WATER QUALITY IN THE MONASAVU RESERVOIR AND WAILOA RIVER IN 1986

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INSTITUTE OF NATURAL RESOURCES

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Report prepared for the Fiji Electricity Authority

October, 1987

INTRODUCTION

Since the filling of the Monasavu reservoir in 1983 small scale limnological and monitoring studies have been carried out by some USP scientists (Gibbons and Brodie, 1985, Gangaiya, 1986). This report presents the results of the 1986 monitoring of the reservoir and the Wailoa River.

The Monitoring Programme

1. The Organisation

The monitoring of the Monasavu reservoir and the Wailoa River were carried out in July and December with details of the parameters analysed as shown in Table 1. The programme was carried out in accordance with the proposal submitted to the FEA at the end of 1985 (Appendix I).

2. Sampling Sites

The sites chosen for sampling in 1986 remained the same as for previous years (1984, 1985). Figure 1 shows the location of the three sampling sites in the reservoir while Figure 2 shows the sampling stations along the Wailoa River. Station 4 is located at Laselevu Village.

3. Record of Data

Apart from temperature and dissolved oxygen which were determined on site, the rest of the measurements were made at the INR laboratory. Table 2 and 3 give the results of the analyses carried out on the samples.

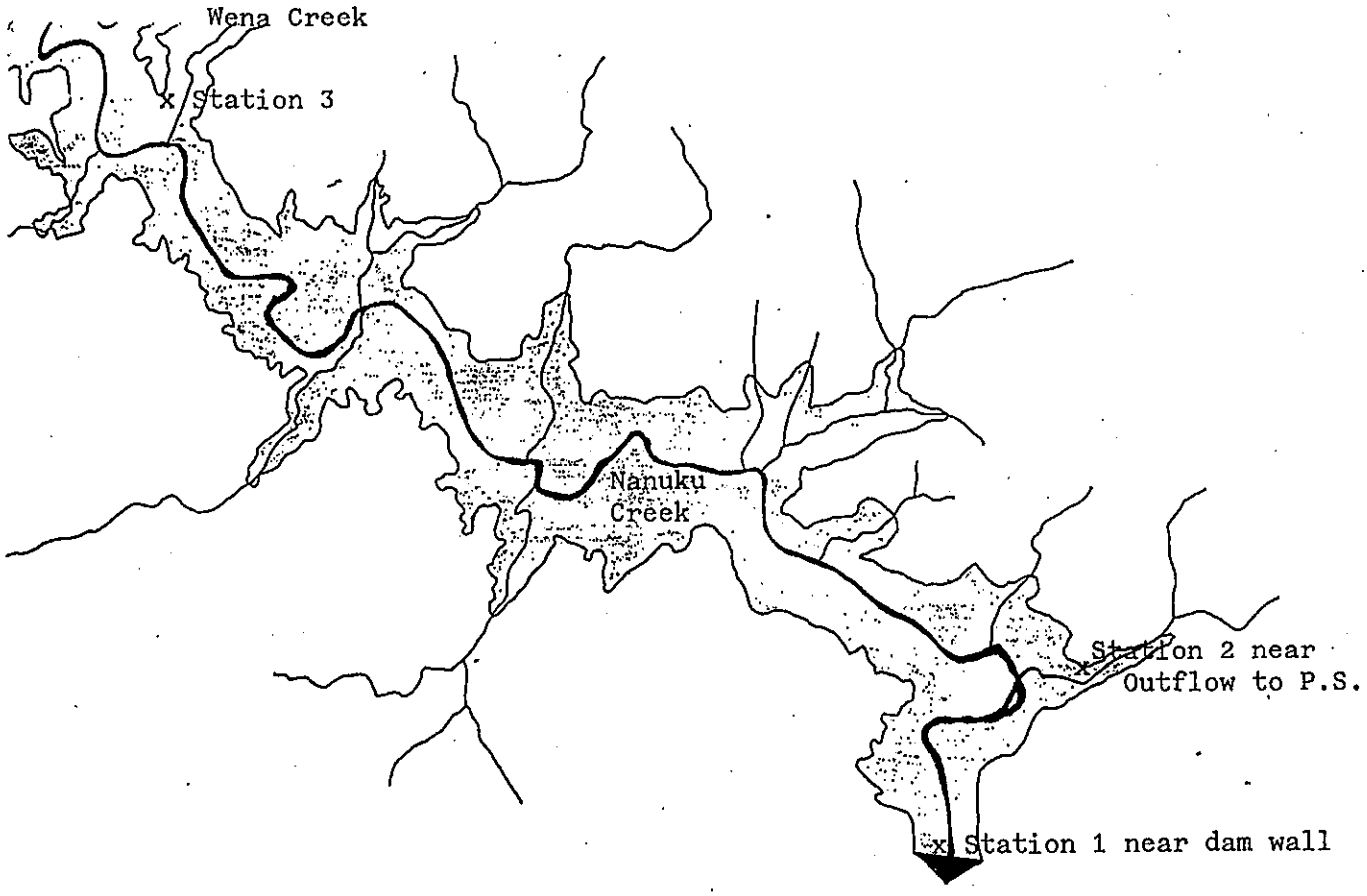

