Nutrient Water Quality of Banica River in Dumaguete City, Philippines 1991-1993

C. Dumancas, P. Suarez, M.A. Juguilon, R. F. Lozada, M.T. Patula, N. Rubio, N. Tan, and H. Zamora

ABSTRACT. The river water of Banica River is analyzed for its pH, dissolved oxygen, biochemical oxygen demand, phosphate-phosphorus, nitrate-nitrogen and ammonia-nitrogen content to establish baseline data. An effective rehabilitation scheme is the expected outcome.

INTRODUCTION

Banica River has its headwaters in the upland of Valencia, Negros Oriental. It originates as a confluence of Banica Daku, Maite Creek and Apolong River at Tejeros, Valencia. The river passes through the south side of the Dumaguete City commercial district (Figure 1). Old residents of Dumaguete City have remembered the river to be deep and clear; however, at present it is shallow and dirty. Some of the factors that have brought about this condition are trash dumped into the river, domestic sewage and industrial waste. Concerns have been expressed that the river ought to be rehabilitated. However, before a rehabilitation scheme can be effected, the existing condition of the river has to be established.

Thus, this study was conducted by the Chemistry Department of Silliman University in order to establish the baseline data of the biochemical and nutrient levels in the water specifically the pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), phosphate (PO_4-P), nitrate (NO_3-N), and ammonia (NH_4-N).

METHODOLOGY

Two 1-gallon plastic jugs were filled with water samples by submerging the container six inches from the surface at the middle of the river from ten (10) sampling stations along the Banica River (Figure 1). The sample at the river mouth was taken during low tide when no seawater was moving into the river. Two samples for dissolved oxygen and two for biochemical oxygen demand were also collected in separate 300 ml-DO bottles. The sample for DO was immediately fixed with one milliliter manganous sulfate and one milliliter alkaline potassium iodide. The pH of the water was measured *in situ* using a Chem Cadette portable pH meter.

Five hundred ml of the collected water samples were filtered through Whatman #40 filter paper in the laboratory. The filtrate was stored at -20°C and were used for phosphate, nitrate and ammonia analysis.

Dissolved oxygen (DO-zero) was measured using Winkler Method as described by the American Public Health Association Standard Method for Examination of Water and Wastewater (APHA, 1965). The collected water samples for BOD was stored in the dark at 20°C for five days. The remaining dissolved oxygen in the sample after 5-day storage was measured (DO-5). The BOD-5 days was calculated, thus:

$$\text{BOD-5 days} = [\text{DO-zero}] - [\text{DO-5}].$$

If the DO-zero of the sample is below 4 mg/L O_2, the unfiltered water sample was diluted with distilled water at 1:1 volume ratio up to 1:10 depending upon the initial DO value. The diluted water sample was placed in DO bottles and the DO-zero and DO-5 was determined. The calculated BOD-5 for the diluted water sample is

$$\text{BOD-5 days} = [(\text{DO-zero}) - (\text{DO-5})] \times \text{dilution factor}.$$

The inorganic orthophosphate composition of the water was determined using the Molybdo-Ascorbic Acid method as described in the APHA Manual (APHA, 1965). Nitrate was measured using cadmium reduction followed by alpha-napthyl diamine diazotization of the reduced nitrite (APHA, 1965). Ammonia was measured using hypochlorite-salicylate method described by Bower & Holm-Hansen (1980).

RESULTS AND DISCUSSION

pH. The average pH of the Banica River water taken from the different stations over the three-year period is shown in Table 1. The average pH of the river water is slightly above neutral with the lowest at pH 7.23 ± 0.29 for Candau-ay and the highest at pH 7.58 ± 0.19 for Tejeros. Figures 2a and 2b show the pH of the river water taken from the ten sampling stations at various times.

The pH of Banica River water is within the normal pH range of lake and river waters which is around 6.7 - 7.5 (Wen-Young, 1979). The pH of Banica river indicates that neither very acidic nor very basic contaminants have been introduced into the river.

The pH of the river water puts Banica River under the Department of Environment and Natural Resources (DENR) Standard as Class AA to C fresh water (Table 2).

DISSOLVED OXYGEN. The average dissolved oxygen of Banica River water ranges from 0.72 ± 1.45 mg/O_2 at the river mouth to 7.67 ± 1.37 mg/L O_2 at Tejeros, Valencia as shown in Table 1. The average dissolved oxygen of the river water from Tejeros to Bagacay met the DENR minimum requirement of at least 5.0 mg/L O_2 for Class AA to C fresh water as shown in Table 2. Banica river water at Foundation University met the Class D minimum requirement; while the river waters at Market Bridge down to the river mouth failed to meet the Class D criterion of at least 3.0 mg/L dissolved oxygen.

The dissolved oxygen of Banica River at various times in the different sites are shown in Figures 3a and 3b. The dissolved oxygen in the river water are generally higher during the cooler and rainy months of October 1992 to February 1993. The DO of downstream river water from Foundation University to Calindagan has an almost depleted oxygen content during the early sampling schedule from October 1991 to May 1992. It increased to above 3.0 mg/L O_2 during the rainy months of October 1992 to February 1993 and decreased to 1.0 to 3.0 mg/L O_2 in the summer of April to July 1993. The river water at the river mouth was observed to have zero dissolved oxygen from October 1991 to May 1992 and from April to July 1993.

The amount of dissolved oxygen in water is affected by its organic load, water temperature, and river water turbulence (Manahan, 1994). Decomposing organic compound in the water system needs oxygen; thus, decreasing its dissolved oxygen content. High temperature on the other hand decreases the solubility of oxygen in water. Water turbulence is directly related to water volume of the river. Increased water volume speeds up water flow and increases its cascading action over rocks thereby increasing the surface area of the water for oxygen saturation; thus, increasing its dissolved oxygen content. The low DO at downstream area can be attributed to organic load from solid trash - domestic, slaughterhouse and market sewage channelled into the river and low river volume during the summer months. The rainy month of October 1992 as well as the succeeding months slightly improved the DO of the river water except at the river mouth. It must be noted that urban development of the City begins at Foundation University to the river mouth with its domestic sewage channelled into the river.

BIOCHEMICAL OXYGEN DEMAND (BOD). Average biochemical oxygen demand of Banica River water ranges from 1.14 ± 1.04 mg/L O_2 at Palinpinon to 20.80 ± 13.79 mg/L O_2 at the river mouth. The Banica River water at Tejeros, Palinpinon, Dumpsite, and Bagacay met the DENR requirements for Class A and B fresh water with their BOD-5 below the maximum allowable 5.0 mg/L O_2. Candau-ay and Batinguel have Class C river water with BOD-5 between 5.0 - 10.0 mg/L O_2. Banica River at Foundation University, Market Bridge and Calindagan have Class D water with BOD-5 between 10.0 - 15.0 mg/L O_2 while the river mouth water with 20.80 mg/L O_2 failed to meet the Class D requirement.

Figures 4a and 4b show the BOD-5 of the river water at different sampling times over the three-year period. The river water from Tejeros to Batinguel (Figure 4a) met the BOD-5 requirement for Class A and B river water except Candau-ay and Batinguel areas during the months of June and July 1993. During these months, the dissolved oxygen is below 3.0 mg/L O_2 which indicates a high organic load that depletes the oxygen in the water after five days of incubation. There was no unusual activity in those sites during these times except that it was the start of the rainy season. Surface water run-off from the dumpsite cannot be the immediate cause of the high BOD-5 in Candau-ay and Batinguel inasmuch as the sampling station just below the dumpsite have BOD-5 of 1.88 and 2.24 mg/L O_2 during those same two months of June and July 1993.

The BOD-5 of the river water downstream closer to the urban area have values beyond the 10.0 mg/L O_2 DENR requirement for Class D water as shown in Figure 4b. These downstream areas are densely populated. Solid waste thrown into the river, domestic waste, fish washings from the market, washings from the slaughterhouse, and other waste are channelled into the river. These waste have high organic content which needs oxygen or BOD-5 to decompose. The kitchen sink washings of typical homes in the Philippines do not go to the septic tank but are directly channelled into the public drainage system (Duran, 1996). Fish, meat, and food particle washings which have high organic component are drained into the city sewer which leads either to the river or directly into the sea.

PHOSPHATE-PHOSPHORUS. The average phosphate concentration of Banica River ranges from 0.08 ± 0.07 mg/L PO_4-P at Tejeros to 1.13 ± 0.07 mg/L PO_4-P at the river mouth as shown in Table 1. Tejeros river water met the DENR requirement of below 0.1 mg/L PO_4-P for Class AA water. Banica River water at Palinpinon, dumpsite and Candau-ay met the Class A requirement of 0.1 - 0.2 mg/L PO_4-P; while Batinguel and Bagacay have Class B river water with respect to phosphate requirement. Banica River water at Foundation University down to the river mouth can be classified as Class D inasmuch as the DENR did not set a standard for Class D river water with regards to its phosphate content.

