INSTITUTE OF APPLIED SCIENCES

THE UNIVERSITY OF THE SOUTH PACIFIC

WATER QUALITY ASSESSMENT IN THE BA RIVER (BASELINE REPORT)

IAS ENVIRONMENTAL REPORT NO. 68

by

Bale R. Tamata, M.Env.Stud.
Sereana Kubuabola, MSc.

August, 1993

INTRODUCTION

The Institute of Applied Sciences (IAS), USP was contracted by the Fiji Sugar Corporation (FSC) to carry out an assessment of the quality of water in the Ba river before crushing season began in June, 1993. Two staff from the IAS visited the Rarawai mill and collected water samples from the Ba river in early June, 1993.

The request from the FSC is in response to speculation that the Rarawai mill in Ba was responsible for the incidence of fish kill and depleting fish stock in the river. It is intended therefore that the final water quality assessment will cover the pre-crushing, crushing and post-crushing periods from June through to late November of 1993. This report represents the baseline report of the full assessment.

BACKGROUND

The effect of the Rarawai mill effluent on the Ba river has been investigated once before by the Institute of Natural Resources (now known as the Institute of Applied Sciences). The previous study was based on a single sampling visit, and was carried out in January of 1991. The results are contained in a report to the National Environment Management Programme (NEMP), dated July, 1991.

Briefly, the results of the previous study indicated that the mill effluent discharged through main drain 1 was not causing any significant pollution of the Ba river. However, the conclusion drawn from the study has to be viewed with caution since one visit was not sufficient and secondly, other significant sources of pollution such as the solid waste (mill mud and mill ash) were not investigated.

The potential sources of pollution from a sugar mill include waste water from cane washings, waste water from floor washings and washing of equipment. Waste water from cane washings would contain much solid impurities and soil as well as some sugar and may be coloured.

Effluents from the milling process are characterised by high biological oxygen demand (BOD), high chemical oxygen demand (COD) and a high concentration of suspended solids. This waste could present the greatest risk of pollution in the environment if not managed properly.

Another potential source of pollution that is not often investigated is the solid trash that often accumulates in the mill area. This solid waste would have a significantly high concentration of nutrients such as nitrates and phosphates as well as lime. The disposal of such waste must be managed properly to avoid any leachate reaching the waterways, creeks and rivers where problems of eutrophication could arise.

SAMPLING AND ANALYSIS

Sampling of the Ba river water was carried out on June 2nd, 1993, a few days before crushing of cane began at the Rarawai mill.

Altogether six sites were sampled along the Ba river. Fig. 1 shows the location of the sampling sites. The sites were selected in such a way that they cover as wide an area as possible, incorporating the reference location (upstream from potential mill impact), the discharge outlet from the mill, as well as other potential sources of pollution along the river (drainage from town and settlements).

On-site measurements included surface water temperature, pH and dissolved oxygen (DO). Water samples were collected in specially-washed bottles for the laboratory analysis work. In the laboratory, parameters assessed included alkalinity, biological oxygen demand (BOD), nutrients (nitrates, nitrites, phosphates etc.), suspended and dissolved solids and coliform concentrations. The methods used for laboratory analysis work were standard methods for analysis of water and waste waters (APHA, 1989)

SITE LOCATION AND DESCRIPTION

Site 1 - about 5 km upstream from mill (past Nasolo village), at Irish Crossing, beyond possible impact of mill effluent, **reference site.**

Site 2 - about 100m downstream from mill discharge outlet.

Site 3 - at mouth of Elevuka Creek which drains Ba town.

