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Geochemistry of the seepage water from drain hole 0+53 Down, Adit RAA-2 of Tarbela Dam

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ABSTRACT: *Geochemical parameters of the seepage water from drain hole 0+53 Down, Adit RAA-2 of Tarbela Dam are markedly in contrast with the similar parameters of the reservoir water. TDS and EC values are significantly higher and the amount of dissolved oxygen is lower in the drain hole seepage water than those of the reservoir water. The data suggest addition of soluble salts from the rocks of the right abutment into the seepage water while in transit from reservoir to drain hole. This clearly shows removal of soluble material from the country rocks and thus creation of voids in the right abutment. Lower values of dissolved oxygen in seepage water, as compared to those of reservoir water, indicate its consumption for the oxidation of ferruginous minerals during the transit period. Both gypsum and limestone are present in the country rocks with the former having higher oxidation potential and thus considered a preferred target of removal through dissolution, as cmpared to the latter. Therefore, proper future monitoring of the geochemical parameters of the seepage water in various drains is very important for evaluating the geotechnical hazards being posed by the dissolution of gypsum from the country rocks of right abutment of Tarbela Dam.*

INTRODUCTION

Construction of dams, particularly large dams, like Tarbela Dam, results in storage of large quantities of water which exert tremendous pressure on the dam walls and surrounding country rocks. Under these conditions reservoir water develops a tendency to flow through permeable rocks, along joints and fractures, or other weak zones. Long term presence of this water in the country rocks or the dam walls eventually causes saturation with respect to water and leads to high pore pressure. This high pore pressure is unsafe for the structure. Therefore seepage drain holes are provided for the escape of trapped water and thus release of pore pressure. For this purpose a network of adits with seepage drain holes has been provided in the entire length of Tarbela Dam as well as in the country rocks of the right abutment. A systematic study has been initiated for investigating the nature of seepage water from various drain holes of the right abutment of Tarbela Dam. The geochemical studies of seepage water will let us understand the nature and amount of dissolved salts being removed through the seepage water and monitoring geotechnical hazards, if any. For this purpose seepage drain hole 0+53 Dn (Down) of adit RAA-2 (Fig. 1) has been selected for present geochemical investigations.

GENERAL GEOLOGY OF THE RIGHT ABUTMENT

Full description of the geology of this area is beyond the scope of present investigations. However, the details can be found in studies by Calkins et al. (1975), Jan et al. (1981), Kempe

