

WATER QUALITY AND MICROBIOLOGY OF COASTAL WATER, BORACAY ISLAND, 2012

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The data to be presented are taken from the results of the study done by

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- Presently working at the Management Services Division, PENRO Guimaras, DENR, Guimaras, Western Visayas

Research was funded by DOST and by Boracay Foundation Inc. (an association of businessmen, owners/ operators of resorts in Boracay – old timers)

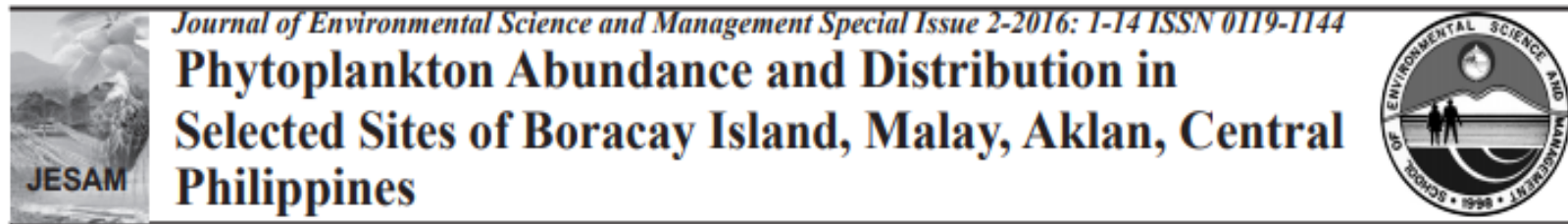
- Results of the research were immediately presented to LGU Malay and DENR Region 6 (May, 2013)



