INSTITUTE OF NATURAL RESOURCES

THE UNIVERSITY OF THE SOUTH PACIFIC

WATER QUALITY IN THE MONASAVU RESERVOIR AND WAILOA DAM - 1991

INR ENVIRONMENTAL REPORT 58

By

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1. INTRODUCTION

The Monasavu hydroelectric scheme, situated on the Nadrau Plateau in central Viti Levu, Fiji was constructed in the period 1977-82. The filling of the dam began in 1982 with minimal vegetation removal. The reservoir is fed directly by the Nanuku Creek. Other small weirs divert streams to the south of Nanuku Creek into a pipeline which eventually empties into the Monasavu reservoir.

Since the filling of the Monasavu reservoir in 1982, the Institute of Natural Resources (INR) has been involved in the monitoring of water quality in the reservoir and Wailoa River for the Fiji Electricity Authority (FEA) (Gibbons and Brodie, 1985; Gangaiya, 1986; Brodie et al., 1987; Naidu, 1988 and Morrison et al., 1990). The principal aim of the study has been threefold; to study the water chemistry of the reservoir; to monitor the Wailoa River below the power station outfall and to monitor the public health status of the reservoir. In 1990, FEA requested that the five weir sites be included in the study.

This report represents the results of the water quality monitoring in 1991.

2. THE MONITORING PROGRAMME

2.1 Organisation

The winter monitoring of the Monasavu reservoir, weirs and Wailoa river was carried out in July 1991. The summer monitoring was carried out in January 1992 and not in December 1991 as originally planned. Table 1 shows the water quality indicators measured at the various sites visted. The parameters stayed basically the same as in the 1990 study except at the weir sites where the number of measurements made were greatly reduced. The parameters chosen at the weir sites were those that would reflect the effect of logging operations in the catchment areas.

Except for temperature, dissolved oxygen and pH which were determined on-site, all other determinations were carried out in the INR laboratory using water samples collected in clean plastic bottles. The unstable determinations such as nitrate, ammonia and phosphate were measured on the day of collection.

The unusual feature of the summer sampling was the extremely low water level in the reservoir, which was approximately 20 meters below normal levels. The low water level is due to low rainfall in Fiji, which in turn is due to a suspected El Nino effect in the South Pacific. The low water levels effected some of the sampling stations in the survey.

Table 1: Summary of Water Quality Monitoring Programme

Water Chemistry:

Location	No of Sites Monitored	Monitoring Sequence	Parameters Measured
Monasavu Reservoir	3 stations each at 3 different depths	July 1991 January 1992	Temperature and dissolved oxygen profiles, clarity, pH, alkalinity, chlorophyll a,b and c, nutrients - total nitrogen, phosphorus and sulphur, ammonia, nitrate, phosphate dissolved and total iron and manganese
Wailoa River	3 stations	As above	As above
Weirs	5 stations	As above	Temperature and dissolved oxygen, pH, total and dissolved iron and manganese, total dissolved solids and suspended solids
Biological Study:			
Monasavu Reservoir	2 stations	January 1992	Invertebrates
Weirs	5 stations	January 1992	Algae

2.2 Location of sampling sites

The sampling sites for both water chemistry and the biological study remained the same as in previous years. These are shown in Figures 1, 2 and 3.

3. WATER CHEMISTRY AT MONASAVU

3.1 Results

The dissolved oxygen and temperature profiles for each of the three stations in the reservoir are shown in Figure 4. The data on water chemistry for the reservoir, weirs and Wailoa river for the winter and summer monitoring are given in Tables 2 and 3 respectively.

3.2 Interpretation of results

3.2.1 The Reservoir

(a) Temperature and dissolved oxygen profiles:
The pattern in winter in 1991 continued to be the same as in previous years with fairly homothermal conditions and relatively high levels of oxygen (> 4 mg/L) at depths of 15 meters or more at all stations.

In summer however, even though the temperature profiles exhibited the same trend of a 2 to 3°C difference between surface and bottom waters, the dissolved oxygen profiles appeared different from previous years. This was particularly noticeable at stations 2 and 3 where deeper waters retained relatively high levels of dissolved oxygen (almost as much in the winter period). The reason for this could be related to the low levels of water in the reservoir, or could be due to the decreasing amount of decomposing organic matter at these depths. Future monitorings will allow us to determine whether or not a permanent change in water quality is occuring.

(b) pH and Alkalinity:
The pH of the water at all three stations was in the range 6 to 8, as expected for most natural waters. A decrease in pH value with depth was noted, especially in the summer period. The alkalinity was in the range 23-58 mg $CaCO_3$/L in winter and 18-35 mg $CaCO_3$/L in summer.

