The chemical composition of Transkei dam water

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Abstract

The water quality of Transkei dams was determined over a period of two years to afford a baseline for future studies in the area and to give an indication as to the present state of Transkei dam water. The more important findings resulting from this study are: the concentrations of determinands generally decrease from the westerly to the easterly situated dams; the catchment area of the Gcuwa and Xilinxa Dams is significantly different as shown by the relatively high concentrations of determinands (macro elements) present in the water; relatively high concentrations of aluminium and iron at Umtata are related to the newness of the Umtata Dam; relatively high concentrations of arsenic are attributed to the leaching of old cattle dip material into the water; and all dams exhibit high turbidity characteristics.

Introduction

The Republic of Transkei, situated in the south-eastern corner of Southern Africa, is extremely well blessed with a high rainfall resulting in an average annual runoff per unit area far in excess of that of the rest of Southern Africa (annual rainfall is about 815 mm). Very little information regarding the quality of this water asset of Transkei was, however, available until an internal report for use in Transkei was published in 1983 (Du Preez, 1983). Because of its very limited circulation a paper on the water quality of Transkei rivers was published (Du Preez, 1985) and the present paper is presented. This data would produce a baseline for future studies in the area and give an indication as to the present state of Transkei water.

Materials and methods

The methods used for collection, preservation, preparation and analysis of the water samples are detailed by Du Preez (1985).

Results and discussion

The ten dams included in this study (Figure 1) are each represented by at least one sampling site at its wall. Because of the extensive aquaculture research programme at the Umtata Fish Research Centre (Prinsloo and Schoonbee, 1984; S A Waterbulletin, 1984), the Umtata Dam was sampled at seven sites (Figure 2). These dams are situated in the western parts of Transkei where the annual rainfall is relatively lower. No major dams are found east and north-east of Umtata.

The most westerly dam is the Bonkolo Dam (No. 5, Figure 1). It is situated on the Komani River upstream from Queenstown. Although this site lies outside Transkei it was included in this study because the Komani River is a tributary of the Great Kei River; the catchment of the Bonkolo Dam lies in a well-developed agricultural region where the results of the contamination of the water resources should be observable; and the Bonkolo Dam is relatively close to most of the Transkei dams.

The geometric mean values of all the determinands in the mercuric chloride preserved samples for all sites for the period June 1979 till January 1982 are presented in Table 1. Since conductivity, Si and F^- analyses were performed only by the Department of Water Affairs (Du Preez, 1985), and since most of the Umtata Dam samples were not sent to Pretoria for duplicate analyses of the other determinands, the former are not included in Table 1 for sites 2A to 2F.

Profile across Transkei

Most of the dams lie on a line that connects the Bonkolo and Umtata Dams; the exceptions are the Xilinxa and Gcuwa Dams (Figure 1). When the latter two dams are excluded from a comparative study, a gradual decrease in concentration of most determinands is evident in going from the west to the east. This trend is similar to that found for the rivers of Transkei (Du Preez, 1985) and points to different geological and soil conditions in Western Transkei and the adjoining areas of the Republic of South Africa. The Gcuwa and Xilinxa Dams have relatively high values for most determinands and do not fit in the above trend. The Gcuwa Dam, which was sampled over the whole 2,5 year period, is in fact only a local (short-term) storage reservoir for Butterworth. The Xilinxa Dam, which is upstream from the Gcuwa Dam, serves as the real water reservoir for Butterworth. This dam was sampled only after it became apparent that the results of the Gcuwa Dam were anomalous. The Xilinxa Dam data in Table 1 thus refer to a shorter sampling term. It nevertheless is clear that not only do these two dams have very similar water-quality characteristics (Table 1) but they also have quite different water-quality characteristics compared to most of the other Transkei dams. However, no obvious visual difference between the catchments of all the dams under discussion was discernable. Further, industrial or agricultural pollution of dams within Transkei is either not possible or suspected.