Two articles from her research were published in JESAM in 2016 –

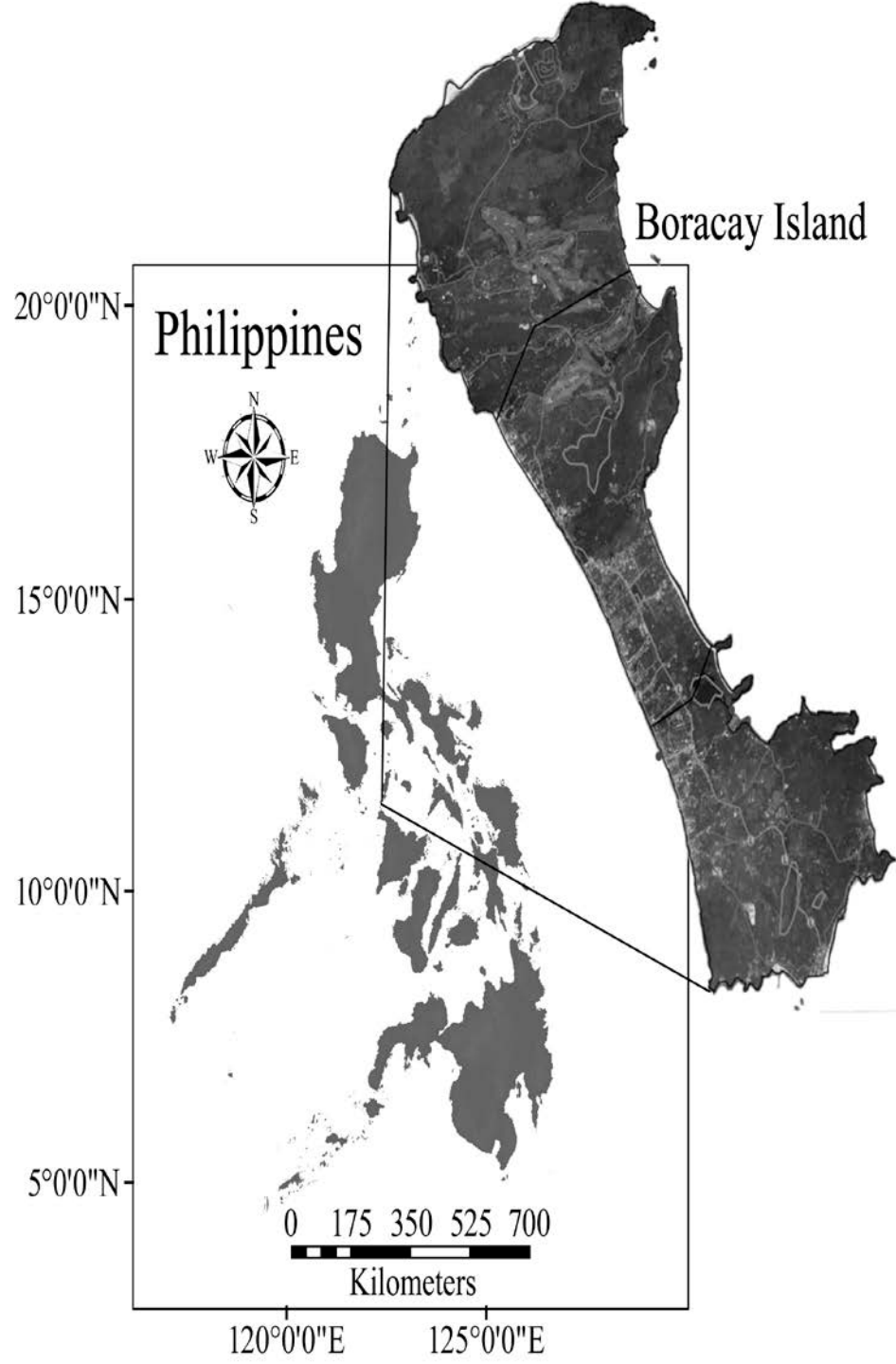


Limates, V. G., Cuevas, V. C. and E. A. Benigno



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Introduction

- Island measures 6.8 km by 3.3 km at its widest distance,
 - elevation, 50 - 105 m above average sea level
 - has thin layer of Karstic topsoil covering coralline limestone;
 - porous - domestic wastes and effluents can easily penetrate and cause contamination of both the groundwater and the coastal waters
- Rapid population growth, unplanned developments, irresponsible tourism activities,
- reclamation of mangrove areas are some of the major reasons of the degradation



Situation in the Island as of 2012

From LGU – Malay

340 resorts, hotels, cottages, lodging houses, apartments

Big hotels and resorts – have their own STP = Sewerage treatment plants

77 were conducting monthly desludging activity – with DENR permit

Mangrove swamp no. 6 – occupied by informal settlers (migrants) with no sewerage facilities

- improper solid waste management practices, made the mangrove swamps as liquid and solid waste catchment areas of informal settlers



Boracay Island Water Corporation (BIWC) –
operates and manages the sewerage system

Records of BIWC

Balabag village - 28 commercial establishments and
34 residential buildings were not connected to the
sewerage system

only 167 houses in Balabag and Manoc-manoc were
connected

one big resort in Yapak Village within the reach of
the sewerage system was not also connected



Yapak Village – houses have septic tanks

- septic tanks in the Island do not have a properly constructed seepage tile to further purify the effluents
- high population density areas during peak tourist season may cause overflow of septic tanks,
- grey water of residents of these establishments not connected to the sewerage system

discharged to the ground, mangrove swamps or septic tanks and some directly to the drainage canal

- Literature shows as early as 1996, there was already nutrient overloading in coastal water of the island.



7 sampling sites – bi monthly sampling Feb. 2012 – Dec. 2012 – 6 sampling periods

selection of sites based on: type of adjacent land use, - mangrove swamp condition - presence of households, commercial establishments connected or not connected to the sewerage system

