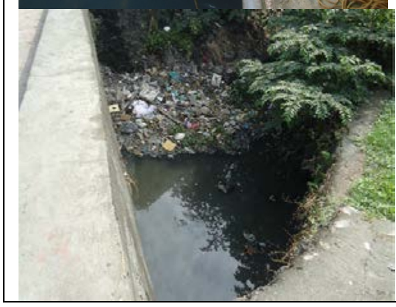
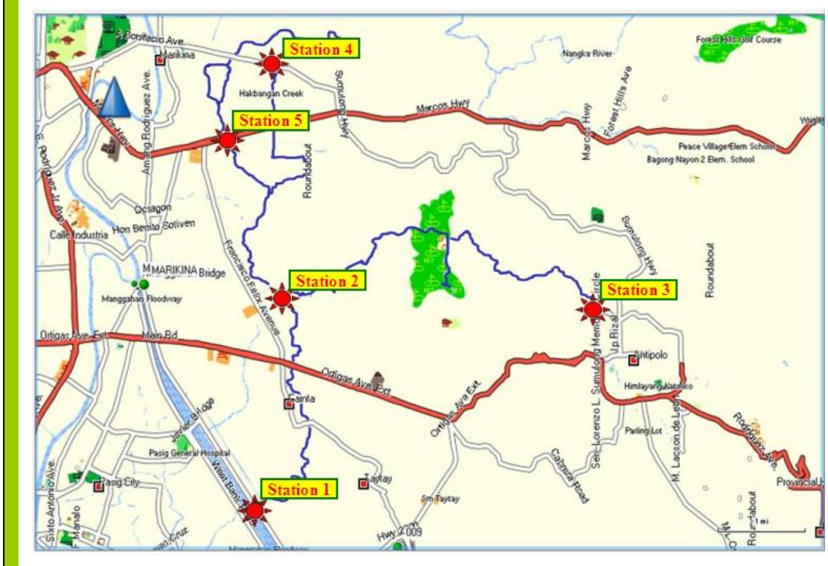


Environmental Laboratory and Research Division *Resource Management and Development Department* LAGUNA LAKE DEVELOPMENT AUTHORITY

# WATER QUALITY ASSESSMENT OF SAPANG BAHO RIVER, CAINTA, RIZAL, PHILIPPINES 2011



# SAPANG BAHO RIVER
# WATER QUALITY ASSESSMENT
# REPORT
# 2011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# WATER QUALITY ASSESSMENT OF SAPANG BAHO RIVER, CAINTA, RIZAL, PHILIPPINES

*Lisette T. Aragoncillo, Victoria G. Baltazar, Cruzadel de la Cruz, Marinel A. Hernandez*
**Laguna Lake Development Authority – Environmental Laboratory and Research Division**

## 1.0 Introduction

The River Rehabilitation Program was launched in 1996 and placed under the Community Development Division (CDD) for implementation. It utilizes an integrated approach to watershed management. It takes into account both water quality and quantity in the continuum of an inter-related eco-system, from the rivers' headwaters to the downstream areas of thriving urbanization all the way to the lake basin.

Twenty-four (24) sub-basins comprise the Laguna de Bay Sub-basin. These are used as basic units for planning and implementation of the following river rehabilitation strategies such as strengthening of River Councils and partnership with the Federation of Riverbasin Council (FRBC). (LLDA, 2011)

Sapang Baho river is one of the tributary rivers draining to Laguna de Bay and is one of the priority tributary rivers under the LLDA's River Rehabilitation Program. One of the priority programs in support of the River Rehabilitation Program is the conduct of water and sediment quality sampling of Sapang Baho River led by the Environmental Laboratory and Research Division (ELRD). Water quality sampling was done on February 02, 2011 (for the dry season) and August 16, 2011 (for the wet season).

## 2.0 Background Information

Sapang Baho, which when literally translated, means "smelly creek", is one of the major tributary rivers of Laguna de Bay (Figure A) and is regularly monitored by the Laguna Lake Development Authority (LLDA) through one of its 34 river monitoring stations. The Sapang Baho River is a river system that runs through Rizal Province (particularly Cainta and Antipolo City) and Marikina City in the Philippines (Figure A).

The municipality of Cainta is a first-class urban municipality in the province of Rizal, Philippines. It is the province's most prosperous town, one of the oldest (established 1571), and the town with the smallest land area (43.00 $km^2$). Cainta serves as a gateway to the rest of Rizal province from Metro Manila. It is one of Rizal's more urbanized towns because of its proximity to Manila. Cainta is bounded on the north by Marikina City and San Mateo, on the west by Pasig City, and on the east and south by Taytay. It lies in the Marikina Valley, is 10% rolling hills and 90% residential-industrial. It has the province's most number of rivers and streams. Cainta is politically subdivided into seven barangays, namely, San Andres (Poblacion), San Isidro, San Juan, San Roque, Sta. Rosa, Sto. Domingo and Sto. Nino.

Antipolo, (officially, "City of Antipolo") is a city in the Philippines located in the province of Rizal; about 25 kilometers east of Manila. It is the largest city in the Calabarzon Region in terms of population. It is also the seventh most populous city in the country with a population of 633,971 in 2007. It was converted from a municipality into a component city of Rizal Province on April 4, 1998 under Republic Act No. 8508. On March 14, 2011, Antipolo was declared a "highly-urbanized city" by President Benigno Aquino; such proclamation however still needs to be ratified in a plebiscite. The city is popular for being a pilgrimage site. Its higher elevation than that of Metro Manila affords it a scenic view of the metropolis, especially at night. The Hinulugang Taktak National Park, which was once a popular summer get-away is being restored to become again one of the city's primary attractions. Antipolo is politically divided into 16 barangays. Barangays Dela Paz, San Isidro, San Jose and San Roque or parts of it is within the core of the city proper or the poblacion.

The City of Marikina is known as the Shoe Capital of the Philippines" which is located on the island of Luzon. Marikina City is one of the cities that comprise Metro Manila, the National Capital Region of the Philippines. Marikina City is a lush valley bounded by mountain ranges and sliced by a river. Located along the eastern border of Metro Manila, it is bordered on the west by Quezon City, to the south by Pasig City and Cainta, Rizal, to the east by Antipolo City, the capital of Rizal province, and to the north by San Mateo also in Rizal province. It is approximately 21 km. away from Manila, and lies within 14° 38' 24" N, 121° 5' 50" E. One of the most important places in Marikina City is Marikina River, a tributary of the Pasig River which runs through the center of the city. The river in fact occupies a part of the Marikina Valley and is sometimes prone to flooding along the riverbanks especially during monsoon rainy season. Marikina City is divided into 16 barangays. These barangays are then grouped into 2 geographical districts, as per Republic Act No. 9364. District 1 occupies the southwest side of Marikina River and the entire south of Marikina City, and District 2 occupies the northwest (Loyola Grand Villas) side of Marikina River and the entire northern and eastern part of Marikina City which is considered as the bigger district of the 2 in terms of land area.

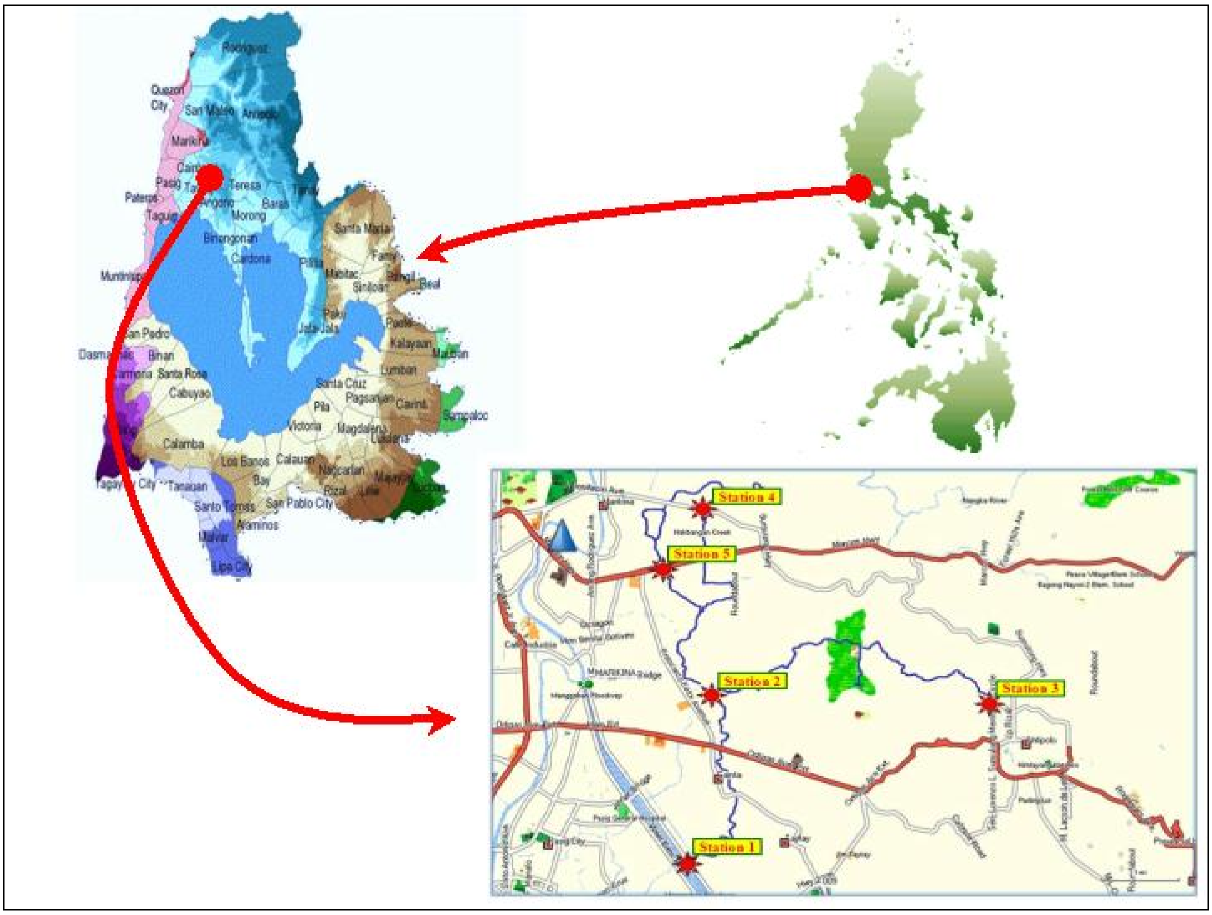



Figure A. The Laguna de Bay Watershed

The water quality of Sapang Baho river, one of the major tributary rivers of Laguna de Bay, has been monitored by the LLDA since 2003. Based on the BOD and DO concentrations (Figure B), results showed that the BOD and DO consistently failed the water quality criteria of 7 mg/L and 5 mg/L, respectively. Likewise, water quality in terms of total coliforms remarkably exceeded the criterion for total coliforms of 5000 MPN/100 mL with annual values ranging from 1.97 x $10^6$ to 7.21 x $10^{11}$ MPN/100 ml and peak values in 2006 (Figure C). However as also presented in Figures B and C, it is very noticeable that the water quality has been improving with its decreasing BOD and total coliforms and increasing DO concentrations through the years.

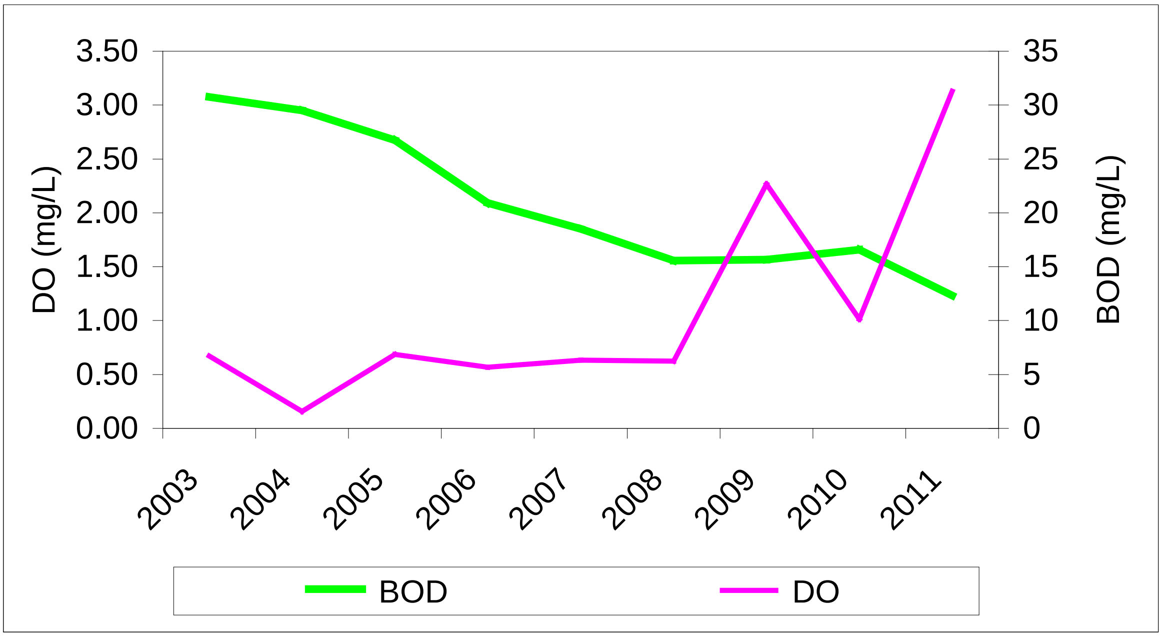



Figure B. Water quality of Sapang Baho River based on BOD and DO (2003-2011).

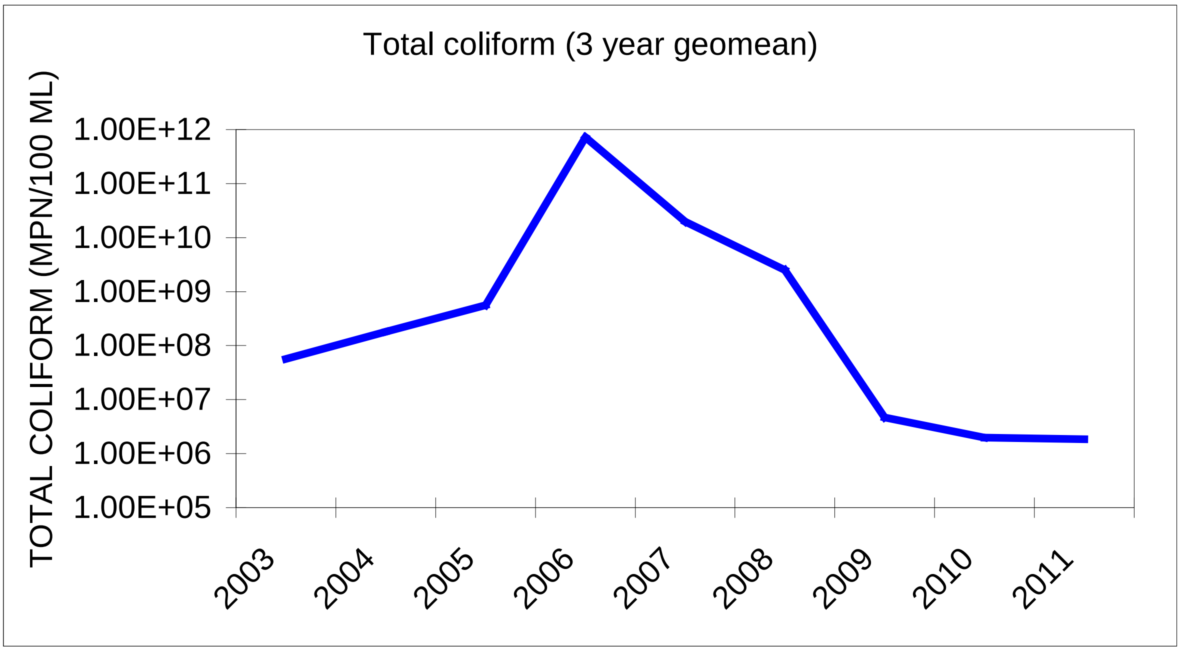



Figure C. Water quality of Sapang Baho River based on Total Coliforms (2003-2011).

