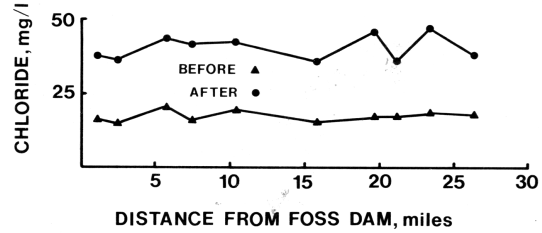

FIGURE 5. Chloride concentration in the Washita River before and after commencement of FDP brine discharge. Each point represents the yearly mean at a particular site.

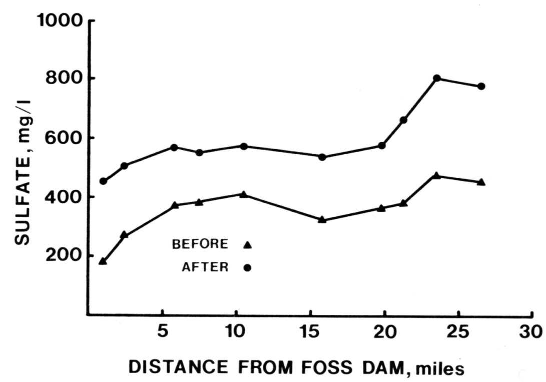

FIGURE 6. Sulfate concentration in the Washita River before and after commencement of FDP brine discharge. Each point represents the yearly mean at a particular site.

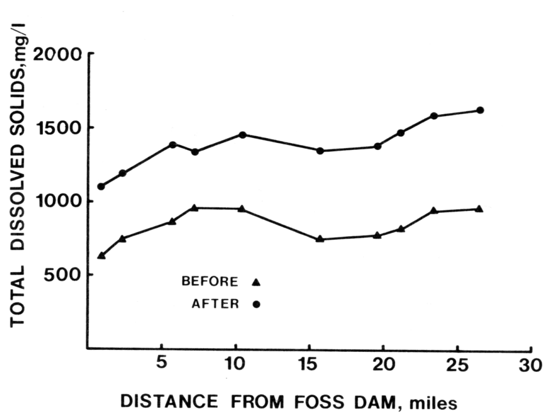

FIGURE 4. TDS concentration in the Washita River before and after commencement of FDP brine discharge. Each point represents the yearly mean at a particular site.

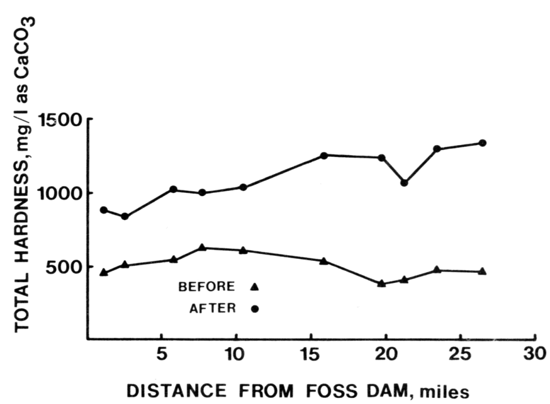

FIGURE 7. Hardness in the Washita River before and after commencement of FDP brine discharge. Each point represents the yearly mean at a particular site.

tions, and the decrease in alkalinity after the FDP became operational; these differences were significant (Table 2, $P < 0.01$). The pH did not change significantly.

Factors which possibly caused changes indirectly or directly, in the concentrations of dissolved minerals in the Washita River were runoff, tributaries, FDP brine discharge, and Foss Reservoir. In the tributaries, which included runoff effects, only chloride and hardness increased, but the percentage change and F values (Table 2) of these constituents were much higher in the river than in the tributaries and it is unlikely that the tributary changes were responsible for the greater changes in the river. The changes in the river are probably due to the combined influence of the FDP brine and releases from Foss Reservoir.

The low pH of the brine is the probable cause of the alkalinity decrease due to the reaction of the acidic brine with the bicarbonate ions in the river:

$$H^{+}_{brine} + HCO_3^{-}{}_{brine} \rightarrow H_2CO_3 \rightarrow H_2O + CO_2$$

The buffering capacity of the river prevented a pH change, but the capacity of the river to resist future pH fluctuations was reduced (10).

Oklahoma's Water Quality Standards (11) lists as the beneficial uses of the Washita River: public and private water supply, fish and wildlife propagation, agriculture, municipal and industrial cooling water, primary and secondary body contact recreation, and aesthetics. The investigation showed that both before and after the FDP became operational: (a) without treatment the river water was unsuitable for drinking due to high concentrations of sulfate and dissolved solids (12), (b) the river water was suitable for irrigation of salt-tolerant plants (13) and (c) the water met the requirements of all the other beneficial uses (14).

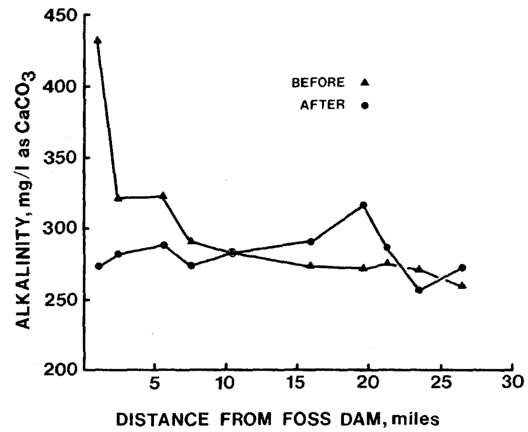

FIGURE 8. Alkalinity in the Washita River before and after commencement of FDP brine discharge. Each point represents the yearly mean at a particular site.

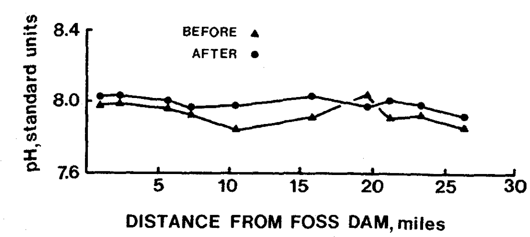

FIGURE 9. pH in the Washita River before and after commencement of FDP brine discharge. Each point represents the yearly mean at a particular site.

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