Comparison of water quality of dams in Transkei and in the Republic of South Africa

Table 2 contains water quality data of a number of dams in South Africa; additional information can also be obtained from Grobbelaar (1979), Stegmann *et al.* (1981) and Schutte and Bosman (1973). From Table 1 it is clear that the Gcuwa and Xilinxa Dams are comparable to the Hartbeespoort Dam with respect to conductivity, Na^+, Cl^-, Ca^{2+}, Mg^{2+} and total alkalinity even though the latter dam is polluted due to industrial and domestic effluent. Pollution on a similar scale cannot take place in Transkei, however, even though Na^+ and Cl^- values are the highest for the two Transkei dams. The water quality of the other Transkei dams compares favourably with those dams in South Africa where no pollution is expected.

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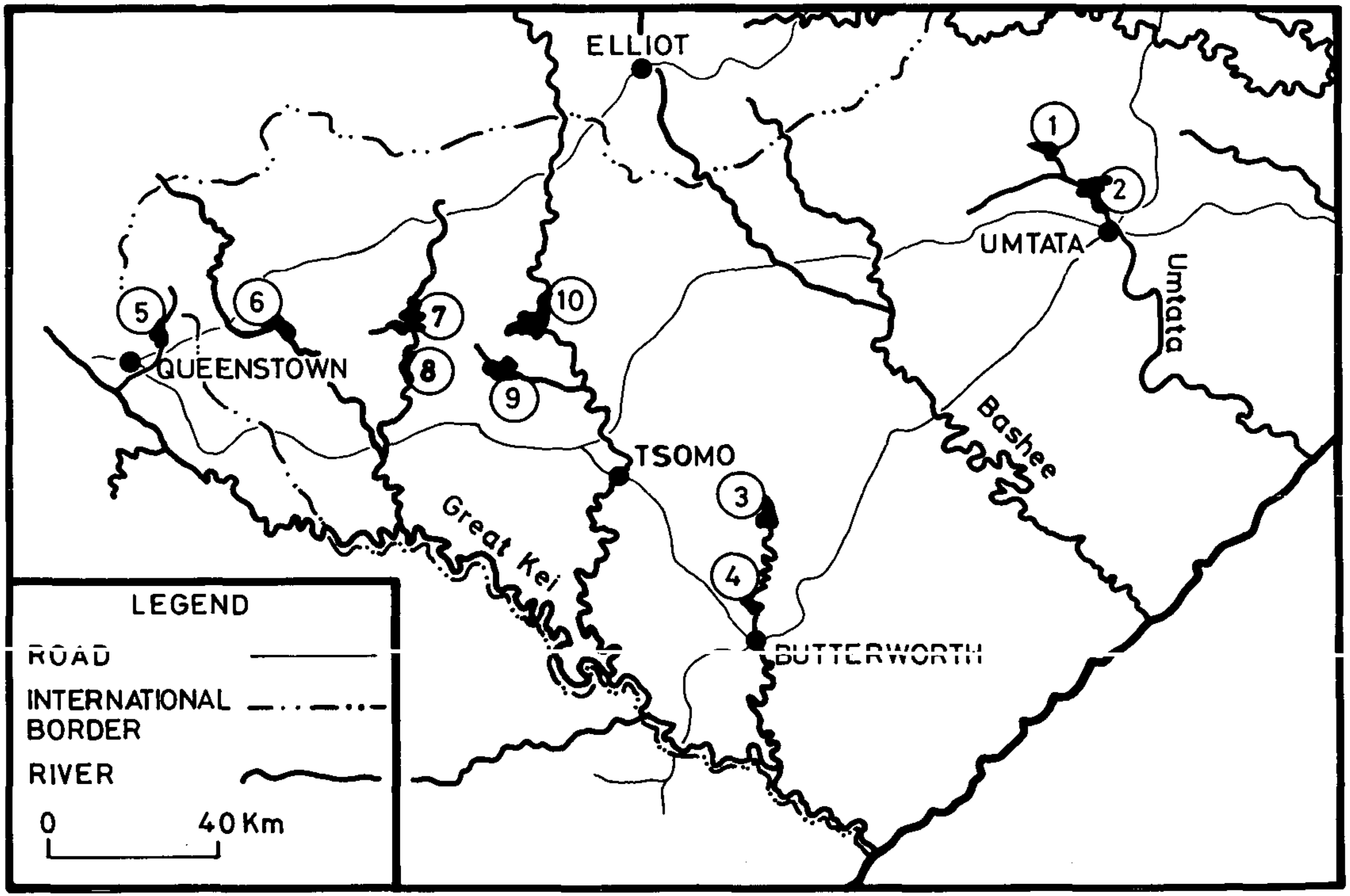

