Water Quality Report

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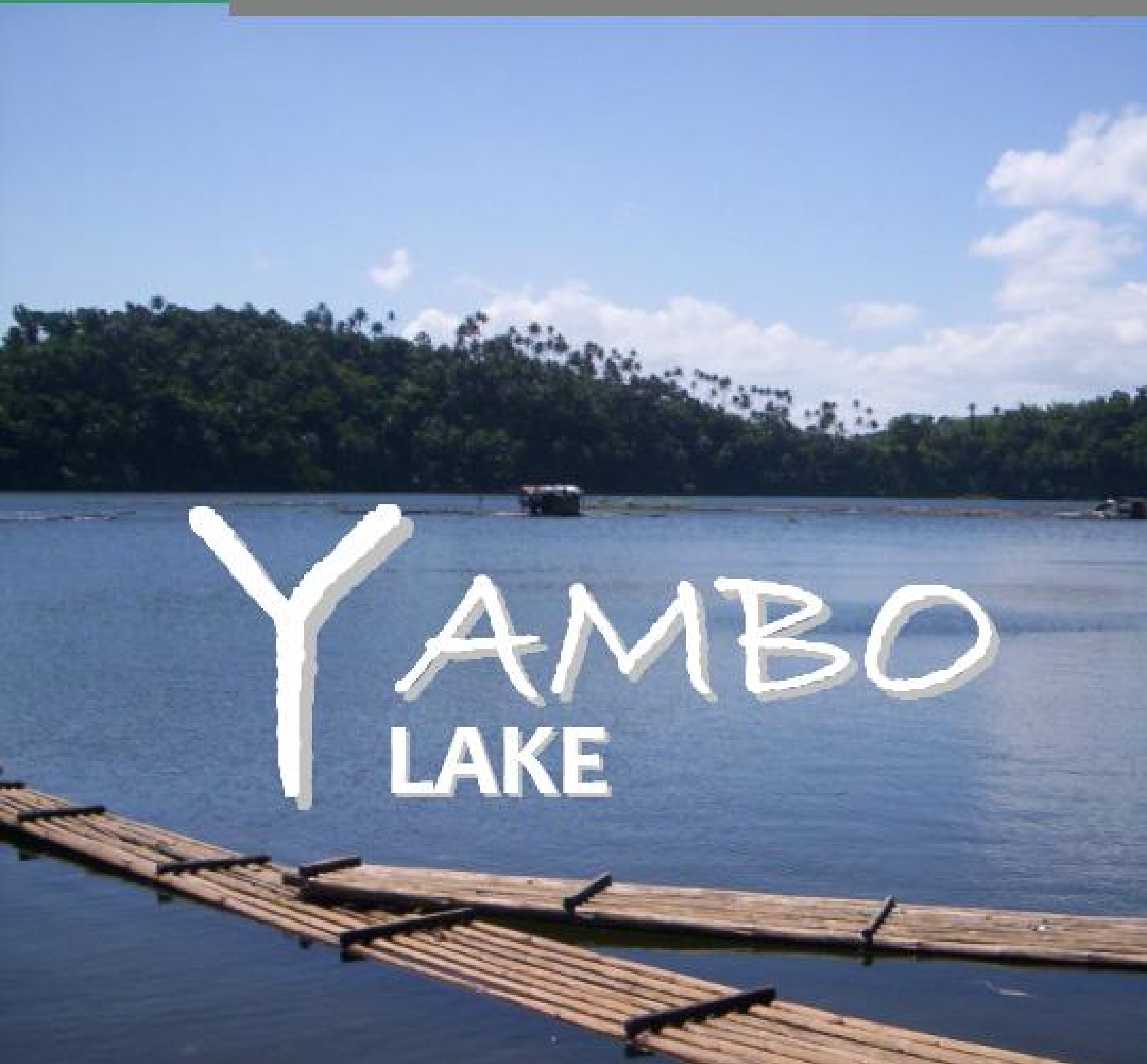

Laguna Lake Development Authority
Environmental Quality Management Division

WATER QUALITY REPORT ON YAMBO LAKE
2002 – 2005

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YAMBO LAKE

LAKE FEATURES

Yambo Lake is shared by two municipalities: Brgy Sulsugin, Nagcarlan and Brgy. San Lorenzo, San Pablo City. It is adjacent to Pandin lake. It has a surface area of 30.5 hectares. Yambo is suitable for swimming, outings and picnics.

WATER QUALITY MONITORING PROGRAM

The Laguna Lake Development Authority (LLDA), by virtue of RA 4850, as amended, has the primary responsibility to promote the development of the Laguna de Bay region, while providing for environmental management and control, preservation of the quality of life and ecological systems, and the prevention of undue ecological disturbance, deterioration and pollution.

Since the 1970's, the LLDA has been conducting regular water quality monitoring with the following objectives:

- To accurately assess the suitability of the lake for all its present and intended beneficial uses;

- To evaluate the impacts of development activities on the lake's water quality that will serve as important criteria for environmental planning and management; and

- To provide sound technical basis for water resources management policies and programs for the lake.

Routine monitoring programs conducted by LLDA cover the Laguna de Bay and its tributaries as well as the Seven Lakes of San Pablo City and Tadlac Lake in Los Banos.

METHODOLOGY

Water quality monitoring was conducted in Yambo Lake in 1986 up to the first quarter of 1989 on monthly basis. The monitoring was stopped in the next four years and it was in May, 1994 when the activity was again resumed. However, due to poor road condition, sampling was conducted only on an intermittent basis. It was in 2002 when road construction was completed that regular monitoring of Yambo was made.

One sampling station was established for Yambo lake. During the conduct of the sampling activity, water temperature and dissolved oxygen concentration are measured at the surface (s) and at 2,4,6,10,15, 20 and 25 meters depth. A composite water from the aforementioned depths is taken for water quality analysis. The chemical parameters analyzed at the laboratory include pH, total suspended solids (TSS), total dissolved solids (TDS), turbidity, chloride, nitrate, ammonia, inorganic phosphate, biochemical oxygen demand (BOD) and chemical oxygen demand (COD). Zooplankton and phytoplankton samples are collected by passing five pails of lakewater through a 35-micron mesh-sized plankton net. Zooplankton sample is preserved in a 10% formalin solution. On the other hand, phytoplankton sample is preserved with Lugol's solution. Chlorophyll sample is collected by grab method at the surface. Water transparency is likewise measured and all the physical observations including weather condition are noted and recorded.

At present, monitoring is conducted during the first (January, February, March) and last quarters (October, November and December) and in June and September.

EVALUATION OF RESULTS

This report presents the water quality monitoring data from 2002 to 2005 since this period represented a more complete set of data.

Monthly data and annual averages are presented in Table 1. The variations of key parameters from 2002 to 2005 are depicted in the figures using a three-year moving trend analysis based on annual means.