Figures 5a and 5b show the PO_4-P content of the river water over the three-year period. Upstream river water has minimal phosphate content in spite of the laundry detergents used by residents. Decomposed organic waste, polyphosphates of detergents and fertilizer runoffs are major sources of phosphates in the water system (Manahan, 1994). The downstream area from Foundation University to the river mouth have higher phosphate content above the Class C requirement of 0.4 mg/LO_4-P. The accumulated detergent washings coupled with domestic waste maybe responsible for the high phosphate content of the river water in the down-stream area.

NITRATE-NITROGEN. The average nitrate-nitrogen of the Banica River water is shown in Table 1. It ranges from 0.07 ± 0.13 mg/L NO_3-N at Tejeros to 0.98 ± 0.91 mg/L NO_3-N at Calindagan. The nitrate content of the Banica River water met the Class AA maximum requirement of 1.0 mg/L NO_3-N. Figures 6a and 6b show the nitrate-nitrogen content of the river water at different months. Nitrate is the final oxidation product of nitrogenous organic compounds.

AMMONIA-NITROGEN. Table 1 shows the average ammonia-nitrogen of Banica River water over the three-year period from October 1991 to July 1993. The ammonia-nitrogen content of Banica River water ranges from 0.02 ± 0.04 mg/L NO_3-N at Batinguel to 1.31 ± 1.72 mg/L NO_3-N at the river mouth. Figures 7a and 7b show the ammonia-nitrogen content of Banica River water at different months. The river water in downstream stations from Foundation University to the river mouth have higher ammonia-nitrogen as compared with those taken from the up-stream area. The DENR did not set a standard for ammonia-nitrogen in water.

Ammonia is the direct by-product of living organisms, fresh organic waste, as well as anaerobic decomposition of organic materials. The safe concentration of ammonia for fresh and seawater species is less than 1.0 mg/L NH_3-N (Wen-Yong, 1979). Ammonia in the gaseous state is very toxic to living organisms but is harmless in ionic state. Water with low pH and high calcium content converts the gaseous ammonia to less toxic ammonium ions. In the presence of oxygen in the water, ammonia is oxidized into nitrite then nitrate ion.

Table 3 summarizes the classification of Banica River water at different stations with regard to its pH, oxygen and nutrient content. Taking the lowest classification met by the river water at various sampling stations, Tejeros, Palinpinon, and dumpsite can be classified to have Class A river water; Banica River at Bagacay can be classified as Class B water; Batinguel and Candau-ay have Class C river water while the river at the back of Foundation University has Class D qualities. Banica River at Market Bridge, Calindagan and at the river mouth failed to meet the requirement of Class D water with respect to its dissolved oxygen. The water of Banica River at its river mouth also failed to meet the biochemical oxygen demand of Class D water.

CONCLUSIONS

Urbanization of Dumaguete City has changed the water quality of Banica River from Tejeros, Valencia down to the river mouth. Banica River at Tejeros down to the dumpsite met the requirement of Class A river water. The river water at Bagacay has Class B qualities while Batinguel and Candau-ay met the Class C river requirements. The river water at Foundation University met the Class D criterion. Banica River from the Market Bridge to the river mouth failed to meet the Class D requirement with regard to its dissolved oxygen. Banica River at the river mouth also failed to meet the biochemical oxygen demand requirement of Class D water.

The major factors that have affected the quality of Banica River are domestic, market, slaughterhouse, and surface water runoff with high organic content. Impounding the domestic, municipal, and industrial organic waste in properly constructed septic tanks minimizes the oxygen demand of the water in the river. Reforestation of Banica River watershed also increases the water volume of the river; thereby improving its dissolved oxygen and biochemical oxygen quality.

REFERENCES

APHA, 1965. *Standard Method for the Examination of Water and Wastewater.*

Bower, C.E. and T. Holm-Hansen. 1980. "A Salicylate-Hypochlorite Method for Determining Ammonia in Seawater." *Can. J. Fish. Aquatic Sci;* 27:794 - 798.

Duran, Pedro, Jr. Engineer, June 14, 1996. *Private Communication.*

Manahan, S. 1994. *Environmental Chemistry,* 6th ed. London: Lewis Publishers.

Wen-Young, T. "Aquaculture Water," *Paper presented during Conference on Standardization of Methodology of Water Pollution.* Hongkong: Hongkong Baptist College.

Table 1. **The average and standard deviation of the pH, DO, BOD, and nutrients concentration of the Banica River water samples from October 1991 to July 1993.**

Site	pH (units)	DO (mg O_2/L)	BOD (mg O_2/L)	PO_4-P (mg/L)	NO_3-N (mg/L)	NH_4-N (mg/L)
Tejeros	7.58 ± 0.19	7.67 ± 1.37	1.14 ± 1.62	0.08 ± 0.07	0.07 ± 0.13	0.04 ± 0.07
Palinpinon	7.49 ± 0.25	6.86 ± 1.27	1.14 ± 1.04	0.10 ± 0.08	0.09 ± 0.19	0.05 ± 0.05
Dumpsite	7.34 ± 0.29	6.02 ± 1.66	1.87 ± 1.86	0.12 ± 0.08	0.08 ± 0.10	0.02 ± 0.05
Candau-ay	7.23 ± 0.45	5.76 ± 1.80	6.34 ± 12.96	0.17 ± 0.14	0.12 ± 0.15	0.06 ± 0.22
Batinguel	7.25 ± 0.46	5.98 ± 2.67	6.38 ± 12.00	0.21 ± 0.17	0.26 ± 0.38	0.02 ± 0.04
Bagacay	7.30 ± 0.30	5.20 ± 1.81	3.57 ± 3.51	0.28 ± 0.21	0.16 ± 0.20	0.04 ± 0.06
Foundation	7.41 ± 0.39	3.15 ± 3.06	10.91 ± 10.32	0.45 ± 0.29	0.22 ± 0.24	0.23 ± 0.53
Market	7.33 ± 0.41	2.37 ± 2.93	12.97 ± 11.03	0.77 ± 0.46	0.74 ± 0.66	0.69 ± 0.98
Calindagan	7.36 ± 0.50	1.99 ± 2.13	12.63 ± 8.97	1.01 ± 0.49	0.98 ± 0.91	0.85 ± 1.20
River Mouth	7.33 ± 0.40	0.72 ± 1.45	20.80 ± 13.79	1.13 ± 0.54	0.82 ± 0.87	1.31 ± 1.72

Table 2. Water quality criteria for conventional and other pollutants contributing to aesthetics and oxygen demand for fresh waters (DENR Administrative Order No. 34, Series of 1990).

PARAMETER	UNIT	CLASS AA	CLASS A	CLASS B	CLASS C	CLASS D
pH		6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.0-9.0
DO (minimum)	mg/L	5.0	5.0	5.0	5.0	3.0
BOD-5	mg/L	1	5	5	7(10)	10(15)
PO_4-P	mg/L	nil	0.1	0.2	0.4	..
NO_3-N	mg/L	1.0	10	NR	10	..

Table 3. Classification of Banica River water based on its nutrient and oxygen content.

Site	pH	DO	BOD	PO_4-P	NO_3-N
Tejeros	Class AA	Class AA	Class A	Class AA	Class AA
Palinpinon	Class AA	Class AA	Class A	Class A	Class AA
Dumpsite	Class AA	Class AA	Class A	Class A	Class AA
Candau-ay	Class AA	Class AA	Class C	Class A	Class AA
Batinguel	Class AA	Class AA	Class C	Class B	Class AA
Bagacay	Class AA	Class AA	Class A	Class B	Class AA
Foundation	Class AA	Class D	Class D	Class D	Class AA
Market	Class AA	below D	Class D	Class D	Class AA
Calindagan	Class AA	below D	Class D	Class D	Class AA
River Mouth	Class AA	below D	below D	Class D	Class AA

Table 1. The average and standard deviation of the pH, DO, BOD, and nutrients concentration of the Banica River water samples from October 1991 to July 1993.