Figure 1.
Sampling sites in and around Transkei

TABLE 1
RESULTS OF CHEMICAL ANALYSES OF TRANSKEI DAMS: ANNUAL GEOMETRIC MEAN VALUES (mg/ℓ) FOR THE PERIOD JUNE 1979-JANUARY 1982

Station No.*	Dam	Sample Site No.	pH	Conductivity (mSm^{-1})	Ca^{2+}	K^+	Mg^{2+}	Na^+	Cl^-	PO_4^{3-}-P	SO_4^{2-}	NO_3^--N	NH_4^+-N	Si	F^-	Total Alkalinity$^+$	Total Hardness$^+$
T2Q04	Mabeleni	1	6,0	4,36	1,04	0,70	1,19	3,61	4,94	0,01	3,28	0,34	0,16	3,24	0,05	9,75	9,33
T2Q05	Umtata	2A	6,2	5,75	3,73	0,42	2,21	5,80	5,62	0,04	2,40	0,28	0,07	5,66	0,05	12,69	22,10
—	Umtata	2B	7,0	—	4,55	0,45	3,34	5,48	11,37	0,09	0,95	0,62	0,14	—	—	9,66	20,53
—	Umtata	2C	7,0	—	7,98	0,58	4,59	8,36	9,73	0,10	0,95	0,40	0,11	—	—	15,28	19,86
—	Umtata	2D	7,0	—	3,65	1,70	3,11	8,49	9,13	0,09	2,85	0,58	0,14	—	—	20,19	25,72
—	Umtata	2E	7,1	—	7,60	0,77	4,37	9,50	8,64	0,14	1,43	1,10	0,15	—	—	26,49	32,49
—	Umtata	2F	7,3	—	6,34	0,79	4,14	9,08	8,13	0,16	2,20	0,78	0,12	—	—	25,42	31,03
T2Q03	Umtata	2G	6,5	8,14	4,83	2,86	3,34	7,73	9,14	0,14	5,22	0,71	0,18	5,90	0,09	30,00	30,22
S7Q04	Xilinxa^x	3 (Dec 81/Jan 82)	7,3	39,73	15,46	2,23	8,96	41,59	57,47	0,02	7,81	0,22	0,05	5,46	0,49	74,88	—
S7Q02	Gcuwa	4	7,6	51,11	22,52	2,35	14,04	54,84	62,02	0,19	11,43	0,54	0,16	7,73	0,40	110,69	122,76
S7Q02	Gcuwa^x	4 (Dec 81/Jan 82)	7,8	58,14	25,74	1,54	17,51	59,64	72,77	0,02	6,69	0,16	0,04	5,28	0,29	156,86	—
S3Q02	Bonkolo	5	8,0	43,06	28,14	3,99	19,28	29,73	32,70	0,04	9,85	0,59	0,12	3,26	0,48	158,87	169,00
S1Q02	Xonxa	6	7,9	34,30	24,98	2,19	15,10	22,79	19,30	0,02	7,51	0,36	0,07	2,12	0,65	130,99	136,74
S2R01	Lubusi	7	7,6	26,64	19,05	2,73	10,45	20,32	17,05	0,06	7,82	1,00	0,11	3,77	0,53	93,64	104,00
S2M02	Lanti Weir	8	7,5	27,31	19,75	2,69	10,61	21,12	16,72	0,03	8,44	0,83	0,12	4,11	0,49	94,58	107,70
S5Q01	Tsojana	9	7,2	17,95	11,96	2,91	7,03	12,85	15,71	0,10	4,80	0,68	0,14	9,55	0,22	50,43	31,86
S5R01	Ncora	10	6,8	10,28	7,62	2,77	4,12	6,34	6,61	0,06	3,55	0,61	0,12	6,99	0,19	24,65	39,39

