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GENERAL NOTES

CONCENTRATIONS OF TOTAL DISSOLVED SOLIDS AND SELECTED CATIONS IN DARDANELLE LAKE, ARKANSAS

One indicator of water quality is the amount of ionic compounds dissolved in the water. This can be measured indirectly by determining the total dissolved solid (TDS), the great bulk of which is ionic. TDS is an important criterion for the quality of irrigation water.

Although salts present in irrigation water provide some nutrients essential to plants, excessive salt concentration inhibits plant growth. Excessive Na^+ replaces Ca^{2+} and Mg^{2+} in the soil thus strongly influencing the physical properties and plant nutritional capabilities of the soil.

High salinity in drinking water presents very little health hazard, limited to minor and temporary disturbance of the digestive system.

In 1972 and again in 1973, personnel of the Arkansas Department of Pollution Control and Ecology measured, among a large number of variables, TDS in the Arkansas River (Water pollution control survey of the Arkansas River Basin, Arkansas Department of Pollution and Ecology, Water Division, 1,233 pp. 1974). In 1972, the average value of TDS was 482 mg/l for the period from August to October; in 1973, the average value was 377 mg/l but for the period June - August. The water of 1972 was classified as having a high salinity hazard and a medium sodium hazard as irrigation water. But, it was concluded that since the concentration of salt and the TDS had decreased, the quality of the water had improved from 1972 to 1973. The survey states, "Now the river meets the U. S. Public Health Service drinking water standard of 500 ppm dissolved solids even during periods of low flow."

Actually this decrease probably was due to the different collection times, since there is a very definite seasonal variation in TDS in the Arkansas River. Since 1973, values of TDS in the period August - October have increased. As a part of a study of the radioactivity in the Dardanelle Lake section of the Arkansas River (Chittenden, Radionuclides in the Arkansas River upstream and downstream from the Nuclear I power generating facility, 27 pp., 1978), the total dissolved solids were measured in the process of determining the gross beta activity of the water. TDS is defined, in this work, as the material in solution or suspension which will pass through Whatman 42 filter paper.

The TDS was determined by evaporating a 100-500 ml aliquot of water that had been filtered through Whatman 42 paper. The residue was quantitatively transferred to a stainless steel counting planchet and dried to constant weight at 105°C.

The Na^+ and K^+ concentrations were determined by flame emission spectroscopy using a Jarrell-Ash Dial Atom A. A. Spectrometer. The hardness was determined by the standard EDTA titration.

Figure 1 summarizes the variation in the mass of dissolved solids per liter of water collected from the surface at the dam (Station 4). Samples from both Stations 3 and 4 are typical of Arkansas River water, but more data is available for TDS at Station 4. TDS varied widely during 1976, rising to a maximum in June, falling, and then rising to a second, lower and broader maximum in autumn. The June maximum appeared again in 1977. Since the project ended in September, 1977, it is not known if the autumn maximum also appeared in 1977.

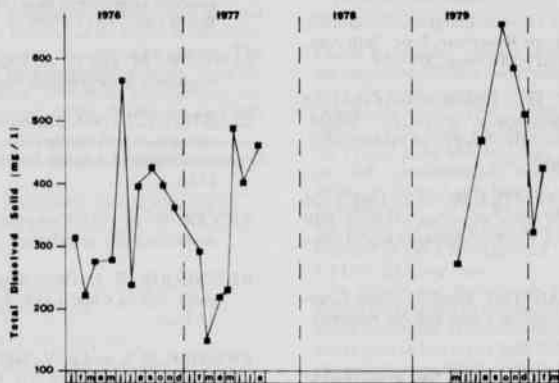


Figure 1. Total dissolved solids (TDS) distribution for water at the dam (Station 4).

The study was resumed in May, 1979, and monthly sampling was begun in October. The autumn maximum is quite pronounced. Unfortunately sampling was not done in June or July, so the summer maximum for 1979 is not known. Since May, 1979, the Na^+ concentration has varied from 46 ppm (in January, 1980) to 140 ppm (in October, 1979); total hardness (Ca^{2+} and Mg^{2+} , expressed as Ca^{2+}) ranged from 36 ppm to 62 ppm, for the same months; the range of K^+ was 1.5-2.6 ppm. The variation of these concentrations followed that of TDS quite closely.

These trends are quite similar to those exhibited by the surface water of the Lake Powell section of the Colorado River (Johnson and Merritt, Water Resources Res., 15:873-884, 1979). The Colorado River is used as a comparison because it also carries a substantial load of dissolved material. A plot of the seasonal variation of TDS in Lake Powell also exhibits two maxima, the more pronounced being the earlier of the two.

Dissimilarities are also evident. In Lake Powell, the more pronounced maximum in TDS usually occurs in the spring rather than June, and the autumn maximum is barely noticeable, but it does exist. In the Colorado River, TDS varies only slightly during the year, 500-600 mg/l at the surface and 600-700 mg/l in subsurface water. This TDS remained fairly constant over a three year interval. The TDS of the Arkansas River shows much wider variation (240-540 mg/l in 1976).