### 3.0 Sampling Stations and Sampling Frequency

Collection of water samples for physico-chemical, microbiological and biological analyses and sediment sample for biological analysis (for benthic macroinvertebrates analysis) was conducted at the different designated stations along the stretch of Sapang Baho River located in Cainta, Rizal which originated both from Marikina and Antipolo cities. Designated sampling stations are as follows:

- **Station 1 - Mouth, Sapang Baho River**
- **Station 2 - Village East Subdivision**
- **Station 3 - Hinulugang Taktak National Park**
- **Station 4 - Brgy. Mayamot, Antipolo City**
- **Station 5 - Boundary of Cainta & Marikina**

Table 1 presents the description and profile of the each sampling stations and Figure 1 presents the geographical location of the Sapang Baho river sampling stations.


**Figure 1. Location of Sapang Baho Sampling Stations**

**Table 1. Description of Sapang Baho River Sampling Stations.**

<table>
<tr><td colspan="3">Description/Profile of the Sampling Stations</td></tr>
<tr><th>Stations</th><th>Dry Season</th><th>Wet Season</th></tr>
<tr><td>Station 1. Mouth – Sapang Baho River. The mouth of Sapang Baho with GPS reading of P0296388, UTM 16110940 is located in Brgy. San Juan, Cainta, Rizal. It is located in a residential area. One side of the riverbanks is concreted. The station is characterized by the presence of garbage, vegetation and thick growth of water hyacinth.</td><td></td><td></td></tr>
<tr><td>Station 2. Village East Subdivision. Station 2 with GPS Reading of P0296900, UTM 1614529 is located at the Village East Subdivision in Cainta, Rizal. Located in a residential area, there is presence of few garbage in the vicinity. Backyard vegetation was noted on one side of the river bank.</td><td></td><td></td></tr>
</table>

| *Description/Profile of the Sampling Stations* | | |
|---|---|---|
| **Stations** | **Dry Season** | **Wet Season** |
| Station **3. Hinulugang Taktak National Park** (with GPS reading of P0302445, UTM 1614386). Hinulugang Taktak National park is located at Taktak Road, Brgy. Dela Paz, Antipolo City.. Hinulugang Taktak falls is a part of Antipolo's natural and cultural heritage and proclaimed a National Park on June 15, 1952. The waterfalls of Hinulugang Taktak are famed for this energetic lift and as tourist destination. During the sampling (both dry and wet seasons), presence of bubbles on the surface of the water is very evident and with pungent odor. The fast flowing water coming from the falls is clear showing the sandy/pebble bottom, dried leaves/branches and few garbages. Both riverbanks are concretely riprapped with presence of trees and other flowering plants. |  |  |

| *Description/Profile of the Sampling Stations* | | |
|---|---|---|
| **Stations** | **Dry Season** | **Wet Season** |
| **Station 4. Brgy. Mayamot, Antipolo City.** The river/creek with GPS reading of P0296815 UTM 1618572 is located near the Bottling Warehouse (formerly owned by Coca-cola, Philippines) at Brgy. Cupang, Marikina City. There are presence of garbage (especially plastics) in both sides of the concreted river banks. The river system receives discharges from slaughterhouse and residential areas resulting to blackish coloration and slow flow of the water. |  |  |

| *Description/Profile of the Sampling Stations* | | |
|---|---|---|
| **Stations** | **Dry Season** | **Wet Season** |
| **Station 5. Boundary of Cainta & Marikina.** Station 5 with GPS reading of P0295911 UTM 1617280 is located in Marcos Highway near the MMDA outpost and Police Station. It has 2 culvert outlets (new sidewalk on top), both river banks are concrete. The river is approximately 6m width with water depth of <1-2 ft. Few illegal settlers are visible along the said river system. |  |  |

## 4.0. Methodology

### 4.1 Water and sediment quality sampling, sample processing and laboratory analysis

Reconnaissance of Sapang Baho River was undertaken by the ELRD and CDD staff on February 01, 2011 in order to assess the actual situation, recent activities and existing development of the area along the river system for proper designation of the sampling locations.

Actual collection of water and sediment samples was undertaken by the ELRD staff at five (5) designated stations on February 02, 2011 for the dry season and August 16, 2011 for the wet season. Collection of water samples for physico-chemical, microbiological and biological analyses was done using an improvised water sampler (pail) and collection of sediment samples for biological analysis (benthic macroinvertebrates) was done using Surber and Ekman grab.

The collected water samples were transferred to designated sampling bottles as follows:

- glass container for the oil and grease analysis,
- nalgene (polypropylene) bottle for heavy metal analysis,
- glass container for dissolved oxygen (fixed onsite)
- gallon plastic container for the rest of the physico-chemical analysis.

Water samples placed in nalgene (polypropylene) bottle and a gallon plastic container were stored in a cooler with ice before being submitted to LLDA-ELRD.

Water samples for microbiological analysis were transferred to a sterilized borosilicate glass bottle and placed in a cooler with ice during storage and transport to the LLDA-ELRD.

Collected samples for biological analyses (benthic flora and fauna) were transferred from the appropriate sampler (ekman or surber sampler) to a small plastic containers preserved by Lugol’s and 10% formalin solution for benthic flora and fauna analyses, respectively.

Air and water temperature were measured on site. Field observations were also noted to include GPS reading for proper mapping of the sampling stations.

Table 2 presents the prescribed method of analysis for each parameter.

**Table 1. Physico-chemical, Bacteriological and Biological Parameters and their method of analysis.**

| Parameters | Method of analysis |
|---|---|
| **PHYSICO-CHEMICAL PARAMETERS** | |
| pH | Glass Electrode |
| Solids | |
| Total Solids (TS) | Gravimetric |
| Total Suspended Solids (TSS) | Gravimetric |
| Total Dissolved Solids (TDS) | Gravimetric |
| Biochemical Oxygen Demand ($BOD_5$) | Winkler Azide (Dilution Technique) |
| Chemical Oxygen Demand (COD) | Dichromate Reflux Method |
| Dissolved Oxygen (DO) | Winkler Azide |
| Oil and Grease (O/G) | Gravimetric (Petroleum Ether Extraction) |
| Nitrogen Compounds | |
| Nitrate ($NO_3$) | Sodium Salicylate |
| Ammonia ($NH_4$) | Phenol Hypochlorite |
| Total Nitrogen (TN) | Koroleff's Method |
| Inorganic Phosphate | Ascorbic Acid |
| Total Phosphorus | Ascorbic Acid |
| Chloride | Argentometric Titration |
| Alkalinity | Titration |
| Conductivity | Platinum Electrode |
| Calcium Hardness | EDTA Titration |
| Total Hardness | EDTA Titration |
| Turbidity | Nephelometric |
| Heavy Metals | |
| Cadmium (Cd) | AAS – Direct Air Acetylene Flame |
| Lead (Pb) | AAS – Direct Air Acetylene Flame |
| **MICROBIOLOGICAL PARAMETERS** | |
| Total Coliforms | Multiple Tube Fermentation |
| Fecal Coliforms | Multiple Tube Fermentation |
| Detection of *E. coli* | Biochemical tests |
| **BIOLOGICAL PARAMETERS** | |
| Benthic macroinvertebrates | Stereo Microscope – Total count |
| Phytoplankton | Inverted Microscope – Total count |

## 5.0 Results and Discussions

### 5.1 Field Observations and In-situ Measurements

Field observations were recorded during the sampling activities (for dry and wet seasons) and are presented in Tables 3 and 4.

**Table 3. Field Observations and In-situ Measurements (Dry Season)**

Name of Activity : Sapang Baho River Sampling (River Rehabilitation Program)
Date of Sampling : February 02, 2011
Sampling Team : Bileynnie P. Encarnacion, Ireneo G. Bongco, Lisette T. Aragoncillo

| Stations | Mouth of Sapang Baho (Manggahan Floodway) Cainta, Rizal | Village East Subdivision (Buick Street) Cainta, Rizal | Hinulugang Taktak, National Park, Brgy. Dela Paz, Antipolo, Rizal | Brgy. Mayamot, Antipolo, Rizal (confluence of Coca-Cola/Cupang | Boundary of Cainta/Marikina (Marcos Highway near MMDA/Police Station) |
|---|---|---|---|---|---|
| Station Number | 1 | 2 | 3 | 4 | 5 |
| Date | 2 February 2011 | 2 February 2011 | 2 February 2011 | 2 February 2011 | 2 February 2011 |
| Time | 11:45 AM | 11:00 AM | 9:05 AM | 9:45 AM | 10:25 AM |
| GPS Reading | P 0296388 | P 0296900 | P 0302445 | P 0296815 | P 0295911 |
| | UTM 1610940 | UTM 1614529 | UTM 1614386 | UTM 1618572 | UTM 1617280 |
| Water condition | Very slow flow | Fast flowing | Fast flowing | Slow flow | Slow flow |
| Air Temperature ($^{o}$C) | 26 | 26 | 26 | 25 | 26 |
| Water Temperature ($^{o}$C) | 25 | 25 | 23 | 24 | 24 |
| Color | Black | Greenish brown | Clear with pebbles | Blackish | Black |
| Nature of River Bed | Sandy/muddy bottom | Sandy | Sandy/pebbles bottom | Sandy bottom | Sandy bottom |
| Weather condition | Sunny | Sunny | Sunny | Sunny | Sunny |
| Other observations | Thick growth of water hyacinth, residential at one side of the river banks, presence of garbage. | Backyard vegetation on one side of the river bank, residential area, few garbage. | Bubbles on the surface of the water, dried leaves & branches, presence of garbage, both river banks concrete, with trees and other flowering plants. | Presence of garbage (plastic, etc.), discharge from slaughterhouse and residential. Both river banks concrete. | Presence of garbage, with 2 culvert outlets (new sidewalk on top), both river banks concrete. |

**Table 4. Field Observations and In-site Measurements (Wet Season)**

Name of Activity : Sapang Baho River Sampling (River Rehabilitation Program)
Date of Sampling : August 16, 2011
Sampling Team : Bileynnie Encarnacion, Cruzadel dela Cruz, Victoria G. Baltazar, Marinel A. Hernandez, Michael Salandanan

| Stations | Mouth of Sapang Baho (Manggahan Floodway) Cainta, Rizal | Village East Subdivision (Buick Street) Cainta, Rizal | Hinulugang Taktak, National Park, Brgy. Dela Paz, Antipolo, Rizal | Brgy. Mayamot, Antipolo, Rizal (confluence of Coca-Cola/Cupang | Boundary of Cainta/Marikina (Marcos Highway near MMDA/Police Station) |
|---|---|---|---|---|---|
| Station Number | 1 | 2 | 3 | 4 | 5 |
| Date | 16 August 2011 | 16 August 2011 | 16 August 2011 | 16 August 2011 | 16 August 2011 |
| Time | 12:15 AM | 10:08 AM | 9:02 AM | 11:06 AM | 10:40 AM |
| GPS Reading | P 0296388 | P 0296900 | P 0302445 | P 0296815 | P 0295911 |
| | UTM 1610940 | UTM 1614529 | UTM 1614386 | UTM 1618572 | UTM 1617280 |
| Water condition | Very slow flow | Fast flowing | Fast flowing | Moderately flowing | Moderately flowing |
| Air Temperature ($^oC$) | 33 | 30.5 | 28 | 31 | 31 |
| Water Temperature ($^oC$) | 35 | 27 | 26 | 29 | 28.5 |
| Color | Greenish | Brown | Clear with pebbles | Black | Greenish brown with black scums floating |
| Nature of River Bed | Sandy/muddy bottom | Sandy bottom | Pebbles bottom | Sandy/muddy bottom | Sandy/muddy bottom |
| Weather condition | Sunny | Sunny | Sunny | Sunny | Sunny |
| Other observations | Full of garbage floating and on sides (wrappers, plastics, etc.), the stretch of the river newly dredged, high water level observed, width 25-30 m, depth 6 ft. | Residential area, garbage on sides of the river banks, fish fry and janitor fish present in the water, width ≈ 10m, depth <2ft water, presence of leech. | Presence of bubbles after the falls with pungent odor presence of garbage on both sides (wrappers, plastics, etc.) head to fist size stones, ≈10-15m, water depth <1 ft. | With lots of garbage (diaper, plastic, etc.), width ≈ 6m, water depth <1 ft., discharge from slaughterhouse and residential. Both river banks concrete. | Lots of garbage, thin oil film on the water surface, fish fry seen in the area (*Poecilia latipina*, locally known as "kataba" approx. 6m width water depth <1-2 ft. |

## 5.2 Results and Evaluation of the Physico-chemical Analyses

The results of analysis for the physico-chemical parameters are tabulated in Table 5 and presented in Figures 2 a-o.

**Table 5. Results of the Physico-chemical Analyses of Water Samples (Dry/Wet Seasons).**

| Parameters | Stations | | | | | | | | | | WQ Criteria DAO 34 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dry Season | | | | | Wet Season | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | |
| PH, units | 6.6 | 6.9 | 6.9 | 6.7 | 6.8 | 7.4 | 7.4 | 7.94 | 7.36 | 7.37 | 6.5-8.5 |
| TSS, mg/L | 0.5 | 2 | 2 | 8 | 17 | 12 | 20 | 12 | 12 | 53 | <30 inc. |
| TDS, mg/L | 341 | 284 | 227 | 373 | 342 | 240 | 232 | 213 | 369 | 275 | 1000 |
| TS, mg/L | 341 | 286 | 229 | 381 | 359 | 252 | 252 | 225 | 381 | 328 | * |
| BOD, mg/L | 21 | 9 | 20 | 55 | 71 | 10.75 | 7 | 5.25 | 26.5 | 26 | 10 |
| COD, mg/L | 60 | 16 | 36 | 111 | 147 | 24 | 12 | 16 | 64 | 56 | * |
| DO, mg/L | 0.05 | 3 | 5.6 | 0.7 | 0.05 | 3.3 | 2.8 | 6.9 | 0 | 0 | 5 (min) |
| O/G, mg/L | < 1 | < 1 | < 1 | 3 | 8 | < 1 | < 1 | < 1 | < 1 | < 1 | 2 |
| NO3, mg/L | 0.0302 | 2.0748 | 0.1126 | 0.0779 | 0.0604 | 0.1203 | 1.598 | 1.6982 | 0.0508 | 0.0539 | 10 |
| $NH_3^-$, mg/L | 6.476 | 3.254 | 5.626 | 7.818 | 7.617 | 2.854 | 1.201 | 3.085 | 4.738 | 5.108 | * |
| TN, mg/L | 15.9 | 10 | 15.6 | 25.8 | 32.7 | 15 | 10.2 | 15.1 | 26.1 | 31.2 | * |
| IPO4, mg/L | 1.5336 | 1.0058 | 1.1622 | 1.6132 | 2.378 | 0.5298 | 0.5008 | 0.5353 | 0.546 | 0.9632 | 0.4 |
| TP, mg/L | 2.1878 | 1.3886 | 2.0786 | 2.2936 | 3.2598 | 0.9488 | 1.092 | 0.9842 | 1.7516 | 1.8922 | * |
| Cl, mg/L | 60 | 37 | 41 | 56 | 56 | 30 | 30 | 30 | 37 | 30 | 350 |
| Alk., mg/L | 240 | 146 | 160 | 276 | 280 | 144 | 124 | 108 | 196 | 192 | * |
| Cond.,uS/cm | 718 | 482 | 469 | 810 | 819 | 369 | 328 | 329 | 575 | 466 | * |
| CaH, mg/L | 104 | 88 | 64 | 120 | 88 | 64 | 64 | 68 | 80 | 84 | * |
| TH, mg/L | 160 | 136 | 100 | 172 | 148 | 140 | 80 | 100 | 168 | 144 | * |
| Turb., NTU | 4 | 3 | 1 | 4 | 8 | ** | ** | ** | ** | ** | * |
| Heavy Metals | | | | | | | | | | | |
| Cd, mg/L | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 | <0.003 | 0.0038 | <0.003 | 0.0052 | <0.003 | 0.01 |
| Pb, mg/L | <0.001 | 0.001 | 0.001 | 0.002 | 0.001 | | | | | | 0.05 |

** - Turbidity meter not functional

Note:

TSS – Total Suspended Solids, mg/L
TDS – Total Dissolved Solids, mg/L
TS – Total Solids, mg/L
BOD – Biochemical Oxygen Demand, mg/L
COD – Chemical Oxygen Demand, mg/L
DO – Dissolved Oxygen, mg/L
O/G – Oil & Grease, mg/L
$NO_3^-$ - Nitrate, mg $NO_3$-N/L
$NH_3^-$ - Ammonia, mg $NH_3$-N/L
TN – Total Nitrogen, mg/L
$IPO_4^-$ - Inorganic Phosphate, mg $PO_4$-P/L
TP – Total Phosphorus, mg/L
Cl – Chloride, mg/L
Alk – Alkalinity, mg$CaCO_3$/L
Cond. – Conductivity µS/cm
CaH – Calcium Hardness, mg/L $CaCO_3$/L
TH – Total Hardness, mg/L $CaCO_3$/L
Turb. – Turbidity, NTU
Cd – Cadmium, mg/L
Pb – Lead, mg/L

**a) pH**

The pH is a measure of hydrogen ion concentration or a measure of the acidity or alkalinity of a solution. Measured pH in all stations both from dry and wet season ranged from 6.6 to 7.94 units and are within the acceptable range of the water quality criteria for Class C waters (6.5 to 8.5 units) (see Figure 2a and Table 5).

