Available online at www.scholarsresearchlibrary.com

Scholars Research Library

Annals of Biological Research, 2015, 6 (10):32-42
(http://scholarsresearchlibrary.com/archive.html)

ISSN 0976-1233
CODEN (USA): ABRNBW

Analysis of waste loading (N and P) of Brgy. Sapang IV-I, Ternate, Cavite to Maragondon River, Philippines

Marlon C. Pareja

Biological Sciences Department, College of Science and Computer Studies, De La Salle University – Dasmarinas, Cavite, Phiippines

---

ABSTRACT

Waste loading analysis was done for the Maragondon river by Barangay Sapang IV-I in Ternate, Cavite using chemical hydrographic data and geographic information systems. Results show that Barangay Sapang contributes high nitrogen and phosphorus load coming from households and urban runoff created by low incidence of proper sewage treatments. Community maps were made utilizing GIS as a tool to establish specific sites where pollutants occur. It is recommended that the municipal government create effective programs to decrease waste load to the river since the latter is an important source of livelihood for the stakeholders.

INTRODUCTION

Population increase is one of the pressing and pertinent issues faced today by human societies [1] . This increase in population has triggered an increase in the number of people living in coastal areas. About half the world's population of which most are found in the world's large cities, together with the world's agriculture and a high proportion of the infrastructure associated with transport lie within about 100 km of the coastline [2]. As reported by Gouldie [1], these anthropogenic impacts on coastal areas have become severe in the last decades. Human activities in the coastal areas have impacted greatly on the global biogeochemical cycles of many elements and compounds which will not only have direct effects on ecosystem and environmental quality and sustainability but also has an indirect effect on climate change. One of these most highly dense coastal areas are estuaries. Estuaries are very dynamic systems since physical and chemical changes constantly changes due to fluctuations of biological populations fluctuate dependent also to natural cycles. Reactive materials like nutrients behave differently due to adjustments caused by matter cycling and many chemical reactions acting independently and sometimes synergistically. Unfortunately, there is a worldwide inadequate availability of data on types, rates and causes of changes to coastal ecosystems. Tracking environmental changes also are proven to be difficult for estuaries due to distinguishing impacts of human actions and natural variations [3]. With the increasing population and its ecological impact, data are important in the formulation of a rational and integrated long-term strategy for the sustainability of coastal areas especially with climate change [4] since estuaries are often considered to be net heterotrophic ecosystems and act as a source of CO2.

One of the direct impacts of anthropogenic activities in the estuaries is pollution. Estuaries are areas in which anthropogenic effects have its most direct influence due to increased nutrient loads which triggers an increase hazard of adverse impacts. Dynamics of these impacts are results of complex chain of events varying over different scales in space and time. This can be ultimately attributed to the accumulation of anthropogenic nitrogen and phosphorus in river water on its way to the ocean [5]. Domestic waste constitutes a major pollutant contributor in coastal systems in the Philippines due to low compliance to septic tanks and sewage treatment tanks facilities). Total Nitrogen (TN) and Total Phosphorus (TP) loading can be measured scientifically through community profiling [6].

Maragondon river, located in the province of Cavite, is one of the major tributaries of Manila Bay – a 1,700 km^2 water system that has economic, historical and cultural importance. One of the municipalities transcended by the river is Ternate. Ternate (14°24’ N, 120°50’ E) is a fourth class lowland municipality comprising of 10 barangays. It has an area of 54.7 km^2 (4,350 ha) with a population of 33,604 (2007) and a density of 374/km^2. It is bounded on the South by the municipalities of Maragondon and Naic, East by Naic, West by Nasugbu and North by Manila Bay. Since it is coastal community, fishing and tourism are its major economic activities. Brgy. Sabang IV-A (Sabang I) is one of Ternate’s barangays that is located on the west riverbank of Maragondon River with fishing as its major source of income.

This research determined the waste loading in terms of nitrogen and phosphate of Brgy. Sabang as an initial study in measuring the total waste loading of all coastal communities to Maragondon river. This research will give an essential understanding on the ecological and biochemical dynamics of the relationship of human communities to the coastal ecosystem. It aims to provide the institutions and policy makers a grasp and a tool in formulating an integrated management program pertaining to pollution control in coastal areas.

MATERIALS AND METHODS

Study Site

Barangay Sapang IV-I with coordinates 14°24’ N, 120°50’ E is one of the ten barangays of the Municipality of Ternate in the Province of Cavite. It is located on the west riverbank of Maragondon River with fishing as its major source of income (Figure 1). The site is suitable venue for waste loading studies since (1). The site is on the marginal side of the riverbank; (2) Initial visual observation shows that household runoff drains into the river. Proper requests were made to authorities in conducting the study.