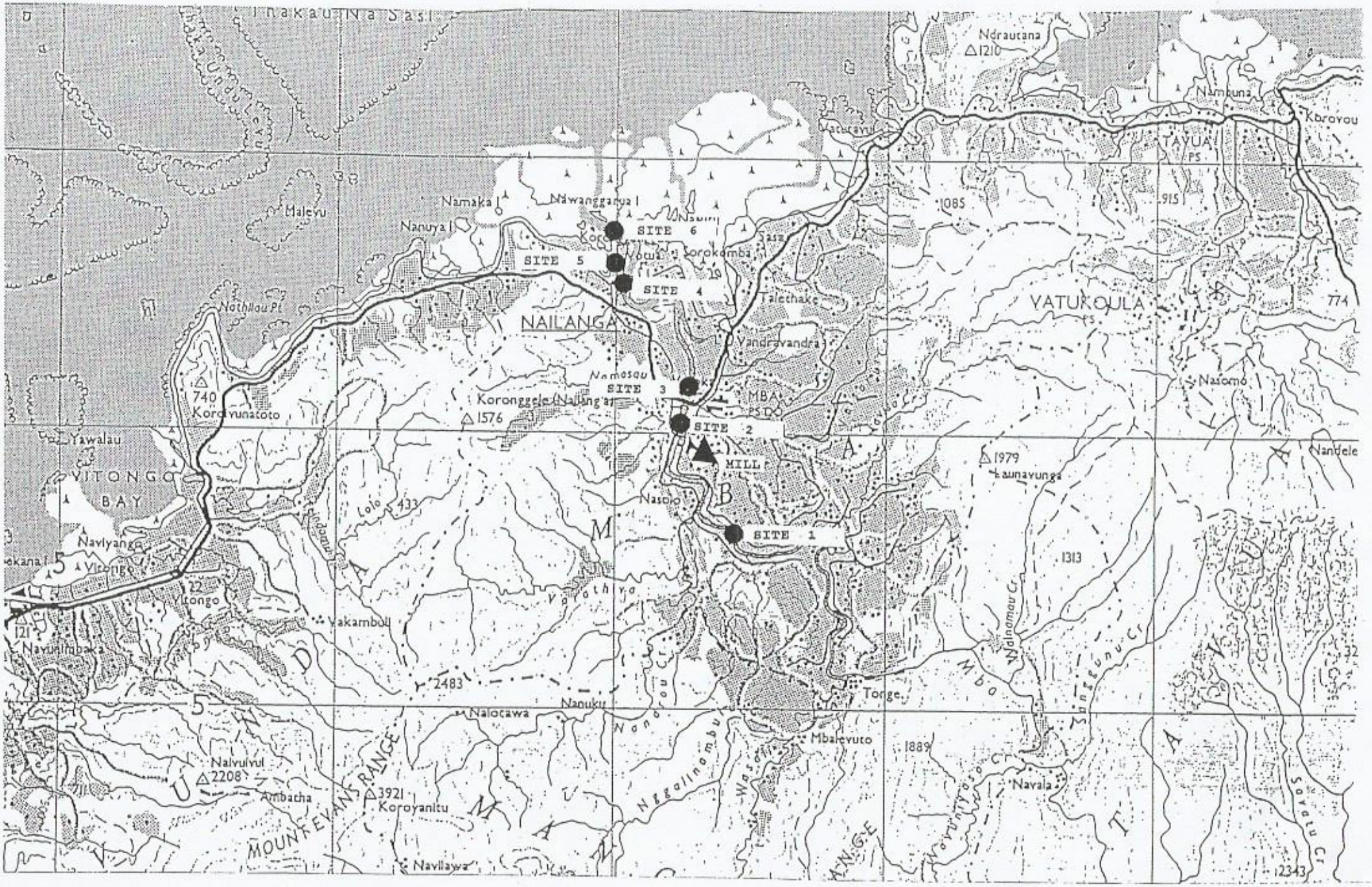
Site 4 - where creek draining Nailaga village and hospital discharges into Ba river.

Site 5 - about 300 upstream from Votua village.

Site 6 - about 75m downstream from Votua village.

Note : Sites 5 and 6 were selected to cover the critical area of concern (Votua village).

Fig. 1 LOCATION OF SAMPLING STATIONS ALONG THE BA RIVER



RESULTS

Table 1 shows the results for all of the measurements and analysis carried out on the six water samples.

pH, Temperature

The general physical parameters of pH and temperature were very similar for the six sites and the values are well within acceptable range for unpolluted waters.

The pH values were all about neutral (pH 7), and they satisfy required international standards of pH 6.5 - 9.0 for receiving waters (US EPA, 1976). Temperature was fairly constant for the six sites.

Dissolved oxygen (DO), BOD

The dissolved oxygen values were very similar and they varied from 6.6 to 7.2 mg/l, indicating oxygen saturation of the water at all sites. Biological oxygen demand values were also very similar, ranging from 2.6 to 3.6 mg/l. These values indicated very little or no pollution in the river, according to internationally-recognised criteria (see Discussion below).

The results for dissolved oxygen levels and BOD indicated that organic pollution was not a problem in the river during the sampling occasion.