Assessment of the water quality was based on the criteria for key parameters for Class C Waters as provided in the DENR Administrative Order No. 34.

Table 1. Water Quality Monitoring Data of Yambo Lake from 2002 to 2005

	pH	COD	BOD	NH3	NO3	IPO4	TDS	TSS	Cl
DATE	units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
2002									
28-Jan-02	7.1	20	3	0.2719	0.2755	0.0212	122	0.5	7
27-Feb-02	7.3	2	3	0.0619	0.1503	0.0619	119	0.5	9
18-Mar-02	8.3	2	0.9	0.0593	0.039	0.0013	116	3	9
4-Jun-02	7.2	2	0.5	0.0135	0.054	0.001	108	9	11
26-Sep-02	7.1	20	2	0.0186	0.0681	0.001	95	2	19
15-Oct-02	7	2	2	0.1516	0.2443	0.001	102	1	11
13-Nov-02	7.2	16	2	0.0268	0.001	0.0108	90	0.05	11
11-Dec-02	7.3	2	2	0.0276	0.0587	0.0097	101	2	11
Average:	7.3	8	2	0.0789	0.1114	0.0135	107	2	11
Std. Dev:	0.4	9	1	0.0898	0.1011	0.0208	12	3	4
2003									
16-Jan-03	7.4	8	0.9	0.0414	0.0174	0.077	105	0.5	7
13-Feb-03	7.5	8	1	0.1253	0.0834	0.0244	108	2	7
12-Mar-03	7.5	2	1	0.2143	0.1763	0.5481	124	0.5	6
18-Jun-03	7.4	66	0.05	0.0553	0.229	0.0095	112	0.5	7
16-Sep-03	7.4	8	0.6	0.0534	0.5871	0.0075	98	0.5	11
21-Oct-03	7.2	31	1	0.0967	0.021	0.0232	114	0.5	11
18-Nov-03	7.1	32		0.1129	0.048	0.0238	103	0.5	26
11-Dec-03	7.2	2	1.1	0.1647	0.0415	0.046	98	0.5	22
Average:	7.3	20	1	0.1080	0.1505	0.0949	108	1	12
Std. Dev:	0.2	22	0	0.0600	0.1923	0.1845	9	1	8
2004									
20-Jan-04	7.2	11	2	0.0206	0.0124	0.0297	95	10	78
12-Feb-04	7.3	54	2	0.2017	0.3172	0.0443	106	14	93
11-Mar-04	7.1	15	2	0.2584	0.1448	0.0419	97	6	33
17-Jun-04	7.2	2	2	0.1163	0.0495	0.0333	85	5	15
16-Sep-04	7.5	45	3	0.2503	0.0953	0.0361	99	18	7
14-Oct-04	6.9	8	2	0.2945	0.0068	0.0404	113	6	15
17-Nov-04	7.8	2	2	0.199	0.0836	0.0324	84	19	11
17-Dec-04	7.2	8	0.7	0.0966	0.0063	0.0098	87	2	11
Average:	7.3	18	2	0.1797	0.0895	0.0335	96	10	33
Std. Dev:	0.3	20	1	0.0937	0.1044	0.0108	10	6	34
2005									
13-Jan-05	7.5	2	0.7	0.1304	0.0921	0.0011	69	0.5	11
17-Feb-05	7.2	43	0.7	0.1187	0.1078	0.0074	115	109	11
10-Mar-05	7.5	27	2	0.1397	0.1406	0.0057	98	10	11
16-Jun-05	7.6	8	2	0.1666	0.0747	0.0066	110	0.5	7
14-Sep-05	6.6		2	0.3594	0.001	0.0196			7
20-Oct-05	6.8	15	2	0.0871	0.0057	0.0052	104	2	11
17-Nov-05	7.4	4	1	0.0194	0.1276	0.001	119	6	7
15-Dec-05	7.4	4	2	0.0893	0.001	0.0155	113	0.5	4
Average:	7.3	15	2	0.1388	0.0688	0.0078	104	18	9
Std. Dev:	0.4	15	1	0.0995	0.0584	0.0066	17	40	3

pH

The pH scale ranges from 0 (strongly acidic) to 14 (strongly basic). The pH measures exactly 7, in pure water.

Most lakes are basic (alkaline) when they are first formed and become more acidic with time due to the build-up of organic materials. As organic substances decay, carbon dioxide (CO_2) forms and combines with water to produce carbonic acid, a weak acid, which lowers water's pH. Most fish can tolerate pH values of about 5.0 to 9.0. When pollution results in higher algal and plant growth (e.g., from increased temperature or excess nutrients), pH levels may increase, as allowed by the buffering capacity of the lake. Although these small changes in pH are not likely to have a direct impact on aquatic life, they greatly influence the availability and solubility of all chemical forms in the lake and may aggravate nutrient problems.

pH is not a problem for Yambo lake since the measured values are within the criteria set for Class C waters which is between 6.5 to 8.5.

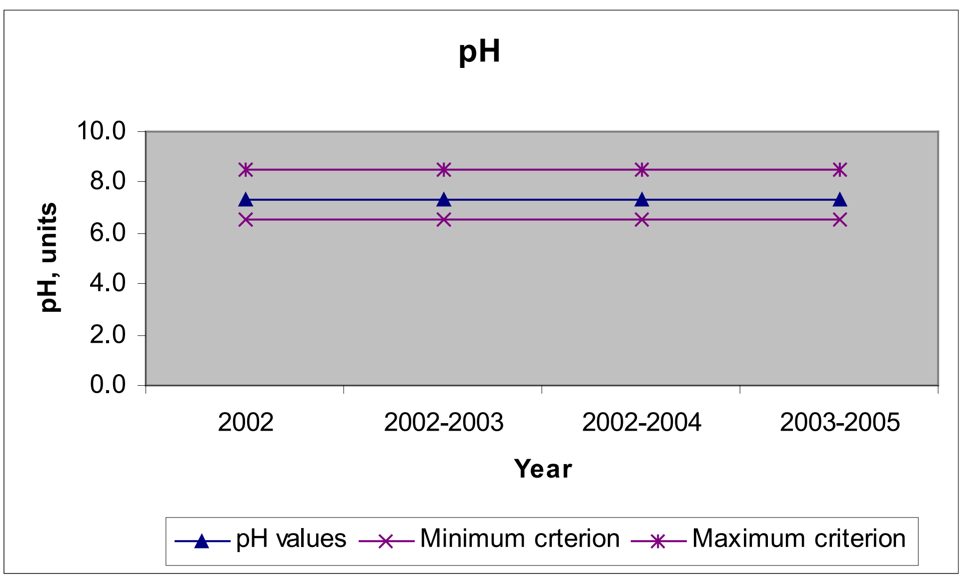

Figure 1. Three-year trend of pH values in Yambo Lake

Nitrate (NO_3)

Nitrate is a major ingredient of farm fertilizer and is necessary for crop production. When it rains, varying nitrate amounts wash from farmland. Nitrates stimulate the growth of plankton that provides food for fish. This may increase the fish population. However, if algae grow too wildly, oxygen levels will be reduced and fish will die.