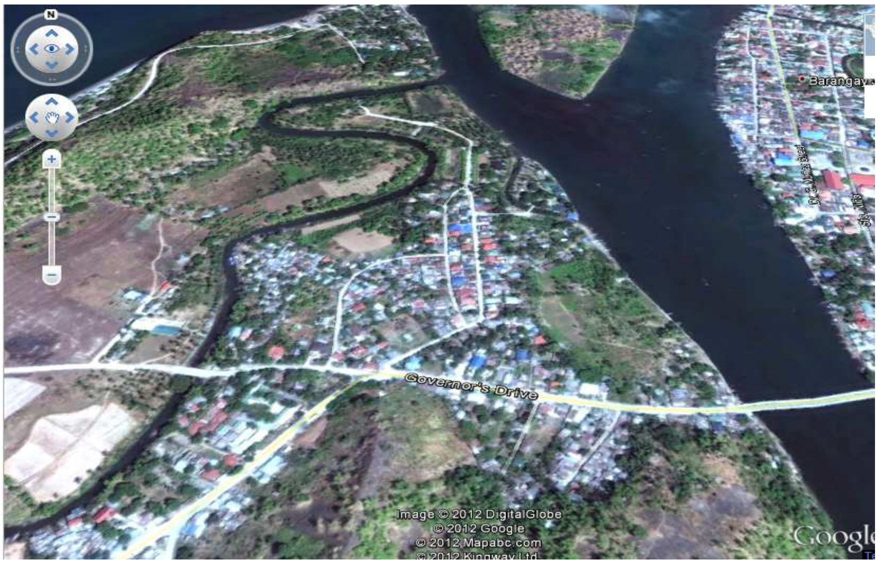

Figure 1. Barangay Sapang IV-I in Ternate, Cavite (Taken from Google Earth, downloaded June 23, 2011)

Data Gathering

Community profiling was conducted in the barangay during the months of November to February 2010 using face-to-face interview and municipal data. The following data were gathered following the procedure of San Diego-McGlone et. al. [6]:

a. Number of Households
b. Number of Livestocks
c. Aquaculture Production
d. Number of Household with Septic Tanks

A global positioning system (GPS) was used in the collection of geographic data and also based on data coming from municipal government. Data on soil erosion and precipitation was taken from the Provincial Agricultural Office and Bureau of Agricultural Statistics websites.Community mapping using a Quantum GIS Version 1.2.7 software was used to create GIS-based data with technical assistance provided by the Lasallian Institute for the Environment (LIFE) of De La Salle Philippines.

Water samples, for Biological Oxygen Demand (BOD) reading, were collected from Maragondon river coming from two (2) stations. Station 1 will be located about 10 meters upstream and Station about 10 meters downstream of the study site following the procedures suggested by Valiela et. al [7]. Water samples were preserved and read following standard protocols. One-way ANOVA will be utilized to determine significant difference between upstream and downstream BOD.

Data Analysis

Chemical hydrographic data analysis were based on the determination of Total Nitrogen (TN) and Total Phosphorus (TP) using WHO and standard procedures [6] . Dissolved inorganic nitrogen (DIP) and dissolved inorganic phosphorus were computed following stoichiometric formula done by various authors [8] and [9].

GIS-based data was used in knowing the highest sources of domestic pollution and establishing the relationship of the human community to the river and the coastal ecosystem.

RESULTS

Community profile

Barangay Sabang (Figure 2) was found to have a population of 6,564 individuals distributed into 1,576 households in an area of 5.4 km^2 based on municipal records. Most of its populace’s economic activity is either related to fishing/aquaculture or tourism working as resort employees.

Table 1 presents the summary of the profile of Brgy. Sabang IV-I (Sabang 1). Results shows that the 78.76% (1,242) of the total households do not have proper sewerage systems. Domestic waste are directly dumped into the river system. Livestock is composed of backyard piggeries and feral poultry are common which waste are also untreated. The Maragondon river plays an important role in the community’s aquaculture activity being its primary aquaculture site. The organization of the aquaculture business is not synonymous with business with corporate identities but rather dependent on who owns the means or tools of production (*banca* or net owners). This is typical of any underground economic activity in the country. Since there is no accounting records of production, estimates from owners and caretakers of the aquaculture were done. Based on estimates, 51 tons of milkfish and other species are being produced per year together with about 12 tons of prawn and other related species in a year. Non-point agricultural run-off were estimated to be 86.42 tons. This may be due to the topographic characteristics of the barangay being near *Mts. Palay-palay/Mataas na Gulod* Protected Landscape.

Table 1. Community Profile of Barangay Sabang IV-I (Sabang 1) in the Municipality of Ternate, Province of Cavite

Profile	Activity
Population	6,564 persons
Unsewered households	1,576 households
Livestock* a. Piggery b. Poultry (feral & caged)	 89 heads 73 heads
Aquaculture* a. Milkfish and others species b. Prawn	 51 tons/year 12 tons/year
Non-point Agricultural runoff**	86.42 tons/year

*Legend: * based on interview accounts and observation*
***estimation coming from Provincial Agricultural Office and various sources*

Community Map

Figure 4 shows the GIS-based community maps of Brgy. Sabang IV-I (Sabang 1) showing distinct and important landmarks. Based on the map, households and economic activity are concentrated geographically between the two river systems of Maragondon River (Figure 3). This land distribution set-up is common to the Philippines and in most parts of the world where high economic activities are usually found near coastal areas. Barangay Sabang can be said to be a major contributor of waste load to the Maragondon River system.