Site	pH (units)	DO (mg O_2/L)	BOD (mg O_2/L)	PO_4-P (mg/L)	NO_3-N (mg/L)	NH_4-N (mg/L)
Tejeros	7.58 ± 0.19	7.67 ± 1.37	1.14 ± 1.62	0.08 ± 0.07	0.07 ± 0.13	0.04 ± 0.07
Palinpinon	7.49 ± 0.25	6.86 ± 1.27	1.14 ± 1.04	0.10 ± 0.08	0.09 ± 0.19	0.05 ± 0.05
Dumpsite	7.34 ± 0.29	6.02 ± 1.66	1.87 ± 1.86	0.12 ± 0.08	0.08 ± 0.10	0.02 ± 0.05
Candau-ay	7.23 ± 0.45	5.76 ± 1.80	6.34 ± 12.96	0.17 ± 0.14	0.12 ± 0.15	0.06 ± 0.22
Batinguel	7.25 ± 0.46	5.98 ± 2.67	6.38 ± 12.00	0.21 ± 0.17	0.26 ± 0.38	0.02 ± 0.04
Bagacay	7.30 ± 0.30	5.20 ± 1.81	3.57 ± 3.51	0.28 ± 0.21	0.16 ± 0.20	0.04 ± 0.06
Foundation	7.41 ± 0.39	3.15 ± 3.06	10.91 ± 10.32	0.45 ± 0.29	0.22 ± 0.24	0.23 ± 0.53
Market	7.33 ± 0.41	2.37 ± 2.93	12.97 ± 11.03	0.77 ± 0.46	0.74 ± 0.66	0.69 ± 0.98
Calindagan	7.36 ± 0.50	1.99 ± 2.13	12.63 ± 8.97	1.01 ± 0.49	0.98 ± 0.91	0.85 ± 1.20
River Mouth	7.33 ± 0.40	0.72 ± 1.45	20.80 ± 13.79	1.13 ± 0.54	0.82 ± 0.87	1.31 ± 1.72

Table 2. **Water quality criteria for conventional and other pollutants contributing to aesthetics and oxygen demand for fresh waters (DENR Administrative Order No. 34, Series of 1990).**

PARAMETER	UNIT	CLASS AA	CLASS A	CLASS B	CLASS C	CLASS D
pH		6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.0-9.0
DO (minimum)	mg/L	5.0	5.0	5.0	5.0	3.0
BOD-5	mg/L	1	5	5	7(10)	10(15)
PO_4-P	mg/L	nil	0.1	0.2	0.4	..
NO_3-N	mg/L	1.0	10	NR	10	..

Table 3. **Classification of Banica River water based on its nutrient and oxygen content.**

Site	pH	DO	BOD	PO_4-P	NO_3-N
Tejeros	Class AA	Class AA	Class A	Class AA	Class AA
Palinpinon	Class AA	Class AA	Class A	Class A	Class AA
Dumpsite	Class AA	Class AA	Class A	Class A	Class AA
Candau-ay	Class AA	Class AA	Class C	Class A	Class AA
Batinguel	Class AA	Class AA	Class C	Class B	Class AA
Bagacay	Class AA	Class AA	Class A	Class B	Class AA
Foundation	Class AA	Class D	Class D	Class D	Class AA
Market	Class AA	below D	Class D	Class D	Class AA
Calindagan	Class AA	below D	Class D	Class D	Class AA
River Mouth	Class AA	below D	below D	Class D	Class AA

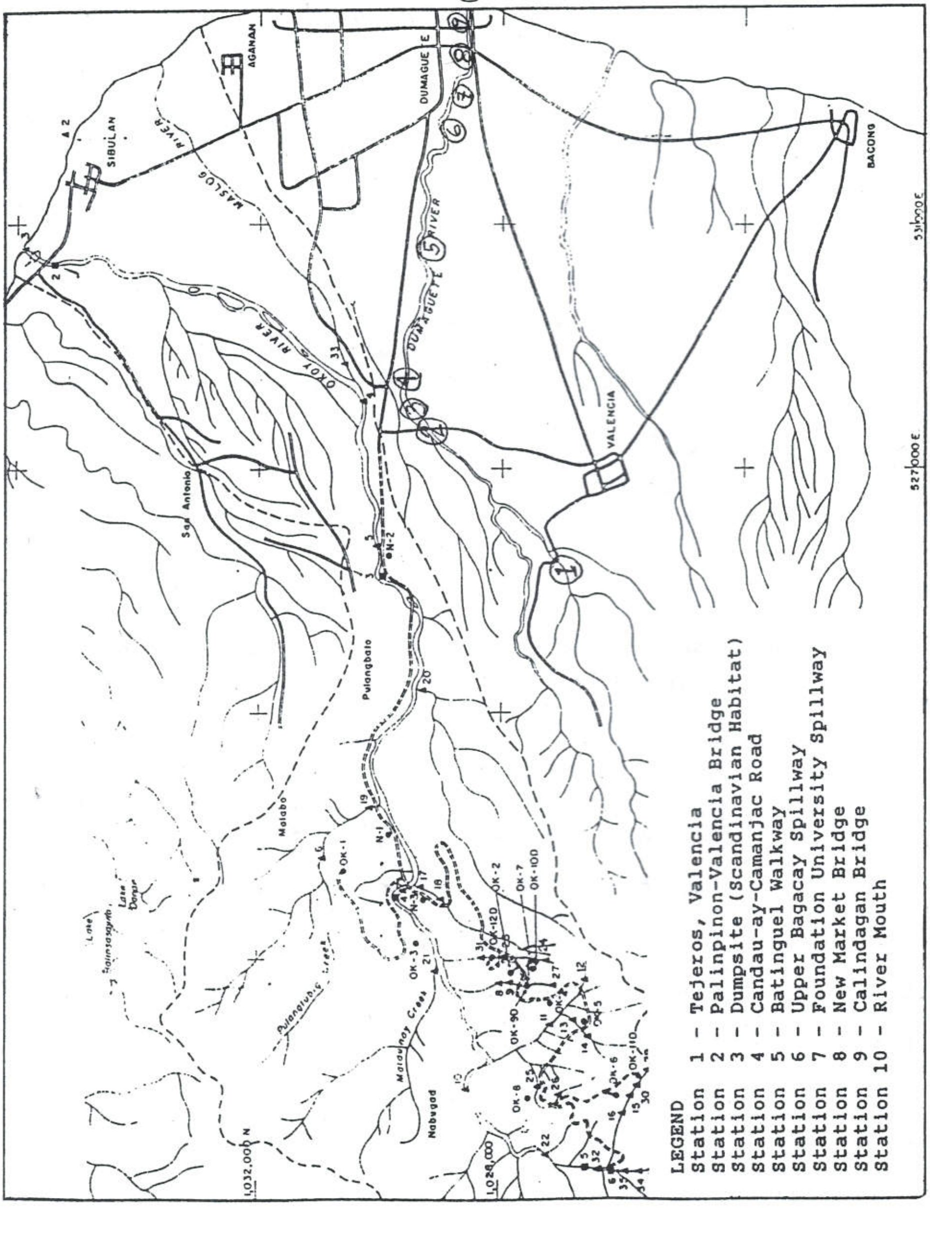

Figure 1. Banica River sampling stations.