(c) Nutrients: Nitrogen
An increase in the concentration of total nitrogen with deph was note at most stations in both the summer and winter periods. Hoever, the amounts present in winter (1.5 - 3.5 mg/L) was higher than the amounts in summer (0.6 - 2.6 mg/L).

For nitrate, the amounts present in winter were relatively low with no particular pattern with depth. Unfortunately, temperature data for summer can not be reported because contamination of the samples resulted in unnaturally high levels.

The concentrations of ammonia also increased with depth with greater amounts in bottom waters in summer than in winter.

(ii) Nutrients: Phosphorus

The total phosphorus content generally increased with depth which was noticeable particularly in the summer period. Greater amounts were present in the summer (39 - 450 μg/L) than in the winter months (12 - 124 μg/L).

Phosphate concentrations followed a similar pattern with greater amounts in summer and with an increase in concentration with depth.

(iii) Nutrients: Total Sulphur

Total sulphur values were found to be mostly less than 1.7 mg/L.

d) Chlorophyll

The chlorophyll content of surface water tended to be higher with generally greater amounts of chlorophyll a in summer than in winter with greater amounts of chlorophyll b and c in winter than in summer.

e) Total and dissolved iron and manganese

The total and dissolved iron and manganese continued to be lower in winter than in summer with a notable increase in concentrations with depth, especially in summer. In the surface, the iron and manganese are oxidised and precipitated as particulate matter which then sinks to the bottom. This process and the reduction under relatively anoxic conditions at depth explain the patterns observed.

3.2.2 The Weirs

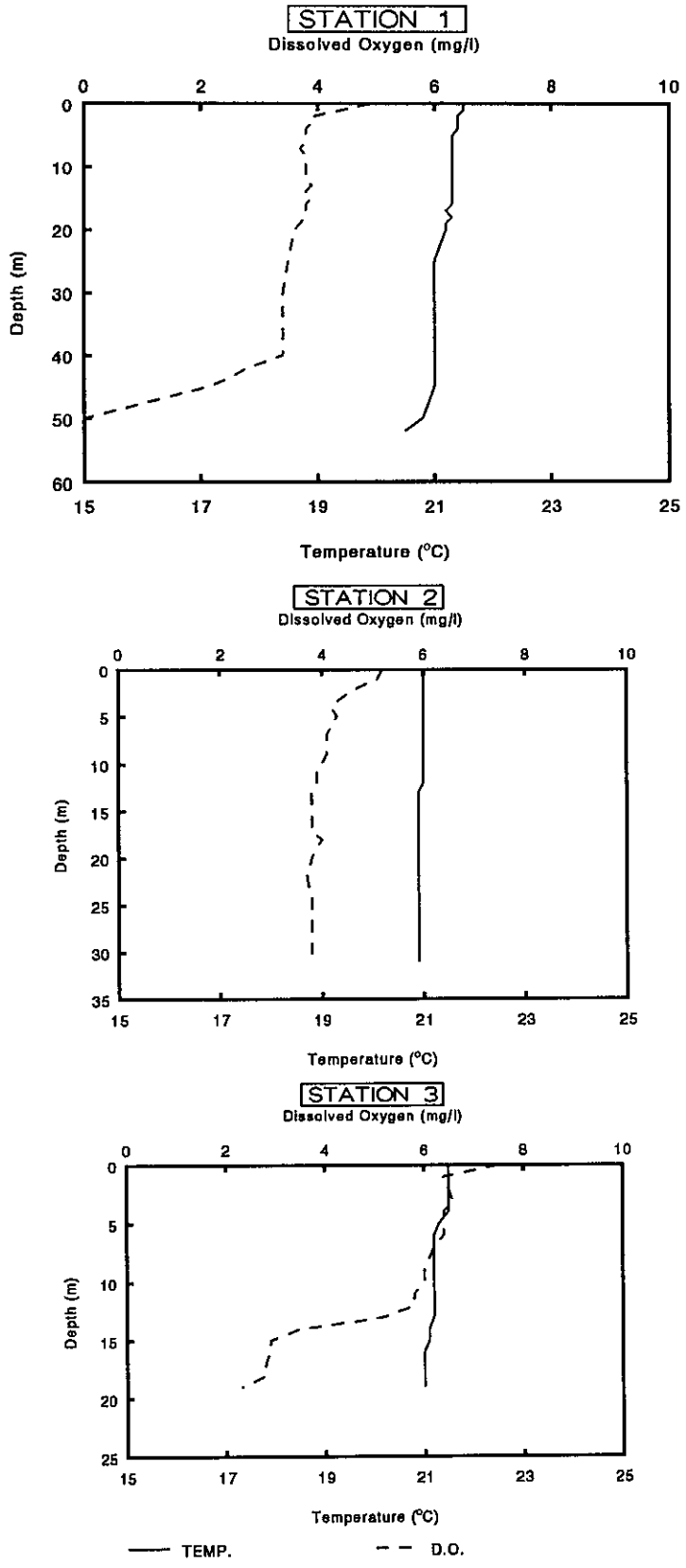
The temperature and dissolved oxygen content of the water in the weirs remained relatively unchanged over the winter and summer periods.