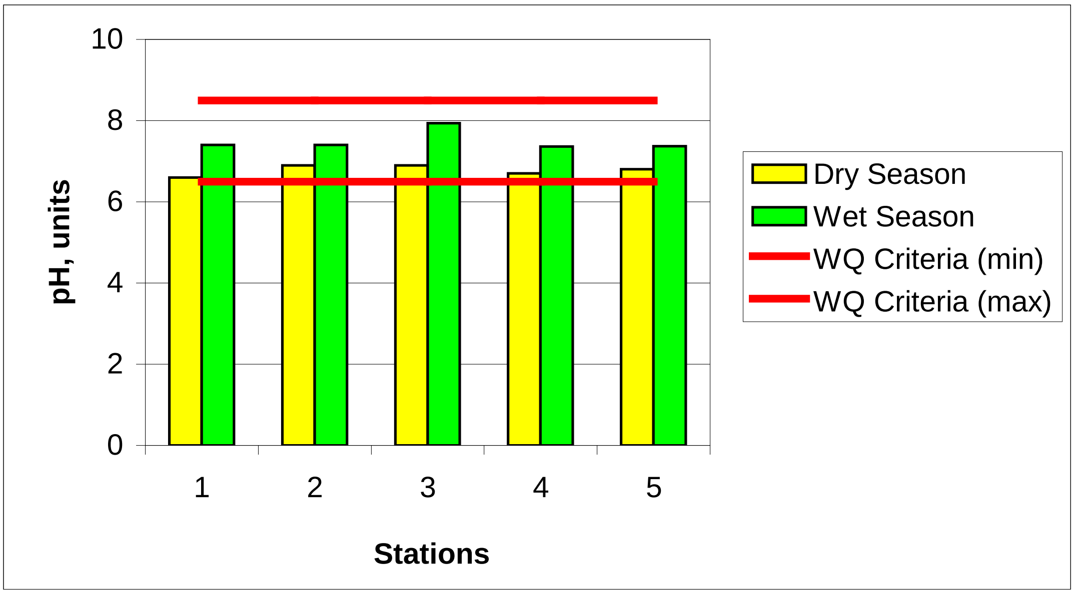



Figure 2a. pH

**b) Solids: Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and Total Solids (TS)**

The amount of solids in the water column will affect photosynthesis and may affect the behavior of the flora and fauna of the aquatic environment. Total solids also affect water clarity. Higher solids have several negative effects, such as decreasing the amount of light that can penetrate the water, thereby slowing photosynthetic processes which in turn can lower the production of dissolved oxygen; high absorption of heat from sunlight, thus increasing the temperature which can result to lower oxygen level; low visibility which will affect the fish' ability to hunt for food; clog fish' gills; and prevent development of egg and larva. It can also be an indicator of higher concentration of bacteria, nutrients and pollutants in the water. Some of the factors that affect the concentration of SS are high flow rate, soil erosion, urban run-off, septic and wastewater effluents, decaying plants and animals and bottom-feeding fish.

The set criterion only entails that increase of the measured TSS should not exceed 30 mg/L of the receiving body of water. Measured TSS ranged from 0.5 mg – 17.0 mg/L during the dry season, while 12.0 – 53.0 mg/L recorded during the wet season. There is no set criterion for TS under the Water Quality Criteria (DAO 34) and the measured concentrations ranged from 229 to 381 mg/L, with Station 4 recording the highest concentrations and Station 3 recording the lowest (Figure 2b).

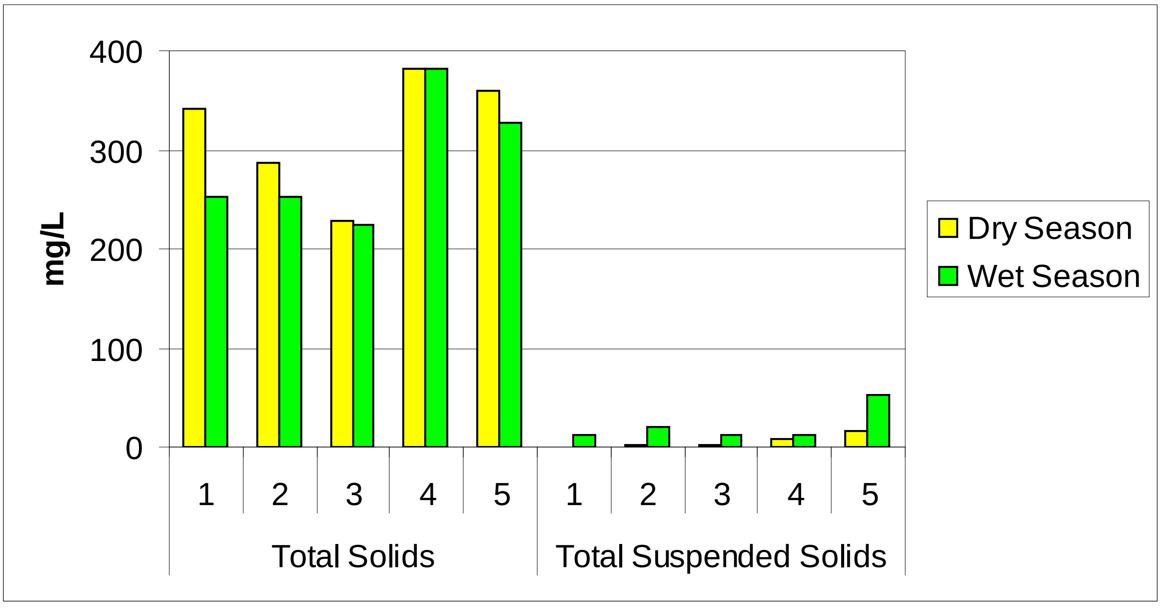



Figure 2b. Total Solids and Total Suspended Solids

The measured TDS during the dry season for the 5 designated stations ranged from 229-381 mg/L and for the wet season ranged from 213-369 mg/L and are within the Class B water quality criterion of 1,000 mg/L (Figure 2c). It is noticeable that lower TDS values are observed in the wet season compared to the dry season. Station 3 registered the lowest while Station 4 recorded the highest in both seasons. This is also being manifested in the field data (Tables 3 and 4) wherein Station 3 recorded a clear water and Station 4 with blackish water.

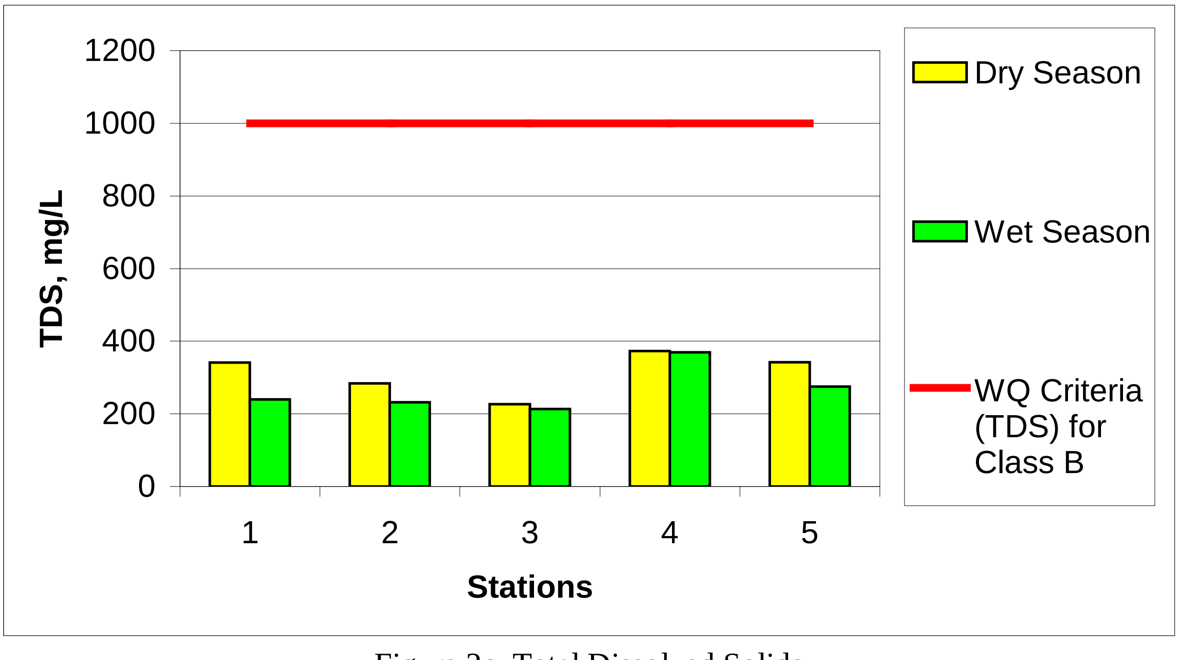



Figure 2c. Total Dissolved Solids

**c) Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)**

Biochemical oxygen demand is the amount of oxygen required for the aerobic microorganisms present in a sample to oxidize the organic matter to a stable inorganic form. A good water quality should have maximum BOD values of 10.0 mg/L. For dry season, all the designated stations exceeded the set criterion for BOD of 10.0 mg/L except in Station 2. In the wet season, Stations 2 and 3 passed the set criterion of 10.0 mg/L. All other stations did not conform to the set criterion for BOD in the wet season. (Figure2d, Table 5).

Chemical oxygen demand (COD) is a measure of the oxygen equivalent of the organic matter in a water sample that is susceptible to oxidation by a strong chemical oxidant, such as dichromate. The COD test is not specific; it does not identify the oxidizable material or differentiate between the organic and inorganic material present (Chapman, 1992). Chemical oxygen demand (COD) does not differentiate between biologically available and inert organic matter, and it is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. References stated that COD values are always greater than BOD values which is also being presented in the data sets for the dry and wet seasons (Figure 2d and Table 5). There is no set criterion for COD in the Class C Water Quality Criteria (DENR DAO 34).

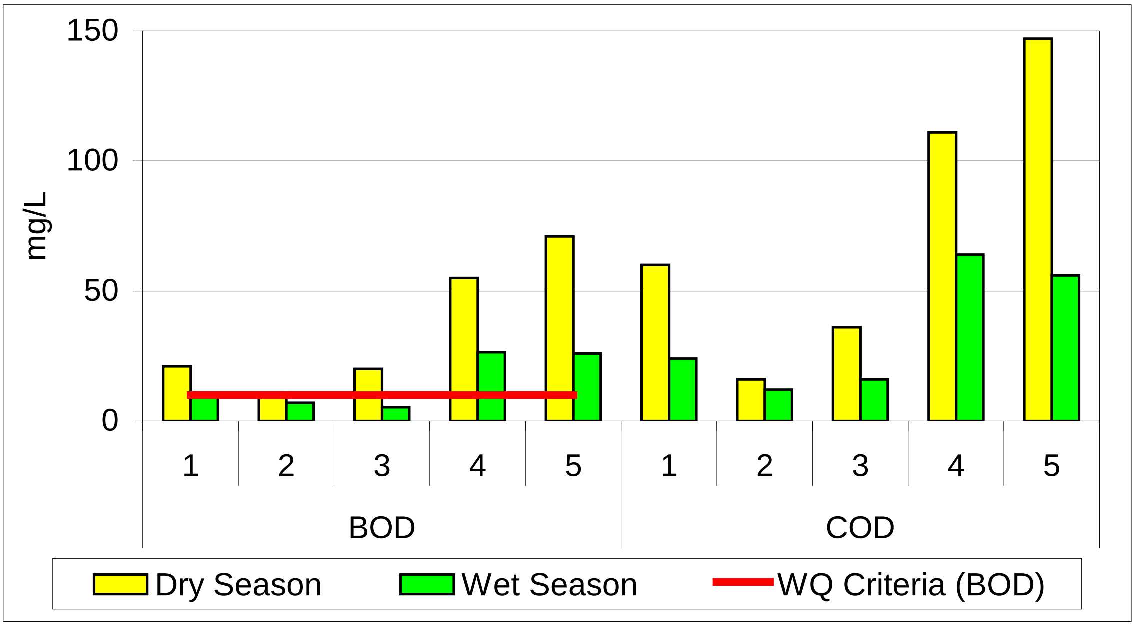



Figure 2d. Biochemical Oxygen Demand and Chemical Oxygen Demand.

It is clearly presented in Figure 2d, that BOD and COD concentration were higher in the dry season compared to the wet season. During the dry season, most of the tributary rivers are characterized by low flow or zero flows, and as a consequence, river water quality downstream is usually very poor due to lack of dilution (Dickens and Graham, 1998).

**d) Dissolved oxygen**

Dissolved oxygen, as an indicator of the quality of water also indicates how aquatic life survives. The lower the DO, the poorer the water quality, which is unfavorable for fish to live. A healthy aquatic environment good for fishery, should have a minimum DO concentration of 5 mg/L. The dissolved oxygen concentrations in all the stations consistently failed based on Class C Water Quality Criteria (DENR DAO 34) except in Station 3 during the dry and wet season. The fast flowing water coming from the falls keeps the water aerated and oxygen from the air mixes with the water column adding up to the oxygen content in the water, particularly in Station 3. (Figure 2e, Table 1 & Table 5). Station 5 recorded the lowest DO concentrations in both the dry and wet seasons. With the presence of organic pollution in Station 5, there is great demand of oxygen by the bacteria to decompose the organic matter therefore depicting high levels of BOD (Figure 2d). The low DO levels (Figure 2e), is due to the fact that the oxygen that is available in the water is being consumed by the bacteria. Since less dissolved oxygen is available in the water, fish and other aquatic organisms may not survive.