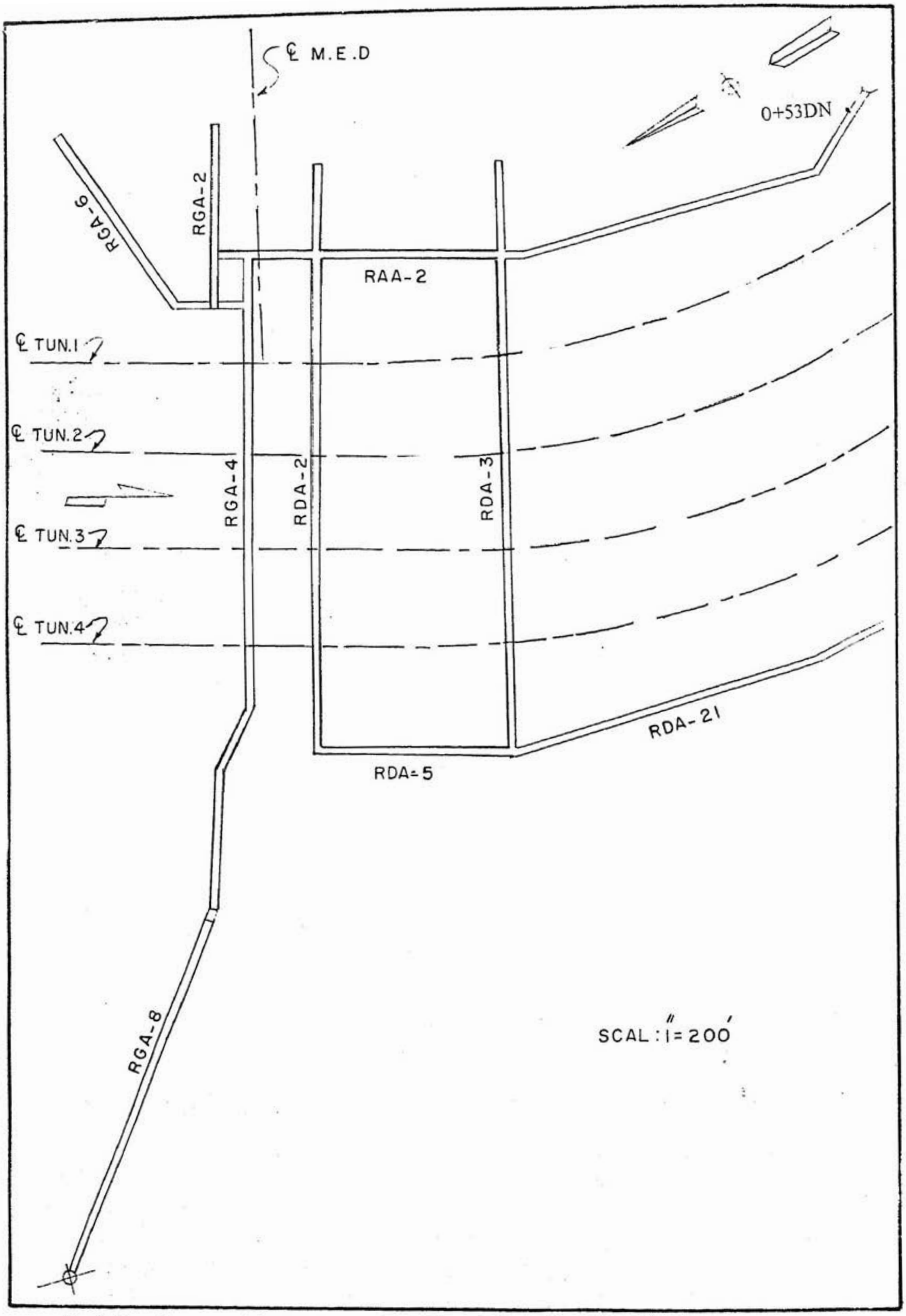

Fig. 1. Lacation map of drain hole 0+53 Down in Adit RAA-2 of right abutment of Tarbela Dam.

and Jan (1980), Martin et al. (1962) and Siddiqui (1973). Generally there are three main types of rocks: chloritic and graphitic schists, sugary limestone, and a mass of a basic rock - gabbro; all of Lower Paleozoic age. The area shows severe effects of deformation due to various phases of tectonics, particularly those related to the Himalayan orogeny. Presence of gypsum has been reported after petrographic studies, and it occurs as small lenses, along joints and fractures, and in disseminated form, mostly in sedimentary and metamorphic rocks. The dissolution potential of gypsum is 7.8×10^{-3} gm/l, whereas that of limestone is 3.9×10^{-5} gm/l. Thus excess dissolution or removal of gypsum is possible during the life time of large dams like Tarbela Dam, but limestone dissolution takes place at much slower rate and can not pose any geotechnical problem. Thus the present studies will provide important clues about the nature of material being removed in solution through the seepage water at drain hole 0+53 Dn of adit RAA-2.

METHODOLOGY

In order to carry out the present geochemical investigations of the seepage water the studies done include: (1) Total dissolved salts (TDS) determination - TDS of the water samples was monitored through the use of a digital TDS meter, model Hanna HI-8734 with accuracy of ±1%. The TDS meter was regularly calibrated for maintaining the standard pH accuracy. (2) Electrical conductivity (EC) determination - EC of the seepage water samples was monitored through a conductance meter YSI Model 35 using YSI-3402 conductivity cell, with digital read out system. (3) Dissolved oxygen determination - The amount of dissolved oxygen in the seepage water samples was monitored through the use of an oxygen electrode model 97-08 in combination with Orion analog pH meter, model 301. (4) Flow determination - The flow of water through the seepage drain holes was measured through the use of calibrated containers and stopwatch.

DATA

Various parameters mentioned above were monitored at different times covering a period of March 1991 to August 1994. The data are given in Tables 1 and 2 and diagramatically represented in Figures 2-4.

TABLE 1. SEEPAGE WATER DATA FROM DRAIN HOLE 0+53 DOWN OF ADIT RAA-2 FROM THE RIGHT ABUTMENT OF TARBELA DAM.