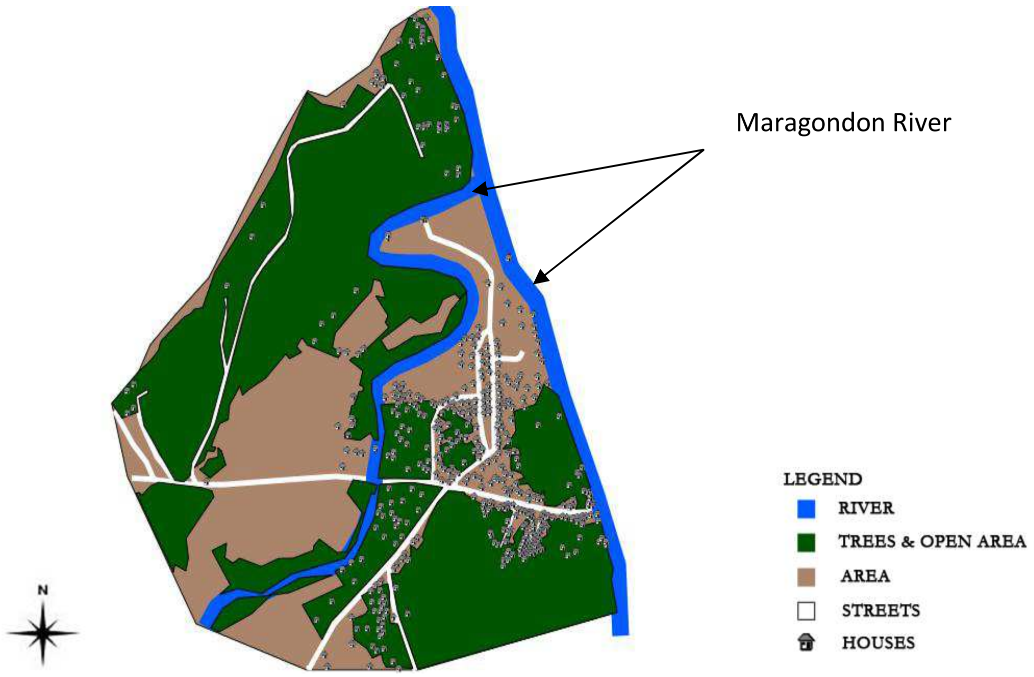

Figure 2. GIS-Based Community Map of Brgy. Sabang IV-I (Sabang 1).

Figure 3. GIS-Based Community Map of Brgy. Sabang IV-I (Sabang 1) Showing Concentration of Economic Activity and Household Distribution between the Two River Systems

Chemical Hydrography

Chemical hydrography of the waste load (Nitrogen and Phosphate) of Barangay Sapang IV-I is shown in Table 2 using stoichiometric formula suggested by San-Diego - McGlone and co-workers [6] . Total nitrogen loading (TN) was computed to be 84.06 tons/year while 25.39 tons/year was from total phosphorus loading (TP). Total dissolved inorganic nitrogen (TDIN) from waste loading was computed to be 573.43 mol/year and total dissolved inorganic phosphorus (TDIP) is 102.37 mol/year giving a DIN:DIP ratio of about 5.57:1 contribution coming from anthropogenic sources. For TN highest contributor is urban runoff (52.92% of total TN) and household sources (45% of TN) (Figure 7). This may be due to high incidence of households without proper treatment facilities of wastewater. While for TP, household sources are the highest contributor at 73% followed by urban runoff at 43% caused by the detergents and domestic waste as major sources of phosphate loading (Figure 8).

Table 2. Nitrogen and Phosporus Loading of Brgy. Sapang IV-I to Maragondon River System Coming from Anthropogenic Sources Using Stoichiometric Formulas

Economic Activity	Total N (kg/yr)	Total P (kg/yr)	DIN mol/yr	DIP mol/yr
A. Household				
a. Solid Waste	12209.04	2428.68	82.8470571	9.79306452
b. Domestic Sewage	26256	6564	178.165714	26.4677419
c. Detergent		6564	0	26.4677419
Sub-Total	**38465.04**	**15556.68**	**261.012771**	**62.7285484**
B. Urban Runoff				
unsewered Areas	44572.1	9383.6	302.4535	37.8371
Sub-Total	**44572.1**	**9383.6**	**302.4535**	**37.8371**
C. Livestock				
a. Piggery	649.7	204.7	4.408679	0.825403
b. Poultry	21.9	51.1	0.148607	0.206048
Sub-Total	**671.6**	**255.8**	**4.557286**	**1.031452**
D. Aquaculture				
a. Milkfish	147.9	132.6	1.003607	0.534677
b. Prawn	62.4	56.4	0.423429	0.227419
Sub-Total	**210.3**	**189**	**1.427036**	**0.762097**
E. Non-point agricultural				
runoff	145.1856	3.4568	0.985188	0.013939
Sub-Total	**145.1856**	**3.4568**	**0.985188**	**0.013939**
TOTAL	**84064.2256**	**25388.5368**	**570.435817**	**102.373132**