FIGURE 1 : Location of the sampling stations in the Monasavu Reservoir

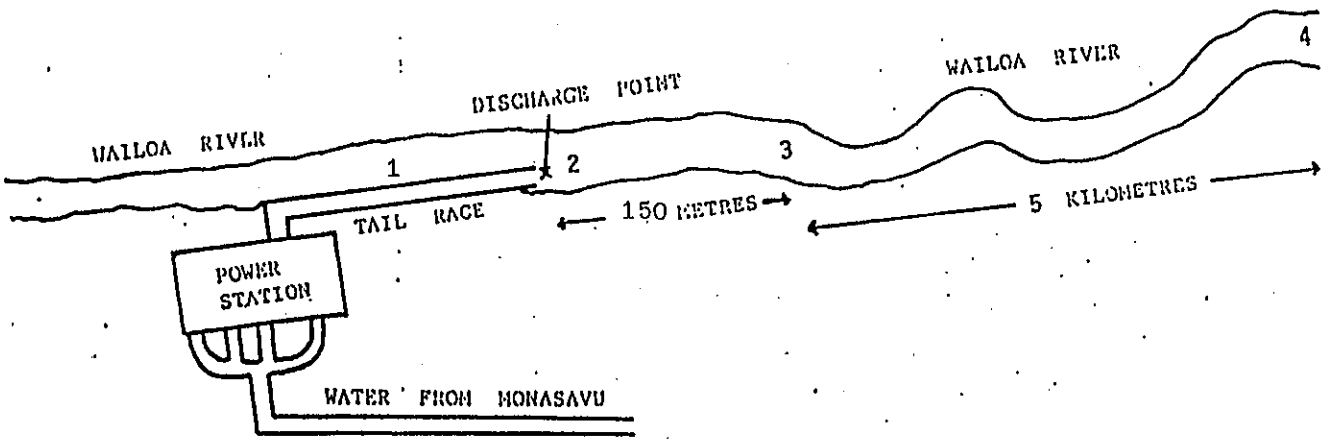

FIGURE 2 : Sampling sites along the Wailoa River

Site : 1 100 m above P.S. discharge
2 Tailrace
3 150 m below P.S. discharge
4 Wailoa at Laselevu

TABLE 1 - Monitoring Programme of Monasavu Reservoir and Wailoa River

	No of Sites Monitored	Monitoring Sequence	Parameters Measured
Monasavu reservoir	3 stations each at 3 different depths	16/7/86 8/12/86	Temperature and dissolved oxygen profiles, pH, alkalinity, chlorophyll a, b, c, nutrients - nitrogen, phosphorus and sulphur, dissolved and total iron and manganese
Wailoa river	3 stations	16/7/86 8/12/86	As for above

4. Interpretation of Results for Water Quality

4.1 The Monasavu Reservoir

a) Temperature and Dissolved Oxygen Profiles

The temperature and the dissolved oxygen profiles for the 3 reservoir stations for both sampling trips are given in Figure 3. As noted previously (1984, 1985) the profiles for the summer months can be characterised by a distinct temperature gradient with virtually no oxygen below 30 m where as during cooler months the reservoir is almost homothermal with oxygenating waters at depth. The important point to note is that zero oxygen level has been increasing from 10-20 m in 1984 to 20-30 m in 1985 and +30 m in 1986. This indicates decreasing amounts of organic matter left at these levels for decomposition. The aerator in the vicinity of station 2 could also be responsible for oxygenated water down to 30 m.