Sampling time	TDS (mg/l)	ECμmhos at 25°C	Dissolved oxygen (ppm)	Fl ow (gallons/minute)
March 91	576	1205	1.0	1.5
July 91	591	1228	0.9	3.0
Aug 91	645	1281	0.7	3.0
Jan. 92	490	1241	1.2	1.0
April 92	620	1441	1.3	1.5
Oct. 92	583	1307	1.2	2.5
Dec. 92	562	1217	1.1	2.0

TABLE 2. GEOCHEMICAL DATA OF THE TARBELA DAM RESERVOIR

Sampling time	TDS (mg/l)	ECμmhos at 25°C	Dissolved oxygen (ppm)
Mar-91	62	187	9.8
Jul-91	65	141	9.7
Aug. 91	70	144	8.4
Aug. 91	69	142	8.9
Sept. 91	71	145	9.4
Jan . 92	65	137	9.2
Feb. 92	71	176	9.5

DISCUSSION

TDS

The TDS values of the seepage water from drain hole 0+53 Dn show variation from 490 mg/l to 645 mg/l (Fig. 2a). This suggests that the amount of dissolved salts being removed through the seepage water of this drain hole varies at different times of a year. This variation could be related to the amount of water in the Tarbela Dam reservoir (i.e., high and low reservoir levels) and needs further investigations.

Considering the TDS value of ~70mg/l for the reservoir water, the TDS values of the seepage water from drain hole under investigation are quite high and indicate a sufficiently large quantity of dissolved salts being removed. This interpretation, however, needs to be taken into consideration in combination with the flow data as described in the following section.

Flow

The data on flow of water shows that the amount of water being discharged from this drain hole varies from 1 gpm to 3 gpm (Fig. 2d). Considering the fact that the drain hole 0+53 Dn is located (a) in rocks close to the reservoir and (b) at lower elevation (1142 feet), a flow of less than 5 gpm suggests a low flow rate. Therefore, at this rate of water discharge abundant material cannot be removed in dissolution. However, it is important to monitor the TDS values and flow rate because an increase in any one of these factors may lead to important clues in future monitoring of the geotechnical hazards.

EC

The EC values were obtained at room temperature. Therefore these were standardized for 25°C, using normal procedure of a 2% change per degree Celsius. These EC values are higher than those obtained for the reservoir water (Tables 1,2; Fig. 2b). These values, however, follow the variation in their corresponding TDS values and a direct relationship exists between these two parameters (Fig. 4). Therefore, while monitoring TDS the data on EC should also be carefully studied for reliable interpretation about the removal of dissolved salts through the seepage water.

Dissolved oxygen

The amount of dissolved oxygen in the seepage water of drain hole under investigation varies from 0.7 ppm to 1.3 ppm (Table 1; Fig. 2c). These values are considerably lower than those of the reservoir water values (8.5 - 10 ppm) (Table 2, Fig. 3c). This indicates the loss of dissolved oxygen in the reservoir water after it enters the country rocks. It is very likely that the dissolved oxygen in reservoir water is utilized for the oxidation of a variety of minerals present in various country rocks while the water is passing through these rocks. The presence of abundant ferruginous oxides around the mouth of the drain hole(s) suggests that such process of oxidation consumes most of the dissolved oxygen from the seepage water. As such process of oxidation cannot proceed at a fast rate at in a temperature