Nutrients

Nitrate concentrations varied from 120 to 430 ug/l, the highest concentration being found at site 3 where the creek draining the town discharges into the Ba river. Of importance for later visits and comparison is the fact that site 2, next to mill effluent discharge site recorded the lowest concentration of nitrates during this pre-crushing visit.

Nitrite values varied from 12 to 79 ug/l. Site 4 had the highest value of 79 ug/l NO_2 which was significantly higher than the other values. The lowest nitrite concentration was recorded for site 1, the reference site.

Ammonia concentrations varied from 19 to 85 ug/l, with sites 4, 5 and 6 recording the highest concentrations. Interestingly at this stage, site 2 near the mill effluent outlet recorded the lowest concentration of 19 ug/l.

Total kjeldhal nitrogen values varied from 0.3 to 1.2 mg/l but sites 5 and 6 near Votua village seemed to be significantly higher than the other sites. The results for the nutrients which showed significant site-related differences are graphed in Fig. 2.

Institute of Applied Sciences, USP

Analytical Results for WATER

Client : Fiji Sugar Corporation, Ba

Date received : 3/06/93

Parameter & Units Lab No.	Field Blank	Site 1 M93/872	Site 2 M93/873	Site 3 M93/874	Site 4 M93/875	Site 5 M93/876	Site 6 M93/877
pH		7.6	7.6	7.5	7.6	7.5	7.6
Temperature (°C)		25.1	25.2	25.5	25.4	25.4	25.5
Dissolved oxygen (mg/L)		6.9	7.2	6.8	6.6	6.7	6.6
Alkalinity (mg $CaCO_3$ /L)		66	65	70	66	68	69
Nitrate (ug/L NO_3)		150	120	430	320	300	390
Nitrite (ug/L NO_2)		12	20	39	79	44	44
Ammonia (ug/L NH_3)		29	19	21	85	61	55
Nitrogen, Total N (mg/L)		0.30	0.38	0.38	0.45	0.90	1.23
Phosphate (ug P/L)		35	39	19	48	20	31
Phosphorus, Total (ug P/L)		60	48	54	57	54	48
Total coliforms (/100 ml)	<1	71,000	81,000	92,000	100,000	na	97,000
Faecal coliforms (/100 ml)	<1	540	630	78,000	580	na	640
Total suspended solids (mg/L)		28	12	10	45	39	42
Total dissolved solids (mg/L)		138	129	126	2,058	3,446	5,940
BOD (mg/L)		3.6	3.2	2.8	2.8	2.6	2.8

TABLE 1

Phosphate concentrations varied from 19 to 48 ug/l with no significant difference between sites. Total phosphorus concentrations also did not differ much for the six sites, with values ranging from 48 to 60 ug/l.

Suspended and dissolved solids

The results for total dissolved solids and suspended solids showed a significant increase in concentrations for the sites downstream of the bridge. The sites upstream of the bridge (sites 1 & 2) showed the lowest concentrations of solids.

Total suspended solids (TSS) concentrations varied from 10 to 45 mg/l, with sites 4, 5 and 6 recording the highest values.

Total dissolved solids (TDS) concentrations varied from 126 to 5940 mg/l. Sites 4, 5 and 6 had significantly higher concentrations than the other sites.

The high solid concentrations in the water at the downstream sites (4, 5 and 6) may be explained by the fact that at the time of sampling, construction work was being carried out on the bridge which was damaged by cyclone Kina early in January. Furthermore, people were being transported across the river in boats, just upstream from these sites.

Microbiological assessment

Both total coliform and faecal coliform concentrations were very high for the five sites sampled. Site 5 was not analysed for coliforms.

Total coliform count varied from 71,000 to 100,000 organisms/100 ml water and faecal coliform count varied from 540 to 78,000 organisms/100 ml.

As far as faecal coliform levels is concerned, all sites exceeded the recommended standard for bathing waters (<350 org/100 ml) according to World Health Organisation (WHO) guidelines (WHO, 1983). The highest faecal coliform count was recorded for site 3 near the mouth of the Elevuka creek, indicating that the town was a significant source of sewage pollution in the river.

Fig. 3 shows the results for coliform counts, BOD and total suspended solids for the six sites.