The Class C water quality criterion for nitrate is set at 10 ppm in lakes, reservoirs and similarly impounded water. The nitrate level in Yambo Lake is very low compared to the set criterion.

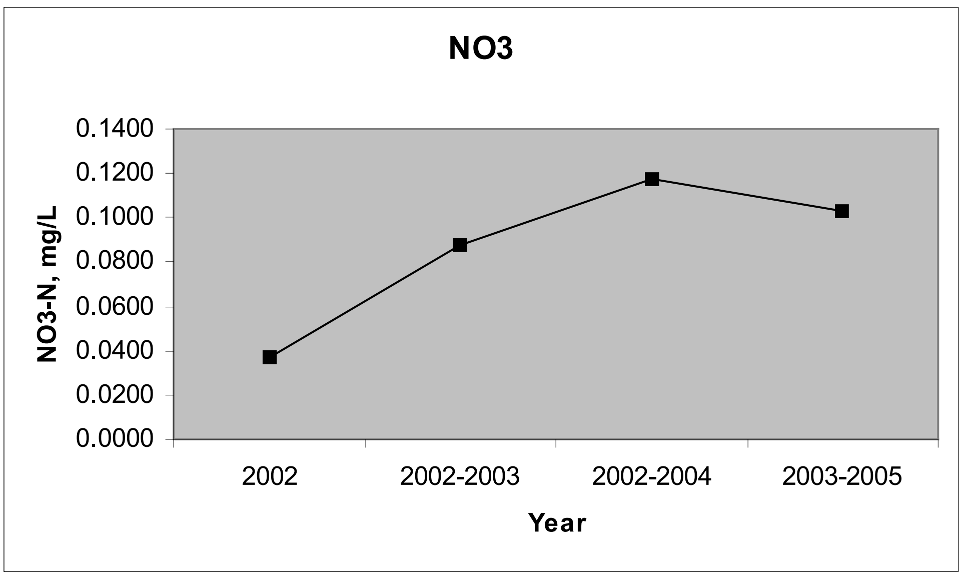

Figure 2. Three-year trend of nitrate levels in Yambo Lake

Ammonia (NH_3)

In nature, ammonia is formed by the action of bacteria on proteins and urea. It is rich in nitrogen so it makes an excellent fertilizer. In fact, ammonium salts are a major source of nitrogen for fertilizers. Like nitrates, ammonia may speed the process of eutrophication in waterways.

Ammonia is toxic to fish and aquatic organisms, even in very low concentrations. When levels reach 0.06 mg/L, fish can suffer gill damage. When levels reach 0.2 mg/L, sensitive fish begin to die. As levels near 2.0 mg/L, even ammonia-tolerant fish like carp begin to die. Ammonia levels greater than approximately 0.1 mg/L usually indicate polluted waters.

The danger ammonia poses for fish depends on the water's temperature and pH, along with the dissolved oxygen and carbon dioxide levels. Remember, the higher the pH and the warmer the temperature, the more toxic the ammonia. Also, ammonia is much more toxic to fish and aquatic life when water contains very little dissolved oxygen and carbon dioxide.

The NH_3 level in Yambo Lake had been on an increasing trend since 2002. There is no set criterion for ammonia. But since other parameters are vital in ammonia's toxicity in water, these parameters should strictly comply with the set standards.

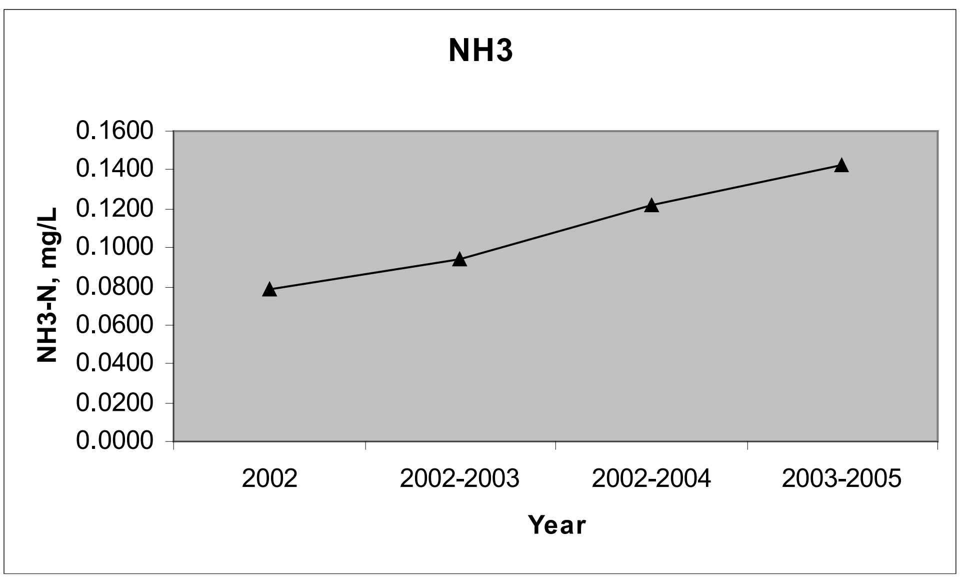

Figure 3. Three-year trend of ammonia levels in Yambo Lake

Inorganic Phosphate (IPO4)

Phosphates come from fertilizers, pesticides, industry, and cleaning compounds. Natural sources include phosphate-containing rocks and solid or liquid wastes. The element phosphorus is necessary for plant and animal growth. Nearly all fertilizers contain phosphates. When it rains, varying amounts of phosphates wash from farm soils into nearby waterways. Phosphates stimulate the growth of plankton and water plants that provide food for fish. This may increase the fish population and improve the waterway's quality of life. If too much phosphate is present, algae grow wildly, choke the waterway, and use up large amounts of oxygen. Many fish and aquatic organisms may die.

Phosphates enter waterways from human and animal wastes, phosphate-rich rocks, wastes from laundries, cleaning and industrial processes, and farm fertilizers. Phosphates is not harmful to people or animals unless they are present in very high concentrations.

For Class C waters when applied to lakes and reservoir, the phosphate concentration should not exceed an average of 0.05 mg/L or a maximum of 0.1 mg/L. The highest recorded phosphate load was measured in 2003 which almost exceeded the criteria. It improved to low levels come 2005 with an average concentration of <0.01 mg/L.