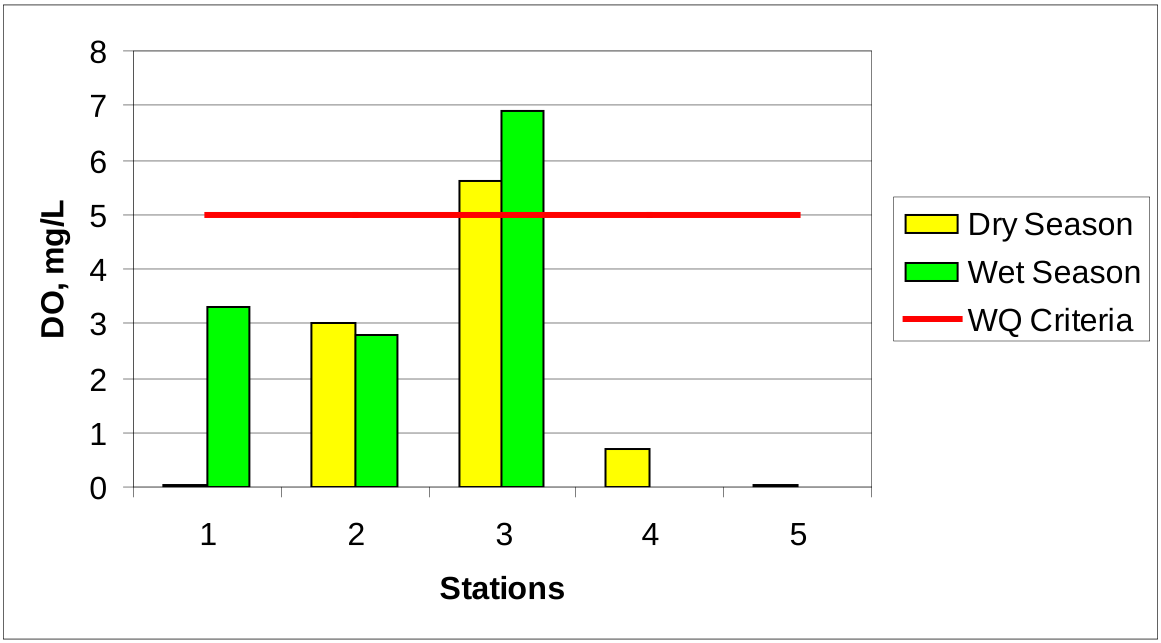



Figure 2e. Dissolved oxygen.

**e) Oil/Grease**

Oil and grease includes not only petroleum oils but also vegetable and natural oils. Sediments, biota, and decaying life forms are often high in natural oil lipids which make up part of the oil and grease measure. Oil and grease in water can cause surface films and shoreline deposits leading to environmental degradation, and can induce human health risks when discharged in surface or ground waters. The water quality criterion set for oil and grease based on DENR DAO 34 is 2 mg/L. All the designated stations consistently passed the set criterion except in Station 4 and 5 during the dry season which exceeded the set criterion measuring at 8 and 3 mg/L, respectively (Figure 2f and Table 5). Station 4 and 5 exceeded the water quality criterion for Oil/Grease because of the presence of garbage and thin oil film in the water column. Station 4 likewise has been receiving discharge from slaughterhouse and residential sources (Table 3 and 4).

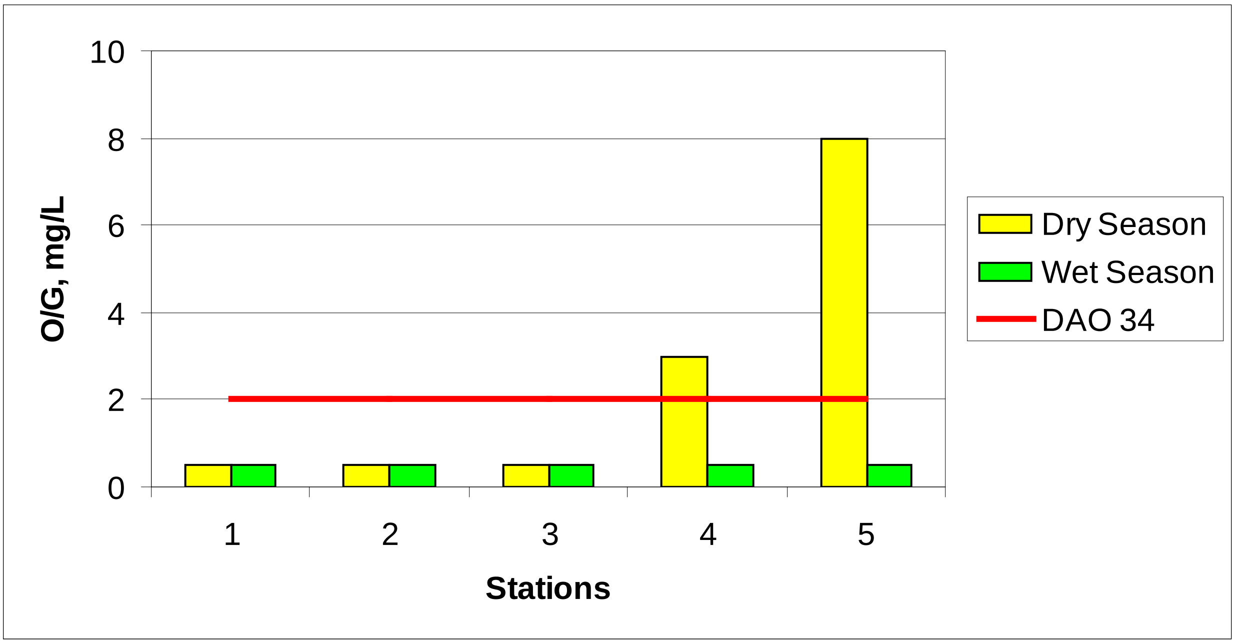



Figure 2f. Oil and Grease.

## f) Nitrogen compounds (Nitrates, Ammonia and Total Nitrogen)

### f.1. Nitrates

Nitrate as nutrients favor growth of aquatic plants (algae) which are food for fish, but if their concentration reaches beyond the allowable limit (maximum 10mg/L) this could lead to excessive growth of algae referred to as "algal bloom". Die-off of algae which occurred normally at nighttime, require oxygen thus resulting to depletion of oxygen and eventually affecting aquatic life especially fishes. Data for nitrate as shown in Table 5 and Figure 2g showed that values are much way below the water quality criteria for Class C of 10 mg/L.

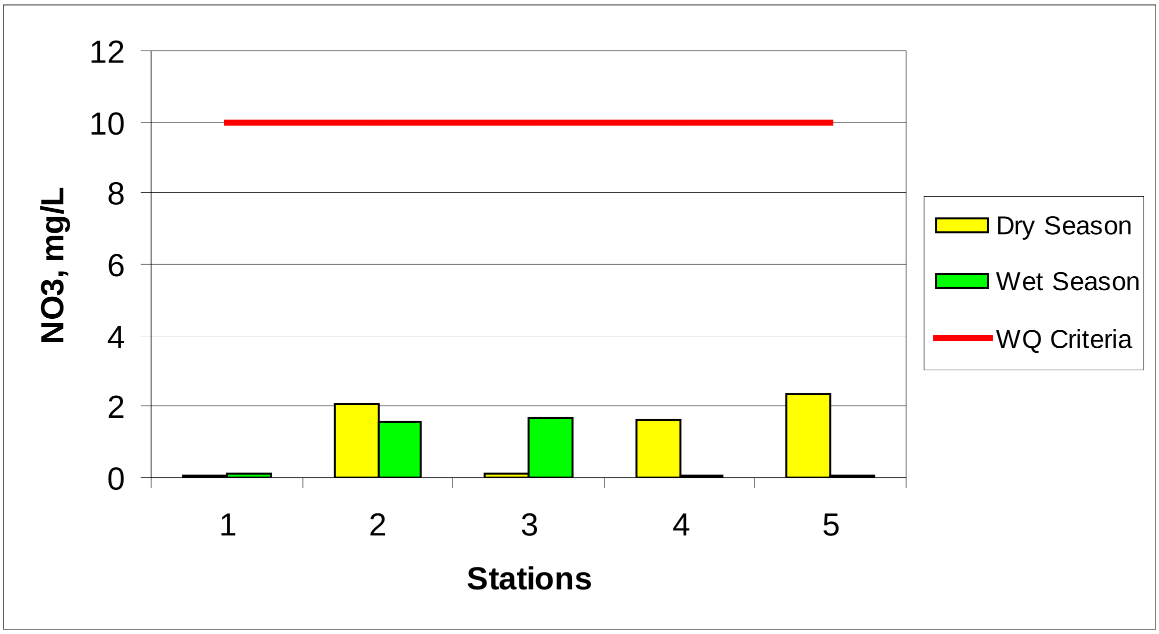



Figure 2g. Nitrates

### f.2. Ammonia

Ammonia ($NH_3$) is a colorless gas with a strong pungent odor. It is easily liquefied and solidified and is very soluble in water. $NH_3$+ is the principal form of toxic ammonia. There is no set criterion for Ammonia based on Class C Water Quality Criteria, however, according to Canadian Environmental Studies Board (1972), ammonia concentrations should not exceed 0.2 mg/L. Meanwhile some reports claimed that concentrations toxic to fresh water organisms ranged from 0.53 to 22.8 mg/L (Brian, 2005). Raised levels affect fish health in several different ways. At low levels (<0.1 mg/litre $NH_3$), it acts as a strong irritant, especially to the gills. Prolonged exposure to sub-lethal levels can lead to skin and gill hyperplasia (the secondary gill lamellae swell and thicken, restricting the water flow over the gill filaments). This can result in respiratory problems and stress as well as creating conditions for opportunistic bacteria and parasites to proliferate. Elevated levels are a common precursor to bacterial gill disease. At higher levels of $NH_3$ (>0.1 mg/liter), even relatively short exposures can lead to skin, eye, and gills damage. Elevated levels can also lead to ammonia poisoning by suppressing normal ammonia excrement from the gills. (Lawson, 1995).

According to the data presented, all the five (5) designated stations with ranged values of 3.254 to 7.818 mg/L in the dry season and 1.201 to 5.108 mg/L during the wet season, extremely exceeded the water quality criterion set by Canadian Environmental Studies Board (1972). This clearly signifies that the water quality in all the stations already affects fish health and higher concentrations were observed during the dry season (Figure 2h & Table 5). Station 2 consistently recorded the lowest concentrations in both the dry and wet seasons. Station 4 recorded the highest in the dry season while Station 5 recorded the highest in the wet season. It is also noticeable that recorded values in the dry season are higher compared to that of the wet season. It has been stated by Dickens and Graham (1998) that higher concentration of pollution occurred during dry season due to lack of dilution.

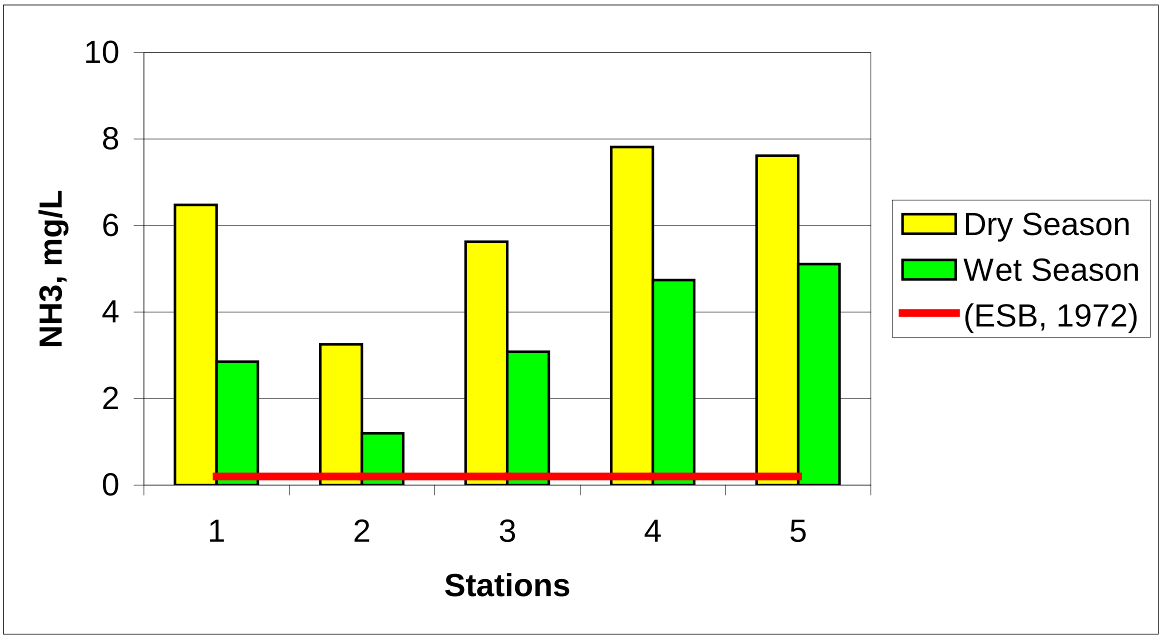



Figure 2h. Ammonia.

### f.3. Total nitrogen

Nitrogen is essential for living organisms as an important constituent of proteins, including genetic material. In the environment, inorganic nitrogen occurs in a range of oxidation states as nitrate ($NO_3^-$), nitrite ($NO_2^-$), ammonium ion ($NH_4^+$), and molecular nitrogen ($N_2$). It undergoes biological and non-biological transformations in the environment as part of the nitrogen cycle. Nitrogen cycles in rivers and lakes are affected by inputs and outputs of materials. Nitrogen can enter an aquatic ecosystem in surface runoff, ground water, streams and by atmospheric deposition as well as be recycled from bottom lake sediments. Agricultural activities associated with cropping and livestock practices are believed to be one of the main sources of contaminants and main causes of impaired water quality in aquatic ecosystems. Nitrogen associated contaminants include inorganic fertilizers and organic livestock wastes.

There is no set criterion for total nitrogen based on Class C Water Quality Criteria. The recorded total nitrogen in all the stations ranged from 10.0 to 32.7 mg/L in the dry season and 10.2 to 31.2 mg/L in the wet season showing that there is slight difference between the two seasons mostly higher in the dry season compared to the wet season. Station 2 recorded the lowest and Station 5 recorded the highest both in the dry and wet seasons. (Figure 2i and Table 5).