TABLE 2 MONASAVU WATER SAMPLES Date : 16/7/86

	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 150 m Below P.S.	Wailoa Laselevu
Total Alkalinity (mg/l $CaCO_3$)	18	15	15	17	16	16	19	17	18	44	14		26
Turbidity	2.4	2.0	38	2.0	2.0	2.2	4.0	3.0	5.0	1.0	2.0		2.0
pH on site	7.0	6.8	6.6	7.1	6.5	6.5	7.0	6.8	6.5	7.6	6.7		7.9
lab													
Total N (mg/l)	4	4.9	5.3	6.3	7.6	3.1	4.0	5.0	5.7	4.1	3.3		5.8
Total P (ug/l)	<6	<6	70	<6	<6	<6	<6	<6	<6	70	110		40
Total S (mg/l)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0		<1.0
NO_3^- (mg/l)	<10	<10	<10	<10	<10	90	<10	<10	<10	140	40		120
NH_3 (ug/l)	50	80	104	44	50	56	32	44	56	50	30		36
Chlorophyll mg/m^3 a	1.1	0	4.3	0.6	0	0	0	0.3	0	0	1.1		2.3
b	1.7	0	8.8	0.6	0	0	0	0.5	0	0	1.4		3.1
c	4.2	0	22	5.5	0	0	0	1.3	0	0	7.6		11.9
Dissolved Mn (mg/l)	<0.1	<0.1	0.5	<0.1	<0.1	0.1	0.1	<0.1	0.3	0.1	<0.1		0.1
Total Mn (mg/l)	0.1	0.1	0.5	<0.1	<0.1	0.1	0.1	0.1	0.3	0.2	0.1		0.1
Dissolved Fe (mg/l)	0.2	<0.2	2.4	0.3	<0.2	0.3	0.2	0.4	0.9	0.3	0.2		0.2
Total Fe (mg/l)	0.2	0.2	2.8	0.5	0.2	0.4	0.4	0.5	1.6	0.5	0.2		0.3
Temperature (^oC)													
Dissolved O_2 (mg/l)	5.0	4.1	2.3	5.4	4.5	0.8	8.6	3.0	0.2				
Depth (m)													
PO_4 (ug/l)	<18	<18	208	<18	<18	<18	<18	<18	<18	<18	<18		<18

TABLE 3

MONASAVU WATER SAMPLES

Date : 8/12/86

	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 150 m Below P.S.	Wailoa at Laselevu
Total Alkalinity (mg/l $CaCO_3$)	16.8	13.7	14.7	16.8	14.7	14.7	18.9	17.9	16.8	42.1	12.6		25.3
Turbidity	6.4	2.8	6.4	3.8	2.4	2.4	2.0	4.4	6.0	3.0	3.2	-	0.4
pH on site	8.30	6.40	6.20	8.10	6.60	6.40	7.20	6.50	6.20	7.85	6.50	-	7.40
pH lab													
Total N (mg/l)	3.0	2.0	1.8	2.0	1.0	1.4	2.8	2.6	2.8	2.2	2.5		2.4
Total P (ug/l)	<6	<6	100	<6	<6	<6	<6	<6	<6	<6	<6	-	<6
Total S (mg/l)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	<1.0
NO_3^- (mg/l)	80	40	3840	<10	40	40	<10	<10	40	250	80	-	410
NH_3 (ug/l)	25	75	205	30	170	165	30	30	190	35	275	-	35
Chlorophyll mg/m^3 a	1.4	0	0.9	0.57	0	0	0	1.0	0	0	0.86		2.3
b	1.7	0	3.8	0.61	0	0	0	2.8	0	0	3.8		3.1
c	4.2	0	9.2	5.5	0	0	0	6.7	0	0	9.2		11.6
Dissolved Mn (mg/l)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10		<0.10
Total Mn (mg/l)	<0.10	<0.10	0.47	<0.10	<0.10	0.16	<0.10	<0.10	<0.10	<0.10	<0.10		<0.10
Dissolved Fe (mg/l)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10		<0.10
Total Fe (mg/l)	0.15	0.41	2.64	0.31	0.41	0.46	0.20	0.66	1.22	0.26	0.66		0.41
Temperature (^oC)	25	19	18	25	20	18.5	27	21	19.5	27	23		24
Dissolved O_2 (mg/l)	8.3	0.4	0.2	8.6	0.35	0.35	8.2	0.7	0.5	7.8	8.8		8.0
Depth (m)	0	25	49	0	15	30	0	10	20	0	-		-
PO_4	<18	<18	306	<18	<18	<18	<18	<18	<18	<18	<18		<18