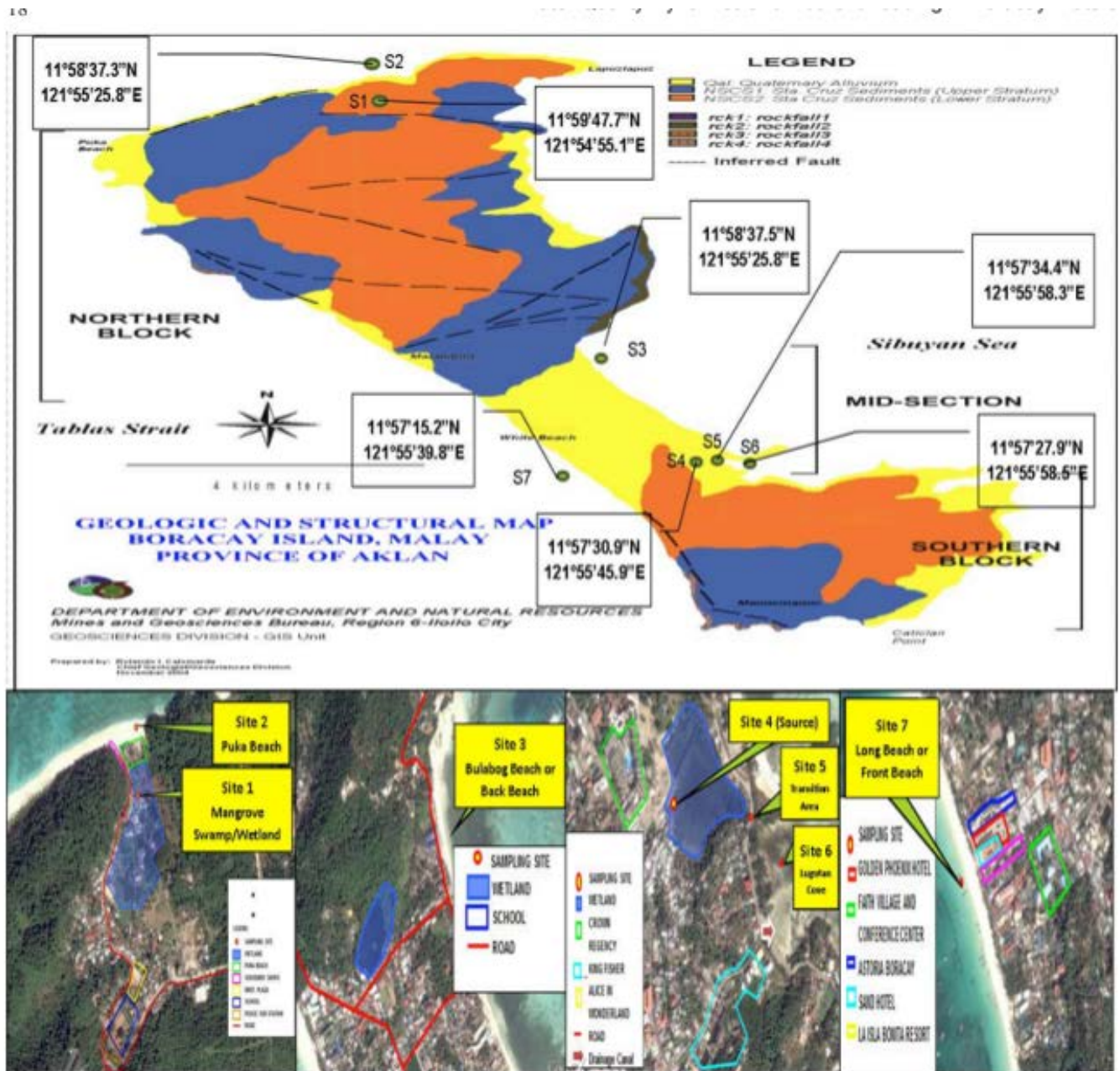


Figure 2. Geologic and structural map of Boracay Island, Malay, Aklan reflecting the seven study sites, (2012).

LOCATION	STUDY SITES FOR THE COASTAL WATER QUALITY ASSESSMENT
1.) Brgy. Yapak	Mangrove swamp 1 (Site 1) and Puka Beach (Site 2)
2) Brgy. Manoc-manoc	Mangrove Swamp 6 (Site 4), transition (Site 5), and Lugotan Cove (Site 6)
3) Brgy. Balabag	Mangrove swamp 6 (Site 4)
4) Long Beach (Brgy. Manoc-manoc and Brgy. Balabag)	Front Beach (Site 7)
5) Bulabog Beach (Brgy. Balabag)	Back Beach (Site 3)



Table 1. Summary of the salient features of the seven study sites in Boracay Island, (2012).