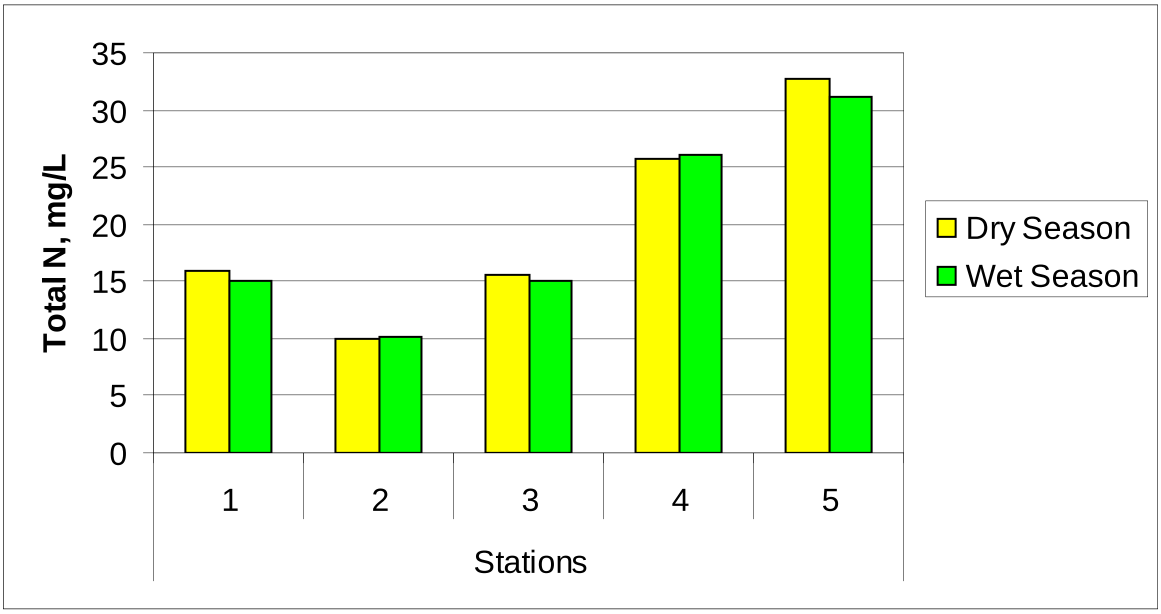



Figure 2i. Total Nitrogen

### g) Inorganic Phosphates and Total Phosphorus

Phosphates enter waterways from human and animal waste, phosphorus rich bedrock, laundry, cleaning, industrial effluents, and fertilizer runoff. Phosphates are plant nutrients and can cause plant life and algae to grow quickly. When plants grow quickly, they also die quickly. This contributes to the organic waste in the water, which is then decomposed by bacteria.

Results for inorganic phosphates ($IPO_4$) (Figure 2j and Table 5) showed that all the designated stations failed to meet the Class C water quality criterion for rivers (0.4 mg/L).

Station 5 recorded the highest values both in the dry season of 3.26 mg/L and wet season of 1.89 mg/L. This is due to the presence of organic pollution brought about by solid and liquid wastes from the residential areas which are directly discharged in the river system (Table 1). The decomposition of these organic matter by bacteria also contributed in high BOD level as depicted in Figure 2d and low concentrations of DO (Figure 2e). It is also noticeable that BOD and $IPO_4$ data sets followed the same trend in all the stations and in both seasons (Figures 2d and 2j).

There is no set criterion for total phosphorus. Recorded values ranged from 1.39 to 3.29 mg/L during the dry season and 0.95 to 1.89 mg/L in the wet season, with Station 5 recording the highest values both in the dry and wet season (Figure 2j).

Both for inorganic phosphates and total phosphorus, datasets depicted that the concentrations are generally higher in the dry season compared to the wet season. This is due to the fact that wet season experienced frequent rains therefore diluting the water draining to the river. Based on Laguna de Bay Monitor 2005, Sapang Baho river is one of the tributary rivers whose concentration of inorganic phosphates exceeded the water quality criteria of 0.4 mg/L. High phosphates concentrations which originated from the tributary rivers will enhance algal bloom and could cause fishkill incidences in the lake.

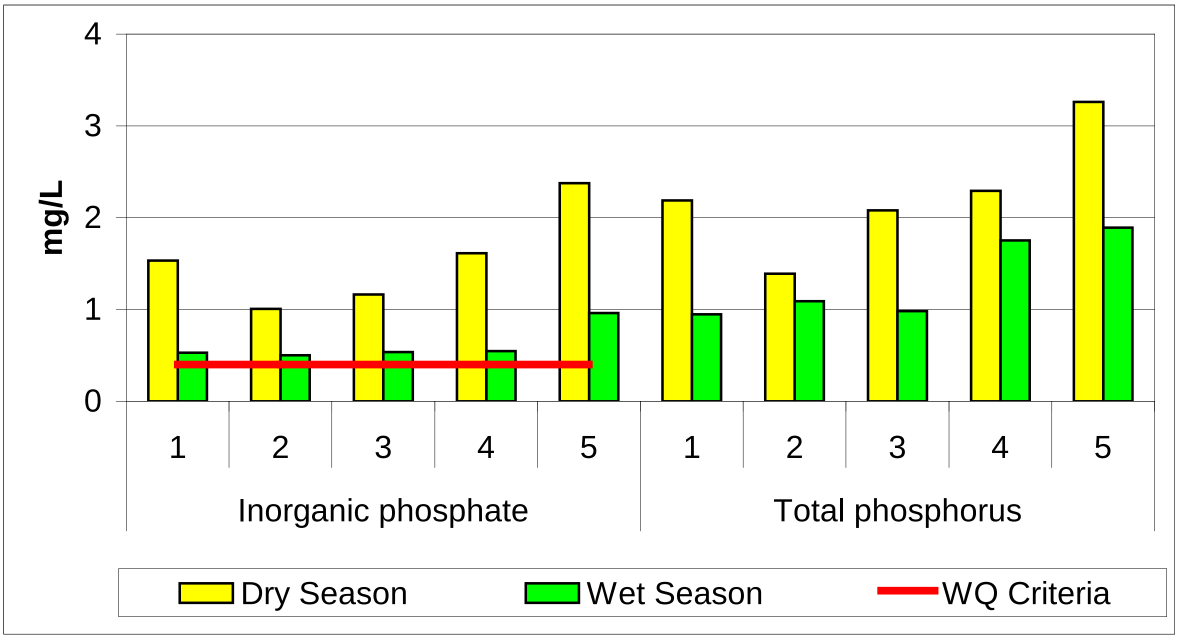



Figure 2j. Inorganic phosphates and Total Phosphorus.

## h) Chloride

Chloride is widely distributed in nature, generally in the form of sodium (NaCl) and potassium (KCl) salts; it constitutes about 0.05% of the earth's outer crust. In freshwater environment, natural background concentrations of chloride should not exceed 350 mg/L based on DENR DAO 34. All the designated stations are within the criterion of DENR DAO 34, which entails that all the designated stations are freshwater environment. (Figure 2k and Table 5)

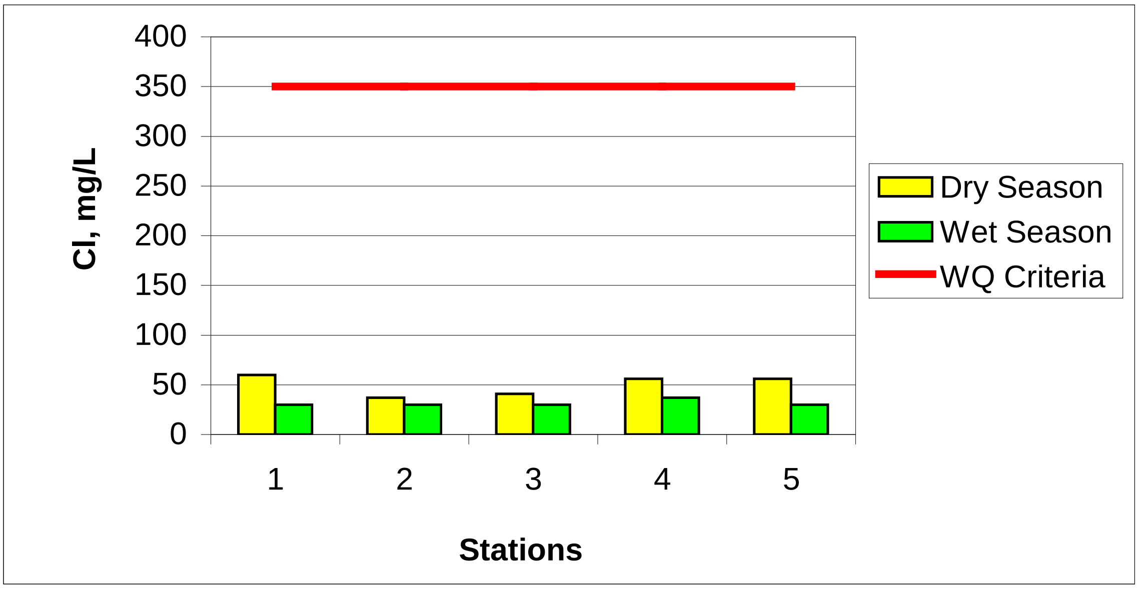



Figure 2k. Chloride

### i) Alkalinity

Alkalinity is the buffering capacity of a water body. It measures the ability of water bodies to neutralize acids and bases thereby maintaining a fairly stable pH. Water that is a good buffer contains compounds, such as bicarbonates, carbonates, and hydroxides, which combine with H+ ions from the water thereby raising the pH (more basic) of the water. Without this buffering capacity, any acid added to a lake or river water would immediately change its pH. Aquatic organisms benefit from a stable pH value in their optimal range. To maintain a fairly constant pH in a water body, a higher alkalinity is preferable. High alkalinity means that the water body has the ability to neutralize acidic pollution from rainfall or basic inputs from wastewater. A well buffered lake or river water also means that daily fluctuations of $CO_2$ concentrations result in only minor changes in pH throughout the course of a day. Alkalinity is important for fish and aquatic life because it protects or buffers against pH changes (keeps the pH fairly constant) and makes water less vulnerable to acid rain. The main sources of natural alkalinity are rocks, which contain carbonate, bicarbonate, and hydroxide compounds. Borates, silicates, and phosphates may also contribute to alkalinity.

There is no set criterion for alkalinity. Data showed that values ranged from 146 to 280 mg/L in dry season and 108 to 196 in the wet season. It is also manifested that dry season were slightly higher compared to the wet season (Figure 2l).

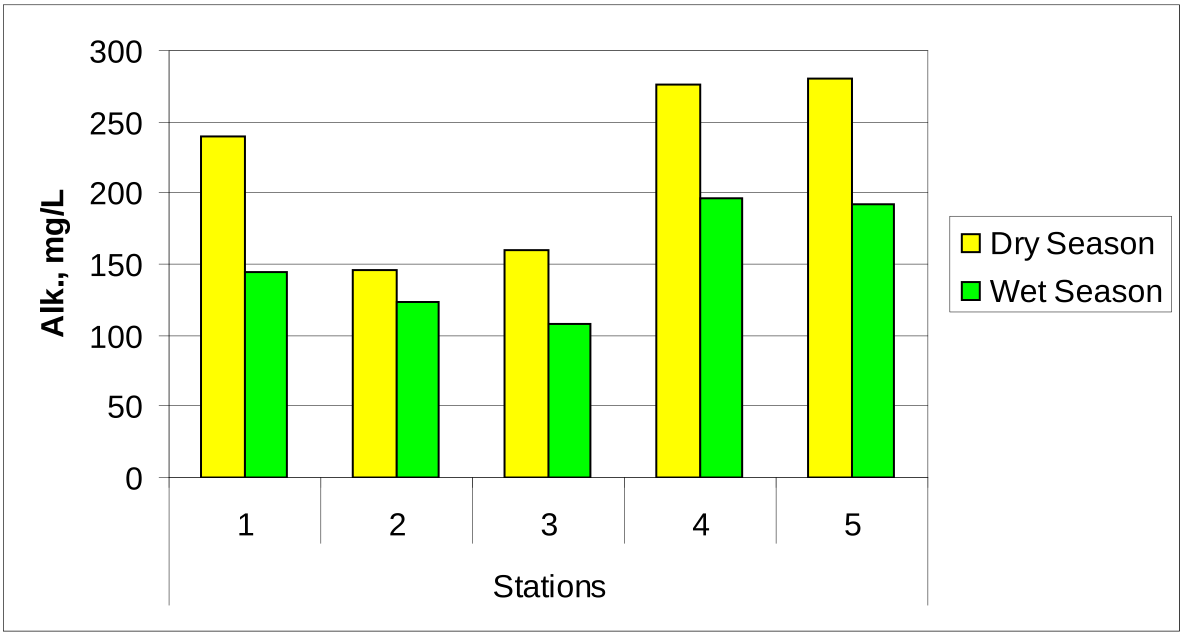



Figure 2l. Alkalinity

### j) Conductivity

Conductivity, or specific conductance, is a measure of the ability of water to conduct an electric current. It is expressed as microsiemens per cm (µS/cm). The degrees to which these dissociate into ions, the amount of electrical charge on each ion, ion mobility and the temperature of the solution all have an influence on conductivity. The conductivity of most freshwaters ranges from 10 to 1,000 µS/cm but may have exceeded 1,000 µS/cm especially in polluted waters or those receiving large quantities of land run-off (Chapman, 1992). As shown in Figure 2m, data ranged from 469 to 819 uS/cm in dry season and 328 to 575 uS/cm in the wet season depicting higher values in the dry season compared to wet season due to lack of dilution during the dry season (Figure 2m and Table 5).

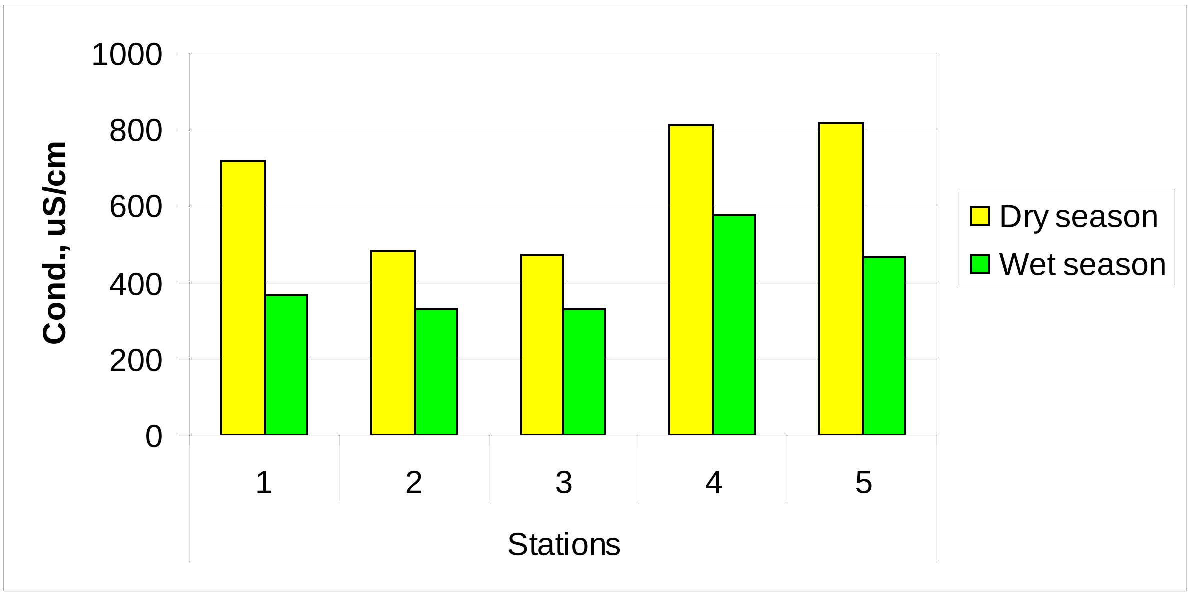



Figure 2m. Conductivity

### k) Calcium Hardness and Total Hardness

Calcium Hardness is caused by the presence of calcium ions in the water. Calcium salts can be readily precipitated from water and high levels of calcium hardness tend to promote scale formation in the water system. Calcium hardness is an important control test in industrial water systems such as boilers and steam raising plants, and for swimming pools. On the other hand, total hardness of water is a measure of the total concentration of the calcium and magnesium ions expressed as calcium carbonate (USEPA, 1994).

There is also no set criterion for both total and calcium hardness based on Class C Water Quality Criteria. For calcium hardness, data presents a range of 64 to 120 mg/L and 64 to 84 mg/L during dry season and wet season, respectively (Figure 2n and Table 5).

The highest value for total and calcium hardness was recorded in Station 4 during the dry season and Station 5 during the wet season. The lowest values for calcium and total hardness was recorded in station 3 both in the dry season, while second lowest both in the wet season.