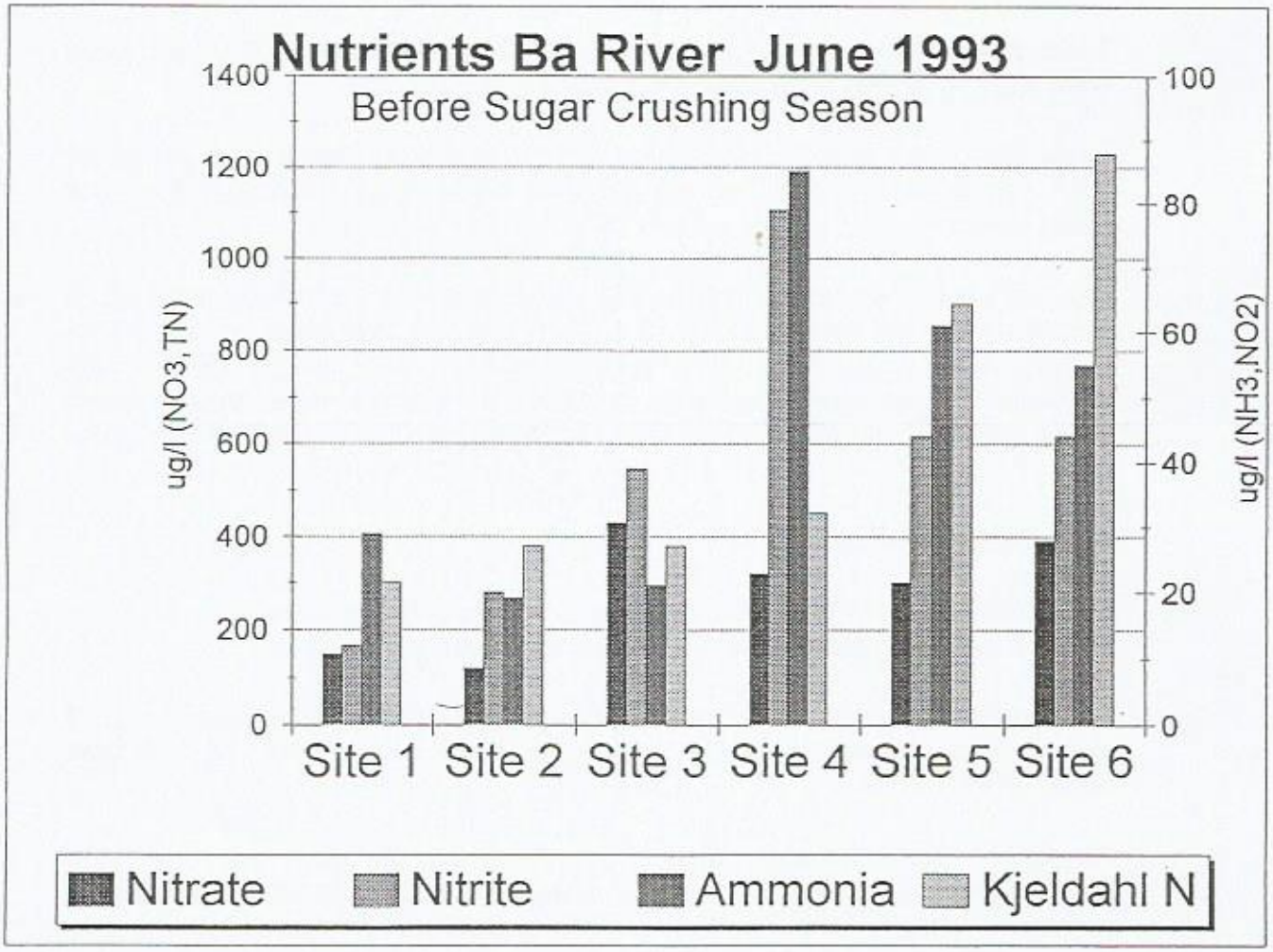

Nutrients Ba River June 1993
Before Sugar Crushing Season
1400
1200
1000
800
600
400
200
0
ug/l (NO3,TN)
100
80
60
40
20
0
ug/l (NH3,NO2)
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Nitrate
Nitrite
Ammonia
Kjeldahl N