Study Sites	Descriptions	Salient Features
Study Site 1	<p>Mangrove swamp 1 as referred in this study.</p> <p>This is wetland 1 per DENR 6-Survey of wetland areas in Boracay Island.</p>	<p>Adjacent to Puka Beach, Brgy. Yapak</p> <p>Area = 5.31 ha</p> <p>Approximately 49% (2.58 has) of the mangrove swamp was converted into residential areas</p> <p>Approximately 51% (2.73 has) was still covered by mangrove trees</p>
Study Site 2	<p>Referred as “Source” in this study</p> <p>Puka Beach located in Yapak Village.</p>	<p>Adjacent to mangrove swamp 1</p> <p>Named after “puka” shells abundantly found on the beach. No houses and big resorts immediately adjacent to the beach.</p>
Study Site 3	<p>Bulabog Beach located in Balabag Village</p> <p>Also called the back beach</p>	<p>Covered with vast area of seagrass beds</p> <p>Discharge area of two drainage outfalls of Balabag Village and Manoc-manoc Village.</p> <p>BIWC outfall of treated sewage, 850- m away from the beach. Docking area of boats.</p>
Study Site 4	<p>Referred to as “Source” in this study</p> <p>Mangrove swamp 6 per DENR 6, Survey of wetland areas in Boracay Island</p>	<p>An abandoned fishpond area</p> <p>Approximate area of 3.70 has, 10% of the area is covered with mangroves</p> <p>A creek is discharging to the wetlands.</p> <p>Commonly called by the local people as Dead Forest - impoverished of mangrove trees.</p>
Study Site 5	<p>Referred to as “Transition Area” in this study, located in Balabag Village</p>	<p>Fishpond dike under the bridge</p> <p>Exit and entrance of water from the mangrove swamp 6 during low tide and entrance of sea water during high tide</p>
Study Site 6	<p>Lugotan Cove, located in Manoc-manoc Village. Referred to as the repository area of waters from mangrove swamp 6</p>	<p>It is an embayment. Mangrove forest lined the mouth area of the cove.</p> <p>Approximately covered by 3 hectares of seagrass bed</p> <p>Outfall of drainage canal of Manoc-manoc Village</p>
Study Site 7	<p>Long Beach</p>	<p>4- km fine white sand starting from Angol Point in Manoc-manoc to Fridays area in Yapak Village</p> <p>Divided into 3 stations (1, 2, and 3).</p> <p>Frequently visited by tourists. Most populated portion of Boracay Island</p>

Table 2. Summary of parameters analyzed for coastal water quality in Boracay Island, 2012.

Parameters	Method	Reference or Manufacturer
Nitrate (mgL ⁻¹)	Closed Reflux Cell Test	MERCK
Phosphate (mgL ⁻¹)	Closed Reflux Cell Test	MERCK
BOD (mgL ⁻¹)	Respirometric	5210 B 5-Day BOD Test ,APHA AWWA, Standard Method for the examination of water and waste water
DO (mgL ⁻¹)	Glass Electrode	4500-O D, APHA AWWA, Standard Method for the examination of water and waste water
TSS (mgL ⁻¹)	Gravimetric Method	2540 D, APHA AWWA, Standard Method for the examination of water and waste water
pH (range)	Electrometric	4500-H ⁺ ,APHA AWWA, Standard Method for the examination of water and waste water
Temperature (°C)	Mercury-filled Thermometer	2550 B, APHA AWWA, Standard Method for the examination of water and waste water
<i>E. coli</i> (CFU mL ⁻¹)	Petrifilm	3M Microbiology Products
Total Coliform CFU ml ⁻¹)	Petrifilm	3M Microbiology Products
NPK of coastal sediment (OM-%; P-ppm; K-ppm)	OM SA Wildes, P – Olsen’s Method K- Cold H ₂ SO ₄	PCARR, 1980. Standard Methods of Analysis of Soil, Plant Tissue, Water and Fertilizer.

Phytoplankton population in 4 sites



Salient findings:

Boracay Coastal water – highly eutrophic

Standard – nitrate N $>1.9 \text{ mgL}^{-1}$ – eutrophic – US - Europe

DENR – 7 mgL^{-1}

Results – Nitrate N = 1- 8 mgL^{-1}

Lugotan cove – site 6 - nitrate N – 8 mgL^{-1} in April and Sept;

Site 4 – Dead forest and site 5 registered 6 mgL^{-1}

Long Beach – site 7 – had 6 mgL^{-1} in April

Phosphate – Standard - $> 0.1 \text{ mgL}^{-1}$ – accelerates eutrophication

DENR standard – 0.5 mg L^{-1}

Registered - up to 99.0 mgL^{-1} (Long Beach – Site 7)