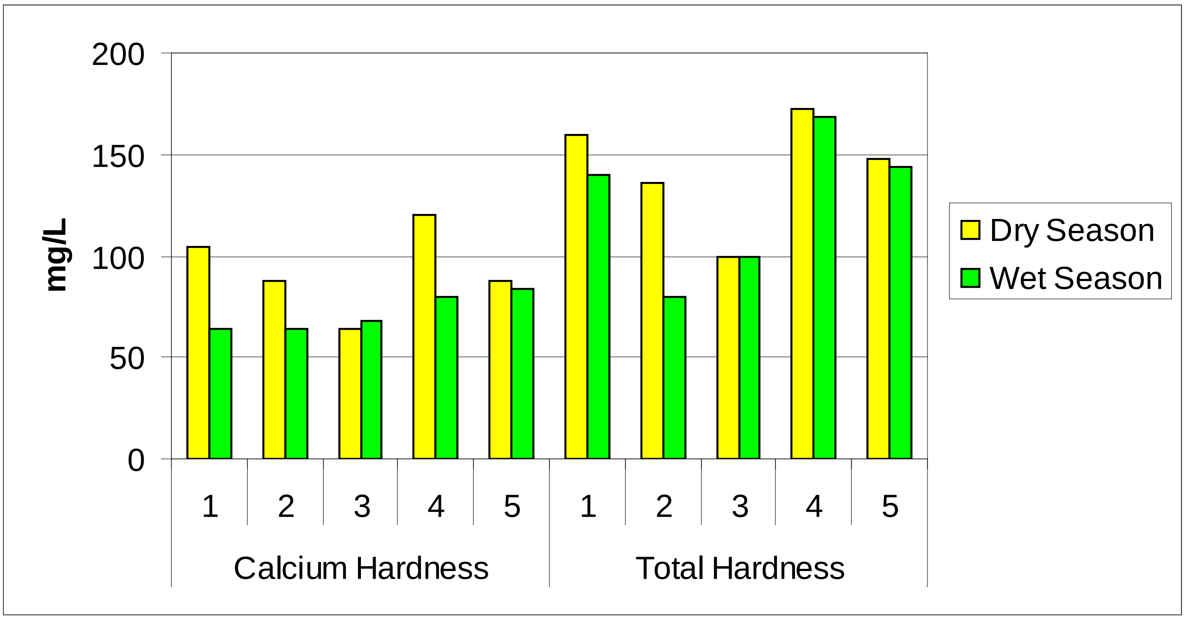



Figure 2n. Calcium Hardness and Total Hardness

### l) Turbidity

Turbidity refers to how clear the water is. The greater the amount of total suspended solids in the water (not to be confused with total dissolved solids above), the murkier it appears and the higher the measured turbidity. The major source of turbidity in the open water of most lakes and rivers is typically floating organisms. Closer to the shores of lakes and in rivers and streams, turbidity is more likely a result of clay and silt particles from erosion, runoff, and resuspended bottom sediments. Turbidity can greatly affect water quality in many ways. Some examples include reducing the amount of light available for plant growth, damaging sensitive gill structures in fish and aquatic organisms, as well as increasing their susceptibility to disease and preventing proper egg and larval development. The highest turbidity during the dry season was recorded at Station 5 with blackish water and the lowest in Station 3 with clear water (Figure 2o). There was no recorded values in the wet season since the equipment used was out of order.

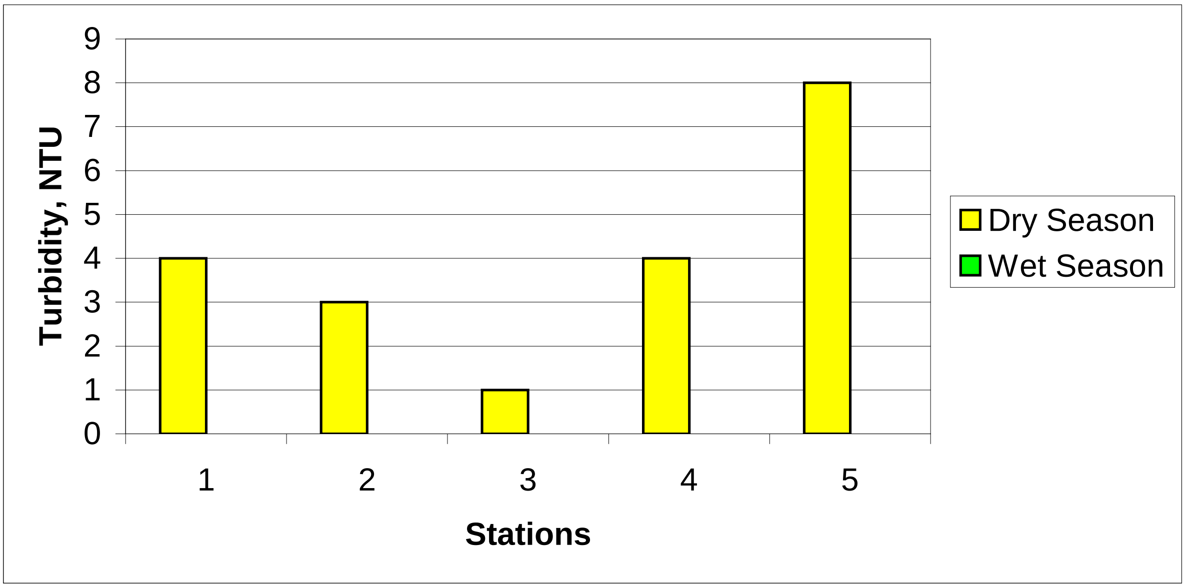



Figure 2o. Turbidity

**m) Heavy Metals**

Heavy metals can accumulate in aquatic environments and cause toxic effects on aquatic life and increase health risks of drinking water. These chemicals are at very low concentrations in the natural environment, and they are typically introduced to surface waters as waste from human activities.

Cadmium is widely used in industry and is often found in solution in industrial waste discharges. Cadmium replaces zinc in the body, and longterm consumption of cadmium may lead to bodily disorders. Cadmium is toxic to both humans and fish and seems to be a cumulative toxicant. The water quality criteria based on DENR DAO 34 is set at 0.01 mg/L. All the designated stations during dry and wet season are within the allowable limit of 0.01 mg/L (Table 5 and Figure 2p).

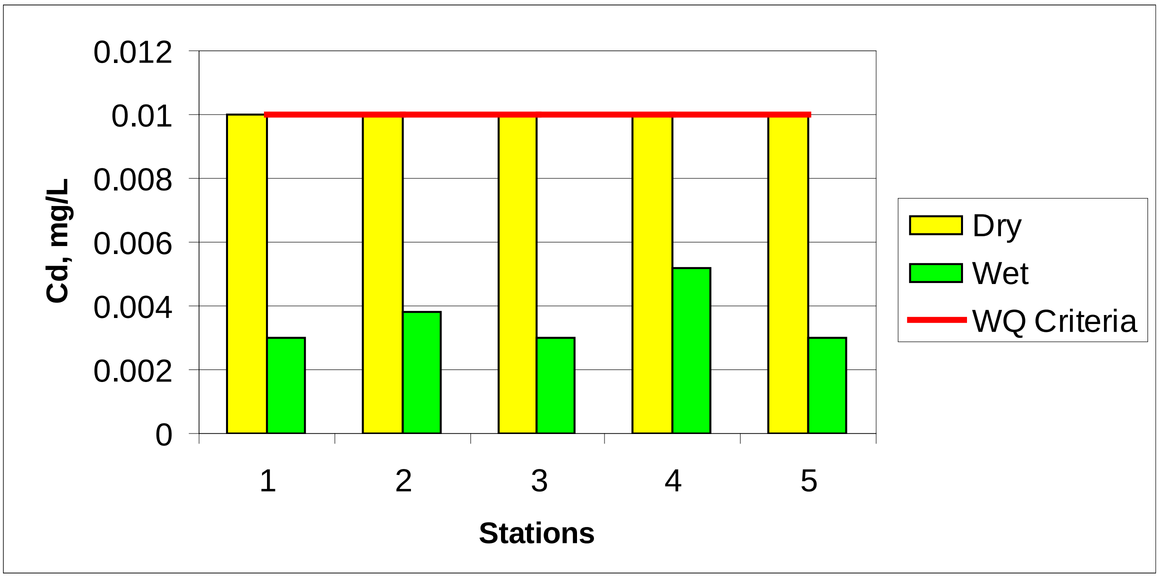



Figure 2p. Cadmium

Lead (Pb) sources are batteries, gasoline, paints, caulking, rubber, and plastics. Lead can cause a variety of neurological disorders. In children, it inhibits brain cell development. Lead also prevents the uptake of iron, so people ingesting lead often exhibit symptoms of anemia including pale skin, fatigue, irritability, and mile headaches. The water quality criteria based on DENR DAO 34 is set at 0.05 mg/L. All the designated stations are within the allowable limit of 0.05 mg/L during the dry season (Table 5 and Figure 2q).

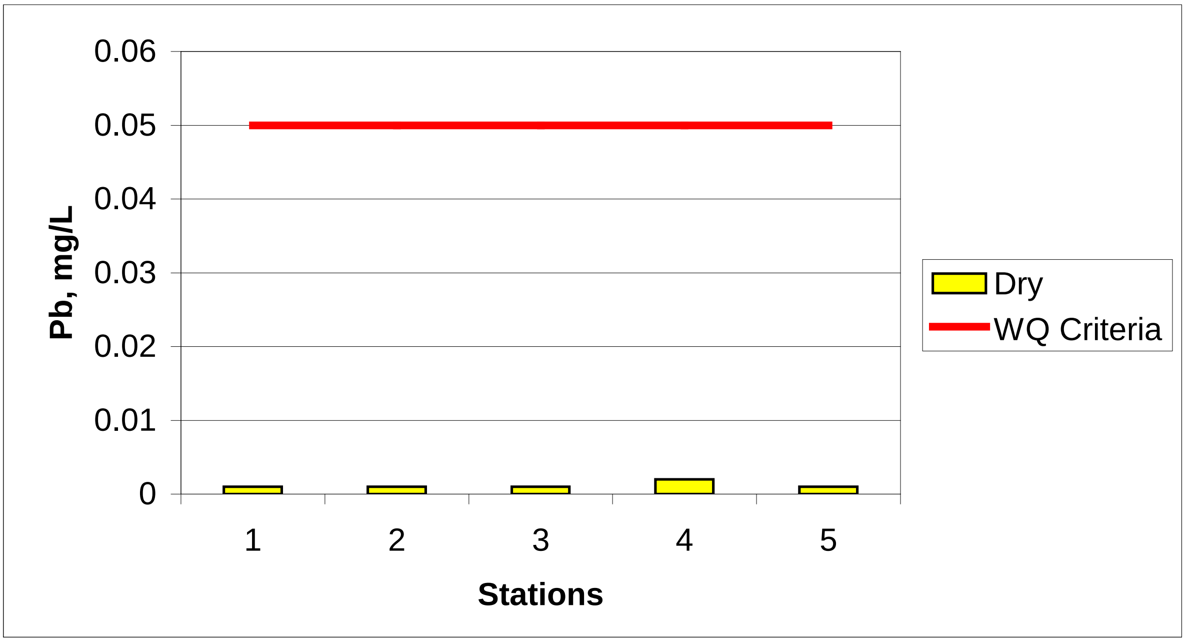



Figure 2o. Lead

### 5.3 Results and Evaluation of Microbiological Analyses

Coliform bacteria are nonpathogenic bacteria that occur in the feces of warm-blooded animals. In polluted water, coliform bacteria are found in densities roughly proportional to the degree of fecal pollution. Coliform organisms are used as indicators of water pollution (Britton G. 1999). Because coliform bacteria are generally hardier than disease-causing bacteria, their presence is indicative that other kinds of microorganisms capable of causing disease may also be present and that the water is potentially unsafe to drink. (Gerba, C.P., et al., 2000). Coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or nonpoint sources of human and animal waste. Coliform bacteria are good indicators of the potential contamination of a water source. These bacteria are used to evaluate the general quality of water.

The results of the microbiological analyses of water samples are presented in Table 6 and Figure 3.

**Table 6. Results of Microbiological Analyses of Water Samples - Dry and Wet Seasons.**

| Stations | Total coliform | | Fecal coliform | | Detection of *E. coli* |
|---|---|---|---|---|---|
| | *Dry Season* | *Wet Season* | *Dry Season* | *Wet Season* | |
| 1 | 3,000,000 | 1,700,000 | 1,700,000 | 400,000 | Present |
| 2 | 160,000 | 330,000 | 160,000 | 330,000 | Present |
| 3 | 160,000 | 1,300,000 | 90,000 | 1,300,000 | Present |
| 4 | 5,000,000 | 14,000,000 | 5,000,000 | 7,000,000 | Present |
| 5 | 3,000,000 | 17,000,000 | 2,400,000 | 4,600,000 | Present |

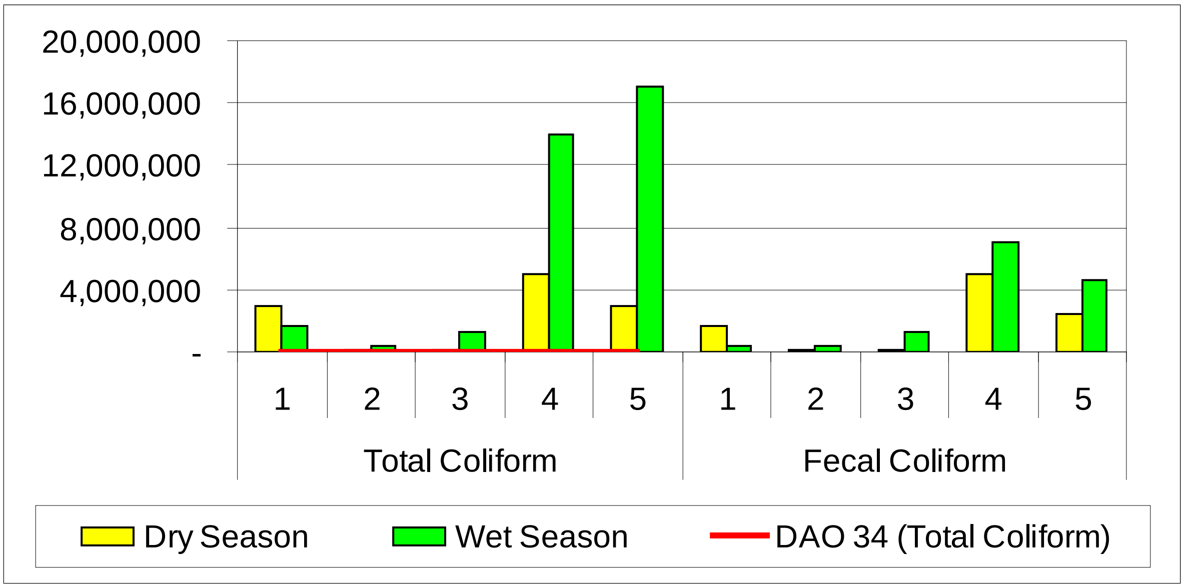



Figure 3. Total and Fecal Coliforms,

Based on the results of analyses, all the five designated stations extremely exceeded the Class C Water Quality Criterion for Total Coliform of 5,000 MPN/100 ml with ranged values of 160,000 to 5,000,000 MPN/100mL during the dry season while 330,000 to 17,000,000 MPN/100 mL during the wet season.

For fecal coliforms, there is no set criterion specified in the Class C Water Quality Criteria, however, their presence of in aquatic environments may indicate that the water has been contaminated with the fecal material of humans or other animals. Measured values for fecal coliforms is remarkably high ranging from 90,000 to 2,400,000 MPN/100 mL in the dry season while 300,000 to 7,000,000 MPN/100 mL in the wet season.

