

WATER QUALITY IN THE MONASAVU  
RESERVOIR AND WAILOA RIVER  
IN 1988

INR TECHNICAL REPORT NO. 89/1

APRIL , 1988

INSTITUTE OF NATURAL RESOURCES  
UNIVERSITY OF THE SOUTH PACIFIC

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WAILOA RIVER IN 1988

Naidu, S.D., Haynes, A. and Peter W.

Report prepared for the Fiji Electricity Authority

April 1989

## INTRODUCTION

At the request of the Fiji Electricity Authority (FEA) the Institute of Natural Resources monitored the water quality of Monasavu reservoir and the Wailoa river. The programme was carried out in accordance with the proposal submitted to the FEA at the beginning of 1988 (Appendix 1).

### The Monitoring Programme

#### 1) The Organisation

The monitoring of the Monasavu reservoir and the Wailoa river were carried out in July and December and the details of the parameters analysed are shown in Table 1.

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	21/7/88 13/12/88	Temperature and dissolve oxygen profiles, pH, alkalinity, chlorophyll a, b and c, nutrients total-nitrogen, phosphorus and sulphur, ammonia, nitrate, nitrite, dissolved and total iron and manganese. Invertebrate survey
Wailoa	3 Stations	21/7/88 13/12/88	As for above

## 2) Sampling Sites

The sites chosen for sampling in 1988 remained the same as for previous years (1984-1987) for comparison purpose. 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) Results

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

## 4) Interpretation of Results

### 4.1 The Monasavu Reservoir

#### a) Temperature and Dissolved Oxygen profiles

Figure 3 shows the temperature and the dissolved oxygen profiles of the three reservoir stations obtained in July 1988. As in previous years (1984-1987) the lake is fairly homothermal during this period with sufficient levels of oxygen even at depths of 66 m. No measurements for dissolved oxygen/temperature were made in December because the instrument malfunctioned on site.