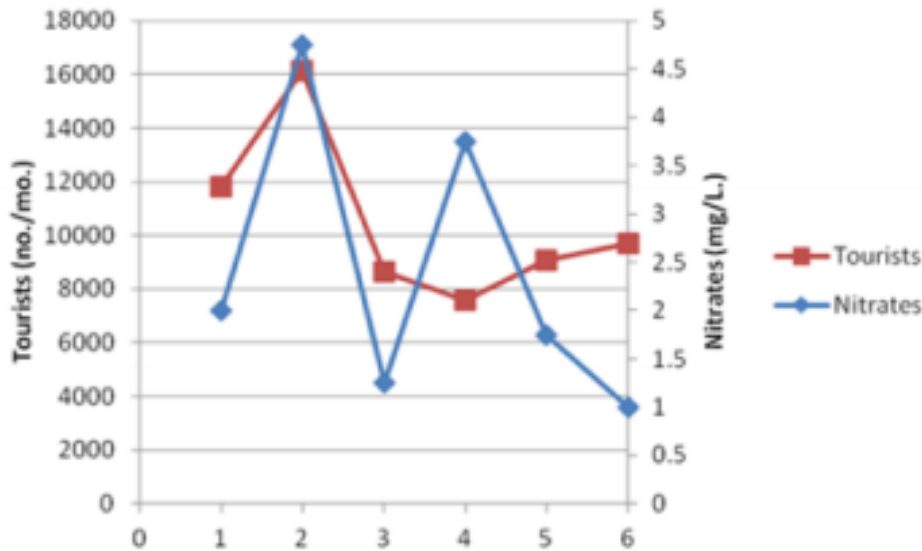


Figure 6. Relationship of tourist arrivals with nitrates level in water column (1- February 29, 2-April 27, 3-June 27, 4-September 4, 5-October 18, and 6-December 19).

High levels of N and P in the coastal water occur during peaks of tourist arrivals.

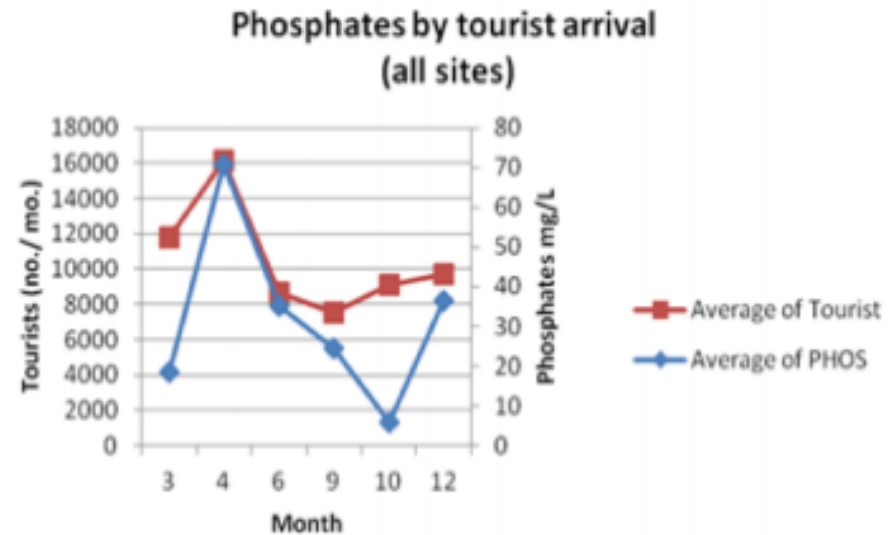


Figure 7. Relationship of tourist arrivals with phosphates level in water column (1- February 29, 2-April 27, 3-June 27, 4-September 4, 5-October 18, and 6-December 19).

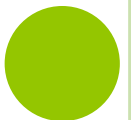
- “Dead Forest” or Mangrove Swamp 6, lowest DO - April
- months of April, February and September 2012 with readings of 0.7 mg L⁻¹, 1.5 mg L⁻¹ , and 3.39 mg L⁻¹
 - served as the catchment area of surface water, ground water, and sewage from adjacent communities within and around the mangrove swamp
 - at its elevated portion located are:
 - wet market, stores, restaurants/eatery, pawnshop/jewelry shops, parlor and salons
 - All are not connected to a sewerage system,
 - their waste waters drain into the swamp via the creek
 - Organic matter used up the O₂ in water; conversely there was high BOD during months of Feb and April



Lugotan cove and high nitrate level

presence of two sewage canals servicing the houses, small restaurants and establishments in Barangay Manoc manoc

- voluminous waste water and sewage discharged by informal settlers within and adjacent the dead forest