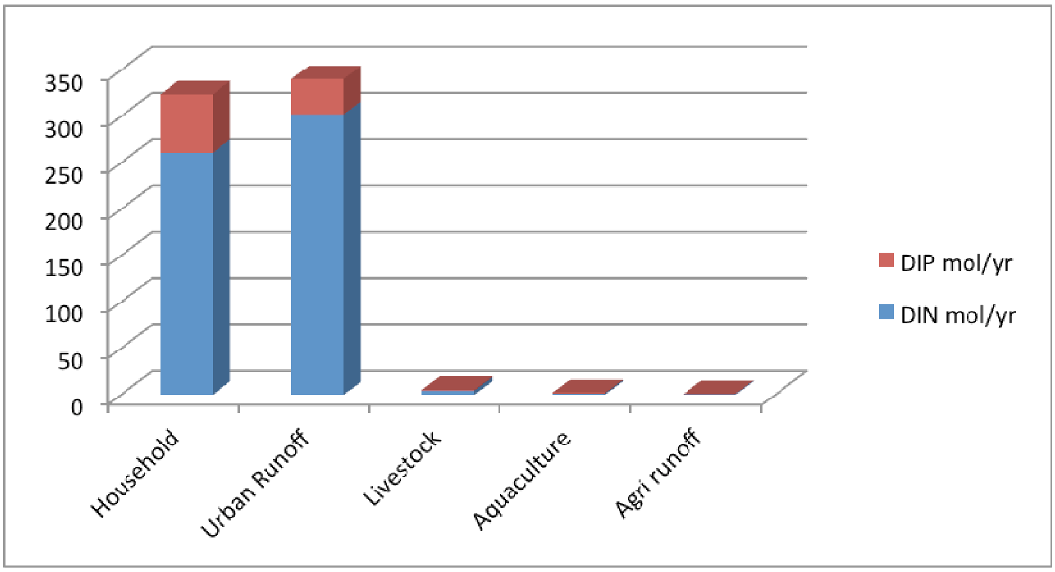

Figure 4. Relative Distribution of Total Nitrogen (TN) and Total Phosphate (TP) Loads of Brgy. Sapang IV-I to Marangondon River System from Anthropogenic Sources

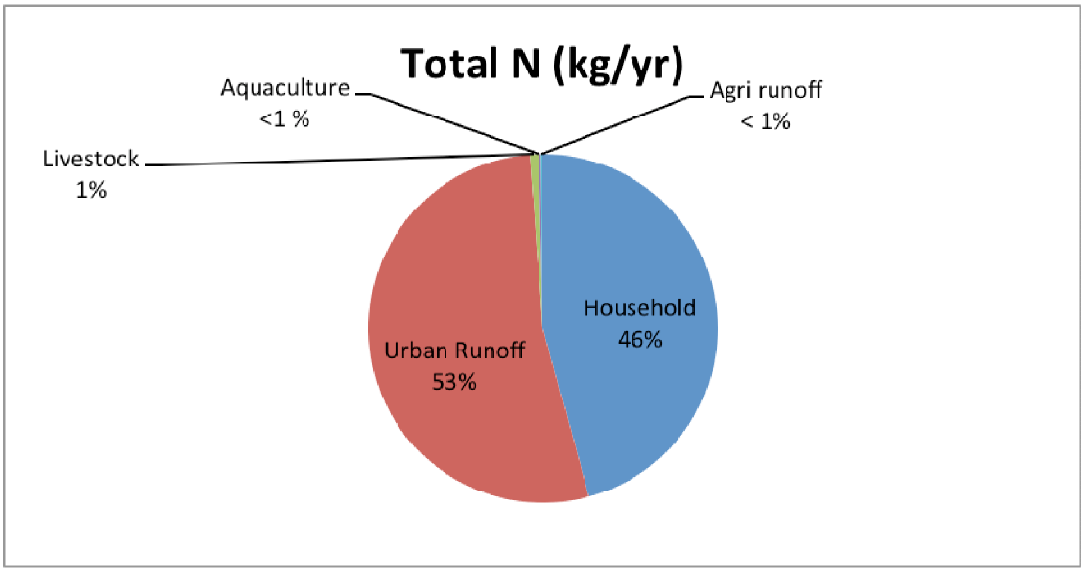

Figure 5. Percentage Distribution of Total Nitrogen (TN) Load of Brgy. Sapang IV-I to Marangondon River Systems

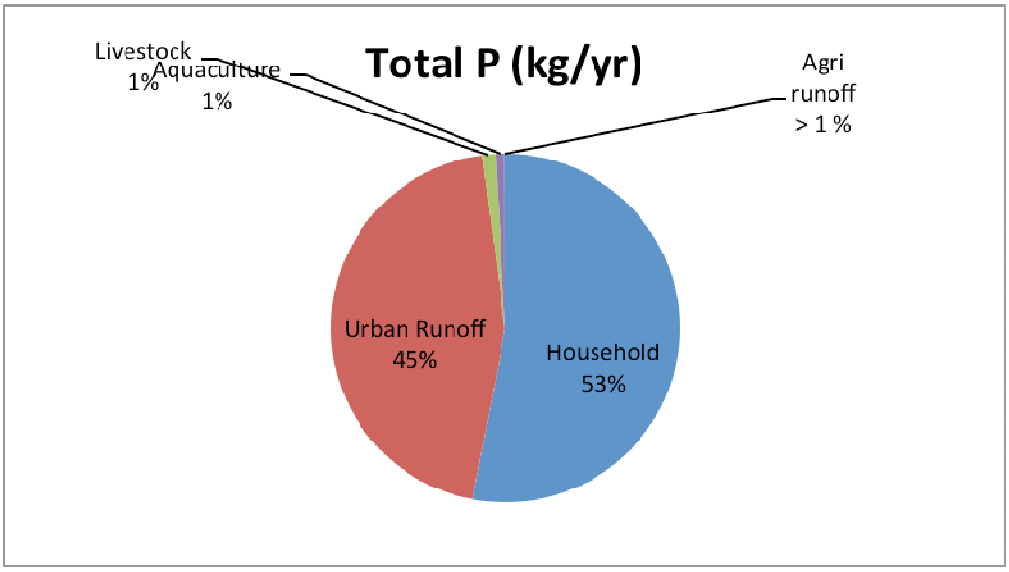

Figure 6. Percentage Distribution of Total Phospate (TP) load of Brgy. Sapang IV-I to Marangondon River Systems