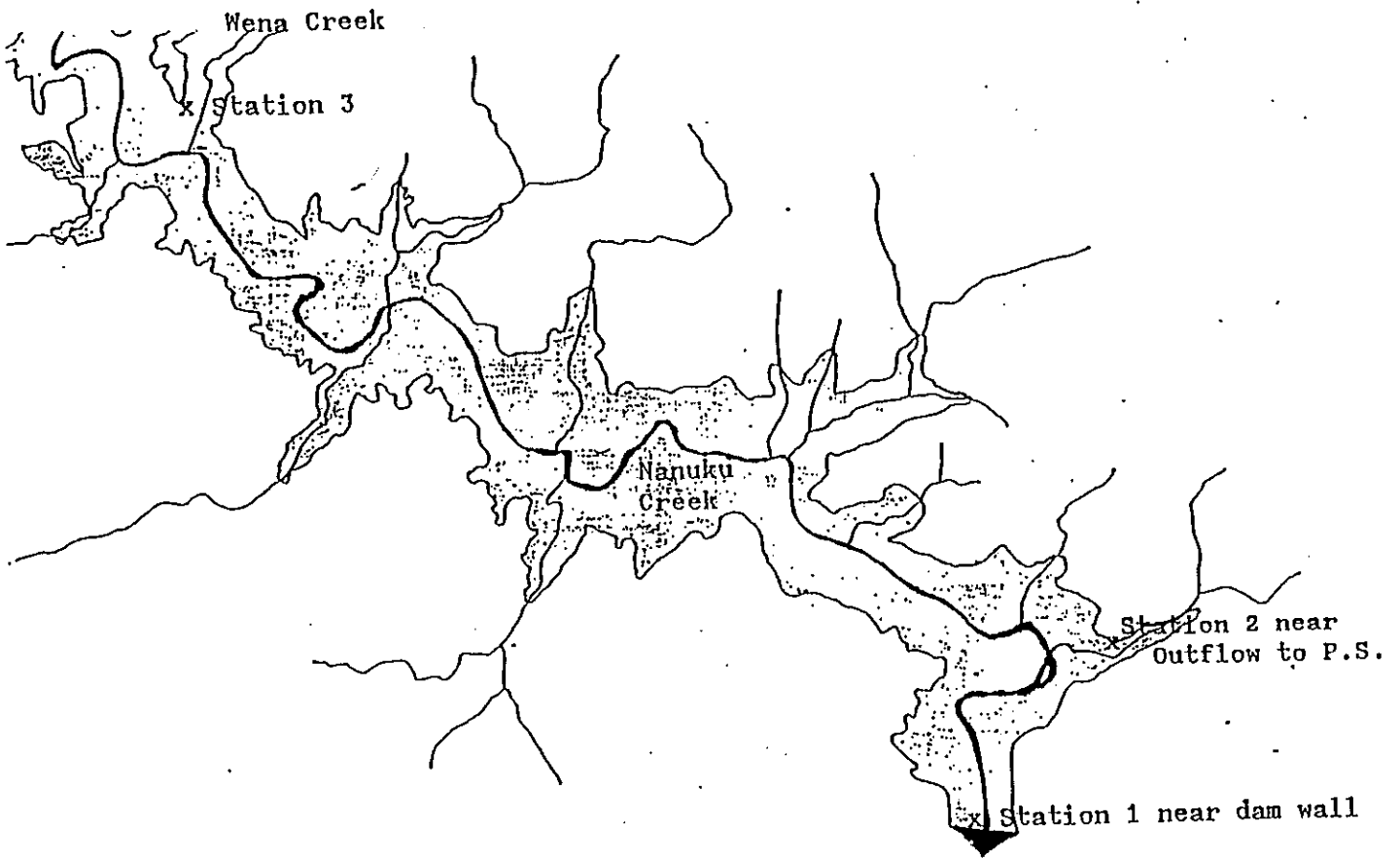


FIGURE 1: Location of the sampling stations in the Monasavu Reservoir

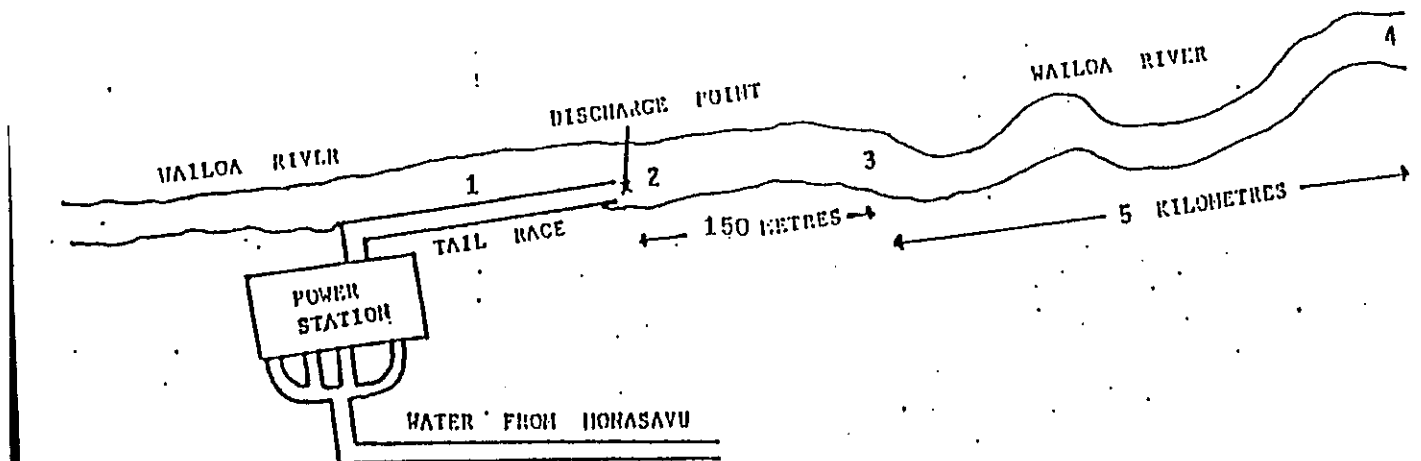


FIGURE 2: Sampling sites along the Wailoa River

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

TABLE 2 : ANALYTICAL DATA FOR MONASAVU WATER SAMPLES

INR Laboratory No. M88/	MONASAVU WATER SAMPLES										Date : 21.7.88		
	995	996	997	998	999	1000	1001	1002	1003	1006	1004	1005	Waioa at Laselevu
	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	Waioa Above P.S.	Waioa Tailrace	Waioa at Laselevu	
Total Alkalinity (mg/l CaCO <sub>3</sub> )	14.7	29.8	46.6	14.8	15.4	13.7	15.4	15.7	16.1	32.0	13.0	20.7	
Turbidity Seechi disc 1.5m				2.0m			2.0m						
pH on site lab	7.7	7.1	6.8	8.2	7.3	7.2	7.7	7.0	7.1	7.7	7.1	7.4	
Total N (mg/l)	2.2	1.6	2.7	6.0	2.1	2.0	2.2	1.5	3.5	1.6	1.5	1.5	
Total P (ug/l)	11.3	11.3	120.0	21.3	11.3	33.8	11.3	11.3	77.5	47.5	10	33.8	
Total S (mg/l)	3.8	4.6	3.8	5.6	4.6	4.4	4.6	4.4	5.6	3.8	4.6	1.8	
NO <sub>3</sub> <sup>-</sup> (ug/l)	9.9	203.4	57.0	9.9	24.8	153.8	9.9	17.4	285.2	267.8	96.7	203.4	
NH <sub>3</sub> (ug/l)	24.0	58.0	130.0	94.0	26.0	42.0	76.0	34.0	46.0	24.0	24.0	32.0	
Chlorophyll mg/m <sup>3</sup>	a 5.1 b 39.1 c 170.6	6.2 11.6 75.9	28.5 50.3 156.9	1.1 11.1 41.7	2.3 2.4 22.0	8.6 16.8 57.3	9.9 27.9 99.0	12.5 25.1 124.8	2.8 15.1 114.3	13.9 30.8 155.2	4.0 11.0 26.8	1.7 6.8 31.9	
Dissolved Mn (mg/l)	<0.1	<0.1	0.25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Total Mn (mg/l)	<0.1	0.1	3.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Dissolved Fe (mg/l)	<0.1	<0.1	4.5	<0.1	<0.1	0.1	0.5	<0.1	0.4	<0.1	0.1	0.1	
Total Fe (mg/l)	<0.1	0.10	11.5	<0.1	0.12	1.4	0.4	0.12	0.3	<0.1	0.1	0.1	
Temperature (°C)	18.0	17.4	17.0	18.5	18.0	17.0	18.5	18.0	17.2	18.0	18.2	18.0	
Dissolved O <sub>2</sub> (mg/l)	6.8	4.6	3.6	7.6	6.0	4.4	8.2	5.8	5.6	9.2	9.2	9.4	
Depth (m)	0	33.0	66.0	0	21.5	43.0	0	17.0	34.0				
Dissolved PO <sub>4</sub> (ug/l)	12	12	83	12	12	50	21	12	25	45	16	29	