Coastal *E. coli* was higher in dry season than in the wet season

- less dilution and dissipation of polluted water during this time
- highest recorded *E. coli* was observed in the month of April, the month with the highest tourist arrival
- septic tanks may have overflowed
- the flow of the untreated sewage from residential houses and business establishments not connected with the sewerage system may have increased during this period

35/100mL in marine water – EPA; DENR – 100 MPN/100 mL

Salmonella was also detected in Lugotan cove and Dead Forest during these months



Table 4. Water Quality Results (Dissolved Oxygen (DO), Biological Oxygen Demand (BOD, Nitrate, phosphate, Total Suspended Solids (TSS), pH, and Temperature in Seven Sampling Sites at Six Sampling Periods in Boracay Island, (2012).

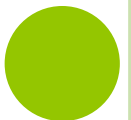
Water Quality Indicators	Date of Water Sampling	Site 1 (Mangrove Swamp - 49% mangrove cover)	Site 2 (Puka Beach)	Site 3 (Bulabog Beach-Front Beach)	Site 4 (tree-impooverished mangrove swamp)	Site 5 (Transition area bet site 4 and 6)	Site 6 (Lugotan Cove)	Site 7 (Long Beach-Front Beach)
DO (mg L ⁻¹)	February 12, 2016	6.74	7.68	7.73	1.59	6.58	8.08	7.99
BOD (mg L ⁻¹)		50	20	50	150	100	100	20
Nitrate (mg L ⁻¹)		3	3	1	5	3	1	2
Phosphate (mg L ⁻¹)		59	0.8	34.3	25.6	62	63.5	20.5
TSS (mg L ⁻¹)		799	458	455	292	315	365	480
pH		7.05	6.89	8.12	7.82	8.07	8.11	6.82
Temperature		26.8	28.8	27	28.5	27.5	27.5	29
DO (mg L ⁻¹)	April 27, 2012	7.14	7.98	7.49	0.07	6.55	6.19	7.19
BOD (mg L ⁻¹)		30	10	10	250	40	20	20
Nitrate (mg L ⁻¹)		3	2	3	2	6	8	6
Phosphate (mg L ⁻¹)		3.7	32.6	79	61.9	36.9	72.5	99.1
TSS (mg L ⁻¹)		153	483	427	206	313	354	488
pH		7.34	8.13	7.76	7.59	8.11	8.08	9.07
Temperature		31	28	30	31	31	30.5	30
DO (mg L ⁻¹)	June 27, 2012	6.8	8.38	7.23	6.28	6.48	4.98	8.03
BOD (mg L ⁻¹)		100	20	20	100	20	20	20
Nitrate (mg L ⁻¹)		1	3	1	2	1	1	0
Phosphate (mg L ⁻¹)		14.7	19.3	21.1	20.8	34.3	16.9	83.6
TSS (mg L ⁻¹)		77	479	477	290	461	463	486
pH		7.77	7.97	7.84	7.98	7.92	7.82	8.04
Temperature		29.5	29	29	30	29	29	28.5
DO (mg L ⁻¹)	September 4, 2012	7.70	5.29	6.53	3.39	6.10	7.39	9.70
BOD (mg L ⁻¹)		5	9	3	16	8	8	2
Nitrate (mg L ⁻¹)		3	1	3	6	6	8	3
Phosphate (mg L ⁻¹)		13.8	27.5	10.6	18.4	0	36.3	23.3
TSS (mg L ⁻¹)		435	33	25	456	405	430	402
pH		7.83	8.05	7.95	8.20	8.26	8.08	7.50
Temperature		29	29	29	29	29	28	28

Temperature		27	27	27	27	27	28	28
DO (mg L ⁻¹)	October 18, 2012	7.74	8.89	6.93	6.19	6.12	7.48	7.59
BOD (mg L ⁻¹)		5	0	2	15	8	11	5
Nitrate (mg L ⁻¹)		3	2	2	2	3	2	1
Phosphate (mg L ⁻¹)		5.1	11.3	1.1	11.3	4.6	2.8	8.6
TSS (mg L ⁻¹)		64	451	465	234	296	319	315
pH		7.45	8.16	7.84	8.26	8.01	8.19	8.16
Temperature		30	30	29.5	30	29	29	29
DO (mg L ⁻¹)		December 19, 2012	4.29	8.15	8.22	8.86	10.46	11.06
BOD (mg L ⁻¹)	11		6	4	26	18	19	3
Nitrate (mg L ⁻¹)	1		1	1	2	2	1	1
Phosphate (mg L ⁻¹)	66.5		66.7	3.4	57.3	38.7	72.5	2.8
TSS (mg L ⁻¹)	194		472	550	448	467	482	458
pH	7.44		8.09	8.02	8.35	8.48	8.63	8.15
Temperature	28		28	28	30	29	29	28