Biological oxygen demand (BOD) of water samples from Maragondon river system shows that mean upstream (station 1) BOD readings to be 5.21 mg/L and mean downstream (Station 2) readings of 4.89 mg/L during the sampling months (Figures 9 and 10). DENR standards connote that the readings classify the river in terms of BOD as Class C surface water. One-way ANOVA result shows that there is significant difference between means. This connotes that there is an increase in organic loading to the Maragondon river between sampling points. Using the stoichiometric formula suggested by McGlone and co-workers (2000), mean TN and TP loading for the Maragondon river are 2.60 mg/L and 0.22 mg/L for upstream and 2.44 mg/L and 0.20 mg/L for downstream, respectively (Table 3). This shows

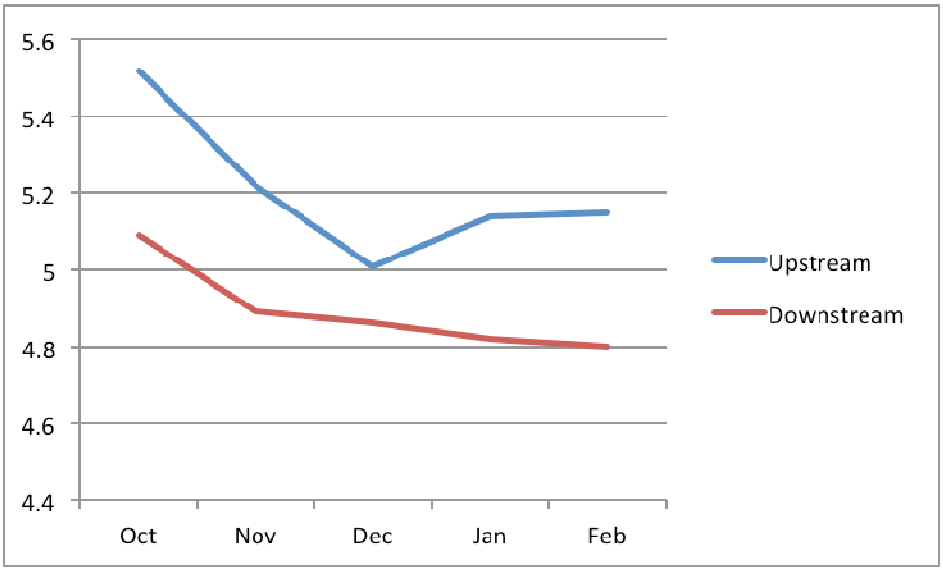

Figure 7. BOD (in mg/L) Readings of Maragondon River in Stations 1 (upstream) and 2 (downstream) during Sampling Months

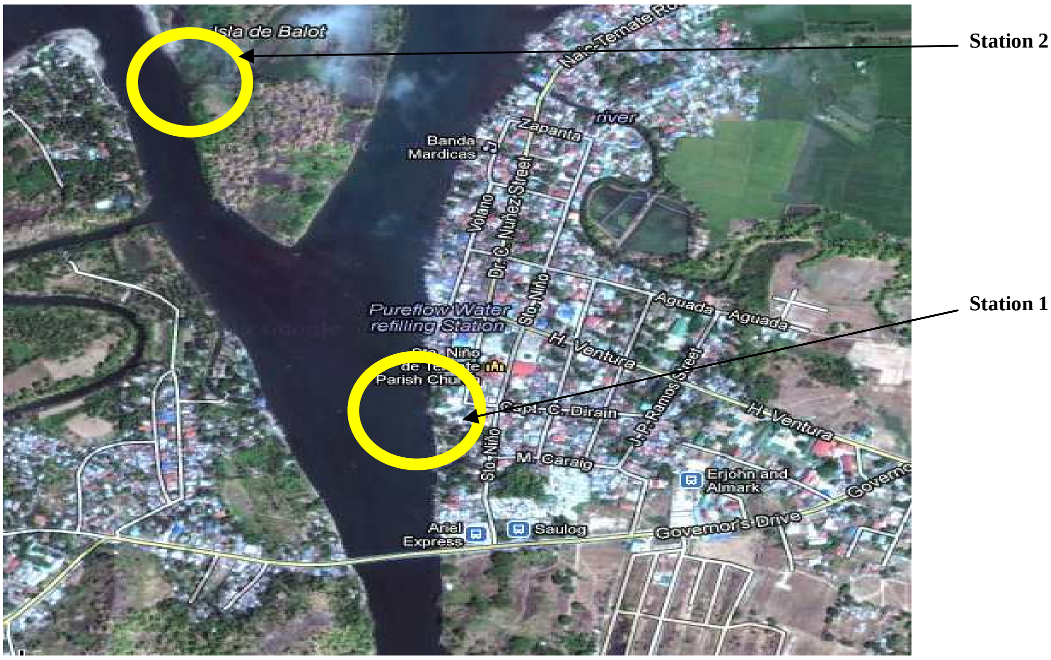

Figure 8. Sampling Sites in Maragondon River Showing Stations 1 and 2. (Google map)

Table 3. Mean TN and TP of Maragondon River Based on BOD Readings from Two Sampling Sites

	Mean BOD (mg/L)	TN (mg/L)	TP (mg/L)
Station 1	5.21	2.60	0.22
Station 2	4.89	2.44	0.20

that domestic loading are contributed by Barangay Sapang IV-I and other barangays located on the eastern bank of the river (Figure 10). The total contribution of TN and TP by Brgy. Sapang IV-I is determined to be 73.04 tons/year and 20.93 tons/year, respectively. How large are these contributions compared to the waste loads of opposite and adjacent barangays needs to be determined.