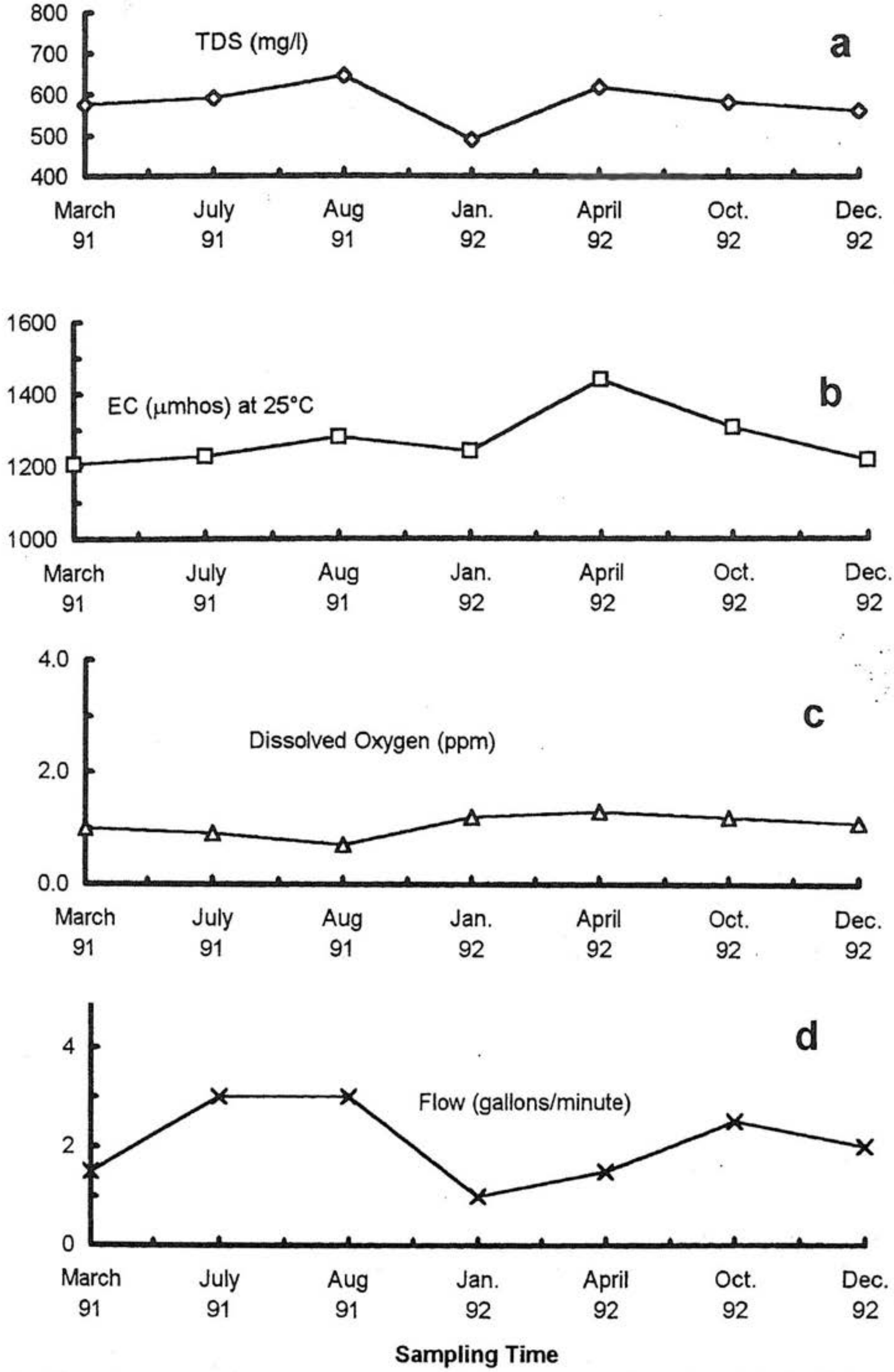

Fig. 2. Plots of various geochemical parameters of the seepage water from drain hole 0+53 Down of Adit RAA-2 from the right abutment of Tarbela Dam.