TABLE 3 : ANALYTICAL DATA FOR MONASAVU WATER SAMPLES

	MONASAVU WATER SAMPLES										Date : 13/12/88				
	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911			
	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	Wailoa P.S.	Wailoa Tailrace	Wailoa at Laselevu		
Total Alkalinity (mg/l CaCO <sub>3</sub> )	13.6	13.1	31.6	14.5	12.8	16.0	15.4	16.3	14.5	38.0	14.5	21.2			
Turbidity (secchi disc-m)	2.0			1.5			1.5								
pH on site lab	8.25	6.70	6.50	7.90	6.85	6.70	7.45	7.00	6.70	7.95	7.00	7.35			
Total N (mg/l)	1.9	1.7	4.5	1.7	1.9	1.9	2.1	2.3	1.9	1.7	2.2	1.2			
Total P (ug/l)	11.3	7.5	233.8	7.5	3.8	22.5	11.3	7.5	15.0	18.8	15.0	11.3			
Total S (mg/l)	3.4	4.0	3.0	4.4	4.0	3.0	2.6	4.0	4.0	5.0	2.6	3.0			
NO <sub>3</sub> <sup>-</sup> (ug/l)	38.4	38.4	121.5	38.4	47.1	47.1	14.9	47.1	47.1	14.9	41.9	76.9			
NH <sub>3</sub> (ug/l)	5	5	1900	12	9	226	5	5	12	5	80	42			
Chlorophyll mg/m <sup>3</sup>	15.7	12.5	4.9	7.9	0.5	5.6	4.5	10.8	11.9	5.7	7.9	3.9			
	51.0	20.1	15.7	16.5	13.6	14.1	24.6	17.4	28.5	17.8	19.3	9.2			
	358.4	124.7	163.4	134.9	78.7	112.1	105.5	106.4	148.2	63.3	94.3	53.9			
Dissolved Mn (mg/l)	<0.1	<0.1	2.9	<0.1	<0.1	0.40	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			
Total Mn (mg/l)	<0.1	<0.1	3.3	<0.1	<0.1	0.42	<0.1	<0.1	<0.1	<0.1	0.13	<0.1			
Dissolved Fe (mg/l)	<0.1	<0.1	3.4	<0.1	<0.1	0.86	<0.1	<0.1	0.21	<0.1	0.13	<0.1			
Total Fe (mg/l)	<0.1	<0.1	3.8	<0.1	<0.1	1.1	<0.1	<0.1	0.23	<0.1	0.37	0.19			
Temperature (°C)	nd	nd	nd	nd	nd	nd	nd	nd	nd	19.5	17.5	20.0			
Dissolved O <sub>2</sub> (mg/l)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd			
Depth (m)	0	29.5	59	0	19.5	39	0	9.5	19						
Dissolved PO <sub>4</sub> (ug/l)	10	5	217	5	5	48	15	15	29	48	29	26			