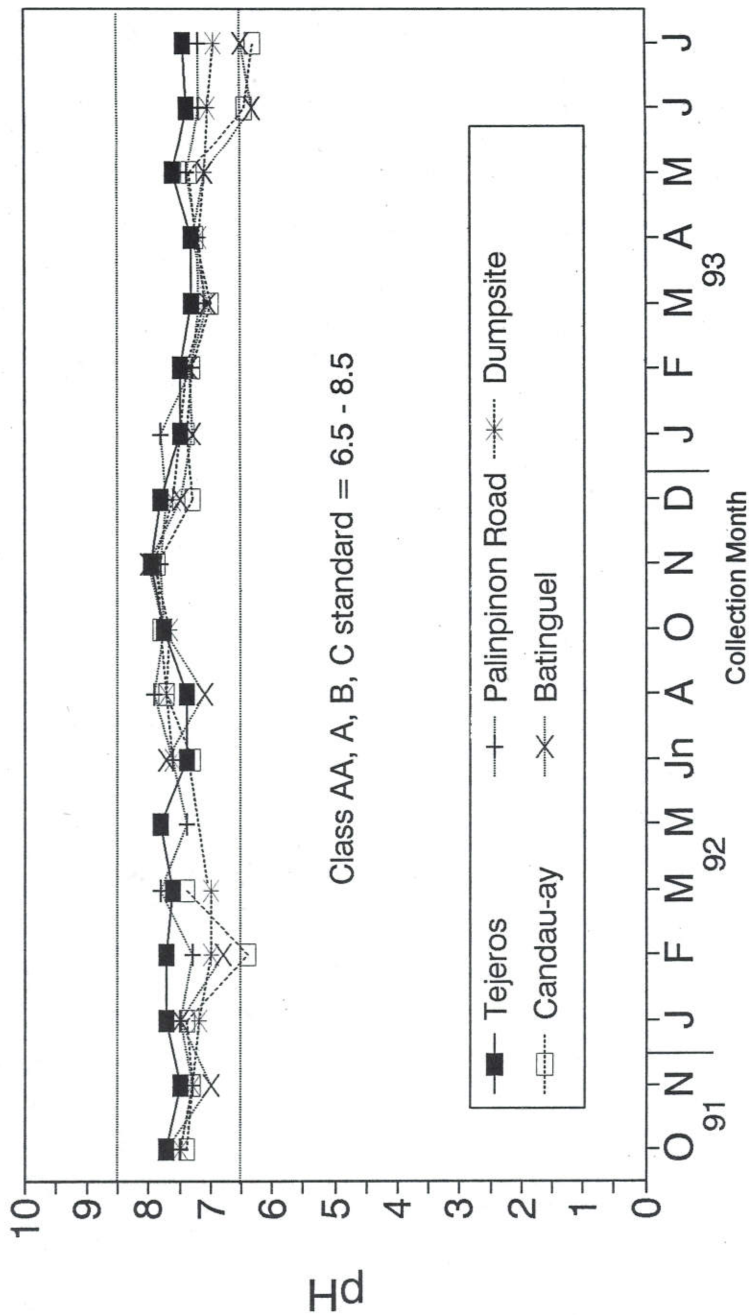

Figure 2a. The pH of Banica River water from Tejeros to Batinguel.

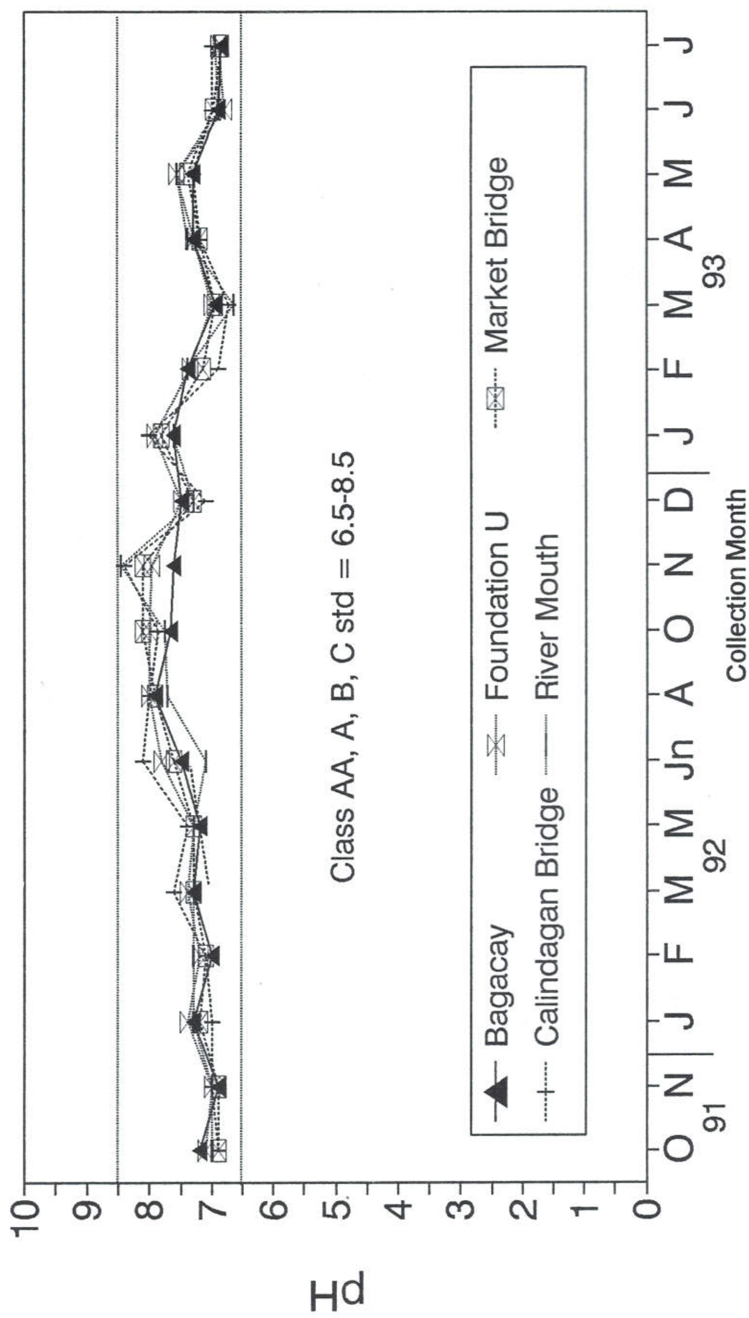

Figure 2b. The pH of Banica River water from Bagacay to River mouth.

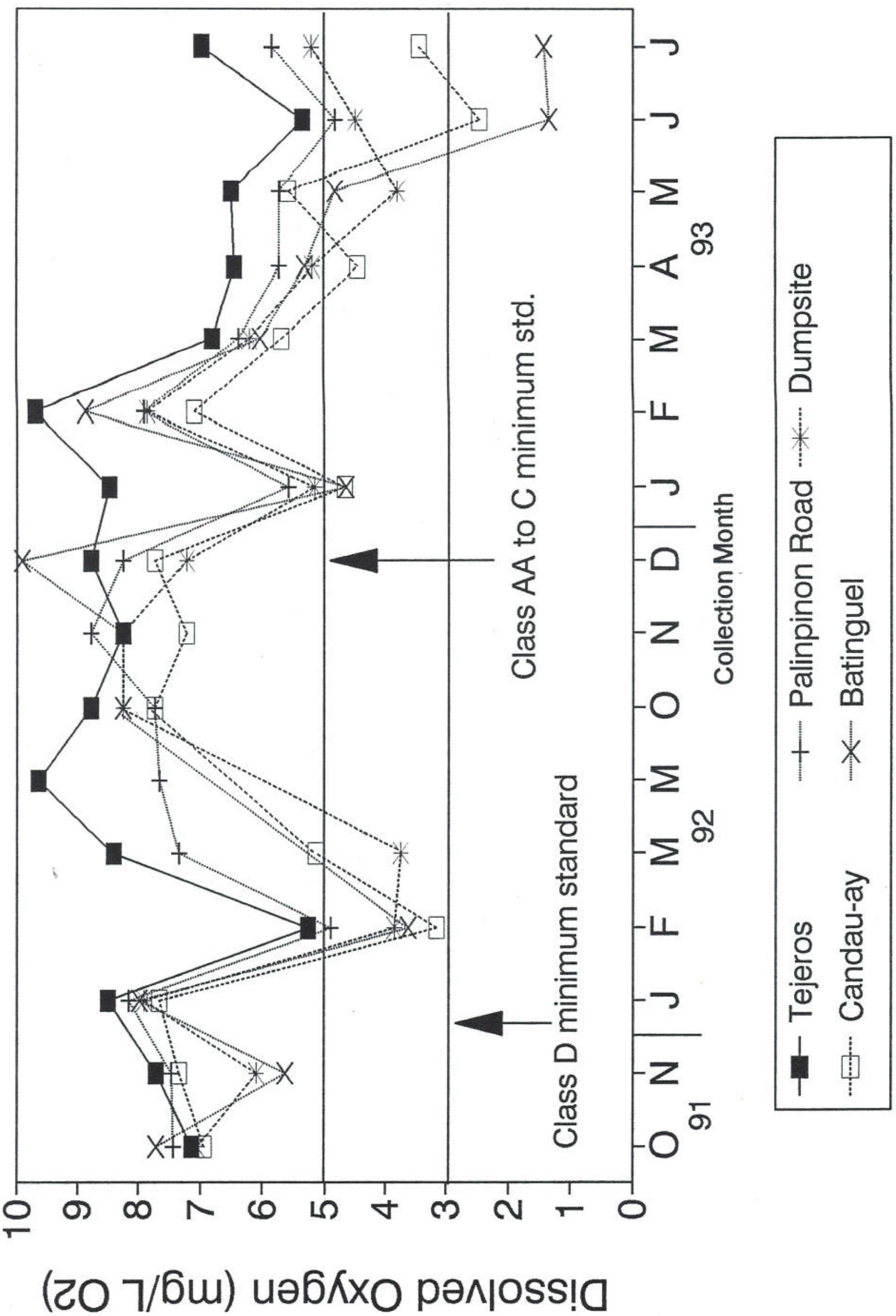

Figure 3a. Dissolved Oxygen (DO) of Banica River from Tejeros to Batinguel.