Figure 2

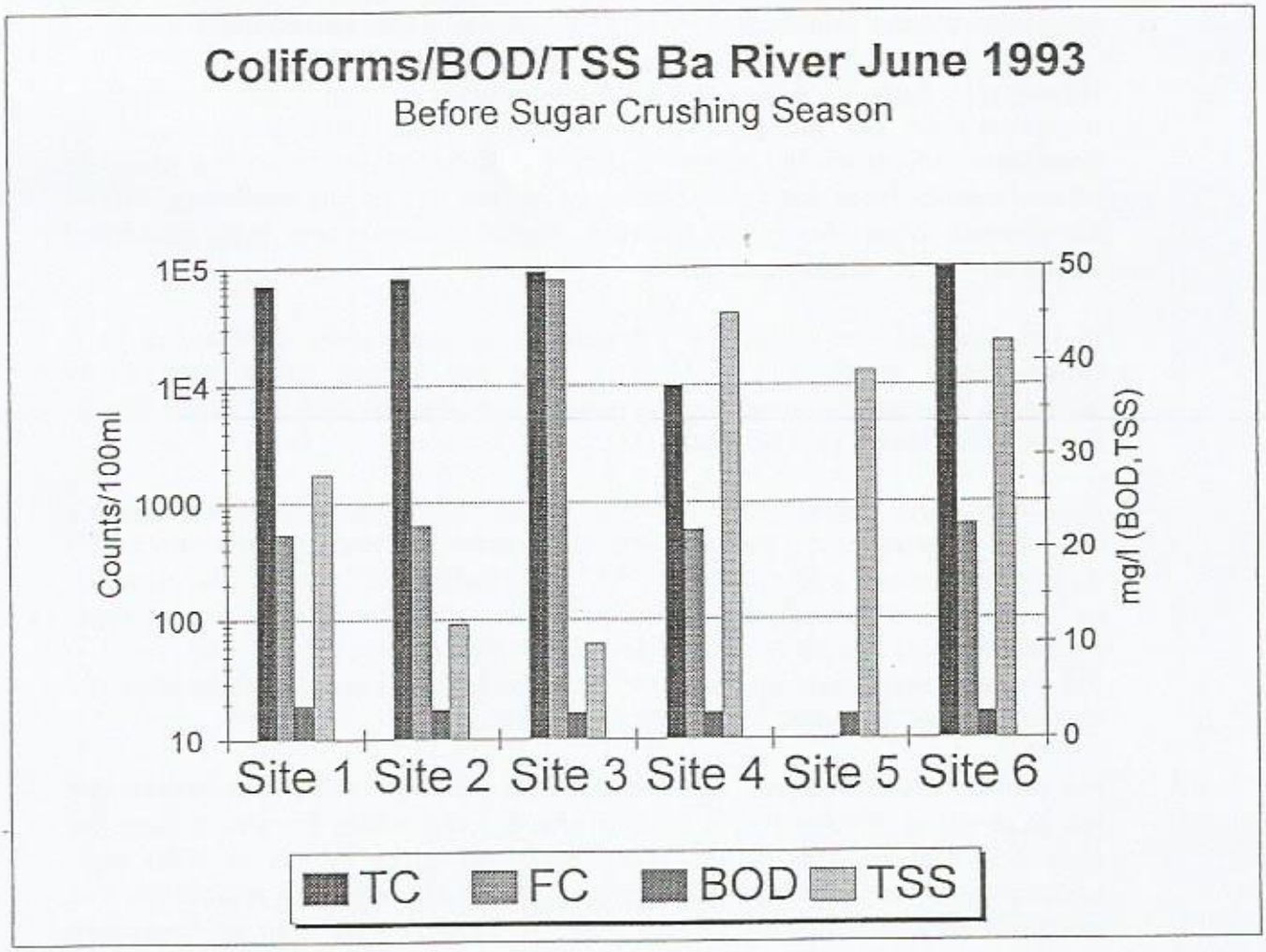

Coliforms/BOD/TSS Ba River June 1993
Before Sugar Crushing Season
Counts/100ml
1E5
1E4
1000
100
10
50
40
30
20
10
0
mg/l (BOD,TSS)
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
TC
FC
BOD
TSS

Figure 3

DISCUSSION OF RESULTS

The results obtained from this visit represent the situation in the absence of any impact from the sugar mill discharge, since crushing had not commenced and no effluent sample was collected or analysed.

The parameters which did not vary much for the six sites included pH, temperature, dissolved oxygen, BOD, alkalinity, total nitrogen, phosphate and total phosphorus concentrations. The values obtained also satisfied recommended levels for unpolluted waters (see Table 2 below). These parameters were unaffected by site location and site variations.