nd = not determined

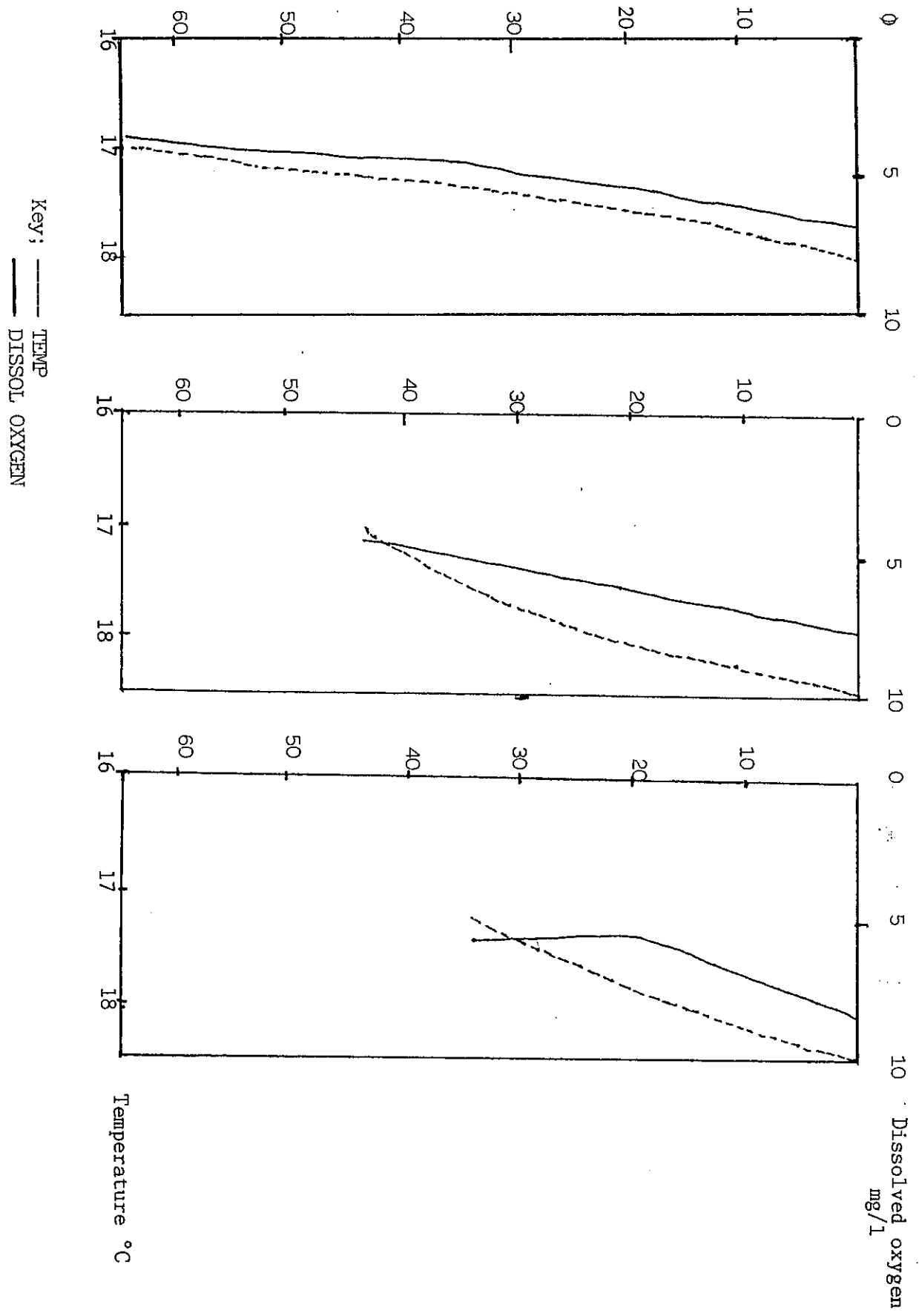


FIGURE 3 : TEMPERATURE AND DISSOLVED OXYGEN PROFILES FOR THE MONASAVU DAM -- JULY 1988

b) pH in the Monasavu Reservoir

The pH of the water in the reservoir at all the stations ranged from 6.5 to 8.2 with a mean of 7.3 during July and 7.1 in December. During December when the lake is stratified there was a difference of up to at least 1.7 pH units from the surface to the bottom while in July the difference was less apparent. This is again consistent with our previous findings.

c) Nutrients

i) Nitrogen

With two monitoring per year it is difficult to show details in the variation of the different forms of nitrogen in graphical form. However figures 4, 5 and 6 give some indications of the levels of nitrate, total nitrogen and ammonia present in the lake. These results are similar to those reported in the previous years. The surface waters continue to show lower levels of nitrate (Figure 4) throughout the year because of higher photosynthetic activity in these areas hence the consumption of nitrate within it. Sufficient oxygen in surface waters prevent formation of ammonia while stratification in summer months prevent re-oxygenation at depths thus explaining the build up of ammonia at depths (Figure 6). As a result of higher levels of oxygen at all depths in July, the production of organic forms of nitrogen increases. This is evident from the increases in total Kjeldahl nitrogen (TKN) in Figure 5.

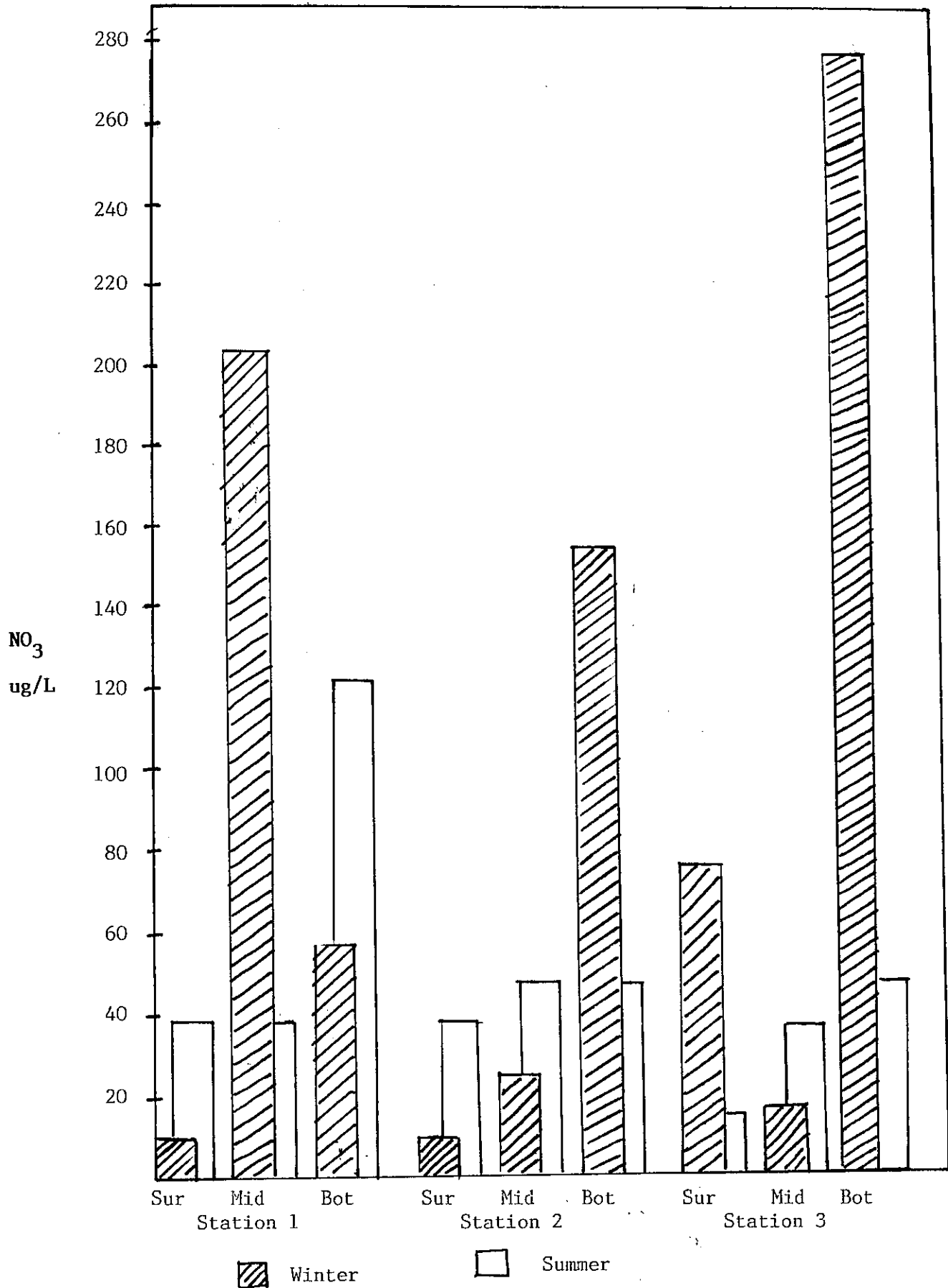


Figure 4 : Variation of nitrate content of the Monasavu Reservoir with time of year in 1988