* Department of Water Affairs
\+ As $CaCO_3$
x Geometric mean calculated for the results of sampling dates 7/12/1981 and 26/1/1982

Urban pollution of water resources in Transkei

Comparison of the Bonkolo Dam (upstream from Queenstown) with the Komani River (downstream from Queenstown; Du Preez, 1985) shows the influence of urban contamination of the water resources. The values of the majority of determinands increase in going from the dam to the river downstream from the town; Mg^{2+}, F^- and total alkalinity are exceptions. The decrease in the concentration of the latter determinands can be ascribed to the influence of the treated sewage effluent. The effect of urban pollution is also illustrated by comparing the Gcuwa Dam (upstream from Butterworth) with the Gcuwa River (downstream from Butterworth; Du Preez, 1985). The less dramatic increase in all the values in going from the Umtata Dam (upstream from Umtata) to the Umtata River just downstream from the Umtata sewage works (Du Preez, 1985) may be due to the fact that the water flow from the Umtata Dam to feed the hydro-electric power station is sufficient to dilute any potential urban contamination.

Turbidity and suspended sediment in Transkei dam water

During January 1982, the amount of sediment per litre of sampled water for each sampling site (except No. 3) was determined. All sediment in the acid-preserved samples coagulated quite well so that the filtration of these samples afforded an easy way of determining the total amount of sediment per sample. The nephelometric turbidity of the mercury preserved samples (very little coagulation of suspended material occurs) of January 1982 was also determined.

A comparison of the turbidity values of the Transkei

TABLE 2
RESULTS OF CHEMICAL ANALYSES* OF SOME SOUTH AFRICAN DAM WATER (mg/ℓ) (SAMPLING SITES AT THE RESPECTIVE WALL)

Dam	Station No.*	Source (river)	Period of Study	pH	Conductivity (mSm^{-1})	Ca^{2+}	K^+	Mg^{2+}	Na^+	Cl^-	PO_4^{3-}-P	SO_4^{2-}	NO_3^--N	NH_4^+-N	Si	F^-	Total alkalinity$^+$	Total hardness$^+$
Vaal	C1R01	Vaal	1-4-1968 to 5-9-1983	7,5	18,4	14,0	3,4	8,0	12,0	7,0	0,04	8,0	0,13	0,09	5,0	0,30	73,0	65,0
Midmar	U2R01	Mgeni	27-2-1968 to 15-8-1983	7,0	7,1	5,0	1,1	3,0	5,0	5,0	0,02	3,0	0,12	0,05	3,8	0,20	27,0	22,0
Albert Falls	U2R03	Mgeni	23-3-1976 to 31-10-1983	6,8	9,0	5,0	1,2	3,0	6,0	6,0	0,02	4,0	0,14	0,07	2,7	0,20	27,0	26,0
Welbedacht	D2R04	Caledon	1-4-1980 to 31-3-1984	7,0	20,2	18,0	2,7	7,1	9,7	11,6	—	9,8	0,52	0,12	5,8	0,28	66,4	—
H.F. Verwoerd	D3R02	Orange	1-4-1980 to 31-3-1984	6,8	15,4	15,8	1,7	5,9	5,6	3,4	—	8,5	0,33	0,05	8,2	0,22	53,5	—
Chelmsford	V3R01	Ngagane	1-4-1980 to 31-3-1984	6,8	27,7	15,2	2,7	6,7	29,2	13,3	—	59,4	0,13	0,05	5,2	0,24	37,8	—
Hartbeespoort	—	Crocodile	1-1-1973 to 31-5-1975	8,2	54,0	35,5	7,3	19,0	41,9	42,3	0,41	64,2	2,09	0,69	3,9	—	128,7	—

* Department of Water Affairs, RSA except for Hartbeespoort Dam (Scott *et al.*, 1977)
\+ As $CaCO_3$

dams and the turbidity values of some South African dams (Walmsley, 1980) clearly indicates that the Tsojana, Ncora and Umtata Dams, and particularly the latter, are similar to those South African dams which have the highest turbidity values e.g. Nahoon, Lindleyspoort, Loskop and Bridle Drift Dams; the Vaal or Hendrik Verwoerd Dams were not included in the latter turbidity study.