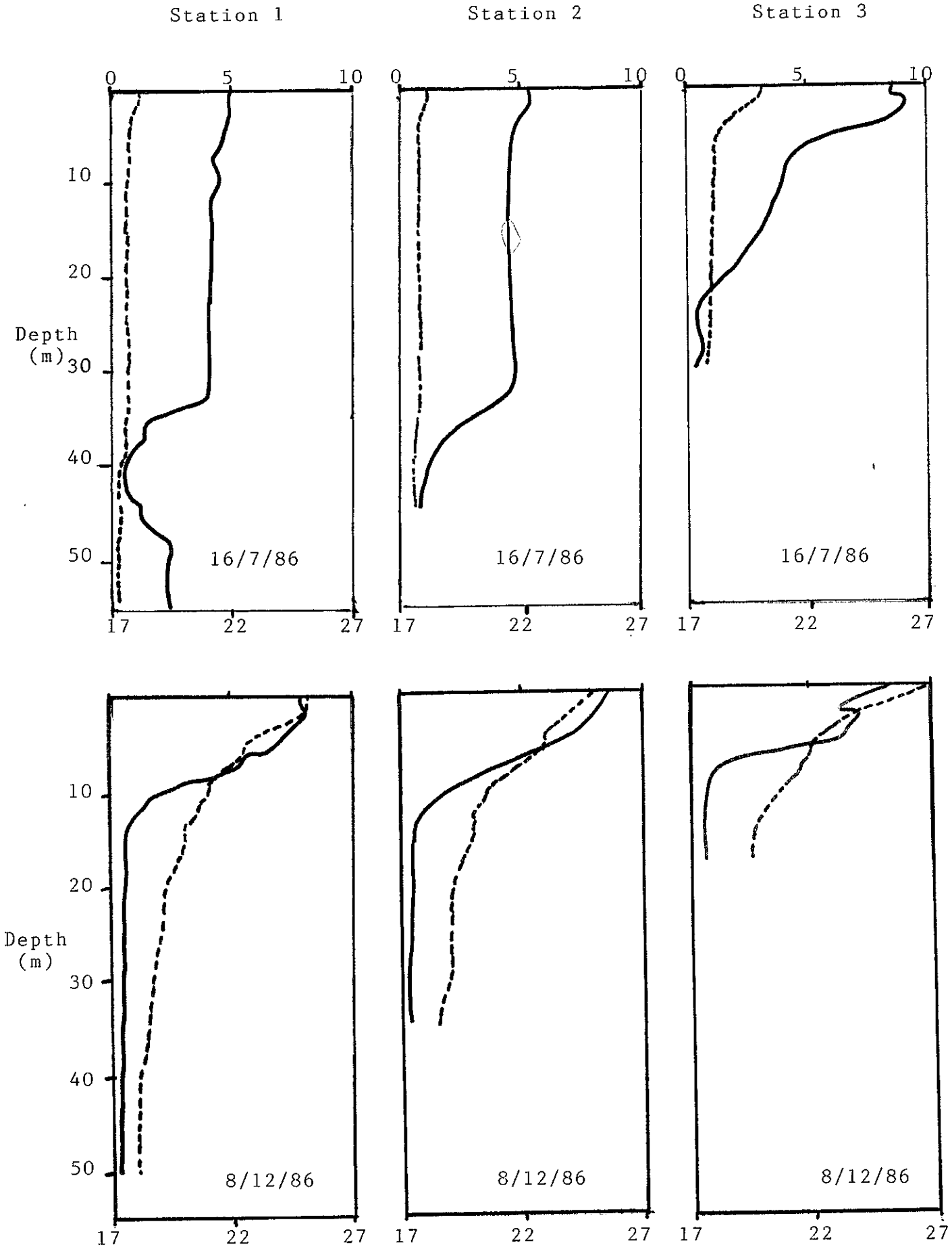

Figure 3 : Dissolved oxygen and temperature profiles for Stations 1, 2 and3 in 1986