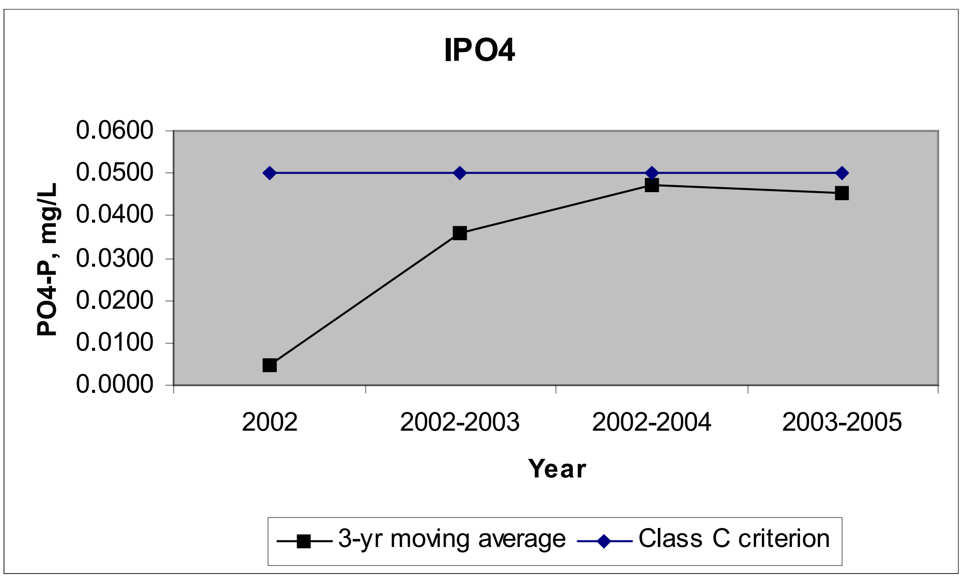

Figure 4. Three-year trend of phosphate levels in Yambo Lake

Solids (Total Dissolved Solids (TDS) and Total Suspended Solids (TSS))

Total Dissolved Solids (TDS) refers to the total amount of all inorganic and organic substances including any minerals, salts, metals, cations or anions dissolved in water. Sources of TDS include agricultural run-off, urban run-off and natural sources such as leaves, silt, plankton, and rocks. While TDS is not considered a primary pollutant, high TDS levels indicate hard water. The concentration may cause the water to be corrosive. It is regulated for aesthetic purposes rather than a health hazard. High TDS concentration may indicate elevated levels of ions that do pose a health concern, such as aluminum, arsenic, copper, lead and others.

Total Suspended Solids (TSS) in the water is a result of soil erosion from agricultural land which is sometimes accelerated by human use. As levels of TSS increase, the water body begins to lose its ability to support a diversity of aquatic life. Suspended solids absorb heat from sunlight which increases water temperature and subsequently decreases levels of dissolved oxygen.

The TDS concentration in Yambo Lake almost doubled from year 2004 to 2005.

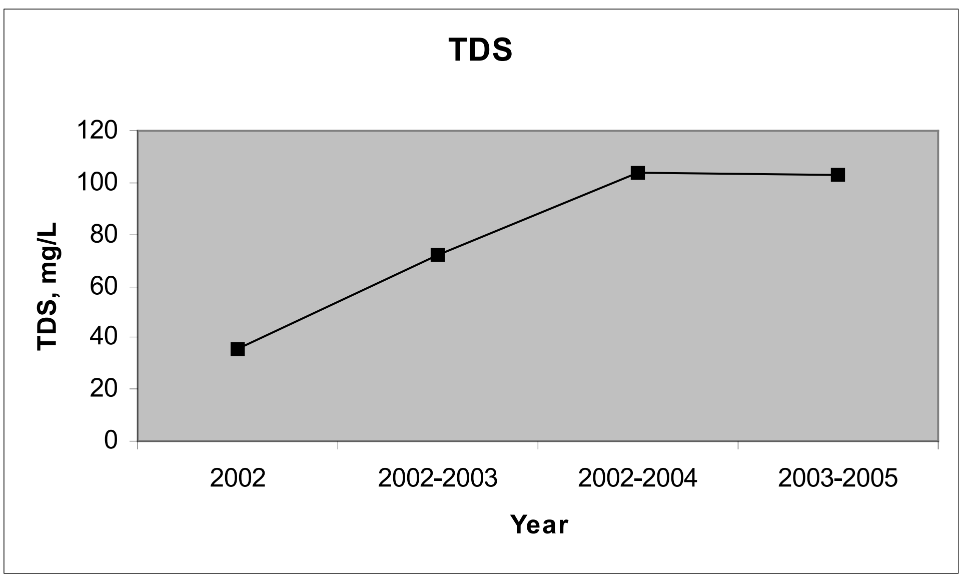

Figure 5. Three-year trend of TDS levels in Yambo Lake

There is no specific concentration level on the criteria set for solids but the increase in concentration of TSS must not be more than 30 mg/L. In 2005, the concentration increased to 10 times the value from the previous year, a concrete proof of the siltation problem in the lake.

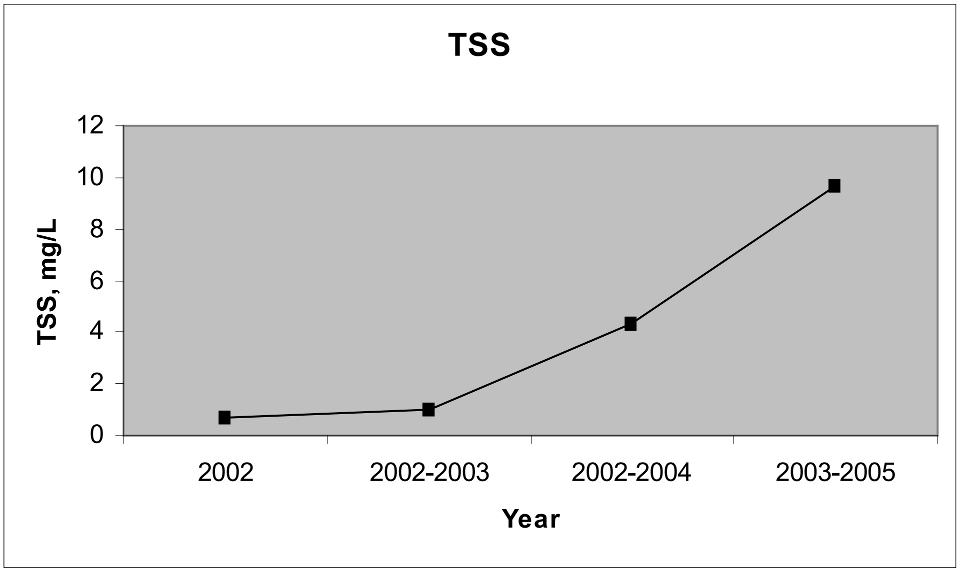

Figure 6. Three-year trend of TSS levels in Yambo Lake

Chloride

Chlorides are salts resulting from the combination of the gas chlorine with a metal. Some common chlorides include sodium chloride (NaCl) and magnesium chloride ($MgCl_2$). Chlorine alone as Cl_2 is highly toxic and it is often used as a disinfectant. In combination with a metal such as sodium it becomes essential for life. Small amounts of chlorides are required for normal cell functions in plant and animal life. Chlorides are not usually harmful to people.