DISCUSSION

Many workers have reported that N and P fluxes worldwide have increased significantly by more than a factor of two over the last centuries [10]. This is due to the massive influx of human activities based on land use and discharge of waste products in surface waters [11]. These waste (nutrient) loading are composed of many parameters (Figure 11). N and P and important indicators of waste loading due to the following reasons:

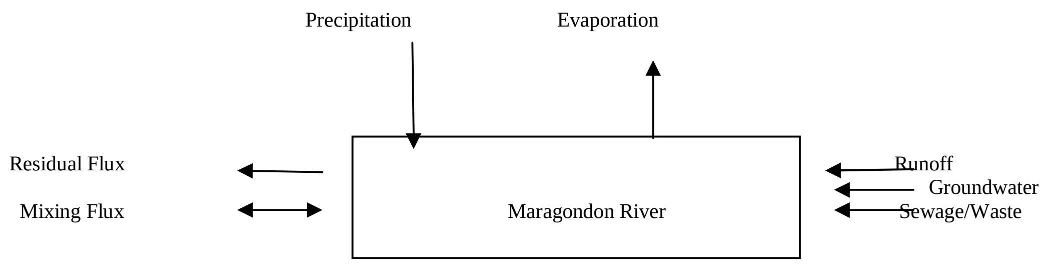

Figure 9. Sources of Nutrient Loads in a Coastal Water Body due to its Interaction with Land and Human Systems [10]

1. These elements, together with carbon, are needed for life's processes. Nitrogen is a key element in protein synthesis and phosphorus is a key element in ATP production [12].
2. N and P have major global sinks and sources (land, ocean, atmosphere) that are depleted in the open ocean by biogeochemical processes, potentially altering ecological function. Imbalance of which can cause pollution and maldistribution of biomass changing life's processes.
3. Environmental transformations associated with anthropogenic activities are altering the biogeochemical cycles of these elements. For example, discharge of waste and sewage products from human-made activities increases concentrations of these elements in surface waters [6]. Land-use practices also alter these concentrations that brings in dramatic disruptions of coastal and estuarine ecosystems These changes may have implications on health (i.e. algal blooms and water-borne diseases) but will also have dire socio-economic impacts [13].

It is therefore imperative that knowledge about nutrient (waste) loading and transformations on land and in the coastal zone is needed to help create important and effective management programs for environmental and resource conservation. During the last decades, most of the knowledge on nutrient (waste) retentions and transformations were based on temperate regions [3]; [13]. But knowledge and predictions and measurement in tropical regions are increasing. In the Philippines, few researches in this field were reported and since the coastal areas of the country is much bigger than its land areas important studies on the relationship and impacts of land ecosystems to coastal ecosystems must be made.

The DIN and DIP ratio of about 6:1 from waste discharges contributed by Barangay Sapang IV-I still conforms to the modified Redfield ratio of 6:1 to 16:1 [14]. Though, it is important to determine how this load is relative to the total DIP and DIN load of the upstream and downstream communities contribution to the river. This will establish if the Maragondon river system is able to breakdown waste inputs and export most of these as N and P out of Manila bay. Studies by Rubio and Pareja [15] indicate that there is a very high organic loading in Maragondon river. Determination of how much this loading is in terms of percentage or proportion that is contributed by Brgy. Sapang IV-I is also needed.

The high TN and TP loading at the river accounted from the barangay can be attributed from the high population density near the river banks. Aggravating this is the severe lack of sewer treatment facilities for both domestic and livestock waste. This is together with a high precipitation rate and being adjacent to *Mts. Palay-palay* which contributes to high runoff. Though, season may be an important factor if Barangay Sabang IV-I is a Phosphorus (P) source or sink, further studies should be done during the summer months. According to Noriega and Araujo [14] , dry seasons make coastal communities as sinks of P since reduction of rainfall decreases runoff to rivers. Rainfall usually contributes to heterotrophic water environment due to the increase in the contribution of terrestrial organic storage [6]. However, increase precipitation also increases nitrogen and phosphorus loads in estuaries [14] which would benefit autotrophic metabolism, especially in urban and agricultural areas. The DIN and DIP of Barangay Sabang IV-I is also much higher than the DIN and DIP river of Jaobotao and Pirapama rivers in Brazil [14]. The barangay also presents a per capita load for the Maragondon river basin of 0.105 moles and 0.02 moles of DIN and

DIP per year, respectively. This translates to a less than one kilogram/person/kilogram contribution per year of DIN and DIP. The values reflect the high population density and low runoff, according to Smith et. al. [10] but this needs to be investigated for a one whole year time setting to validate. The greatest concentration of households is found between the river systems (Figure 12). Economic activity is also prominent to these sites. This contributes to the vulnerability of the river to both point and non-point sources of pollution [16]. It is important that community profiles be represented by community maps since this creates a clearer visual representation of important parameters for natural resources management [17]. The mapping of households of Barangay Sapang IV-I can be a tool for policy makers to pinpoint specific problems and formulate more effective and efficient policies and programs. Proper interventions must be made by the municipal governments on households with low compliance to septic tanks (Figure 11), high incidence of livestock facilities (Figure 12) and source of agricultural runoff (Figure 13).