From an aesthetic and recreational point of view high turbidity is regarded as an index of poor quality since turbid waters can be dangerous for primary and secondary water sport; this applies to most Transkei dams. With regard to their usage for fishing, most of the Transkei dams must also be regarded as being of low quality because of the detrimental effects which suspended solids have on fish production.

TABLE 3
MEAN DIFFUSE ATTENUATION COEFFICIENTS AND SUSPENDED SEDIMENT IN UMTATA DAM

Sample Site Number	Mean k-Value (m^{-1})*	Suspended Sediment $^{+}$(mg/ℓ)
2A	2,10	93,6
2B	3,35	23,1
2C	6,96	206,6
2D	12,83	169,0
2E	15,29	305,1
2F	15,13	287,9
2G	15,21	340,2

*October 1978
\+ July 1981

Umtata Dam

Seven sampling sites were identified on the Umtata Dam and are illustrated in Figure 2. The Umtata Dam represents the only dam which, during the present study, was sampled at more than one site; the results for the Umtata Dam are given in Table 1. There generally appears to be an increase in the concentrations of determinands from where the Umtata River enters the dam, to the wall. Values for suspended sediment (Table 3, July 1981) show a similar trend.

The mean diffuse attenuation coefficients for the Umtata Dam, as measured during October 1978 (Table 3), also generally increase towards the wall. When these values are compared to those obtained for some South African dams (Walmsley and Bruwer, 1980), then it is clear that the Umtata Dam is very turbid; only the Hendrik Verwoerd Dam out of a total of 14 dams, has a higher mean diffuse attenuation coefficient.

The fact that the mean diffuse attenuation coefficients, as well as suspended sediment (Table 3), increase in going from the point of entry of the Umtata River into the dam, to the wall, implies that the Umtata River itself cannot be the source of the lower transparency throughout the greater part of the dam; local factors must contribute to the high turbidity. Wave action with the concomitant erosion of the dam edge must be the main contributing factor towards the increase in turbidity nearer to the wall whereas erosion of the area surrounding the dam will also contribute.