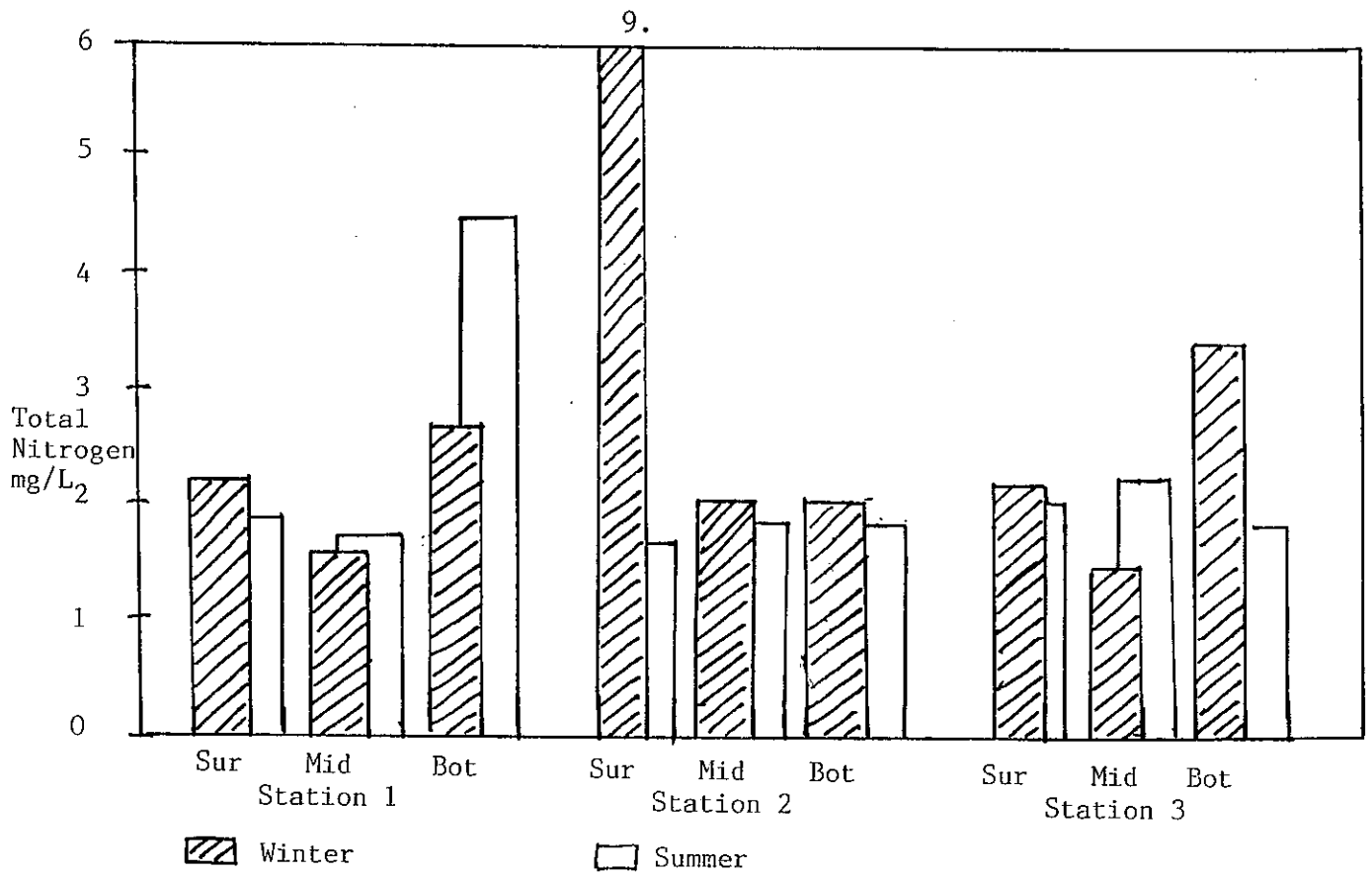


Figure 5 : Variation of total nitrogen (TN) content of the Monasavu Reservoir with time of year in 1987