The pH value of the water was in the range 6 to 8 and generally higher in the winter than in summer. The total and dissolved iron and manganese were generally undetectable or very low.

As in 1990, the total suspended solids were almost negligible and the total dissolved solids were low (4-88 mg/LO, as expected for fresh water. The logging operations, if there are any in the catchment areas of the weirs, are having very little effect on the water quality.

3.2.3 The Wailoa River

The water exiting the power station at the tailrace was rapidly oxygenated and is not noticeably different from the water in the river above the power station. Levels of nutrients and seasonal variations were as for the weir and reservoir waters.



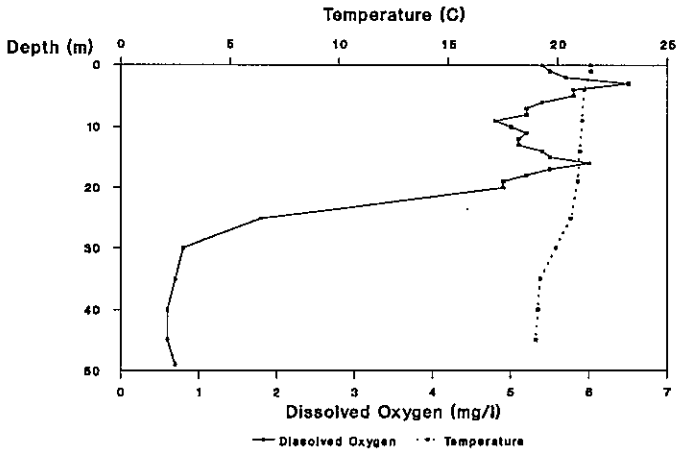
DISSOLVED OXYGEN/TEMPERATURE PROFILE

MONASAVU DAM – JULY 1991

DISSOLVED OXYGEN/TEMPERATURE PROFILES

MONASAVU DAM – JANUARY 1992

STATION 1



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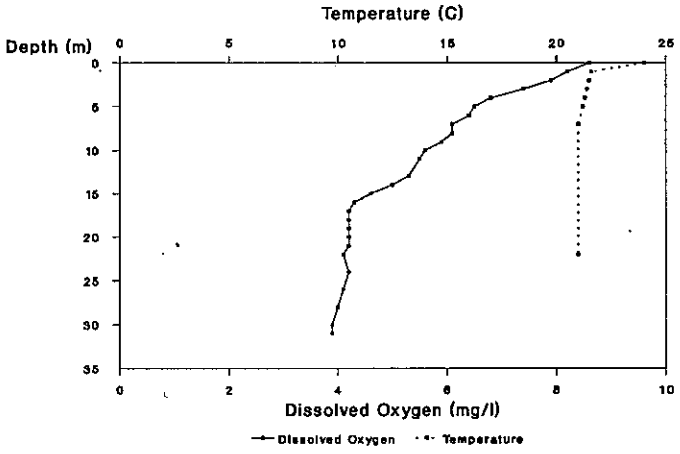