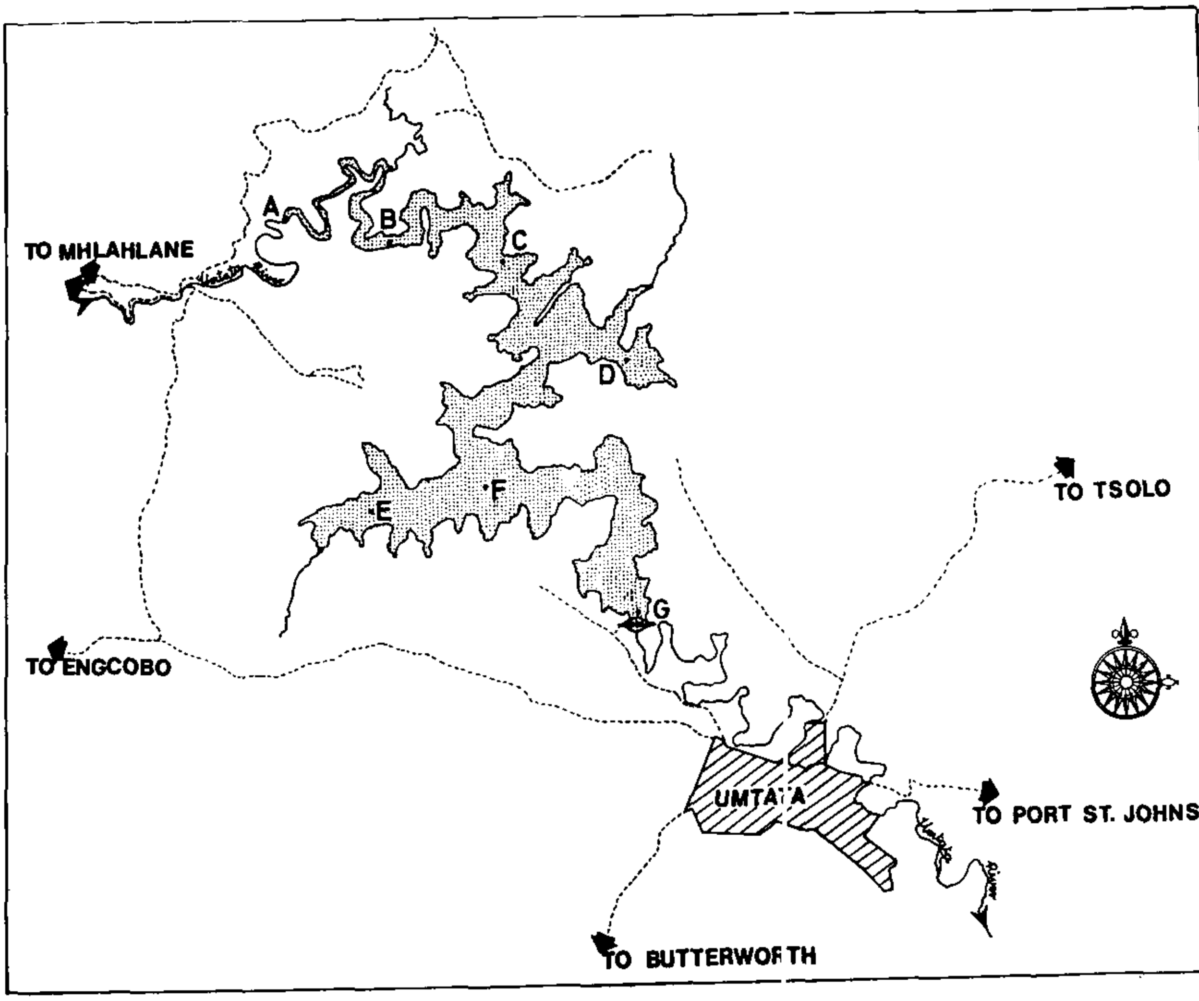

Figure 2.
Sampling sites on the Umtata Dam.

TABLE 4
RESULTS OF TRACE ELEMENT ANLYSES OF TRANSKEI DAMS: GEOMETRIC MEAN VALUES ($\mu g/\ell$) FOR THE PERIOD SEPTEMBER 1980-JANUARY 1982

Dam	Sample Site No.	Aℓ	As	B	Be	Co	Cr	Cu	Fe	Mn	Mo	Ni	Sb	Sr	Ti	V	Zn	Zr+
Mabeleni	1	149	22	4	1	8	4	5	712	14	3	5	10	9	1	3	7	2
Umtata	2G	1932	3	4	1	5	4	4	2040	40	3	5	25	19	1	5	7	2
Xilinxa*	3 (Dec 81/Jan 82)	127	8	31	1	8	5	6	276	44	3	5	23	159	1	3	3	17
Gcuwa	4	513	3	24	1	8	5	4	216	52	15	7	25	55	5	7	5	5
Bonkolo	5	143	12	44	1	8	7	11	103	21	5	5	18	64	2	7	16	20
Xonxa	6	315	9	17	1	11	5	5	150	18	4	3	25	24	1	5	4	22
Lubisi	7	653	22	10	1	8	4	6	384	13	3	5	25	46	1	5	5	3
Lanti Weir	8	666	12	9	1	8	5	7	372	20	3	5	25	46	1	7	24	18
Tsojana	9	765	22	5	1	11	5	8	1178	35	3	7	25	16	1	5	7	2
Ncora	10	783	7	5	1	8	6	3	658	24	3	6	25	13	1	3	7	10

*Geometric mean calculated for the results of sampling dates 7/12/1981 and 26/1/1982
+ Single measurements only: January 1982

TABLE 5
RESULTS OF TRACE ELEMENT ANALYSES* OF SOME SOUTH AFRICAN DAMS ($\mu g/\ell$) FOR THE PERIOD APRIL 1980 TO MARCH 1984