Key : _____ dissolved oxygen
------ temperature

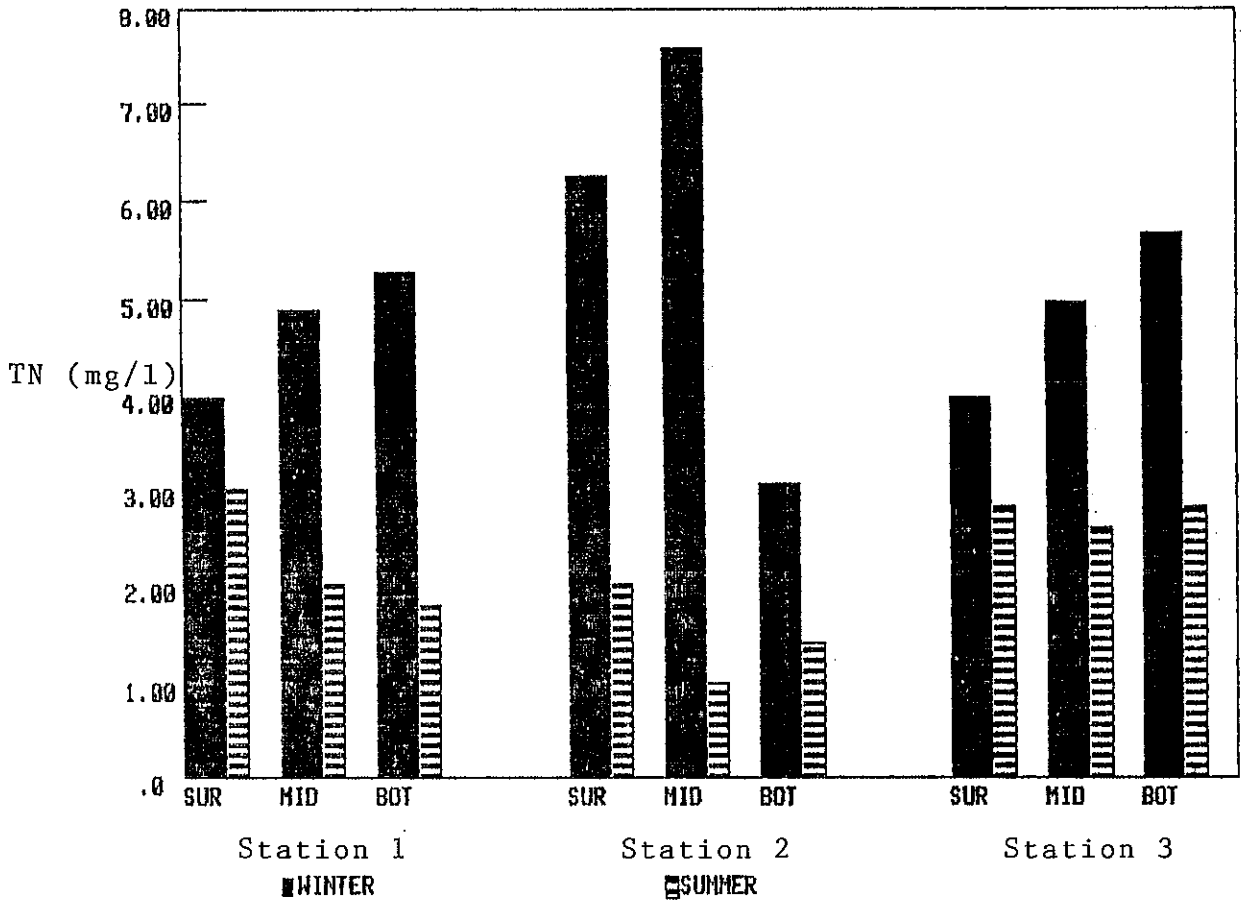

Figure 4 : Variation of total nitrogen (TN) content of the Monasavu Reservoir with time of year in 1986