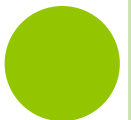
Monitoring of phytoplankton population in the coastal water showed:

- Diatoms dominate the phytoplankton community
- Community composition changes with sampling time as a response to nutrient dynamics and other environmental factors
- presence of fast-growing centric diatoms like *Chaetoceros* and *Rhizosolenia* over pennates diatoms
- could be an indicator of stressed environment



Trichodesmium – a marine nitrogen fixer sensitive to level of nitrate N

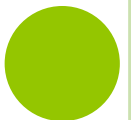
- growth plateau of this organism has reached K or carrying capacity
- indication that the island ecosystem is near its ecological thresholds
- data also showed that nitrate is the limiting nutrient factor
- level of nitrate in the water column controlled the growth of *Trichodesmium* and the phytoplankton genera diversity



Phytoplankton genera increased with the decreasing trend of BOD

Low BOD meant less amount of organic matter in coastal water which implied reduced inputs of waste water particularly sewage.

- Greater diversity – Sept, Oct, Dec;
- lower number of genera – Feb, March, April,
- Macro green algal bloom in April indicates high concentration of nutrients;
- presence of profuse epiphytes on species of seagrass like *Enhalus acoroides* may also signify unhealthy seagrass condition-



Result of Water Quality Sampling

Water Quality Parameters Failed	EQUIVALENT DESCRIPTION
0-4	Excellent
5-8	Very Good
9-12	Good
13-16	Fair
17- and above	Poor

Rating scale for the water quality of mangrove swamps and coastal area in Boracay Island

Summary of the Water Quality Assessment Rating of Seven Study Sites in Boracay Island, 2012.

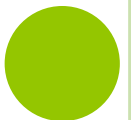
SITES	Parameters Passed	Parameters Failed	Total	Description
1-Mangrove Swamp 1, Brgy. Yapak	38	10	48	Good
2-Puka Beach, Brgy. Yapak	40	10	50	Good
3-Bulabog Beach, Back Beach	33	16	50	Fair
4-Mangrove Swamp 6/Dead Forest	24	24	48	Poor
5-Transition Area-Bridge area	34	16	50	Fair
6-Lugotan Cove, Brgy. Manoc-manoc	26	24	50	Poor
7-Long Beach, Front Beach	39	11	50	Good

Long Beach - characterized of having a four kilometer powdery white sand

- the most populated and visited area in the Island

- Good water quality was recorded in Long Beach (site 7) coastal areas with commercial establishments connected to the sewerage system.

- Only negative part - untreated wastewater from D'Mall is being discharged in this site



Recommendations:

1. Rehabilitation of the mangrove swamps
 - relocate all informal settlers, increase the mangrove cover;
2. Establishment of waste water treatment facility at the outfall of drainage canals before discharging into the coastal water (before Lugotan cove), wet market, parlor, shops, other establishments ;
3. Implement the policy that all residential and commercial establishments should be connected to the Island's sewerage system;

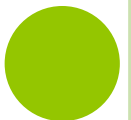


4. Protect and rehabilitate seagrass beds - they have big role in nutrient recycling, water purification, as habitat of marine organisms and provision of other vital ecological services;

5. Implement a collaborative and comprehensive monitoring system as one important proactive strategy

6. Include analysis of P and Nitrates levels in the conduct of regular water quality monitoring

7. Monitor also the neighboring islands for waste water from houses, establishments and sewerage effluent disposal



Boracay Island – Tourist arrivals thru the years

2006 – 0.5 M

2012 – 1 M

2015 - 1.5 M

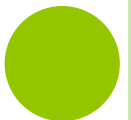
2016 – 1.7 M

2017 – 2 M

2018 – 1st 3 months – 0.3 M

In 2012 – the island was already at its ecological thresholds;

- the concerned agencies did not heed the warnings;
- Tourist arrivals doubled since then.
- We have an ecological backlash!!!



THANK YOU!