Salinity is a measure of the amount of salts in the water. Salts and other substances affect the quality of water. They also have a critical influence on aquatic biota, and every kind of organism has a typical salinity range that it can tolerate. Urban run-off containing high salt concentrations may create saline layers in receiving lakes. Salt water has higher density than fresh water and tends to sink and form a dense layer in the bottom of the lake. This saline layer does not mix with the remainder of the lake water leading to decreased dissolved oxygen level in bottom regions.

Yambo Lake has the highest chloride level of 33 mg/L which is way below the 350 mg/L criteria for Class C water. A slight increase is observed in 2004 but decreased again in 2005 with <10 mg/L concentration.

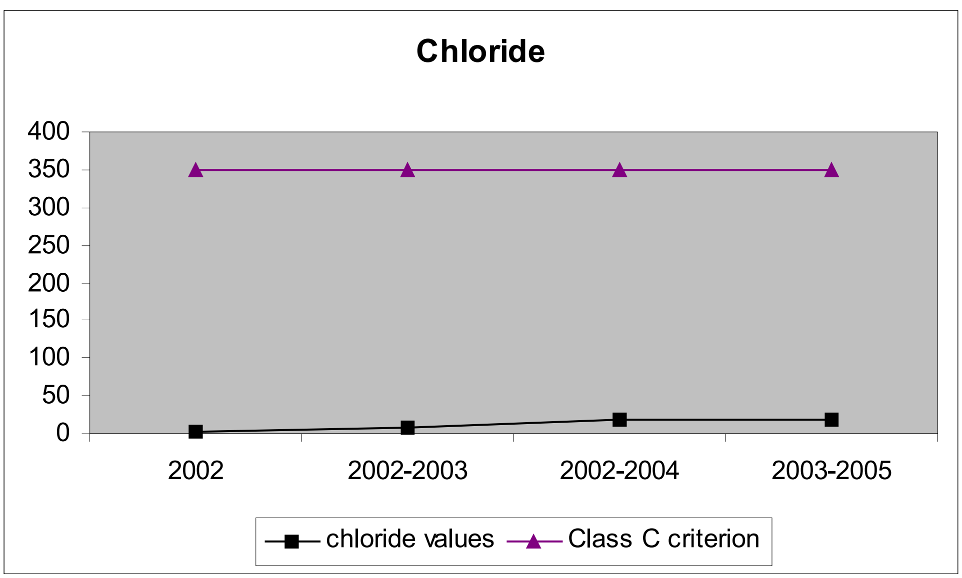

Figure 7. Three-year trend of chloride levels in Yambo Lake

Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand is a measure of the quantity of oxygen consumed by microorganisms during the decomposition of organic matter. Natural sources of organic matter include plant decay and leaf fall. However, plant growth and decay may be unnaturally accelerated when nutrients and sunlight are overly abundant due to human influence. If there is a large quantity of organic waste in the water supply, there will also be a lot of bacteria present working to decompose this waste. Oxygen consumed in the decomposition process robs other aquatic organisms of the oxygen they need to live. In this case, the demand for oxygen will be high (due to all the bacteria) so the BOD level will be high. As the waste is consumed or dispersed through the water, BOD levels will begin to decline. When BOD levels are high, dissolved oxygen (DO) levels decrease because the bacteria are consuming the oxygen that is available in the water. Since less dissolved oxygen is available in the water, fish and other aquatic organisms may not survive.

BOD level for Yambo Lake has been consistently low with almost only 2 mg/L average annually.

Figure 8. Three-year trend for BOD levels in Yambo Lake

Chemical Oxygen Demand (COD)

The chemical oxygen demand (COD) is the amount of oxygen consumed to completely chemically oxidize the organic water constituents to inorganic end products. COD is an important, rapidly measured variable for the approximate determination of the organic matter content of water samples. Some water samples may contain substances that are difficult to oxidize.

An increasing trend in COD concentration is observed from 2002 to 2005 indicating pollution coming mostly from inorganic wastes like nitrogen, ammonia and phosphates. Although small amounts of these nutrients have been recorded for Yambo, these may have contributed to the increasing level of COD.

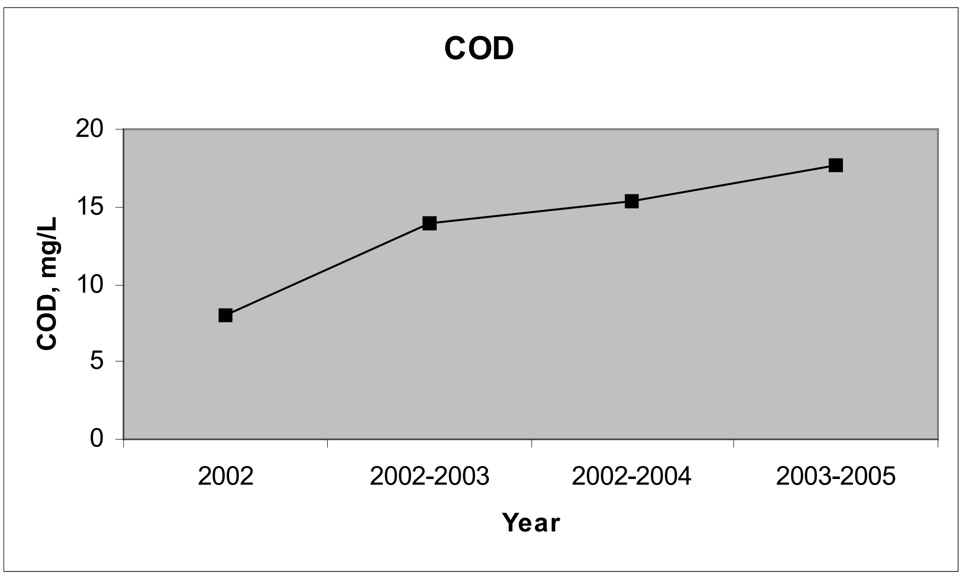

Figure 9. Three-year trend of COD levels in Yambo Lake

Dissolved Oxygen (DO)

Dissolved oxygen is a measure of the amount of gaseous oxygen (O_2) dissolved in an aqueous solution. Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement), and as a waste product of photosynthesis. Most aquatic organisms need oxygen to survive and grow. Adequate dissolved oxygen is necessary for good water quality. Oxygen is a necessary element to all forms of life. Natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms.