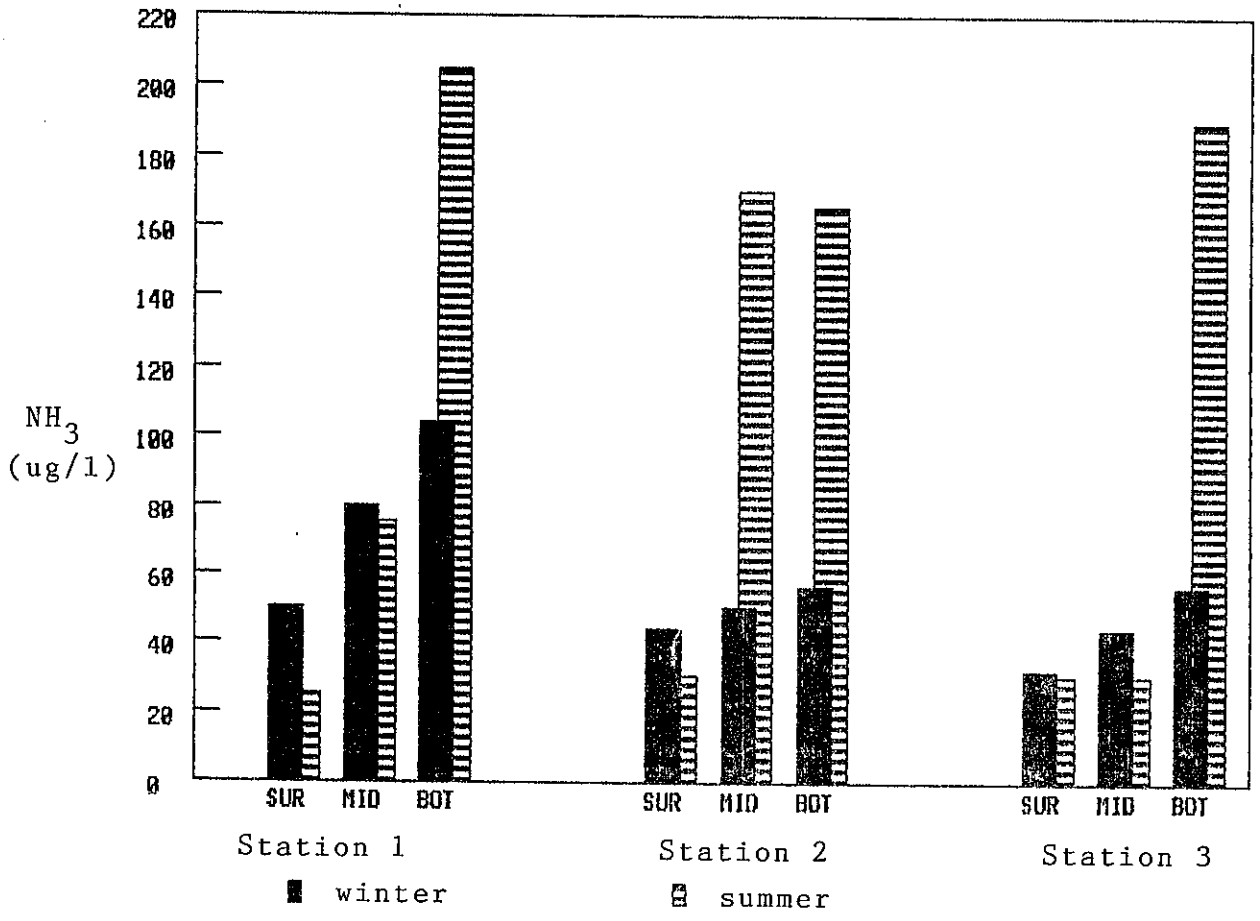

Figure 5 : Variation of ammonia content of the Monasavu Reservoir with time of year in 1986

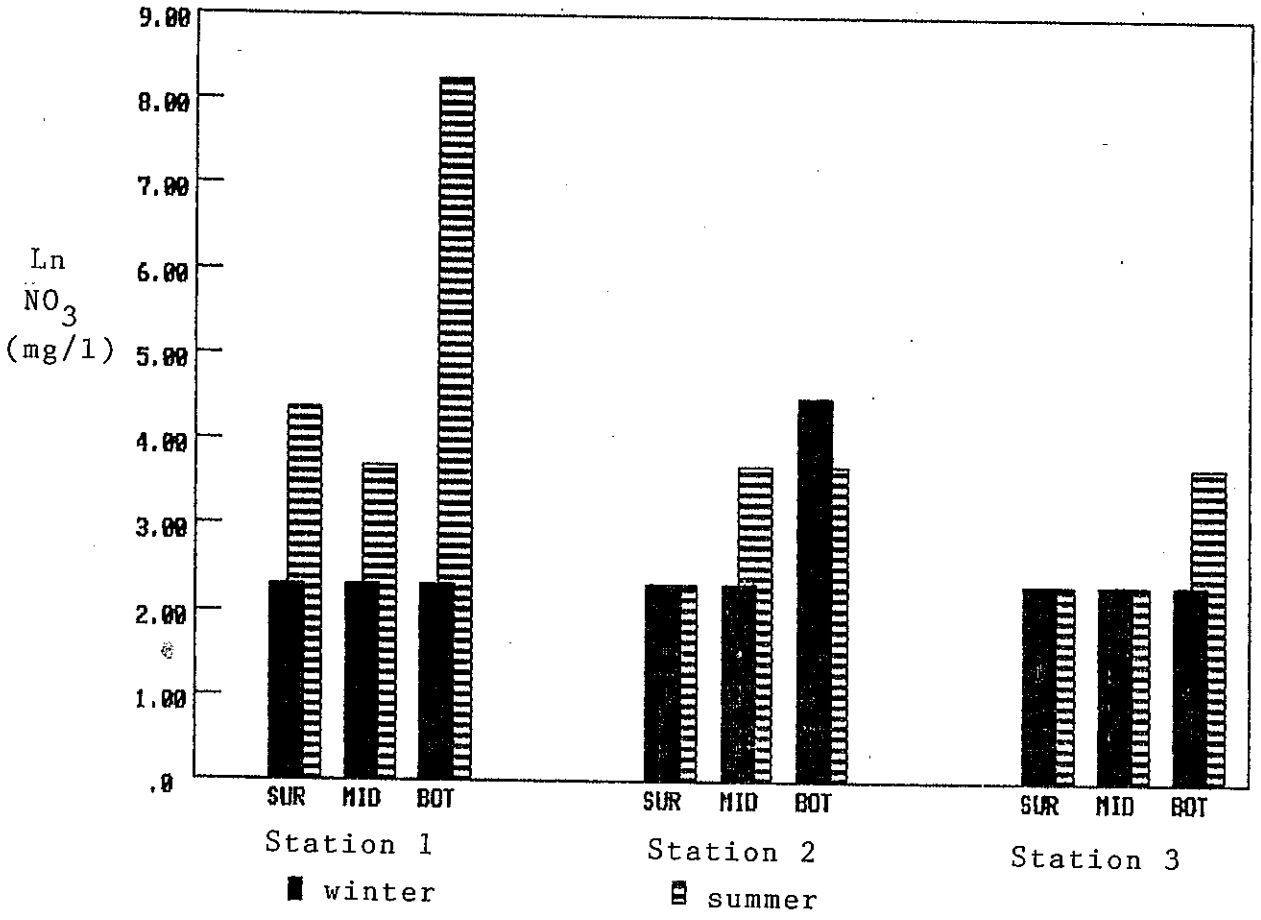

Figure 6 : Variation of nitrate content of the Monasavu Reservoir with time of year in 1986