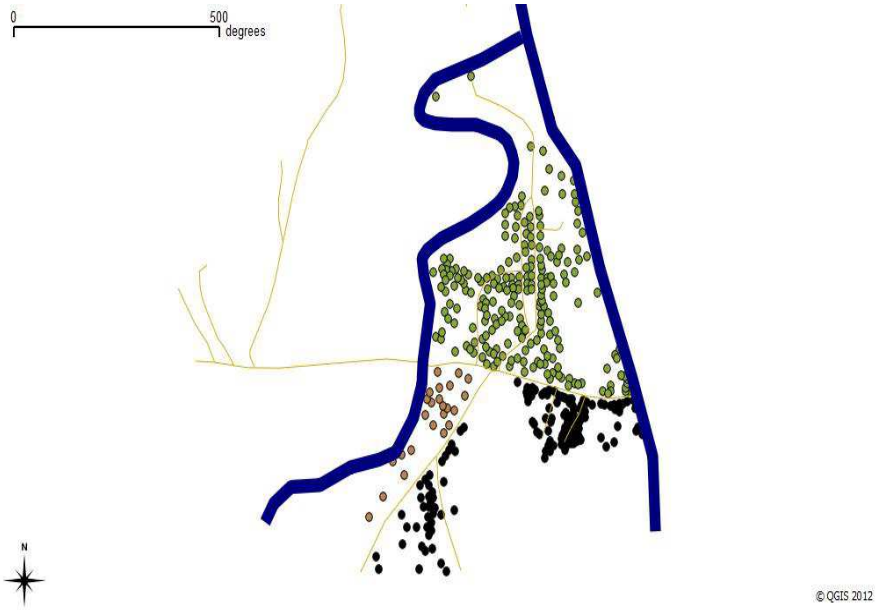

Figure 10. Distribution of Households in Barangay Sabang IV-I

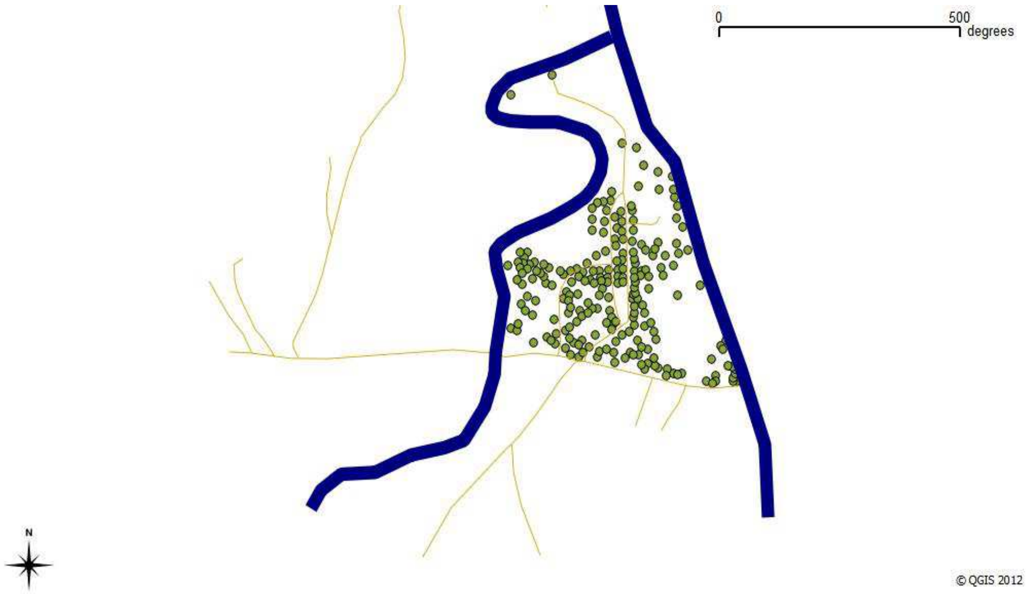

Figure 11. Locations of Households in Brgy. Sapang IV-I with the Lowest Number of Proper Sewer Treatment Facilities

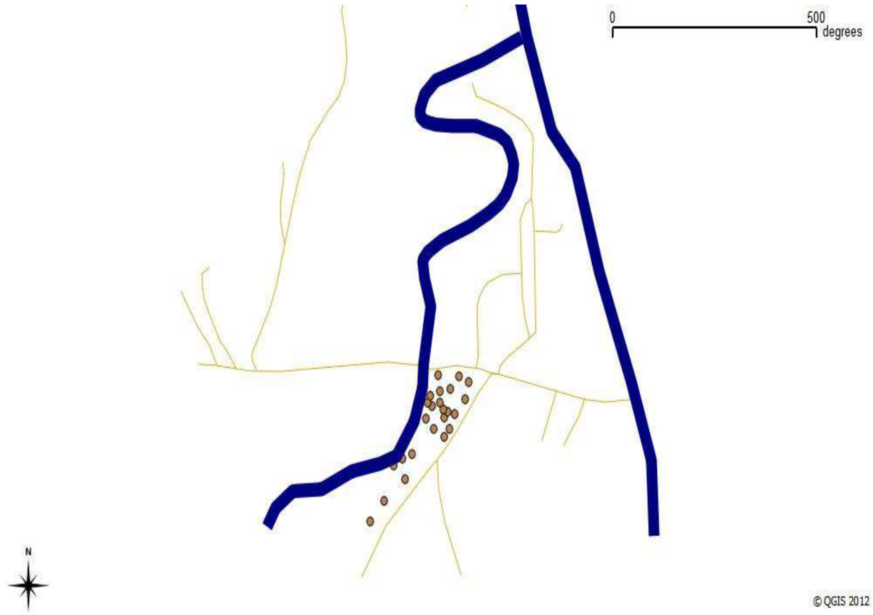

Figure 12. Locations of Households in Barangay Sapang IV-I with High Density of Piggeries