In general, DO levels less than 3 mg/L are stressful to most aquatic organisms. Most fish die at 1-2 mg/L. However, fish can move away from low DO areas. Water with low DO from 2 – 0.5 mg/L are considered hypoxic; waters with less than 0.5 mg/L are anoxic.

For various depths, DO fell below the Class C criteria of 5ppm. Dissolved oxygen concentrations may change dramatically with lake depth. Oxygen production occurs in the top portion of a lake, where sunlight drives the engines of photosynthesis. Oxygen consumption is greatest near the bottom of a lake, where sunken organic matter accumulates and decomposes which explains why the DO decreases as the lake depth increases. Seasonal changes also affect dissolved oxygen concentrations. Warmer temperatures during summer speed up the rates of photosynthesis and decomposition. When all the plants die at the end of the growing season, their decomposition results in heavy oxygen consumption. Other seasonal events, such as changes in lake water levels also cause natural variation in DO concentrations.

Dissolved oxygen (DO) values at different depths were averaged on a monthly basis as shown in Table 2 and Figure 10.

Table 2. Monthly average of DO at different depths (1996-2005)

Depth	D.O. (mg/L)							
	Jan	*Feb*	*Mar*	*Jun*	*Sep*	*Oct*	*Nov*	*Dec*
0	7.9	8.7	8.1	6.9	7.2	7.1	7.7	6.4
2	7.6	8.3	8.3	7.1	7.4	7.3	8.0	6.6
4	6.5	7.4	8.2	7.9	7.3	7.3	7.6	6.7
6	5.3	6.5	7.3	7.8	7.2	7.1	7.7	6.9
10	4.6	5.7	6.1	5.9	6.2	6.8	7.1	6.8
15	5.0	5.3	5.3	5.3	5.1	5.3	5.8	6.3
20	5.6	5.3	5.4	4.0	5.5	5.0	5.2	6.2
25	5.8	4.5	4.9	6.5	4.2	5.2	5.7	5.7

Compliance to DAO 34 Water Quality Criterion
Class C Waters

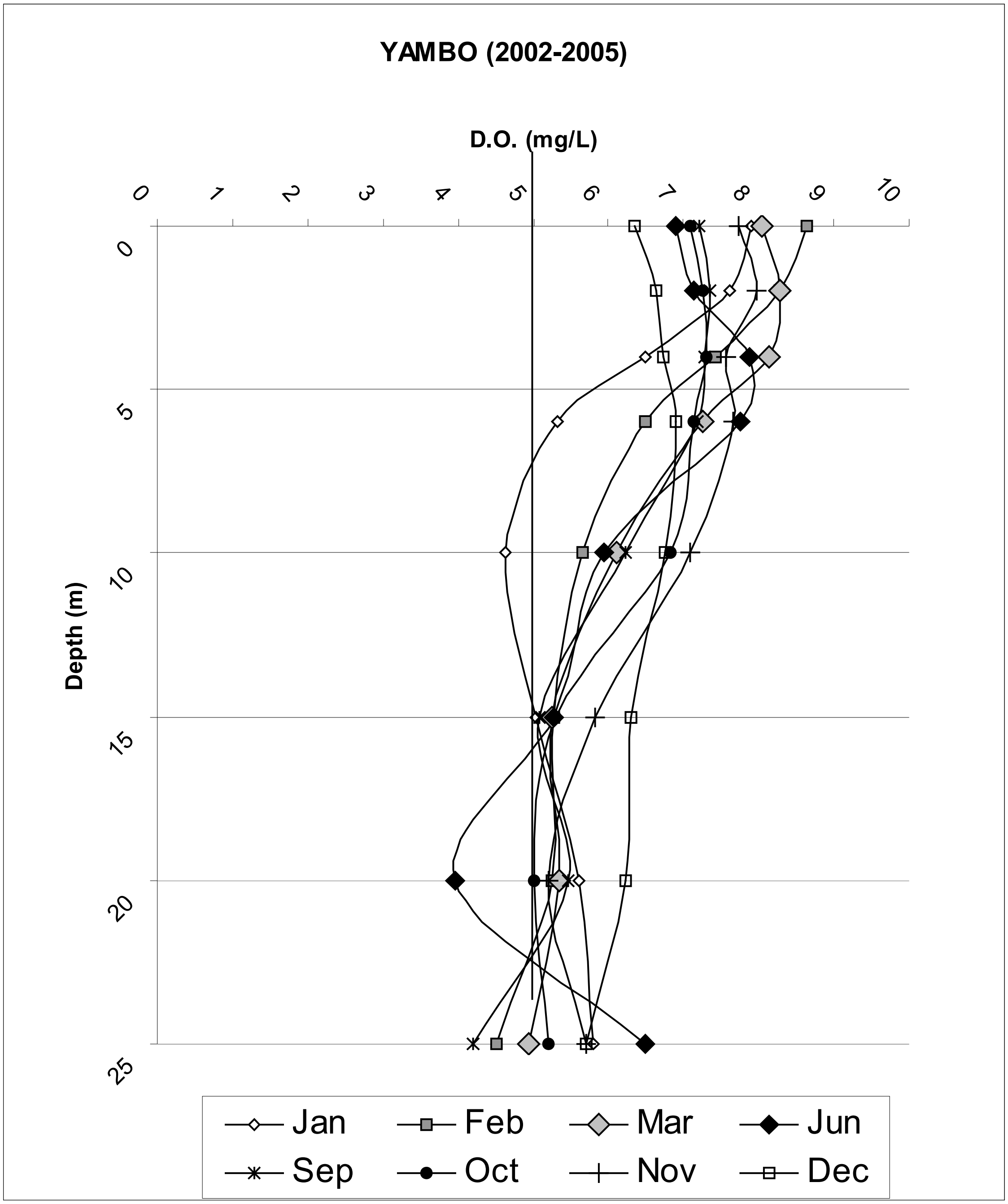

Figure 10. Monthly DO average at different depths

Phytoplankton

The existing microflora of Yambo Lake consist of 25 genera, most of which belong to Chlorophyta (green algae) and Bacillariophyta (diatom). Two other groups such as Cyanophyta (bluegreen) and Pyrrophyta (dinoflagellate) were also present.

Based on the gathered data, increase in algal counts was attained for four (4) years. The most common species identified were *Melosira sp*. (diatom), *Staurastrum sp*. (green algae) and *Microcystis sp*. (bluegreen algae). *Melosira sp*. and *Staurastrum sp*. dominated the counts. Both genera were observed present throughout the period of high algal counts.