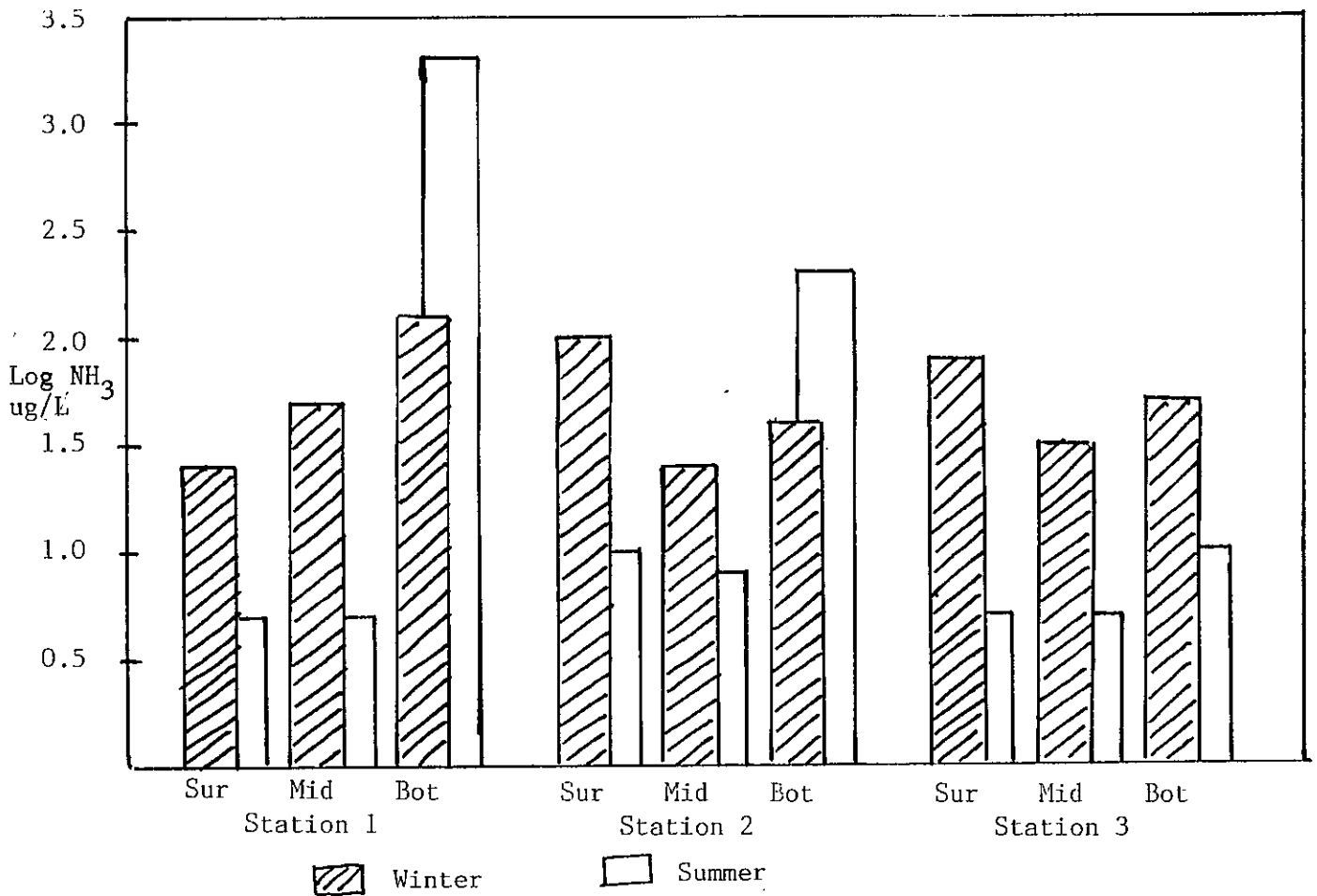


Figure 6 : Variation of ammonia content of the Monasavu Reservoir with time of year in 1988

**ii) Phosphorus**

The total phosphorus concentration in the Monasavu reservoir ranged from 3.8 ug/L to 2334 ug/L. Although it is difficult to show any seasonal variation graphically with two monitorings only, it is apparent from the data (Figure 7) that the circulation of the entire water column in the winter months allows the movement of mobilized forms of phosphorus into the upper layers where they are used up for metabolic processes thus explaining the lower levels in surface and middle waters.

The dissolved reactive phosphate varied between 12 ug/L and 83 ug/L in the July period and between 5 ug/L and 217 ug/L in the stratified conditions of December.

The average reactive N:P ratio in July was 3.2 and 1.2 in December suggesting that nitrate was the limiting factor for phytoplankton production. This was more pronounced in December. The mean total Kjeldahl nitrogen to total phosphorus ratio in Lake Monasavu was 77 in July and 62 in December. Although TKN values are high, nitrogen is not present in forms which may be available to phytoplanktons.

**iii) Sulphur**

As the surface sulphur content continues to be low because any release of sulphur from decomposition of organic matter is quickly oxidised under oxic conditions to sulphate which is reused by biota for protein synthesis.