Dam	Station No.	Aℓ	As	B	Be	Co	Cr	Cu	Fe	Mn	Mo	Ni	Sr	Ti	V	Zn	Zr
Ebenaeser	B8R01	66	6	7	1	8	5	3	176	39	4	6	19	1	2	28	7
H.F. Verwoerd	D3R02	192	11	9	1	8	7	4	122	3	5	8	70	3	5	12	9
Roodeplaat	A2R01	96	6	28	2	24	6	7	57	39	11	16	117	2	6	11	—
Vaal	C1R01	340	7	21	1	30	6	5	218	5	7	17	131	7	5	24	11
Welbedacht	D2R04	1467	8	11	1	10	8	12	1228	73	7	10	113	39	9	47	10
Laing	R2R01	459	6	104	1	7	6	8	243	23	8	9	205	12	6	234	4
Nahoon	R3R01	239	5	55	1	8	6	5	162	76	5	7	208	3	3	58	8

* Department of Water affairs, RSA.

Trace elements

The geometric mean values for the period September 1980 till January 1982 are presented in Table 4. These values refer to the total soluble metal ion concentrations (due to the leaching ability of the nitric acid preservative on particulate matter in unfiltered water samples). Interpretation of Table 4 should be done in relation to data of other dams in the region. Such published results are, however, not readily available. Table 5 therefore provides a reference to the interested reader.

A comparison of trace metal concentrations of Transkei dams with data for selected South African dams shows that there is little difference except for the concentration of Fe and Aℓ at the Umtata Dam and As at a number of other sites (Table 5).

Arsenic

Relatively high values for As were found at the Mabeleni, Lubisi and Tsojana Dams. As for Transkei river water the leaching of arsenic containing dip material from old disposal pits into rivers (Du Preez, 1985), and subsequently into the dams, is proposed to be the cause of the high arsenic values. Unfortunately no correlation between sites with high arsenic values in dams and rivers is possible; no dams are situated downstream from river sites with such abnormal arsenic values and vice versa.

Aluminium and iron

The Umtata River downstream from the Umtata Dam exhibits the highest Al and Fe values in Transkei (Du Preez, 1985). The Umtata Dam also conforms to this pattern, although the Umtata River just upstream from the Umtata Dam has remarkably little Al and Fe in its water (321 and 426 micrograms per litre respectively).

The fact that the present study period coincided with the first four years of the dam's existence may explain this phenomenon; excessive leaching of Al and Fe by water covering virgin soil may account for the high Al and Fe values during the first few years of the dam's existence.

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References

DU PREEZ, A.L. (1983) Chemical composition of Transkei river and dam water. Report, University of Transkei, Umtata, Transkei.

DU PREEZ, A.L. (1985) Chemical composition of Transkei river water. *Water SA* **11**(1) 41-47.

GROBBELAAR, J.U. (1979) Early observations of some limnological characteristics of three Orange Free State impoundments. *J. Limnol. Soc. Sth. Afr.* **5**(1) 47-49.

PRINSLOO, J.F. and SCHOONBEE, H.J. (1984) Observations on fish growth in polyculture during late summer and autumn in fish ponds at the Umtata Dam Fish Research Centre, Transkei, Parts I, II and III. *Water SA* **10**(1) 15-35.

SA WATERBULLETIN (1984) Aquaculture in Transkei, November 1984, 14-17.

SCHUTTE, J.M. and BOSMAN, H.H. (1973) Fisiese en chemiese eien-

skappe van damme in die Republiek van Suid-Afrika. Technical Report No. 56, Department of Water Affairs, RSA.
SCOTT, W.E., SEAMAN, M.T., CONNELL, A.D., KOHLMEYER, S.I. and TOERIEN, D.F. (1977) The limnology of some South African impoundments, I. The physico-chemical limnology of Hartbeespoort Dam. *J. Limnol. Soc. Sth. Afr.* **3**(2) 43-58.
STEGMANN, P., PIETERSE, A.J.H., TOERIEN, D.F., SEAMAN, M.T. and VAN DER WAAL, B.C.W. (1981) A preliminary limnological survey of Swartwater Dam (Qwa-Qwa). *Water SA* **7**(1) 16-27.
WALMSLEY, R.D. and BRUWER, C.A. (1980) Water transparency characteristics of South African impoundments. *J. Limnol. Soc. Sth. Afr.* **6**(2) 69.