In 2002, an increase in algal counts was observed dominated by *Microcystis sp*. with values of 4873 cells/ml. During this period, algal particles were significantly visible in the surface water. Calm weather prevailed coupled with water temperature of 24^{o}C and water transparency reading of 180 cm., which suggest that light penetration reached to almost 2-meter depth. This condition helps enhance growth of algae.

Low counts were experienced in 2003. However, *Melosira sp.,* a diatom, still dominated the total algal population.

The algal composition which represent the Cyanophyta were *Anabaena sp*., *Microcystis sp*. and *Oscillatoria sp.* List of phytoplankton identified shown in Table

Table 3. Phytoplankton Counts by Group, 1996 - 2005

	Bluegreen	**Green**	**Diatoms**	**Dinoflagellates**	**Total**
2002	1129	81	347	15	1572
2003	35	8	49	2	94
2004	10	878	698	0	1586
2005	33	22	2314	2	2371

The algal trend showed an increase in 2002, 2004 to 2005 and very low counts was observed in 2003. The increase in algal counts could have been due to the cleaned-up made the previous year, coupled with an increase in photosynthesis activity. The changes in algal composition may also occur due to the high production.

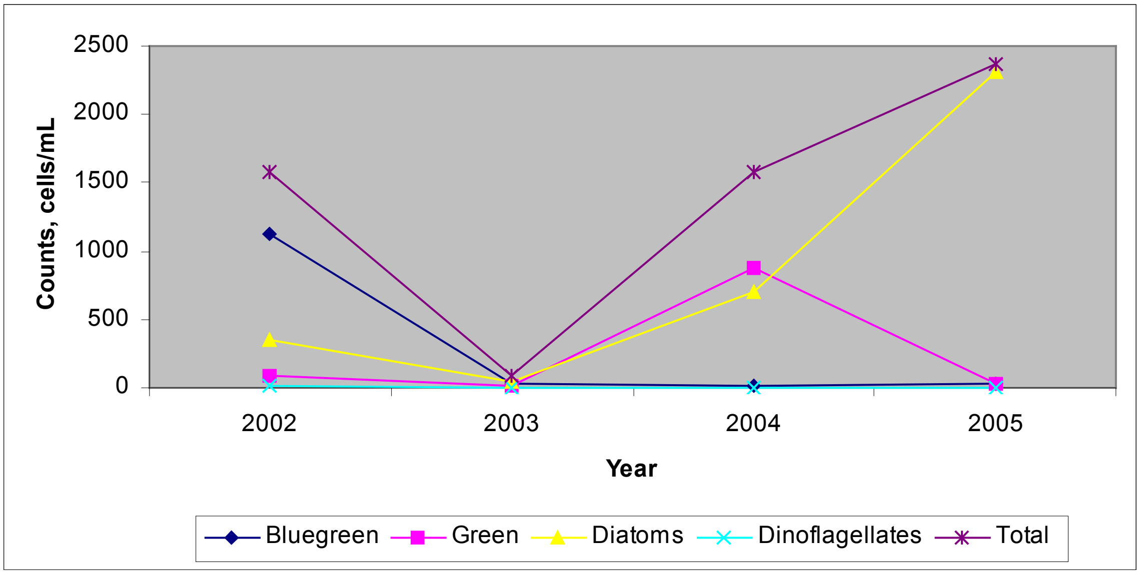

Figure 11. Phytoplankton Counts by Group

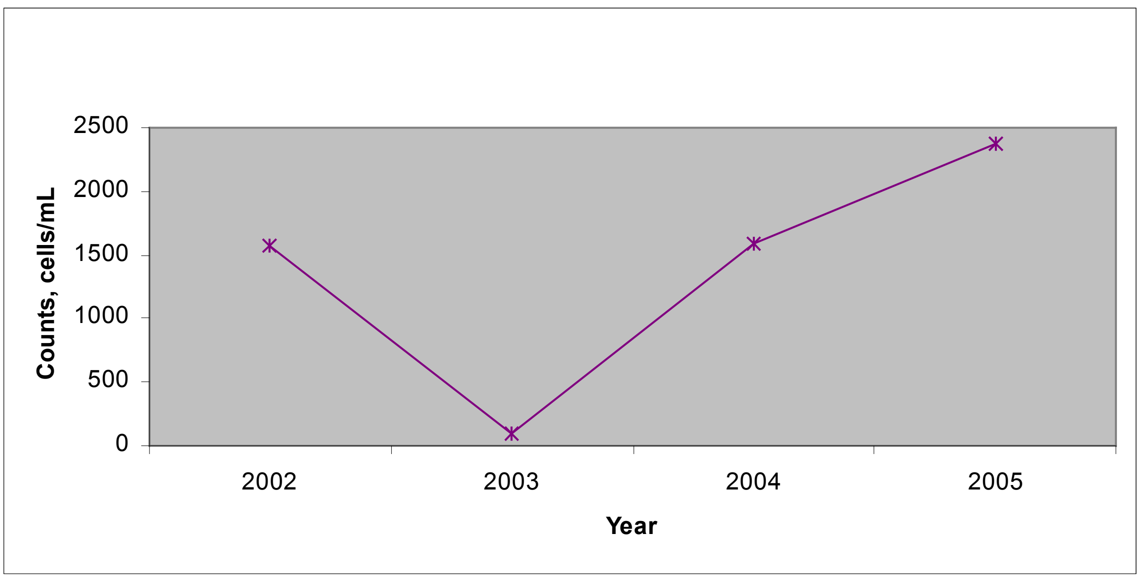

Figure 12. Total Phytoplankton Counts

Zooplankton

Zooplanktons are small animals suspended in the water with limited power of locomotion. Like phytoplankton, they are also part of the food chain of aquatic organism. They play an important part in young and post larval stage of fishes and other aquatic life. In freshwater ecosystem, there are four groups of zooplanktons; protozoa, rotifers and two subclasses of crustacean (copepods and cladocerans).

Data gathered were from 2002 to 2005 due to road inaccessibility in late 90's. There are three groups of zooplankton identified: rotifers, cladocera and copepoda. Among the groups there were three (3) copepods including the nauplii and copepodid stage identified while rotifers and cladocerans comprised of six and three genera, respectively. Cladocerans play a very small part in the population. Copepods dominate the population from 2004 – 2005, while in 2002 – 2003 very low counts was observed. The percentage contribution in 2002 – 2005 of copepods ranges from 70% - 89% with 27 and 18 individuals/liter. In 2003, cladocerans were present but of very minimal in numbers.