b) **pH in the Monasavu Reservoir**

The range of pH for the Monasavu reservoir as in the previous years is between 6-9. Since the pH is within the acceptable range for the reservoirs (Wetzel) there is no cause for concern.

c) **Nutrients**

1) **Nitrogen**

With the limited monitoring it is difficult to show variations of the different forms of nitrogen in graphical forms. However, figures 4,5 and 6 give some indications of the various forms of nitrogen during winter and summer periods for the three reservoir stations. The trends observed are the same as in previous years. What is apparent is that stable stratification in the summer months prevents reoxygenation at depths explaining the increases in the ammonia content at depths at all stations. However, in the winter months the higher levels of oxygen at depths allow the oxidation of organic matter and ammonia to nitrates which explains the general reduction in ammonia content. As a result of higher levels of oxygen at depths the rate of biological activity increases to explain the observed increase in the total nitrogen (TN) at all depths throughout winter.

2) **Phosphorus**

Total phosphorus concentration in the Monasavu reservoir has been low, ranging from 6-100 ug/l. The total phosphorus concentration of most uncontaminated surface waters is between 10 to 50 ug/l (Wetzel) and it is apparent that the surface concentrations in the Monasavu reservoir are generally within the range. In fact total phosphorus concentration has been decreasing steadily in the reservoir over the years.

3) **Sulphur**

The sulphur content has been low at all depths as in previous years.

4) **Total Iron and Manganese**

Figure 7 shows the trends in total iron concentrations with different time of year. Once again with limited monitoring the seasonal variations are not apparent. However, as expected the iron and manganese levels are regulated to a large extent by the variations in dissolved oxygen content of water. The interesting feature of the water system is that at Station 2 the levels of iron and manganese have been low throughout the year and this means that water taken into the power station has been low in iron and manganese. The low levels of iron and manganese can be attributed to higher levels of oxygen at depth. When oxygen is present specially at depths the iron (11) and manganese (11) ions are oxidised and subsequently precipitated as hydroxides and returned to the sediments in the form of particulate matter.

The Wailoa River

There has been a notable reduction in the smell of hydrogen sulphide at the power station at both sampling times.

Comparison of the data from Station 2 bottom waters and the tail race water (Table 4) does not show significant reduction in concentration of iron and manganese. This is probably because the levels were originally low in the Station 2 bottom waters. However this does not mean that deposition of iron and manganese on machinery parts is not of concern for FEA.