STATION 3

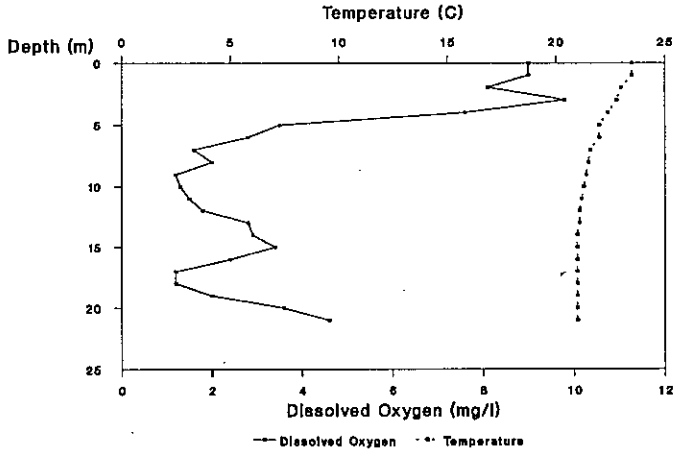

Table 2 : Results for Water Chemistry in Winter

Date : July 1991

	Stn 1 surface	Stn 1 mid	Stn 1 bottom	Stn 2 surface	Stn 2 mid	Stn 2 bottom	Stn 3 surface	Stn 3 mid	Stn 3 bottom	Wailoa above P.S.	Wailoa tailrace	Wailoa at Laselevu
Total Alkalinity (mg/l $CaCO_3$)	23	41	58	24	27	55	23	23	23	54	26	33
Clarity (m)	2m	-	-	1.5	-	-	1.5	-	-	-	-	-
pH lab	7.1	7.0	7.0	6.8	6.8	6.8	6.9	6.8	6.8	7.8	7.2	6.9
Total N (mg/l)	1.9	2.8	3.2	2.4	2.1	3.8	1.6	1.4	1.5	1.4	1.9	1.4
Total P (μg/l)	16	20	36	20	12	124	20	14	24	48	24	32
Total S (mg/l)	<1.7	<1.7	<1.7	<1.7	<1.7	1.7	<1.7	<1.7	2.8	<1.7	<1.7	3.7
NO_3 (mg/l)	0.02	0.02	0.07	0.01	0.05	0.03	0.02	0.01	0.04	0.17	0.01	0.1
NH_3 (μ/l)	56	72	70	44	82	2000	16	22	38	44	74	44
Chlorophyll mg/m^3 - a	0	0	1.4	2.5	1.3	0	0.9	17.0	17.4	0	0	0
b	54	0	19.2	10.6	12.5	6.2	3.8	11.0	4.1	2.1	0	0
c	22	0	60.7	41.0	2.0	5.1	9.2	0	0	30.3	0	39.8
Dissolved Mn (mg/l)	<0.03	0.04	<0.03	<0.03	0.04	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Total Mn (mg/l)	0.06	0.07	0.03	0.03	0.04	0.75	<0.03	<0.03	0.05	<0.03	<0.03	<0.03
Dissolved Fe (mg/l)	<0.05	<0.05	<0.05	<0.05	0.31	0.45	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Fe (mg/l)	<0.05	0.64	0.51	0.65	0.50	6.6	0.16	0.23	0.33	<0.05	<0.05	<0.05
Temperature (°C)	21.5	21.2	21.0	21.5	21.0	20.5	21.0	20.9	20.9	21.0	21.2	22.0
Dissolved O_2 (mg/l)	7.5	6.0	2.3	4.9	3.5	0	5.2	3.8	3.8	7.7	7.6	6.9
Depth (m)	0	10	19	0	25	52	0	16	32	-	-	-
Dissolved PO_4 (μg/l)	<38	<38	<38	<38	<25	741	<38	<38	<38	142	<38	<38

Table 2 : Cont'd/...

Date : July 1991

	Nabilabila	Wainabua	Wainisavulevu	South Waikoso	North Waikoso
Total suspensed solids (mg/l)	<1	<1	<1	<1	1
Total dissolved solids (mg/l)	53	4	57	52	57
Dissolved Mn (mg/l)	<0.03	<0.03	<0.03	<0.03	<0.03
Total Mn (mg/l)	<0.03	<0.03	<0.03	<0.03	0.05
Dissolved Fe (mg/l)	0.05	<0.05	0.20	<0.05	<0.05
Total Fe (mg/l)	<0.05	0.20	0.20	0.08	0.09
Temperature (°C)	19.0	18.2	20.4	17.8	17.8
Dissolved O_2 (mg/l)	7.7	7.1	6.4	7.9	9.2
pH	8.0	7.3	6.4	7.20	8.2