However, certain parameters were showing significant variation, depending on the location of the sites. These parameters could be important indicators for water quality and water pollution in the absence of any impact from the sugar mill or when the mill is not operating. These parameters were ammonia, nitrites, faecal coliform and total dissolved solids and total suspended solids.

In the case of ammonia, the increase in concentration is about 3 to 4 times those of sites 1, 2 and 3, but the values were still within acceptable range for receiving waters as specified by the Canadian Water Quality Guidelines (<730 ug/l).

Site 4 with the highest concentration of ammonia indicated that the creek draining Nailaga town, hospital and close environs was discharging much of this compound into the river. An important factor that would need to be investigated further is the impact of agricultural land use practices, particularly the use of fertilizers and pesticides on the creeks and rivers in the Nailaga area, seeing that ammonia concentrations were significantly higher at sites 4, 5 and 6 than further upstream.

For nitrite concentrations, again site 4 had the highest concentration, the increase being almost 100% that of site 3. The value for site 4 was the only one that did not satisfy recommended limits which is <60 ug/l, according to the Canadian Guidelines. As in the case of ammonia, this observation would again indicate that the Nailaga area was an important source of nitrite in the Ba river.

In the case of faecal coliform concentrations, none of the sites satisfied recommended standards for faecal coliform counts for bathing waters which is <350 organisms/100 ml water (WHO, 1983). This indicated that sewage pollution in the river is quite widespread and significant.

Perhaps the most significant increases were those of the solids in the water as recorded for sites 4, 5 and 6. The increases for these sites over sites 1, 2 and 3 are more than 100%, exceeding recommended standards

as specified by both the Canadian Guidelines and the United States Environmental Protection Agency (USEPA, 1976). As mentioned above, an important source of these materials in the water was the construction work being carried out on the damaged Ba bridge and the increased boating activity in the area. As well as this, the creeks draining Nailaga area and environs could be important sources of suspended and dissolved solids.

Table 2 : Some Recommended Criteria for Receiving Water

Parameter	Criteria	Source
pH	6.5 - 9	CCR (1987)[1]
Dissolved oxygen	>6 mg/l	CCR (1987)
BOD	<5 mg/l	Clark (1986)
Nitrate	<10 mg/l	USEPA (1976)[2]
Nitrite	<60 ug/l	CCR (1987)
Ammonia	<730 ug/l	CCR (1987)
Total nitrogen	No specific limit	
Phosphate	Up to 70 ug/l	(Coral reef growth)[3]
Total phosphorus	<50 ug/l	(Wetzel, 1975)
Suspended solids	Increased over background by not more than 10%	CCR (1987)

1. Canadian Council of Resources, 1987. Canadian Water Quality Guidelines.

2. United States Environmental Protection Agency, 1986. Quality Criteria for Water.

3. Blake and Johnson, 1988.

CONCLUSIONS

From the results and discussion presented above, the following conclusions are drawn :

1. The chemical water quality in the Ba river during the sampling visit was generally good,

2. there was no evidence of significant organic pollution as indicated by the DO and BOD values,

3. Microbiological (sewage) pollution was found to be quite widespread and of concern.

RECOMMENDATIONS

No recommendations can be made at this stage until sampling is undertaken during the crushing season.

REFERENCES

APHA-AWWA-WPCF. 1989. Standard Methods for the Examination of Water and Wastewater. Amer. Pub. Health Assoc., 17th Ed.

Blake, S.G. and Johnson, D.P. 1988. Preliminary report on water quality, current patterns and sediment composition around Hamilton and Hayman Islands, the Whitsundays. Report to the Great Barrier Reef Marine Park Authority (GBRMPA), Department of Geology, James Cook University, Townsville.

Clark, R.B. 1986. Marine Pollution. Clarendon Press, Oxford, 215p.

INR, 1991. Effect of Rarawai mill effluent discharge on the Ba river. Report to the National Environment Management Programme (NEMP).

USEPA, 1976. Quality Criteria for Water. United States Environmental Protection Agency, Washington, D.C., 501p.

Wetzel, R.G. 1975. Limnology. Saunders College Publishing, Philadelphia, 743p.

WHO, 1983. Compendium of Environmental Guidelines and Standards for Industrial Discharges. WHO, Geneva.