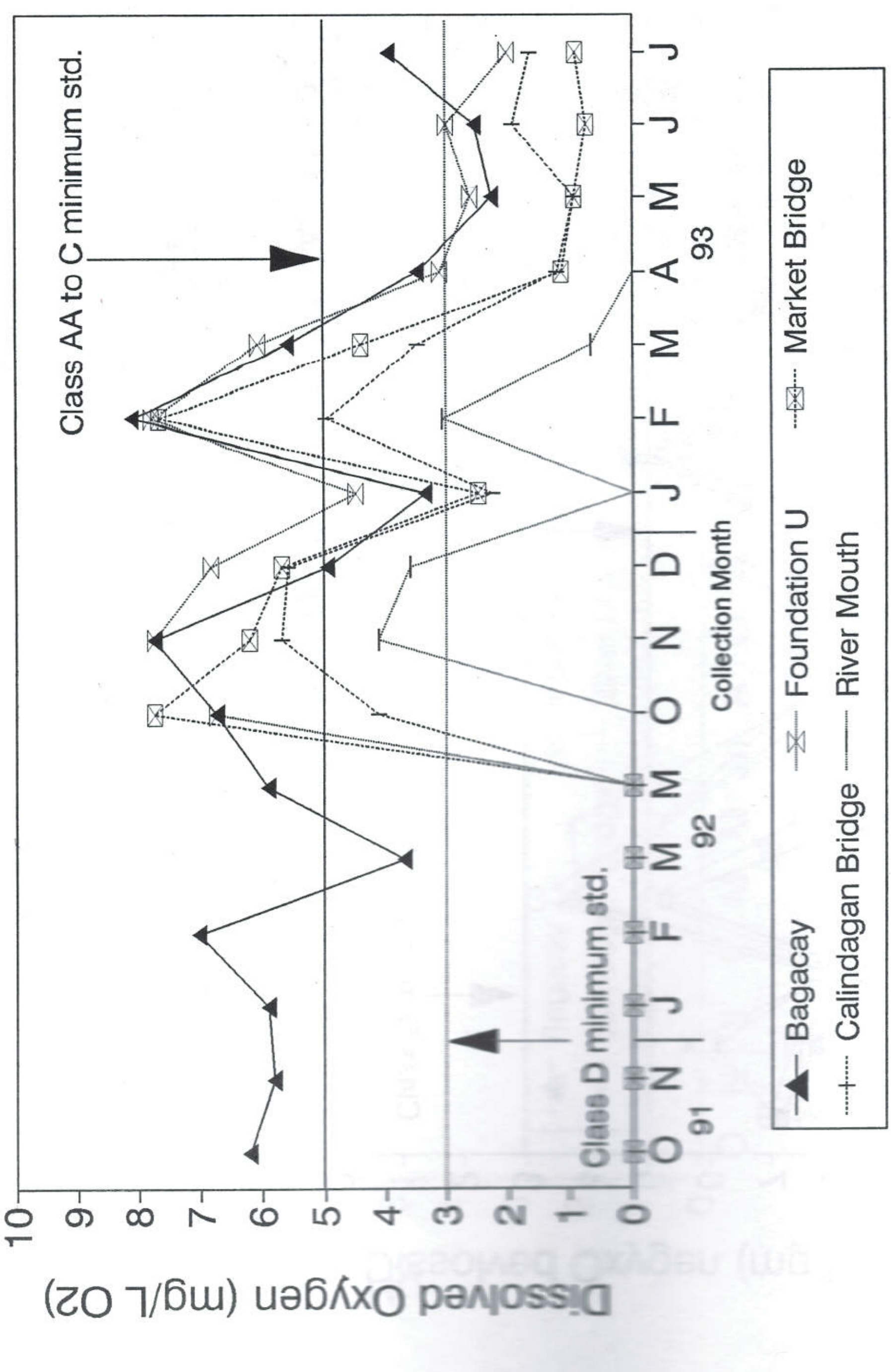

Figure 3b. Dissolved Oxygen (DO) of Banica River from Bagacay to river mouth.

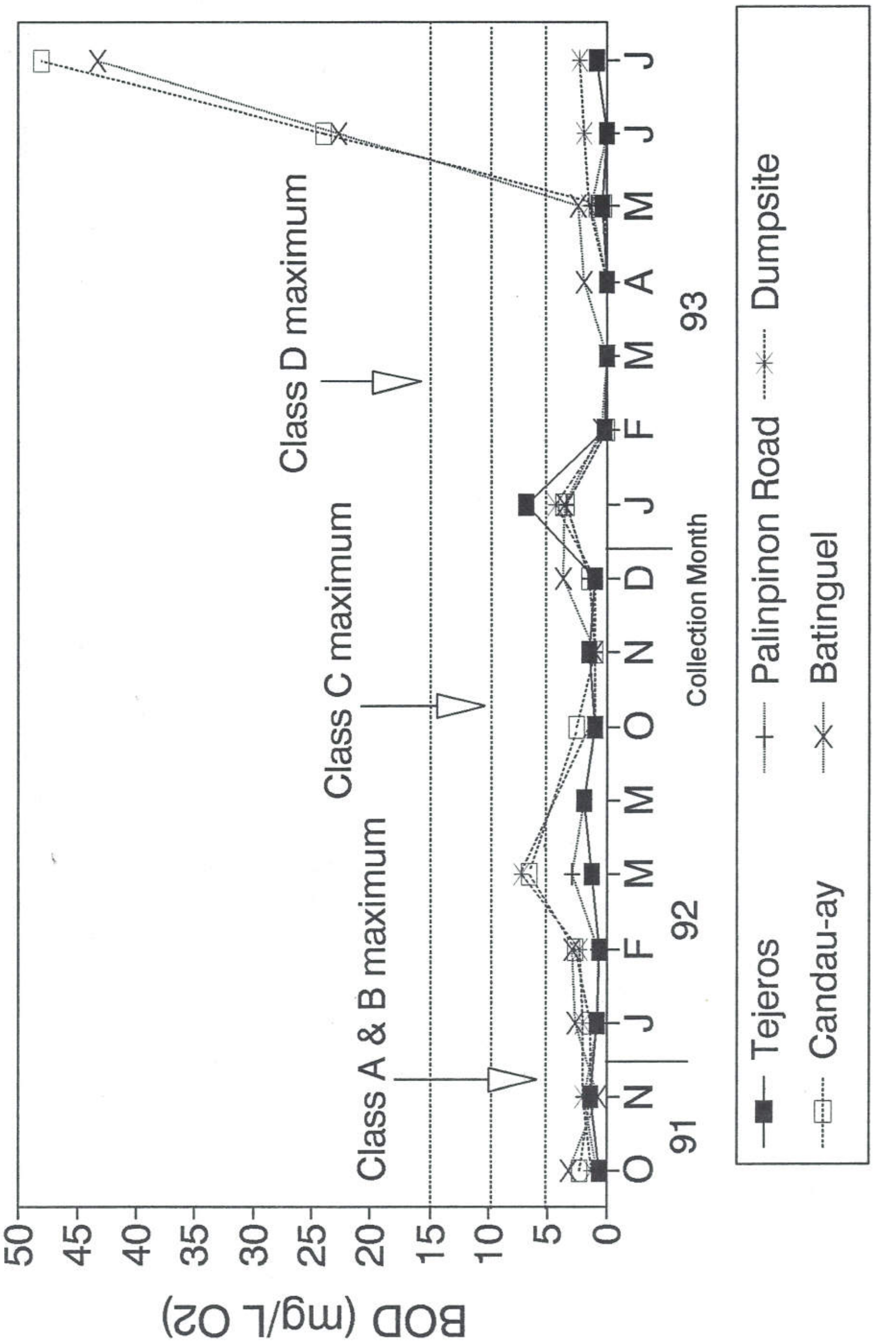

Figure 4a. Biochemical Oxygen Demand (BOD) of Banica River from Tejeros to Batinguel.