Table 3 : Results for Water Chemistry in Summer

Date : January 1992

	Stn 1 surface	Stn 1 mid	Stn 1 bottom	Stn 2 surface	Stn 2 mid	Stn 2 bottom	Stn 3 surface	Stn 3 mid	Stn 3 bottom	Wailoa above P.S.	Wailoa tailrace	Wailoa at Laselevu
Total Alkalinity (mg/1 $CaCO_3$)	18	19	32	20	19	21	20	25	18	35	22	25
Clarity (m)	2	-	-	1.5	-	-	1	-	-	-	-	-
pH lab	7.2	6.9	6.7	7.6	7.0	6.8	8.5	7.0	6.6	7.3	7.0	7.1
Total N (mg/l)	0.6	0.6	1.4	0.6	0.7	2.0	1.4	1.8	2.5	0.5	0.9	1.3
Total P (μg/l)	39	39	450	55	51	170	-	85	270	75	24	45
Total S (mg/l)	<1.7	-	<1.7	<1.7	<1.7	1.7	<1.7	<1.7	2.8	2.7	<1.7	1.8
NO_3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
NH_3 (μ/l)	16	36	2120	<10	12	16	<10	100	348	<10	14	<10
Chlorophyll mg/m^3 - a	4.85	3.25	7.27	5.59	2.51	6.79	16.42	2.12	4.10	0.69	2.77	1.31
b	0.39	0.21	0	0.96	0.35	0	1.26	25	0.14	0.02	0.45	0.42
c	2.44	0	0.58	4.0	3.22	0.06	9.67	0	3.20	0	1.91	0.6039.8
Dissolved Mn (mg/l)	<0.03	0.05	0.46	<0.03	<0.03	0.17	<0.03	0.06	0.10	<0.03	<0.03	<0.03
Total Mn (mg/l)	<0.03	0.06	0.58	<0.03	<0.03	0.10	<0.03	<0.03	0.05	<0.03	<0.03	<0.03
Dissolved Fe (mg/l)	0.08	0.15	2.1	0.10	0.18	1.7	0.14	0.47	2.6	0.37	0.11	0.19
Total Fe (mg/l)	0.11	0.22	2.4	0.10	0.19	1.5	0.06	0.26	2.0	0.04	0.3	0.11
Temperature (°C)	21.5	20.6	19.0	24.0	21.02	21.0	23.5	21.3	21.0	20.2	19.9	20.5
Dissolved O_2 (mg/l)	5.4	1.8	0.7	8.6	4.6	3.9	9.0	1.3	3.6	7.9	7.2	8.0
Depth (m)	0	25	49	0	15	30	0	10	20	-	-	-
Dissolved PO_4 (μg/l)	<38	51	448	<38	51	170	<38	<38	170	<38	<38	<38

Table 3 : Cont'd/...

Date : January 1992

	Nabilabila	Wainabua	Wainisavulevu	South Wainakasou	North Wainakasou
Total suspensed solids (mg/l)	<1	12	<1	1	<1
Total dissolved solids (mg/l)	44	100	21	88	110
Dissolved Mn (mg/l)	<0.03	<0.03	<0.03	<0.03	<0.03
Total Mn (mg/l)	<0.03	<0.03	<0.03	<0.03	<0.03
Dissolved Fe (mg/l)	<0.02	0.04	0.19	0.07	0.05
Total Fe (mg/l)	0.05	0.05	0.10	0.06	0.05
Temperature (°C)	19.5	19.2	19.7	19.7	19.4
Dissolved O_2 (mg/l)	7.9	7.6	7.2	7.9	7.6
pH	6.6	7.3	6.3	7.1	6.9

4. BIOLOGICAL SURVEY

4.1 Reservoir

Since the last survey in July 1990, the level at the lake had dropped about 20 m. The usual two sites (1) at the end of the road below the FEA administration buildings and (2) at the dam edge were visited and no live invertebrates could be found at either site. There were two probable reasons why no invertebrates were found:

a) Few invertebrates had survived the great fall in the lake level during 1991. Evidence of this was seen around the lake shore where large numbers of empty shells of the gastropod Melanoides tuberculata extended from below the present lake level upwards to the lake level in July 1990.

b) Any surviving invertebrates would be a few metres under water due to recent heavy rain at the time of the survey.

In terms of plankton, copepods (Crustacea) very abundant in tows made in the reservoir, and one case of damselfly nymph and two mites (0.4 mm long) were found in the tows. Also present were a small yellow wasp and 2 black flies that had fallen in the water.

4.2 Weirs

The large green alga Chara excelsa that obstructs the outfalls of the weirs after heavy rain was present in Wainikasou South and Wainikasou North weirs but was not obvious in Wainisavulevu weir.

5. CONCLUSIONS

The water quality assessment of the reservoir indicates that the stable cycle of temperature stratification and oxygen depletion in bottom waters in summer and reduced stratification with re-oxygenation of water in winter has persisted in the deeper parts of the reservoir. In the shallow sections, a noticeable change has been observed in summer in that the oxygen levels in the bottom waters are not quite as depleted as in previous years. This may have been due to the unusual water level conditions, which were extremely low due to the El Nino weather conditions being experienced in Fiji in the summer of 1991/2. It may also be attributable to a decreasing amount of decomposing organic material at that depth which could lead to an improvement in water quality.

The water quality in the weirs was also satisfactory with no obvious signs of any effects of logging in the catchment areas. However, the large green algae Chara excelsa continued to be present in the Wainikasou South and Wainikasou North weirs and is likely to obstruct the outfalls after a heavy rain.

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