Stations 1, 4 and 5 recorded the highest total and fecal coliforms in both season because these stations have been receiving discharges from slaughterhouse and residential areas. Meanwhile, Stations 2 and 3 recorded lower concentrations mainly because the water is flowing and less garbage were noticeable in both stations.

Results also depict that higher total and fecal coliforms are recorded during the wet season compared to the dry season except for Station 1 (Figure 3). This might be due to run-off during the rainy seasons that flow into drainage leading to the nearby creeks or tributary rivers.

Furthermore, *Escherichia coli*, a gram-negative bacilli and one of the most frequent causes of many common bacterial infections, is present in all the designated stations and during both the sampling periods. Their presence in water can cause disease such as diarrhea, urinary tract infections and other respiratory illness. Presence of *E. coli* is also an indicator, that water is potentially unsafe for drinking water and recreation.

## 5.4 Results and Evaluation of Biological Analyses

Biological assessment has been introduced to fulfill the limitations of the chemical and microbiological assessments. Qualitative and quantitative analysis of different groups of organisms have led to establishment of bioindicators, indices and systems which can be used to assess pollution and trophic status of water bodies. Biological indicators (or bioindicators) are organisms that can provide information regarding the quality of a certain environment. Different species have particular environmental requirements and the changes of water quality influenced the presence and/or absence of particular species (Cairns & Schalie, 1980). Groups of organisms being used as biological indicators are as follows: microorganisms (bacteria, fungi, microalgae, protozoans, rotifers, cladocerans, copepods) and macroorganisms (macrophytes, insects, amphipods, isopods, molluscs, worms, fish) (Hynes, 1960; Sladecek, 1973; Persoone & De Pauw, 1979; Hellawel, 1986).

### a) Phytoplankton

Phytoplankton or algae refers to microscopic aquatic plants used as food for zooplankton and fish in a lake ecosystem. Phytoplankton (algae) are considered as one of the common bioindicators because they are most responsive to nutrient levels in an aquatic environment. Phytoplankton or algae lie at the base of aquatic food webs and therefore occupy a pivotal position at the interface between biological communities and their physico-chemical environment (Lowe and Pan, 1996). Furthermore, benthic algae have short life cycles and can therefore be expected to respond quickly to changes in the environment (McCormick and Stevenson, 1998).

The quantitative and qualitative analysis of phytoplankton in Sapang Baho designated stations revealed that all the designated stations are already polluted being dominated by *Nitzschia sp.* from Division Bacillariophyta in both dry and wet seasons (Table 7, Figures 4a-4b and Annex 1). Richardson (1968) considers *Nitzschia sp.* to be characteristics of originally rich water. *Nitzschia* species reach great abundance in waters high in organic pollution (Spaulding and Edlund, 2009). During the dry season, the peak count was recorded at 3,805,167 organisms/sq.m. or 99.6% of *Nitzschia sp.* in Station 3. *Gomphonema sp.* which according to Dickman (1975) are commonly found in originally polluted water were also present in some stations.

*Fragilaria sp.,* although not clearly signifying bioindicator of water quality, was also present, however, according to William (1969), its presence indicate pollution from sewage. Despite the dominance of the polluted water algae or phytoplankton, clean water algae (*Navicula sp.* and *Pinnularia sp.*) were also present in Stations 2 and 3 in the dry season, while Station 3, 4 and 5 in the wet season.

**Table 7. Summary of Water Quality Assessment based on Phytoplankton (cells/ml) (Dry and Wet seasons).**

| Stations/ Organisms | Location | CWA | PWA | Others | TOTAL | % CWA | % PWA | % Others | WQ Assessment |
|---|---|---|---|---|---|---|---|---|---|
| **Dry season – February 02, 2011** | | | | | | | | | |
| Station 1 | Mouth of Sapang Baho, Cainta | 0 | 5020 | 2008 | 7028 | 0.00 | 71.43 | 28.57 | **Polluted** |
| Station 2 | Village East Subdivision, Cainta | 89558 | 341873 | 861 | 432292 | 20.72 | 79.08 | 0.20 | **Polluted** |
| Station 3 | Hinulugang Taktak National Park, Antipolo | 5382 | 3828489 | 9867 | 3843738 | 0.14 | 99.60 | 0.26 | **Polluted** |
| Station 4 | Brgy. Mayamot, Antipolo | 0 | 32186 | 1110 | 33296 | 0.00 | 99.67 | 3.33 | **Polluted** |
| Station 5 | Boundary of Cainta & Marikina | 0 | 10570 | 1321 | 11891 | 0.00 | 88.89 | 11.11 | **Polluted** |
| **Wet Season August 16, 2011** | | | | | | | | | |
| Station 1 | Mouth of Sapang Baho, Cainta | 0 | 951 | 3805 | 4756 | 0.00 | 20.00 | 80.00 | **Polluted** |
| Station 2 | Village East Subdivision, Cainta | 0 | 20811 | 718 | 21529 | 0.00 | 96.66 | 3.34 | **Polluted** |
| Station 3 | Hinulugang Taktak National Park, Antipolo | 8611 | 38034 | 718 | 47363 | 18.18 | 80.30 | 1.52 | **Polluted** |
| Station 4 | Brgy. Mayamot, Antipolo | 2220 | 24417 | 0 | 26637 | 8.33 | 91.67 | 0.00 | **Polluted** |
| Station 5 | Boundary of Cainta & Marikina | 1163 | 49998 | 1163 | 52324 | 2.22 | 96.55 | 2.22 | **Polluted** |

Note: CWA – Clean Water Algae, PWA – Polluted Water Algae

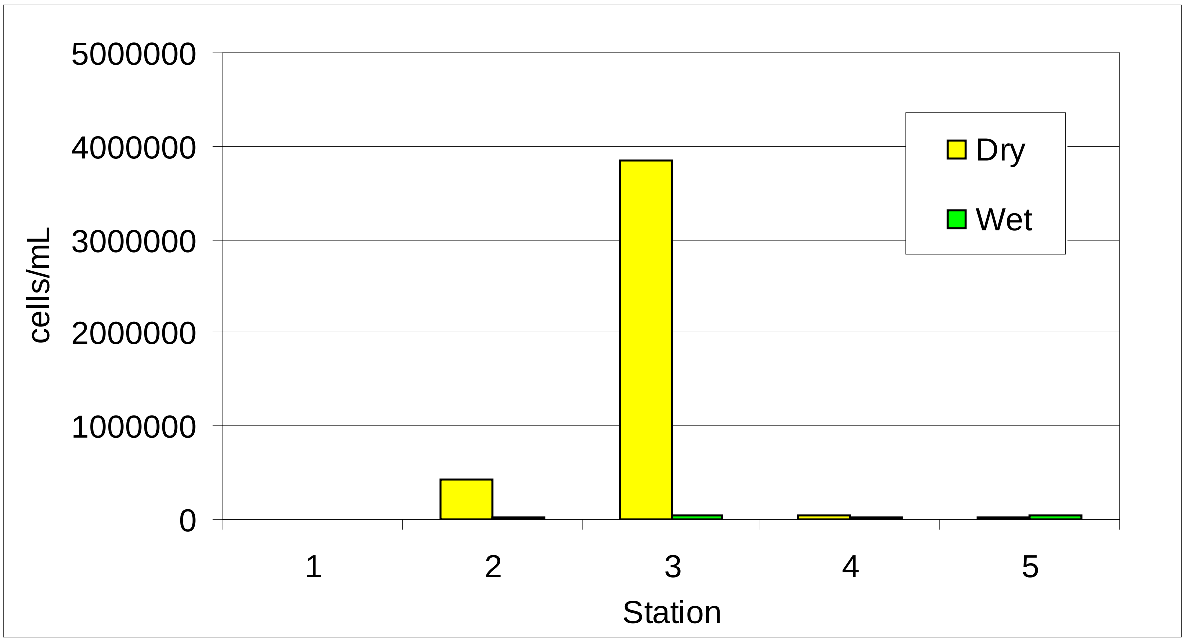



Figure 4a. Water quality assessment based on phytoplankton (Dry and Wet seasons).

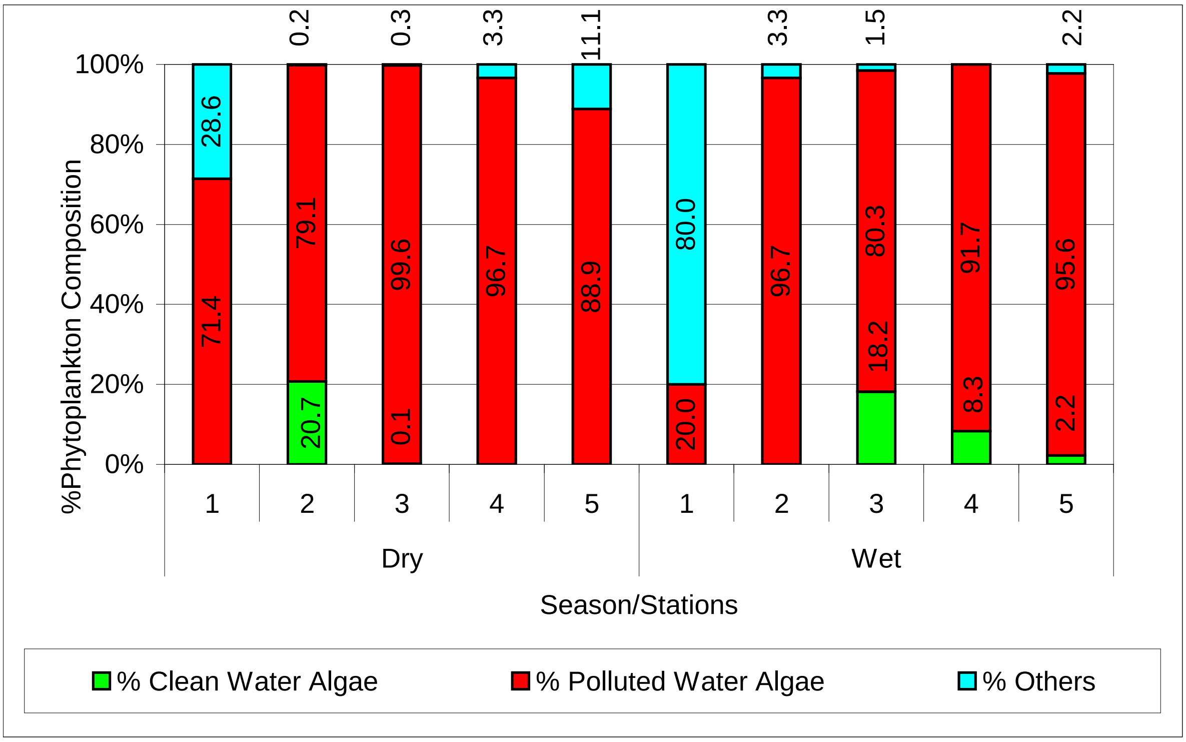



Figure 4b. Percentage composition of phytoplankton (Dry and Wet seasons).

### b) Benthic Macroinvertebrates

Benthic macroinvertebrates are organisms that inhabit the bottom substrates (sediments, debris, logs, macrophytes, filamentous algae, etc.) of the freshwater habitats (Rosenberg & Resh, 1993). These organisms, together with algae, are the most widely used indicators for assessing the quality of freshwater according to a literature survey presented by Hellawell (1986). In reality, benthic macroinvertebrate studies are alone the most widespread biological water quality assessment tools (Metcalfe, 1989; Sladecek *et al.*, 1982; Whitton, 1979; Wiederholm, 1980). Generally, benthic organisms are capable of reflecting anthropogenic perturbations and thus, enable a holistic assessment of aquatic environment. They are the creeping, burrowing, crawling, and swimming animals that feed on organic detritus and benthic algae. This group is represented by different phyla which include insects, mollusks, oligochaetes, ostracods, nematodes and fish juveniles. Studies dealing with their taxonomy and distribution are relatively few and fragmented. Hence, identification of many forms were made up to family and genera levels.

Based on the qualitative and quantitative analysis of benthic macroinvertebrates, the five (5) designated stations portrayed that the water quality is polluted being dominated by Family Chironomidae, Physidae and Naididae (Table 8, Figure 5a-5b and Annex 2a-b).

The organisms belonging to the aforementioned three (3) families of benthic macroinvertebrates are indicator organisms tolerant to organic pollution.

Class Gastropoda belonging mostly to Sub-class Prosobranchia (moderately polluted indicators) were also present mostly in Station 2. Thiaridae belonging to sub-class Prosobranchia of Class Gastropoda are gill-breathing snails derived from marine ancestors. Because prosobranchs depend on oxygen dissolved in the water for respiration, they are intolerant of sites where dissolved oxygen is scarce, such as sites of organic pollution.

**Table 8. Summary of Water Quality Assessment based on Benthic Macroinvertebrates (org./sq.m.) (Dry Season – February 02, 2011).**

| Stations | *Location* | **Total CWI** | **Total MPWI** | **Total PWI** | **Total Others** | TOTAL | % CWI | % MPWI | % PWI | % Others | WQ Assessment |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dry Season – February 02, 2011** | | | | | | | | | | | |
| Station 1 | Mouth of Sapang Baho, Cainta | 0 | 0 | 16 | 0 | 16 | 0 | 0 | 100.00 | 0.00 | **Polluted** |
| Station 2 | Village East Subdivision, Cainta | 0 | 377 | 1666 | 0 | 2043 | 0.00 | 18.45 | 81.55 | 0.00 | **Polluted** |
| Station 3 | Hinulugang Taktak National Park, Antipolo | 67 | 11 | 16110 | 0 | 16188 | 0.41 | 0.07 | 99.52 | 0.00 | **Polluted** |
| Station 4 | Brgy. Mayamot, Antipolo | 0 | 80 | 114 | 0 | 194 | 0.00 | 41.24 | 58.76 | 0.00 | **Polluted** |
| Station 5 | Boundary of Cainta & Marikina | 0 | 191 | 381 | 48 | 620 | 0.00 | 30.81 | 61.45 | 7.74 | **Polluted** |
| **Wet Season – August 16, 2011** | | | | | | | | | | | |
| Station 1 | Mouth of Sapang Baho, Cainta | 0 | 48 | 333 | 0 | 381 | 0.00 | 12.60 | 87.40 | 0.00 | **Polluted** |
| Station 2 | Village East Subdivision, Cainta | 22 | 33 | 55 | 0 | 110 | 20.00 | 30.00 | 50.00 | 0.00 | **Polluted** |
| Station 3 | Hinulugang Taktak National Park, Antipolo | 80 | 0 | 805 | 0 | 894 | 9.96 | 0.00 | 90.04 | 0.00 | **Polluted** |
| Station 4 | Brgy. Mayamot, Antipolo | 0 | 0 | 95 | 0 | 95 | 0.00 | 0.00 | 100.00 | 0.00 | **Polluted** |
| Station 5 | Boundary of Cainta & Marikina | 0 | 0 | 95 | 0 | 95 | 0.00 | 0.00 | 100.00 | 0.00 | **Polluted** |

Note : CWI – Clean Water Indicator, MPWI – Moderately Polluted Water Indicator, PWI – Polluted Water Indicator