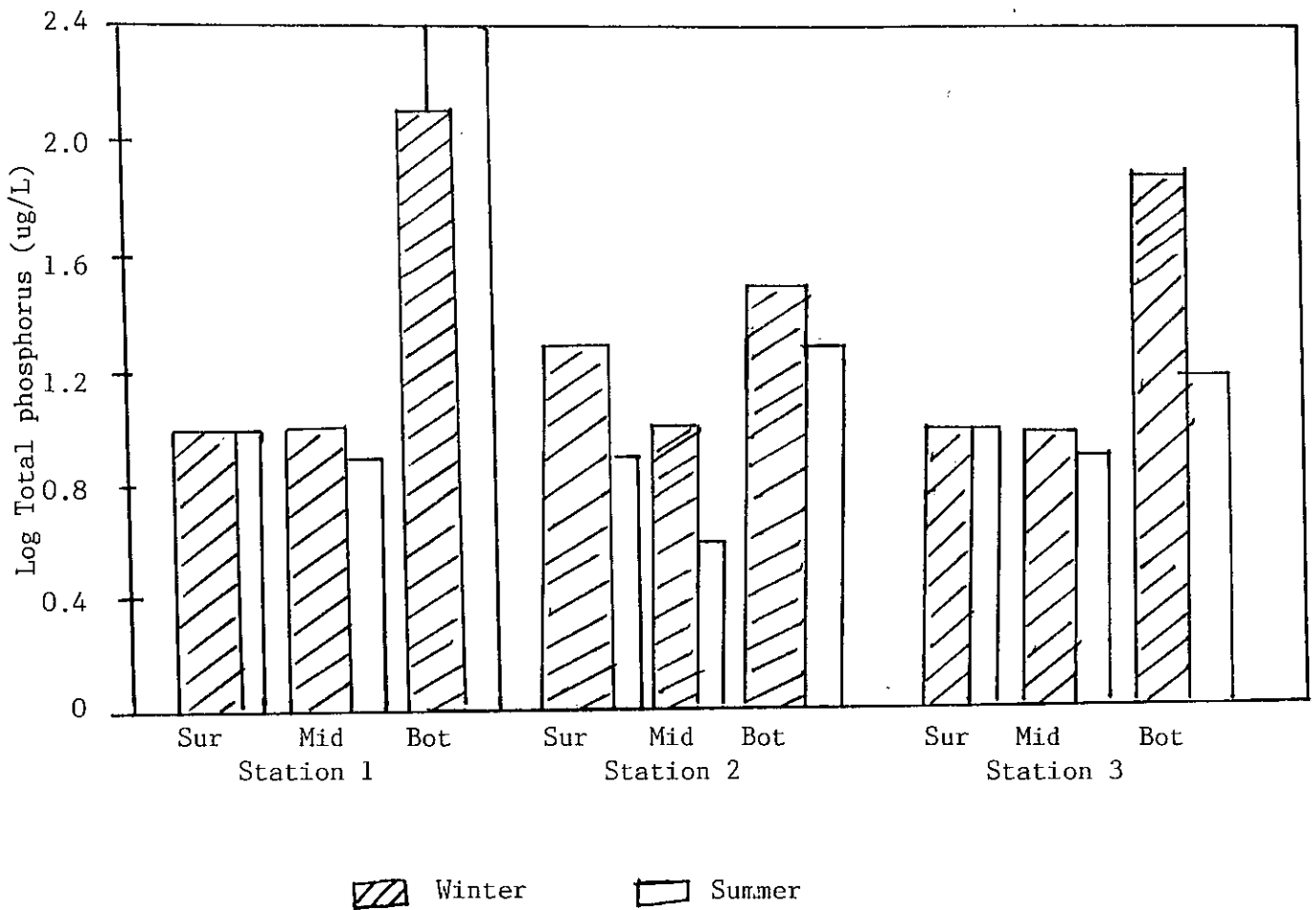


FIGURE 8 : Variation of total phosphorus content of the Monasavu Reservoir with time of year in 1988

Sulphur is fairly uniformly distributed throughout the entire water column unlike other nutrients.

#### iv) Total Iron and Manganese

Figure 8 shows the trends in total iron concentration during both sampling trips. The seasonal variations are not very apparent with only two monitoring. Since the cycling of iron and manganese is regulated to a large extent by dissolved oxygen content of the water, the surface and middle waters continue to have low levels because these ions are oxidised and returned to the sediments as particulate matter.

In the summer months, with the formation of stable stratification these ions migrate back into the water and an increase is observed at depth. This is especially apparent at sites 1 and 2 because of their depths.

#### 4.2 The Wailoa River

The water for the Wailoa power station is drawn from a point which is located at the bottom of station 2 and Table 4 shows the analytical data for the two stations. It is apparent from the results that the power station is receiving water of fairly low dissolved oxygen content. However, this water is oxygenated at the power station and any reduced forms of iron and manganese are also oxidised. The results show that there is considerable reduction in the concentration of iron when the station 2 water appears as tailrace water. It is important to