Below are the lists of zooplankton identified according to groups:

Copepoda

- Nauplius
- Copepodid stage
- *Thermocyclops crassus*
- *Arctodiaptomus*
- *Mesocyclops sp.*

Rotifera

- *Asplanchna sp.*
- *Hexathra fermica*
- *Trichocerra sp.*
- *Brachionus calicyflorus*
- *B. caudatus*
- *B. falcatus*
- *Keratella sp.*

Cladocera

- *Diaphanosoma sp.*
- *Bosmina sp.*
- *Ceriodaphnia sp.*

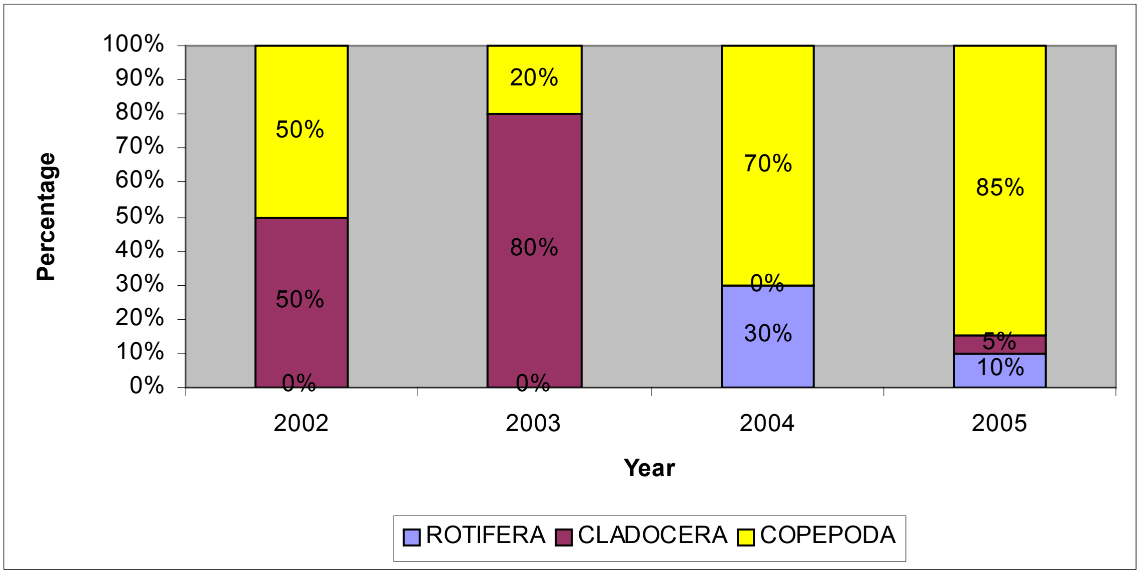

Figure 13. Percentage of Zooplankton by Group

Chlorophyll "a"

Chlorophyll is vital for photosynthesis allowing algae (plants) to obtain energy from light. The most widely distributed form of chlorophyll in plants is chlorophyll 'a'. It is commonly used as an indicator of algal biomass in a body of water.

Based on the four (4) year data, chlorophyll 'a' value ranged from 32.45 to 42.46 μg/liter. Chlorophyll is proportional to algal counts during periods of high counts specifically the green pigment algae (bluegreen and green algae). Periods of low counts often occur during season where thick growth of water hyacinth covered almost the entire surface area. This could inhibit light penetration thereby lessen photosynthetic activity and algal production. Based on the Water Mondriaan classification chlorophyll-a value of the lake fall on the low-level category range of >25 – 50 μg/L for freshwater systems. The low value could be due to the algal composition present. The dominant algae identified was Melosira sp., a diatoms and with no green pigment.

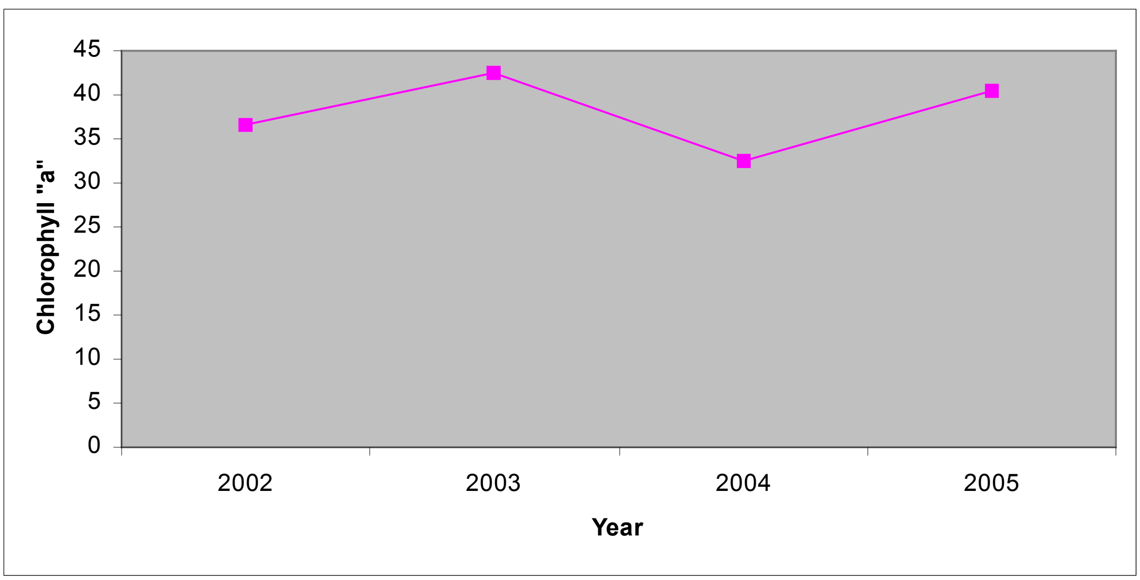

Figure 14. Annual Average of Chlorophyll "a"

CONCLUSIONS AND RECOMMENDATIONS

Unlike the other crater lakes, regular monitoring of Yambo Lake was conducted only from 2002. Based on the water quality parameters evaluated during the study period (2002 – 2005), Yambo Lake has the best water quality.

Yambo Lake met the Class C Water Quality Criteria. This makes the lake still suitable for aquaculture and fishery development.

Annual BOD average even met the Class B criterion. However, it was observed that the BOD values were increasing. Adequate Dissolved Oxygen was available even up to 25 meters.

Nitrate and phosphate met the Class C criteria but increasing in trend. Likewise increasing in the values monitored were ammonia, chemical oxygen demand, total dissolved solids and total suspended solids.

Biological parameters such as phytoplankton, zooplankton and chlorophyll "a" also showed increasing trend.

Yambo Lake may be developed into an ecotourism area in San Pablo City. However, measures must be undertaken to prevent the direct discharge of wastes into the lake.

A Development Plan for Yambo Lake should be established in coordination with all the stakeholders.

Although most parameters are still way below the criteria, efforts to continually preserve the water quality of the lake must continue.

Maintaining the good water quality of the lake does not only depend on agencies like LLDA which monitor the area but also lies in the hands of the community that directly benefits from it.