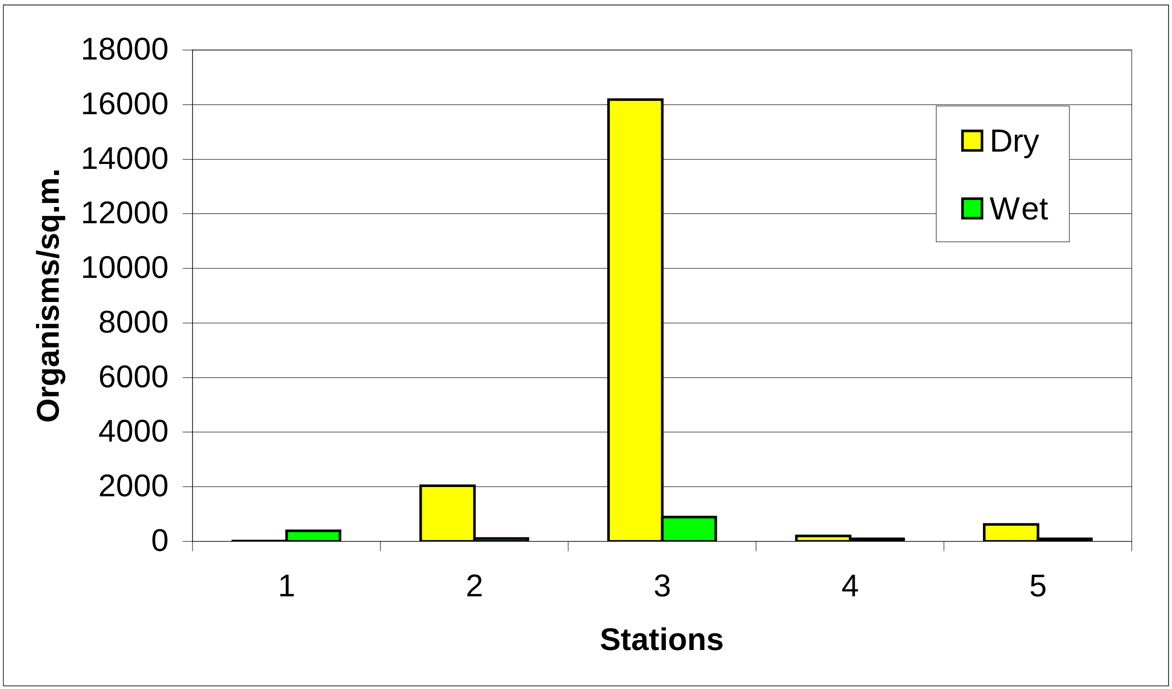
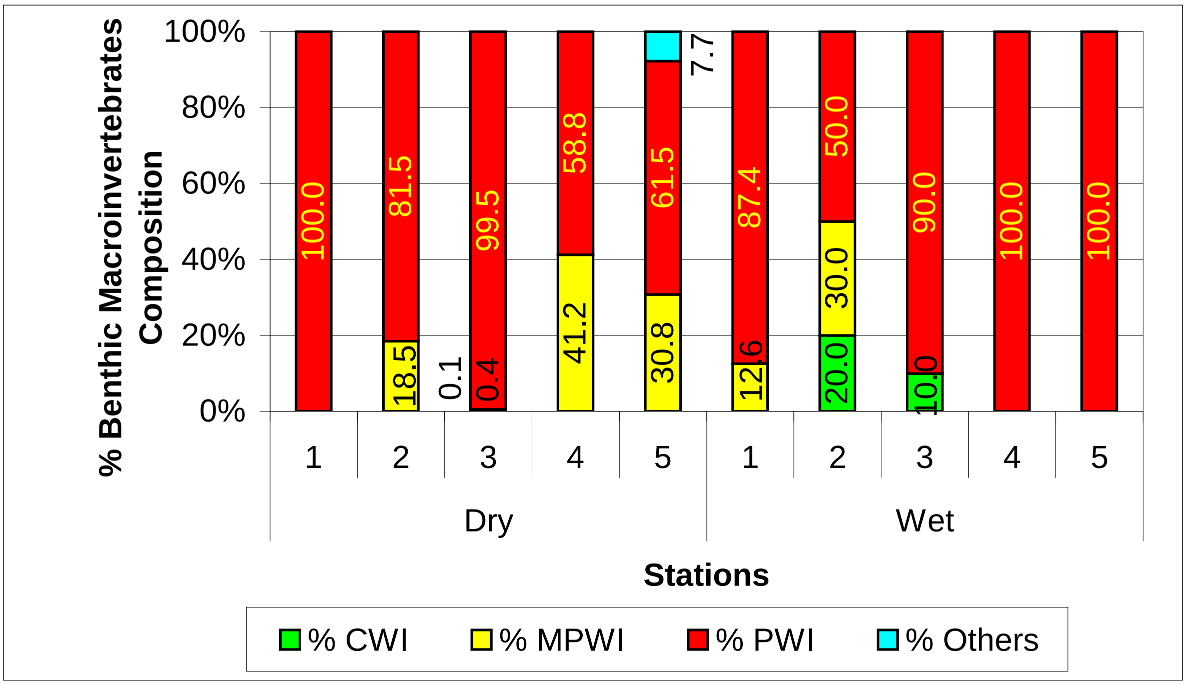



Figure 5a. Water quality assessment based on benthic macroinvertebrates (Dry and Wet seasons).




*Note: CW – Clean Water Indicator, MPWI – Moderately Polluted Water Indicator, PWI – Polluted Water Indicator*

Figure 5b. Water quality assessment based on benthic macroinvertebrates (Dry and Wet seasons).

## 6.0 CONCLUSIONS

Based on physico-chemical, microbiological and biological assessments of the Sapang Baho River, it generally signifies that there is input of organic pollution both from domestic solid and liquid wastes. Solid wastes (garbage) were very visible in all the stations.

Assessment of the water quality based on the physico-chemical analyses depicts that all the five (5) stations have been receiving organic pollution. Stations 1, 4 and 5, manifested elevated levels of BOD, $IPO_4$ and low dissolved oxygen levels (exceeding the allowable limits based on Class C Water Quality Criteria), which are significant considerations of input of organic pollution in Sapang Baho river. However, Stations 2 and 3 portrayed slight exceedance in the 3 aforementioned parameters mainly because the water in both stations were flowing and less garbage is present in both stations. Parameters like pH, total dissolved solids, nitrates, chloride and heavy metals (Cadmiun and Lead) were within the allowable limits based on Class C Water Quality Criteria. Other parameters could not be assessed due to lack of allowable limits based on DAO 34.

Based on the results of microbiological analysis, all the five designated stations extremely exceeded the Class C Criterion for Total Coliform of 5,000 MPN/100 ml in both seasons. Station 4 and 5 recorded the highest total and fecal coliforms in both season because both stations have been receiving discharges from slaughterhouse and residential areas. The presence of *Escherichia coli* in all stations is also an indicator making water potentially unsafe for drinking water and recreation.

Likewise, biological assessment of water quality were based on presence of biological indicators in terms of phytoplankton and benthic macroinvertebrates. *Nitzschia sp.* from Division Bacillariophyto, a polluted water algae dominated in all the stations, while *Gomphonema sp*. from Division Bacillariophyta and *Oscillatoria sp*. from Division Cyanophyta, also polluted water algae, were also present in some stations. Family Chironomidae and Naididae (polluted water benthic macroinvertebrate) were also dominant. Likewise, there is also presence of Family Physidae (also polluted water indicator) in some of the stations. Although in minimum counts, presence of clean water indicators (from Order Ephemeroptera, Trichoptera and Plecoptera) and moderately polluted water indicators (Class Gastropoda) were also evident in stations (Stations 2 and 3) wherein the dissolved oxygen concentrations were within the allowable limits based on DAO 34.

## 7. RECOMMENDATIONS

Water quality assessment in terms of physico-chemical, microbiological and biological analyses signifies alarming input of pollution in Sapang Baho River. Sapang Baho River is hereby recommended for clean-up and rehabilitation. There should be joint and committed efforts not only by the environmental agencies like LLDA but also the communities headed by the Local Government Units (particularly Cainta, Antipolo and Marikina cities). LLDA should improve and strengthen their compliance monitoring program for the industries as potential pollution sources and likewise LLDA should require participation of all the industries within the vicinities of the Sapang Baho River. Furthermore, the Education and Information Campaign (EIC) programs for the communities should be given priority by the LLDA and LGUs. There must be active participation of the River Councils and Environmental Army, giving emphasis on the solid and liquid waste management because these have been the major causes of pollution in Sapang Baho River.

The General Manager of LLDA, Sec. Juan Romeo Nereus O. Acosta gives meaning to LLDA as “Loving the Lake Demands Action”. This is an exact statement that to preserve the lake demands actions by the government and the community and should start from the rehabilitation of all the tributary rivers to Laguna de Bay.

## 8. ACKNOWLEDGMENT

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**Annex1a. Results of Quantitative and Qualitative Analyses of Phytoplankton (Phytoplankton Counts, organisms/sq.m.) (Dry Season).**

**Date of Sampling – February 02, 2011.**

| **Organisms** | **Stations** | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| **Clean water indicator** | | | | | |
| Division Bacillariophyta | | | | | |
| *Navicula sp.* | | 74919 | | | |
| *Pinnularia sp.* | | 14639 | 5382 | | |
| **Sub-total** | **0** | **89558** | **5382** | **0** | **0** |
| **Polluted Water Indicator** | | | | | |
| Division Cyanophyta | | | | | |
| *Oscillatoria sp.* | | 60280 | 16146 | 15538 | 5285 |
| Division Bacillariophyta | | | | | |
| *Gomphonema sp.* | 2008 | 1722 | 7176 | | |
| *Nitzchia sp.* | 3012 | 279871 | 3805167 | 16648 | 5285 |
| **Sub-total** | **5020** | **341873** | **3828489** | **32186** | **10570** |
| **Others** | | | | | |
| Division Bacillariophyta | | | | | |
| *Eunotia sp.* | 1004 | | | | |
| *Fragilaria sp.* | | 861 | 9867 | | |
| *Stauroneis sp.* | | | | | 1321 |
| *Synedra sp.* | 1004 | | | 1110 | |
| **Sub-total** | **2008** | **861** | **9867** | **1110** | **1321** |
| **TOTAL** | **7028** | **432292** | **3843738** | **33296** | **11891** |

**Annex 1b. Results of Quantitative and Qualitative Analyses of Phytoplankton (Phytoplankton Counts, organisms/sq.m.) (Wet Season).**

**Date of Sampling – August 16, 2011.**

| **Organisms** | **Stations** | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| **Clean water indicator** | | | | | |
| Division Bacillariophyta | | | | | |
| *Navicula sp.* | | | 1435 | 1110 | |
| *Pinnularia sp.* | | | 7176 | 1110 | 1163 |
| **Sub-total** | **0** | **0** | **8611** | **2220** | **1163** |
| **Polluted Water Indicator** | | | | | |
| Division Cyanophyta | | | | | |
| *Oscillatoria sp.* | | 1435 | 7894 | | 34882 |
| Division Bacillariophyta | | | | | |
| *Gomphonema sp.* | | | 1435 | | |
| *Nitzchia sp.* | 951 | 19376 | 28705 | 24417 | 15116 |
| **Sub-total** | **951** | **20811** | **38034** | **24417** | **49998** |
| **Others** | | | | | |
| Division Chlorophyta | | | | | |
| *Selenastrum sp.* | | 718 | | | |
| Division Bacillariophyta | | | | | |
| *Melosira sp.* | 3805 | | | | |
| *Rhopalodia sp.* | | | 718 | | |
| *Synedra sp.* | | | | | 1163 |
| **Sub-total** | **3805** | **718** | **718** | **0** | **1163** |
| **TOTAL** | **4756** | **21529** | **47363** | **26637** | **52324** |

**Annex 2a. Results of Quantitative and Qualitative Analysis of Benthic Macroinvertebrates (organisms/sq.m.) (Dry Season).**

**Date of Sampling – February 02, 2011.**

| Organisms | Stations | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| **Clean Water Indicator** | | | | | |
| Class Insecta | | | | | |
| Order Ephemeroptera | | | | | |
| Family Baetidae | | | | | |
| *Baetis bicaudatus* | | | 67 | | |
| **Total CWI** | **0** | **0** | **67** | **0** | **0** |
| **Moderately Polluted Indicator** | | | | | |
| Class Gastropoda | | | | 48 | 48 |
| Family Thiaridae | | | | 32 | |
| *Tarebia granifera* | | 133 | | | |
| *Thiara scabra* | | 100 | | | |
| *Melanoides tuberculatus* | | 100 | 11 | | |
| Family Viviparidae | | | | | |
| *Viviparus viviparus* | | 11 | | | |
| Family Pleuroceridae | | | | | |
| *Brotia costulata* | | 22 | | | |
| Family Ampulariidae | | | | | |
| *Pomacea sp.* | | 11 | | | |
| Family Lymnaeidae | | | | | |
| *Lymnaea sp.* | | | | | 143 |
| **Total MPWI** | **0** | **377** | **11** | **80** | **191** |
| **Polluted Water Indicator** | | | | | |
| Class Gastropoda | | | | 48 | 48 |
| Family Physidae | | | | | |
| *Physa sp.* | | | | | 333 |
| Class Insecta | | | | | |
| Order Diptera | | | | | |
| Family Chironomidae | | | | | |
| *Chironomus sp. (larva)* | | 567 | 10911 | 48 | |
| *Chironomus sp. (pupa)* | | | 1822 | | |
| chironomid (adult stage) | | | 233 | | |
| chironomid (larva) | | 1044 | 2889 | | |
| chironomid (pupa) | | 44 | | | |
| Family Ceratopogonidae | | | | | |
| ceratopogonid larva | | | 11 | | |
| Class Oligochaeta | 16 | 11 | 244 | 48 | |
| Family Naididae | | | 200 | | |
| **Total PWI** | **16** | **1666** | **16110** | **144** | **381** |
| **Others** | | | | | |
| Class Crustacea | | | | | |
| Order Ostracoda | | | | | |
| Family Cyprididae | | | | | |
| *Cypricercus cypricercus* | | | | | 48 |
| **Total Others** | **0** | **0** | **0** | **0** | **48** |
| **GRAND TOTAL** | **16** | **2043** | **16188** | **224** | **620** |

**Annex 2b. Results of Quantitative and Qualitative Analysis of Benthic Macroinvertebrates (organisms/sq.m.) (Wet Season).**

**Date of Sampling – August 16, 2011.**

| Organisms | Stations | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| **Clean Water Indicator** | | | | | |
| Class Insecta | | | | | |
| Order Trichoptera | | | | | |
| Family Hydropsychidae | | | | | |
| *Hydropsyche* | | 22 | | | |
| Orde Plecoptera | | | 89 | | |
| **Total CWI** | **0** | **22** | **89** | **0** | |
| **Moderately Polluted Indicator** | | | | | |
| Class Gastropoda | | | | | |
| Family Thiaridae | | | | | |
| *Thiara scabra* | | 11 | | | |
| *Thiara sp.* | 48 | 11 | | | |
| Family Viviparidae | | | | | |
| *Viviparus viviparus* | | 11 | | | |
| **Total MPWI** | **48** | **33** | **0** | **0** | |
| **Polluted Water Indicator** | | | | | |
| Class Gastropoda | | | | | |
| Family Physidae | | | | | |
| *Physa sp.* | 333 | | 11 | | |
| Class Insecta | | | | | |
| Order Diptera | | | | | |
| Family Chironomidae | | | | | |
| *Chironomus sp. (larva)* | | | 189 | | |
| chironomid (adult stage) | | | 33 | | |
| chironomid (larva) | | | 283 | 95 | |
| chironomid (pupa) | | 11 | 289 | | |
| Class Oligochaeta | | | | | 95 |
| Sub-class Hirudinea | | 22 | | | |
| Family Naididae | | 22 | | | |
| | | | | | |
| **Total PWI** | **333** | **55** | **805** | **95** | **95** |
| **GRAND TOTAL** | **381** | **110** | **894** | **95** | **95** |