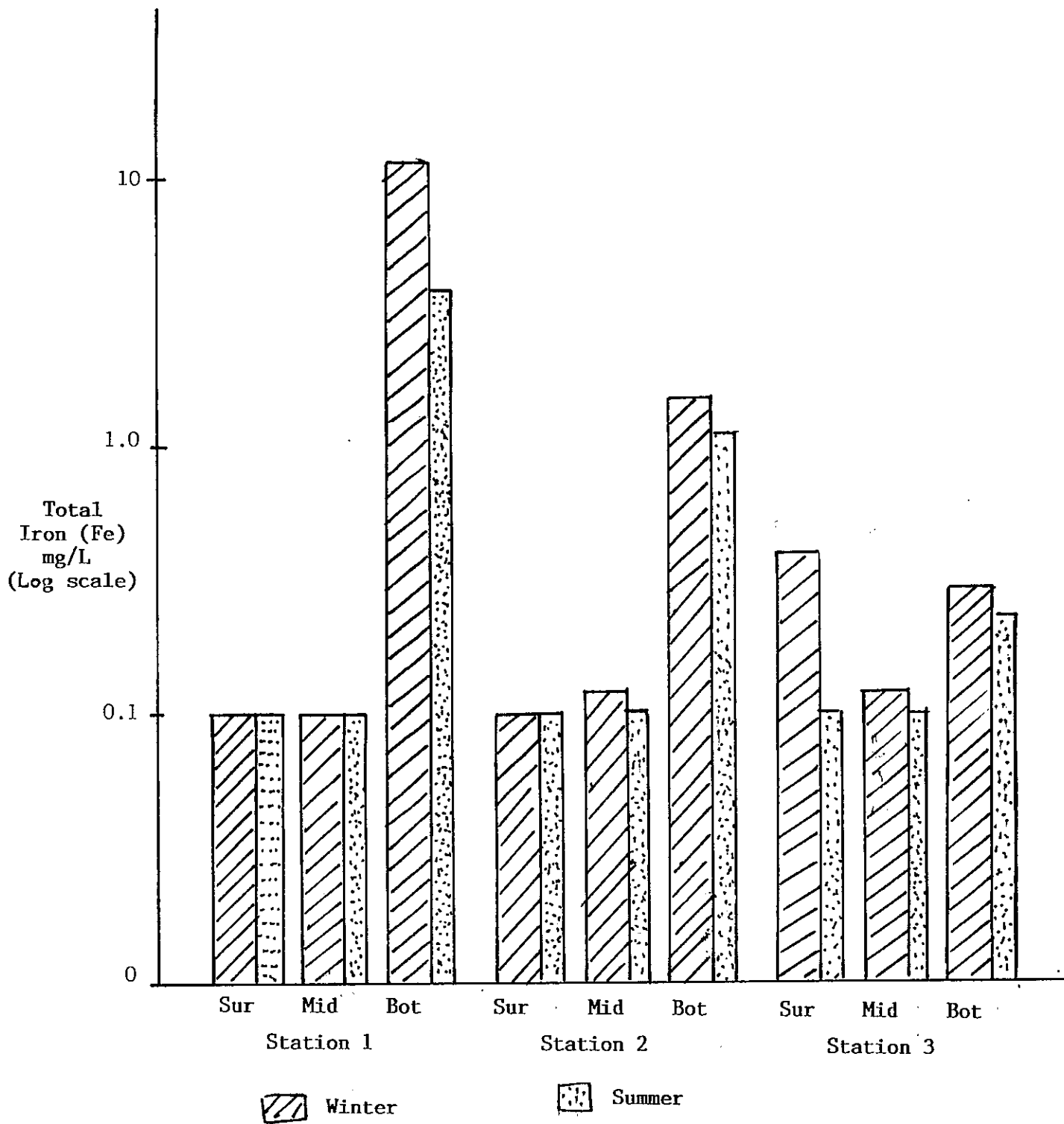


Figure 8 : Variation of total iron (TFe) content of the Monsavu Reservoir with time of year in 1988

point out that regular checks should be made to see that insoluble compounds of iron and manganese are not precipitating and settling on the machine parts.

TABLE 4

Comparison of Data from Station 2 Bottom Waters and Tailrace Water

	Sampling Date	Station 2	Tailrace
Total nitrogen (mg/L)	July 88		
Total P (ug/L)		2.0	1.5
NH <sub>3</sub> (ug/L)		33.8	10
NO <sub>3</sub> (ug/L)		153.8	96.7
Total Mn (mg/L)		<0.1	<0.1
Total Fe (mg/L)		1.4	0.1
pH		7.2	7.1
D.O. (mg/L)		4.4	9.2
TN (mg/L)	Dec. 88	1.9	2.2
TP (ug/L)		22.5	15
NH <sub>3</sub> (ug/L)		226	80
NO <sub>3</sub> (ug/L)		47.1	41.9
Total Mn (mg/L)		0.42	0.13
Total Fe (mg/L)		1.1	0.37
pH		6.7	7.0
D.O. (mg/L)		not determined	not determined

## 5) Invertebrate Survey

A third survey of gastropods in L. Monasavu was made on 20 July 1988.

The two sites visited on 14 July 1987 were again investigated. These were situated (1) at the end of the road (2) at the dam edge. Both are in relatively shallow water where light can reach the substrate. This enables microscopic algae, on which the gastropods feed, to grow.

The only gastropod found was the thiarid Melanoides tuberculata. It was abundant at both sites. Ten specimens of M. tuberculata were dissected. The mantle of two large specimens (28 & 30 mm high) contained many trematode worms. These parasites have been found in M. tuberculata from other habitats in Fiji and it is thought that the other host of the worm is the cane toad. However no tadpoles or toads were discovered in the lake. The lake level was higher than at the same time in 1987 and fewer invertebrate species were found.

Invertebrates found were :

Gastropoda	:	<u>Melanoides tuberculata</u>
Hirudinea	:	fish leech - possibly introduced with its fish host
Planaria	:	small black and white species of flatworm
Odonata	:	abundant dragonfly nymphs and nymph cases
Trichoptera	:	caddisfly larvae (some using young <u>M. tuberculata</u> shells to build their cases)

Porifera : small green sponge

### 5.1 Plankton Survey

July Copepods (Crustaceae) very abundant  
 1. Chironomid larva  
 mosquitoes )  
 other Diptera adults) from surface  
 seeds of Angiosperms) (fallen in  
 sporangia of ferns ) lake)

December Copepods very abundant  
 1. caddis case with larva  
 plant material (fallen in lake)

### 6. Water-weed Survey

A water weed survey was carried out during both sampling. The team concentrated on common weeds like Salvinia auriculata, Gichornia crassipes and Hydrilla verticillata. We are pleased to report that none of these were found in the reservoir.

### 7. Conclusions

The trends observed in the water quality of the Monasavu reservoir and Wailoa river in 1988 were similar to those of previous years. The water quality continues to improve as evidenced by increasing clarity, and lack of smell of hydrogen sulphide at the power station. The water weed survey showed that at present the lake is free from harmful aquatic weeds and the invertebrate survey showed that no harmful parasites are present in the gastropods.

## References

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313900 Ext. 343, 374, 348, 339, 251  
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: FJ2276  
Fax : ~~27833~~ 300373  
Cable : INR, University, Suva.

The General Manager  
Fiji Electricity Authority  
Private Mail Bag  
LAUTOKA

Dear Sir

I write in response to your request for a quotation for water quality measurements in 1988. The quote is as follows for two sampling trips:

1. Wailoa monitoring for pH, oxygen, iron, manganese, total P, S and N, nitrate, ammonia, phosphate and chlorophyll - laboratory charges	\$ 500.00
2. Reservoir monitoring for pH, oxygen, iron, manganese, total P, S and N, nitrate, ammonia, phosphate, alkalinity, turbidity and chlorophyll - laboratory charges	\$1000.00
3. Snail examination, weed examination and zooplankton survey	\$ 350.00
Staff sampling time (4 days)	\$ 860.00
Transport	\$ 360.00
Accommodation - FEA	
Meals	\$ 60.00
Report preparation	<u>\$ 60.00</u>
Total	<u>\$3190.00</u>

The increase in the quotation this year is due to the increases in the cost of imported chemicals and transport charges as a result of the devaluation of Fiji dollar.

I hope this is satisfactory.

Yours sincerely

  
Shamila Naidu  
for DIRECTOR