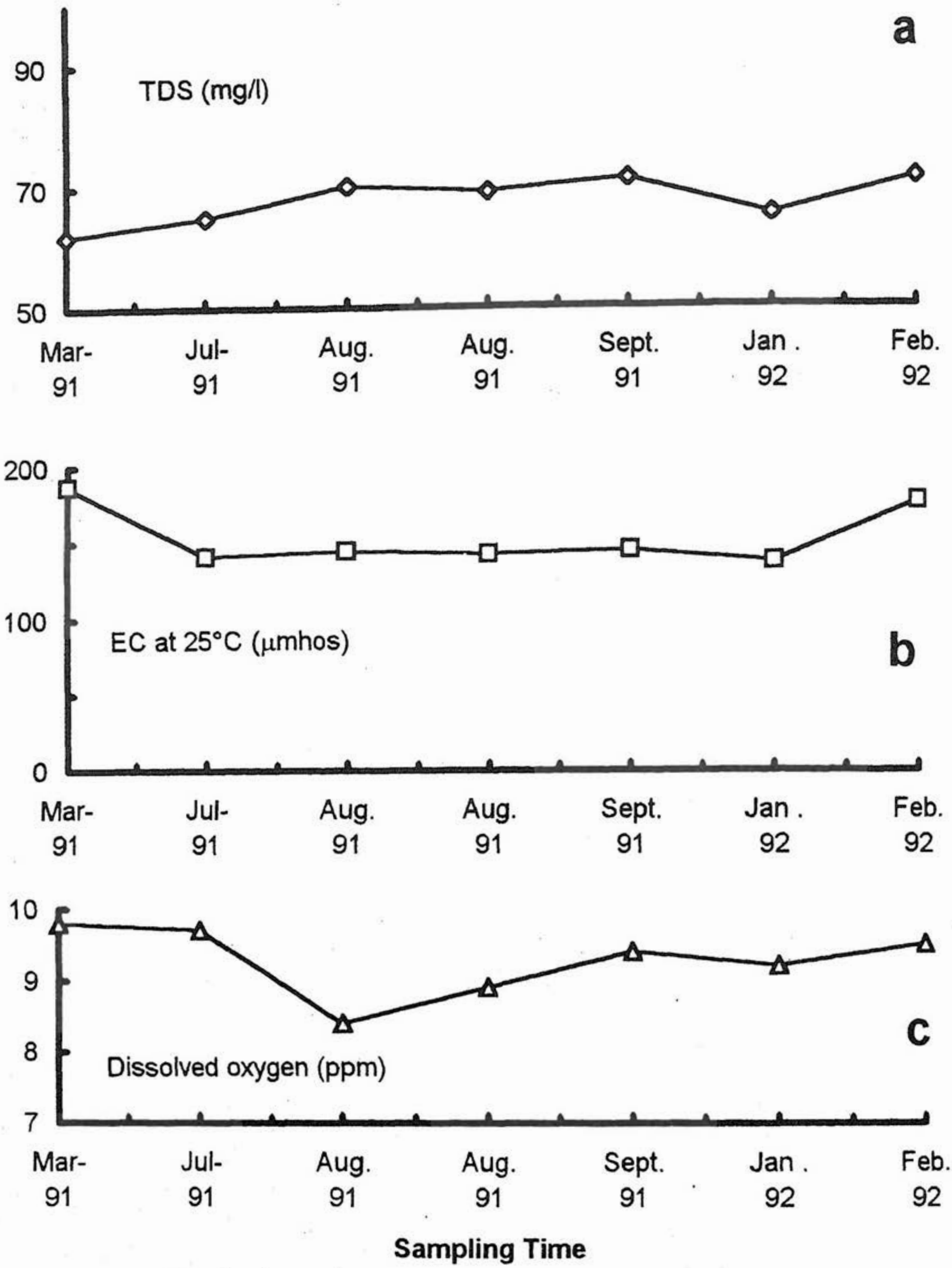

Fig. 3. Plots of various geochemical parameters of the reservoir water from Tarbela Dam.

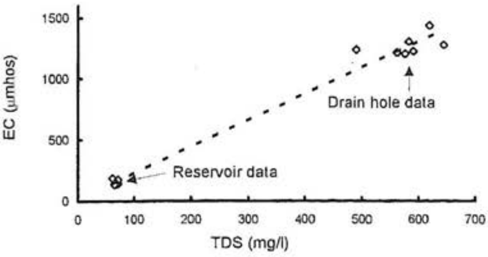

Fig. 4 EC (at 25°C) vs TDS plot of the seepage water from drain hole 0+53 Down of Adit RAA-2 and reservoir, Tarbela Dam

range of ~16 - 17°C, it is likely that the seepage water must have spent sufficient time in the country rocks since leaving the reservoir.

CONCLUSIONS

TDS values of the seepage water, collected from drain hole 0+53 Dn of adit RAA-2 over a period of March 1991 to December 1992, are significantly higher than those of the reservoir water (Table 2; Fig.3), indicating the removal of a large quantity of salts in dissolution. Similarly high EC values correspond to high TDS values in the seepage water from this drain hole, and substantiate the interpretation that sufficiently large quantity of dissolved salts are being removed through the seepage water. At low rate of discharge this process does not pose any geotechnical danger to the area. Future monitoring should be however, concentrated on observing the discharge of seepage water from this drain hole. An increase in flow rate should be immediately given due significance.

The amount of dissolved oxygen in the seepage water is significantly lower than that of the reservoir water. The seepage water has thus spent enough time in the country rocks since its departure from the reservoir. The loss of this dissolved oxygen is attributed to oxidation of various minerals, particularly ferruginous ones, while seepage water was in transit. The presence of ferruginous coating around the mouth of drain hole supports this interpretation. All of the above-mentioned factors suggest that the geochemistry of reservoir water is markedly changed by the time it starts seepage at the drain hole 0+53 Dn of adit RAA-2, and these changes take place during the transit of reservoir water through the country rocks.

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