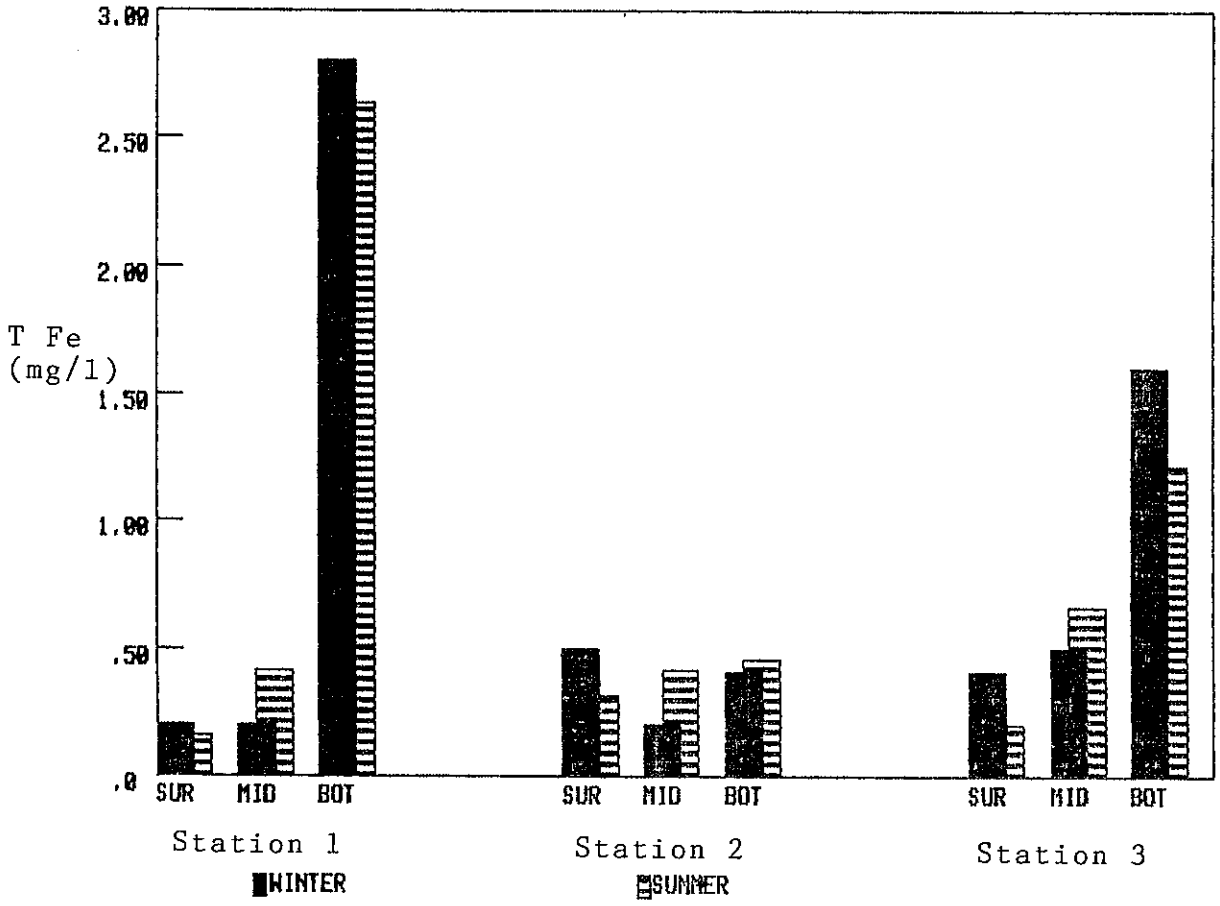

Figure 7 : Variation of total iron (T Fe) content of the Monasavu Reservoir with time of year in 1986

TABLE 4 - Comparison of Data from Station 2 bottom Waters and Tailrace

	Sampling Date	Tailrace	Station 2 Bottom
Total N (mg/1)	23/7/86	3.3	3.1
Total P (ug/1)	23/7/86	<6	110
NH_3 (ug/1)		30	56
Total Mn (mg/1)		0.1	0.1
Total Fe (mg/1)		0.4	0.2
Total N (mg/1	8/12/86	2.5	1.4
Total P (ug/1)		<6	<6
NH_3 (ug/1)		275	165
Total Mn (mg/1)		<0.10	0.16
Total Fe (mg/1)		0.66	0.41

Conclusions

The trends observed in the water quality of the Monasavu reservoir and the Wailoa river in 1986 were similar to those observed in 1985 and 1984 respectively. The operation of an aerator near Station 2 in the reservoir is having a significant effect on the oxygen content of deeper waters during summer. This is clearly evident by the low levels of iron, manganese and ammonia at Station 2 bottom waters. There are indications that the water at the bottom of the reservoir as a whole is improving in quality as evidenced by decreasing turbidity and the notable lack of smell of hydrogen sulphide at the power station.

References

1) Gibbons, J.R.H. and Brodie, J.E. 1985. The environmental and social impact of Monasavu hydro scheme : an appraisal. Science Journal, 1, No. 6.

2) Gangaiya, P. 1986. Water Quality of the Monasavu Reservoir and Wailoa River in 1985. INT Technical Report No. 86/3.

3) Wetzel, R.G. 1975. Limnology. Saunders College Publishing, Philadelphia, PA 191 05.

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OUR REF:-
YOUR REF:-

APPENDIX I

11 December 1985

The General Manager
Fiji Electricity Authority
Private Bag
LAUTOKA

Dear Sir

I write in response to your letter of 19 November and your request for a quotation for water quality measurements in 1986. The quote is as follows for two sampling trips:

1.	Wailoa monitoring for pH, oxygen, sulphide, iron, manganese, total P, S and N, nitrate, ammonia phosphate and chlorophyll - laboratory charges	$700.00
2.	Reservoir monitoring for pH, oxygen, sulphide, iron, manganese, total P, S and N, nitrate, ammonia, phosphate, alkalinity, turbidity and chlorophyll - laboratory charges	$1000.00
	Staff sampling time (4 days)	$700.00
	Accommodation - FEA	
	Transport	$140.00
	Meals	$ 40.00
	Report Preparation	$ 60.00
	TOTAL	$2640.00

I hope this is satisfactory.

Yours faithfully

Jon Brodie
ACTING DIRECTOR