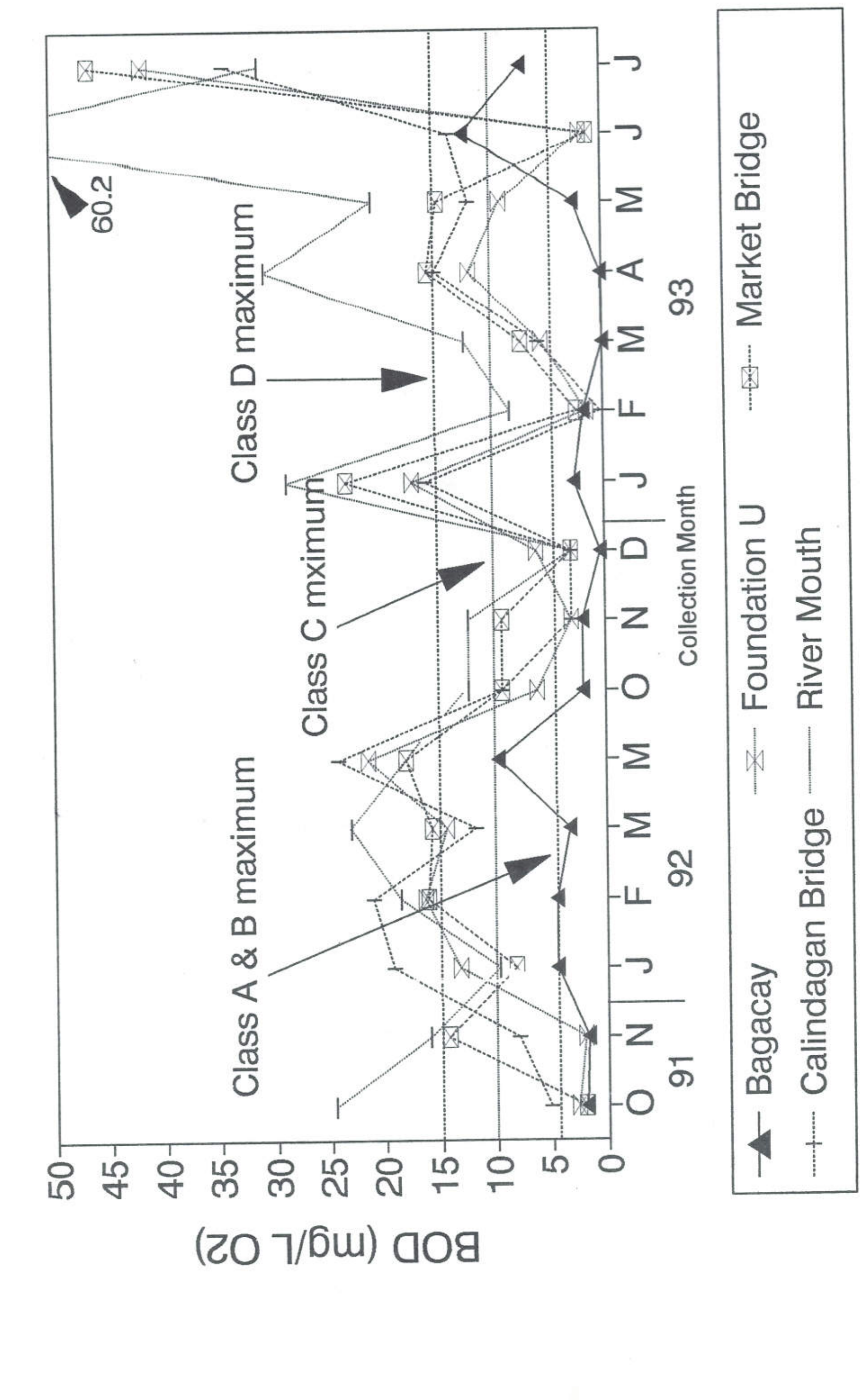

Figure 4b. Biochemical Oxygen Demand (BOD) of Banica River from Bagacay to river mouth.

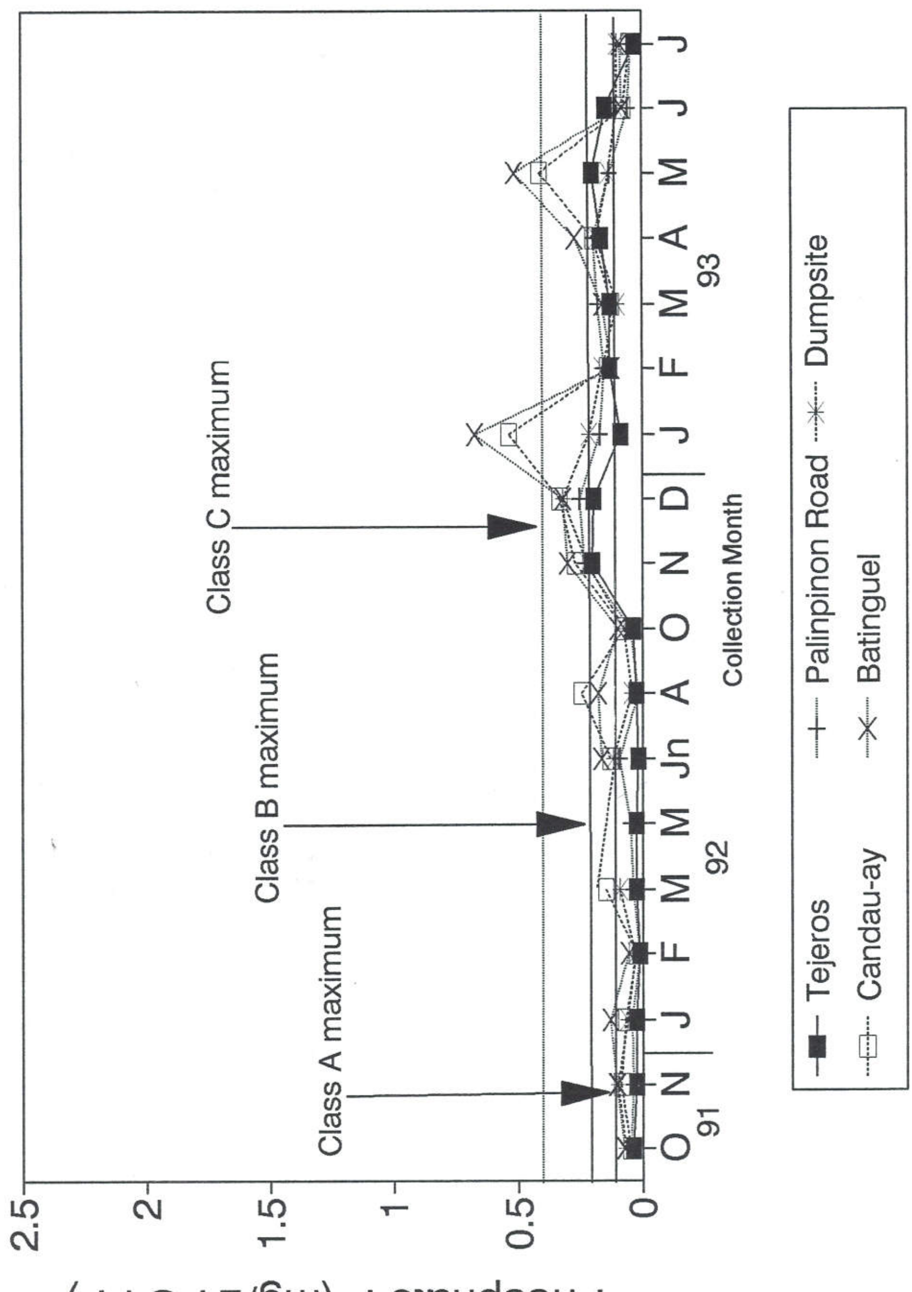

Figure 5a. Phosphate-P in Banica River from Tejeros to Batinguel.