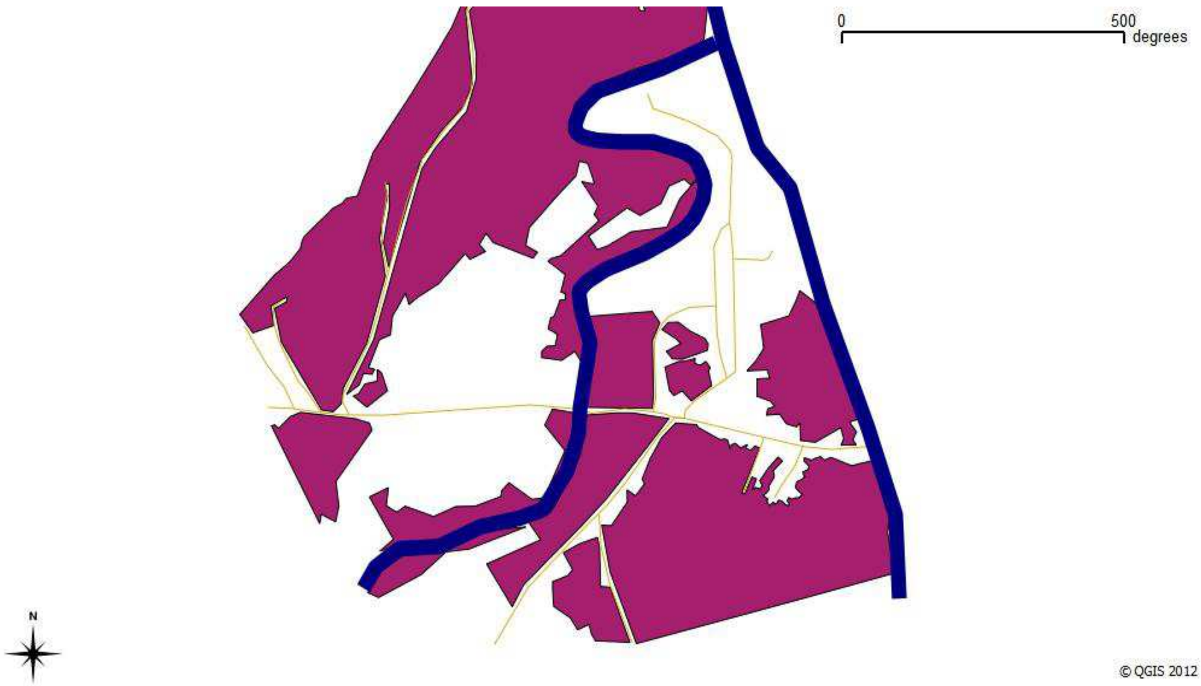

Figure 13. Locations of Possible Sources of Agricultural Runoffs (shaded) in Barangay Sapang IV-I

Recommendations

It is recommended that the municipal government create effective programs to decrease waste load to the river since the latter is an important source of livelihood for the stakeholders. The following are possible interventions:

1. Establishment of a municipal sewage treatment plant.
2. Formulation and implementation of a polluters fee payment system.
3. Creation of a Water Quality Management Council for Maragondon River composed of various representatives of the stakeholders.

REFERENCES

[1] Goudie, A. **1990**. The human impact on the environment. Basil Blackwell Ltd., Oxford, p.34.
[2] Bethoux, J. P. *Oceanol. Acta* **1980** 3**:** 79–88.
[3] Howarth, RW et. al.. *Biogeochemistry* **1996** 35: 75-139.
[4] Holligan, PM and reiners, W.A. *Adv. Ecol. Res*. **1991** 22: 211-255.
[5] Tappin, AD. *Estuar Coast Shelf Sci* **2002** 55: 885–901.
[6] San-Diego-McGlone ML. *Mar. Poll.Bull*. **1999** 40, (4,) pp. 325 – 330
[7] Valiela IG et. al. **1997**. *Ecological Applications* 7(2); 358-380.
[8] Sogreah 1974. Laguna de Bay Water Resources Development Study. LLDA, Pasig City, Philippines.
[9] Swaney and Smith. **2003**. Guidelines for constructing nutrient budgets of coastal systems. In: CROSSLAND CJ, KREMER HH, LINDEBOOM HJ, MARSHALLCROSSLAND JI AND LE TISSIER MDA (Eds) Coastal fluxes in the anthropocene, Berlin, Springer, Berlin, Deutshland, p. 110–111.
[10] Smith, SV et.al. *Bio- Science* **2003** 53: 235–245.
[11] EL Sabrouti, MAN et. al. *Acta Adriat*. **1990** 31**:** 23–35.
[12] Schlesinger, WH. **1997**. Biogeochemistry: An analysis of global change. 2nd ed. San Diego: p.45-47.
[13] Gonzalez, J.A. et.al. **1996**. River pollution: an investigation of the influence of aquaculture and other agro-industrial effluents on communal waterways. Institute of Aquaculture, College of Fisheries, University of the Philippines in the Visayas, 89pp.
[14] Noriega, C. and M. Araujo. *Anais da Academia Brasileira de Ciências* **2011** 83(2): 441-456.
[15] Rubio, J and M. Pareja. *NOCEI Journal* **2011** Vol. 1 No. 1.
[16] Krom, P. et. al. *Limnol. Oceanogr.*, 49(5), **2004**, 1582–1592.
[17] Pareja, M. **2010**. The Use of Geographic Information System in Developing a Community-based and Participatory Disaster Management Program for Lumban, Laguna, The Philippines (unpublished).