It also should be noticed that the TDS is markedly higher in the late summer of 1979 than in the late summers of 1976 or 1977. If the wide autumn maximum in 1977 was similar (in the geometrical sense of the word) to that of 1976, the average TDS in 1977 would have been greater than in 1976 despite lower values during the first half of 1977. The average value of TDS in 1979 can be assumed to be higher still since each monthly value measured was greater than or equal to the corresponding values of 1976 and 1977. If there is, indeed, such a trend, the quality of water in the Arkansas River is seriously deteriorating.

In the Colorado River of the early 1950's, before the system of dams was completed, the TDS did vary over a wide range, 400-1200 mg/l. during the year, but the minimum occurred during the summer, corresponding to a maximum in the volume of water passing along the river. There seems to be no such correspondence in the Arkansas [see (Chittenden, Proc. Ark. Acad. Sci., 33:25-27, 1979) for the discharge at the dam for most of the 1976-1977 period].

The average concentration of Na^+ , K^+ , and total hardness in the world's rivers has been estimated (Livingstone, D. A. 1963. Chemical composition of rivers and lakes. U. S. Geol. Surv. Prof. Paper 440-G, U. S. Government Printing Office, Washington, D. C., 64 pp.) to be respectively, 6.3 ppm, 2.3 ppm, and 21.8 ppm. In the Arkansas River, only the K^+ is "normal", Na^+ ranges from 6-23 times the average and total hardness from 1.5-3 times the average.

The maximum in June may be connected with preparation of agriculture land for planting and with the volume of spring precipitation. The marked maximum in autumn may be connected with the disturbance of the soil at the end of the agricultural growing season. Intensive agricultural activity and irrigation may be causing an increase in the already high salinity in the waters of the Arkansas River.

Further measurements over the next eighteen months should further elucidate the trend in the variation of the TDS. If this trend is a monotonic increase, the problem of water quality in the Arkansas River will be as serious as that in the Colorado River.

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FACTORS AFFECTING THE Sr-90 CONCENTRATION IN DARDANELLE LAKE, ARKANSAS

Variations in the Sr-90 concentration and in the amount of $\text{Ca}^{2+} + \text{Mg}^{2+}$ present in the water of Dardanelle Lake seem to be related in samples collected near the outlet for reactor cooling water (Station 1) and at the dam (Station 4). This dependence was first noticed as a variation of Sr-90 activity with total dissolved solids (TDS). Most of the Sr-90 released by the reactor leaves the lake in solution but some remains behind in the form of ions adsorbed on the surface of sediment particles.

The release of this adsorbed Sr-90 is postulated to be an ion-exchange type of process:



The concentration of Sr-90 activity can be expressed as:

$$A_{90} = B_0 + B_1(A_r) + B_2(C) \quad (1)$$

where A_{90} = the concentration of Sr-90 activity (pCi/l) in lake water

A_r = the concentration of all the activity released by the reactor (pCi/l)

C = the concentration of $\text{Ca}^{2+} + \text{Mg}^{2+}$ (ppm)

B_0 = Sr-90 from fallout present in lake water (pCi/l)

B_1, B_2 = constant coefficients

For studies prior to 1979 (Chittenden, Radionuclides in the Arkansas River, upstream and downstream from the Nuclear I power generating facility, 27 pp, 1978.) only the TDS values were determined. It was found that the concentration of $\text{Ca}^{2+} + \text{Mg}^{2+}$ was a fairly constant (10 ± 1)% of TDS. Thus

$$C = (0.10 \pm 0.01)(\text{TDS}) \quad (2)$$

Combining equations (1) and (2),

$$A_{90} = B_0 + B_1(A_r) + B_3(\text{TDS}) \quad (3)$$

where $B_3 = B_2(0.10 \pm 0.01)$

The data for the individual collecting stations (Chittenden and McFadden, Proc. Ark. Acad. Sci. 32:31-34, 1978.) were treated statistically using the MINITAB package available on the Harris/7 system at Arkansas State University. Regression analyses were used to derive the coefficients for equation (3) and correlation coefficients were calculated for Sr-90 activity and TDS. Table 1 summarizes these values.

Table 1. Results of Statistical Analysis of Data

Station	1	2	3	4
Location	Downstream	Upstream	Upstream	Downstream
Amount of Sr-90 Adsorbed	High	Low	Low	Moderate
B_0	0.45	0.63	0.91	0.36
B_1	0.00	0.067	0.00	0.048
B_3	$9.2\text{E}-4$	$0.0\text{E}-4$	$0.0\text{E}-4$	$3.4\text{E}-4$
r	0.82	0.06	0.00	0.45

Note: $9.2\text{E}-4 = 9.2 \times 10^{-4}$