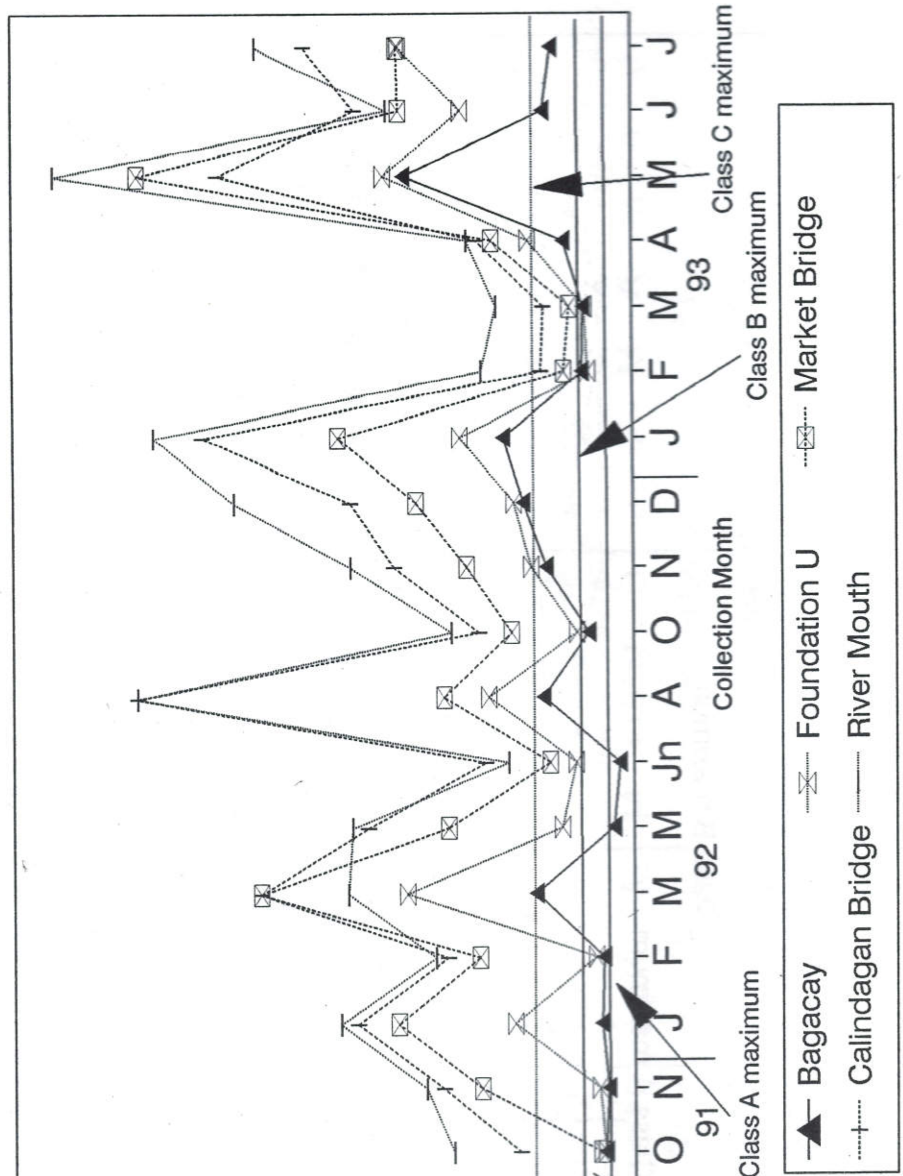

Figure 5b. Phosphate-P in Banica River from Bagacay to river mouth.

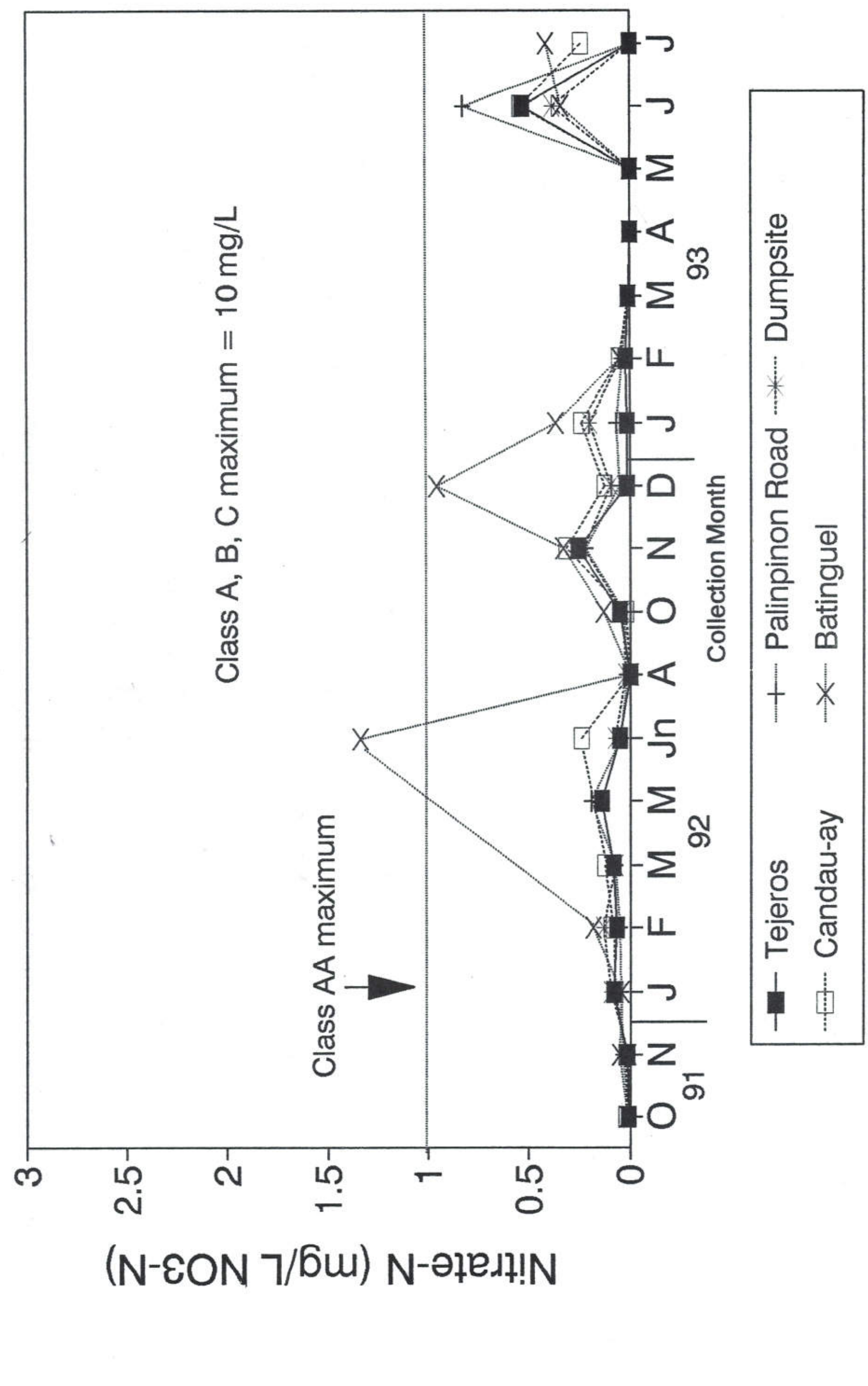

Figure 6a. Nitrate-N of Banica River from Tejeros to Batinguel.

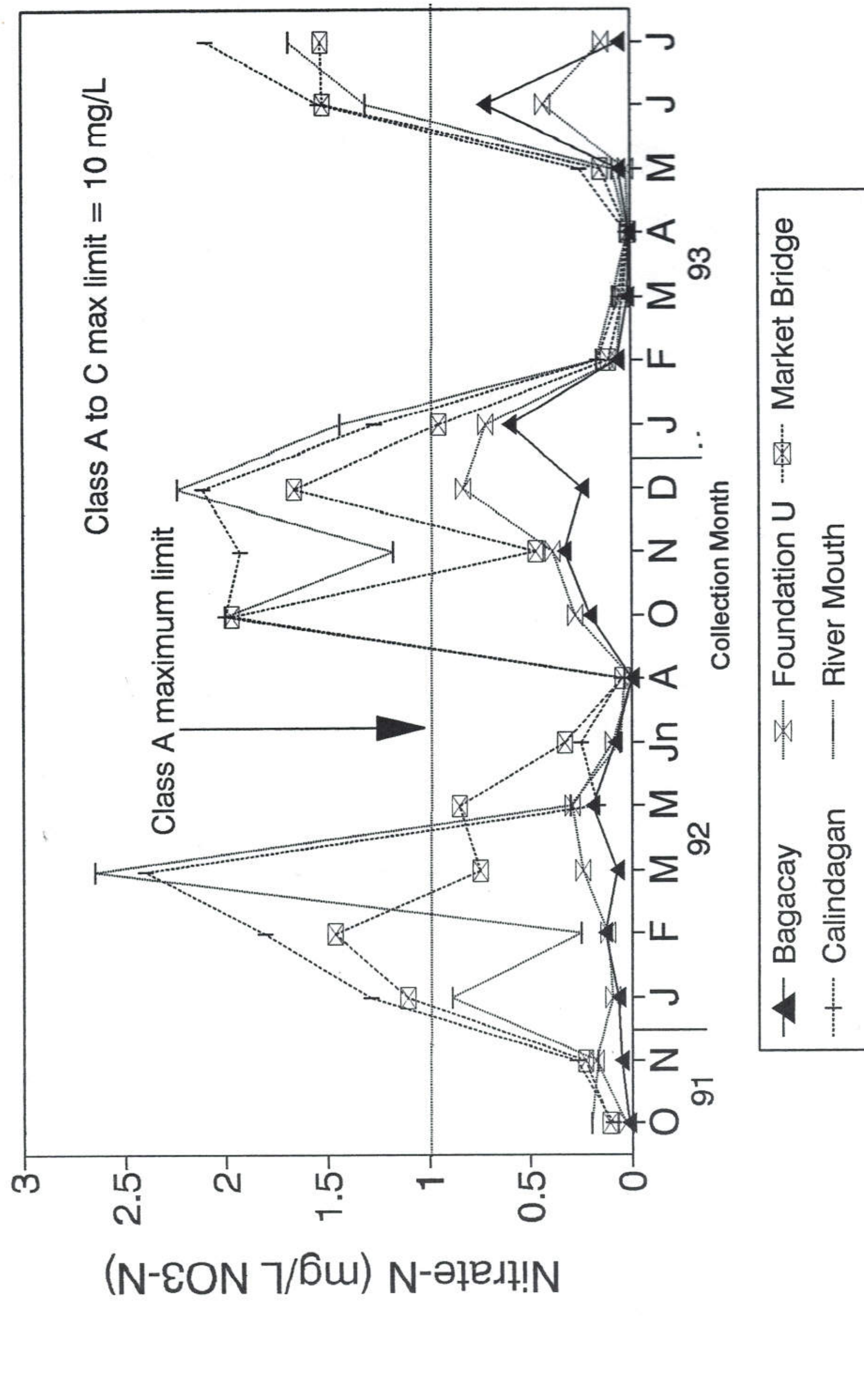

Figure 6b. Nitrate-N of Banica River from Bagacay to the river mouth.

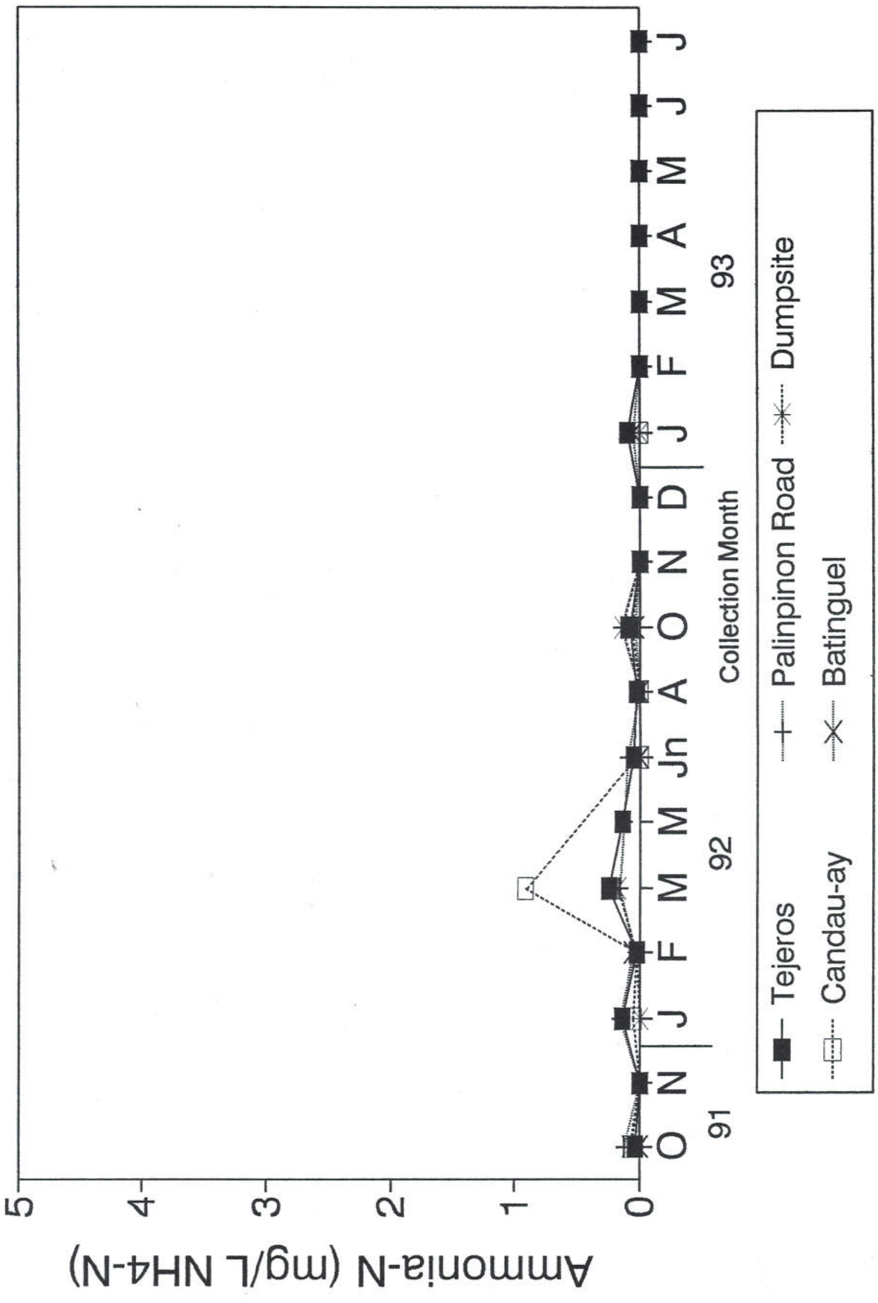

Figure 7a. Ammonia-N in Banica River from Tejeros, Valencia to Batinguel.

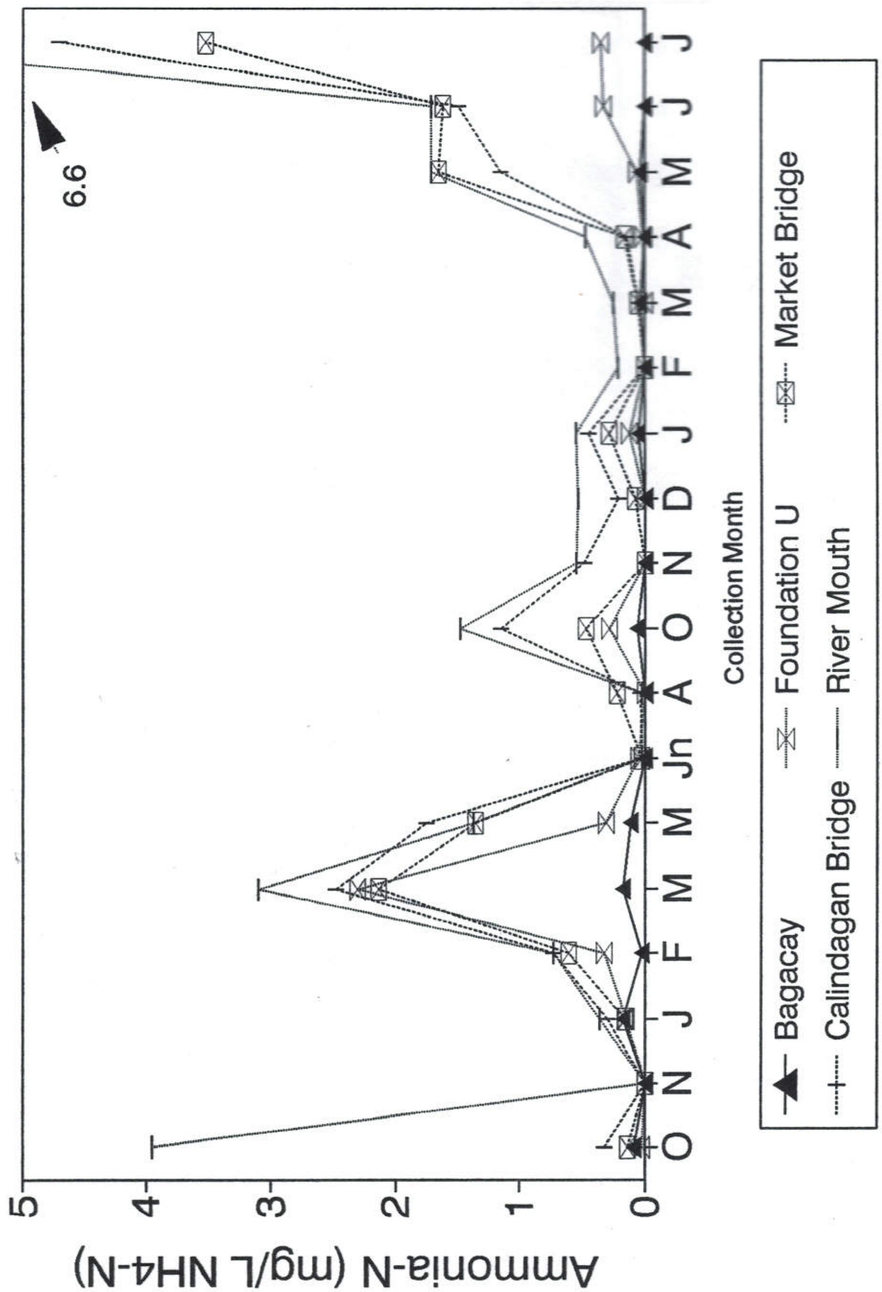

Figure 7b. Ammonia-N in Banica River from Bagacay to the river mouth.