UNIVERSIDAD POLITÉCNICA DE VALENCIA

ESCUELA POLITÉCNICA SUPERIOR DE GANDIA

LICENCIADA EN CIENCIAS AMBIENTALES

"Study of intertidal mollusc communities in a contaminated mangrove (*Navotas, Manila bay*) to determinate which species can act as bioindicators of polluted mangroves"

FINAL PROJECT DEGREE
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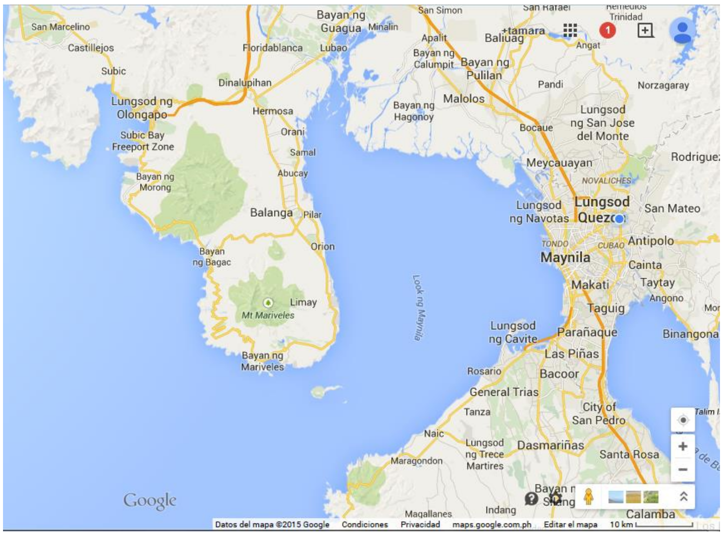
1. INTRODUCTION

1.1 Description of the site

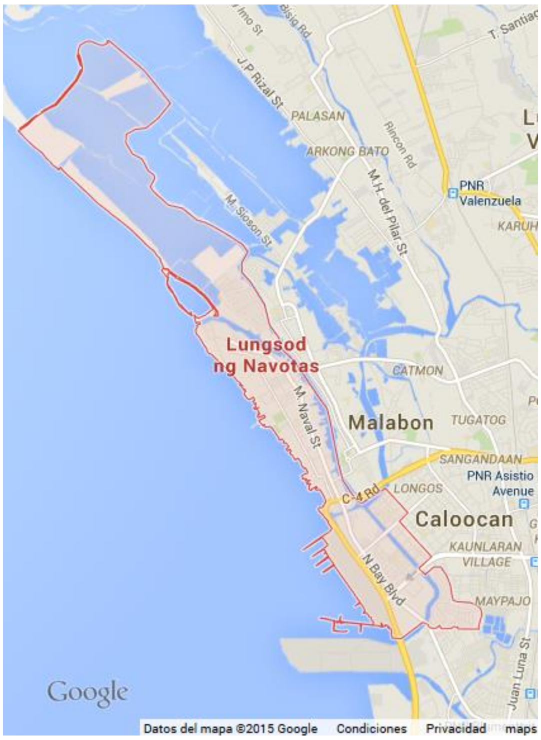
Navotas is a city of the Philippines located in the north of Manila. It is called the "Fishing Capital of the Philippines" because the livelihood of many of its residences were derived directly or indirectly from fishing and its related industries.

It is a narrow strip of land with an aggregated shoreline of approximately 4.5 km. In the north, Navotas shares a common border with the towns of Obando, Bulacan, along Sukol Creek. Along the eastern border runs the Binuangan River, the Daang Cawayan River, the Dampalit River, the Batasan River, the Navotas River, the Bangculasi Channel, the Malabon Channel and the Estero de Maypajo.

It is bordered on the north by Obando, Bulacan along Sukol Creek; on the south by the city of Manila; on the east by Daang Binuangan River, Bangkulasi Channel, Malabon Channel and Estero de Maypajo; and on the west by Manila Bay.



Map 1. Manila Bay. (www.google.com.ph)



Map 2. Navotas City. (www.google.com.ph)

Navotas is politically subdivided into 2 districts, with a total of 14 barangays:

District 1

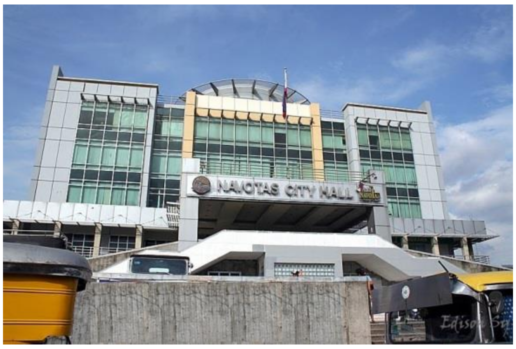
- Bagumbayan North
- Bagumbayan South
- Bangkulasi
- Navotas East
- Navotas West
- Northbay Boulevard North
- Northbay Boulevard South
- San Rafael Village
- Sipac-Almacen

District 2

- Daanghari
- San Jose
- San Roque
- Tangos
- Tanza

Picture 1 . Banrangays of navotas City. http://en.wikipedia.org/wiki/Navotas

Navotas was originally a contiguous part of Malabon and was not separated from it by a body of water. However, sometime in the past, the turbulent waters of Manila Bay gradually eroded a weak strip of land between this town and the district of Tondo, in Manila, until an opening was breached. Seawater continued to flow in through this opening, particularly during high tide carving out the Navotas River in the process. The channel created developed into a regular waterway that has come to be known as the Navotas River. This natural phenomenon seemed to be the origin of the name that today is associated with this area, continually referred to as “nabutas” which over the time gradually evolved into “Navotas”, literally meaning “pierced through” in English.



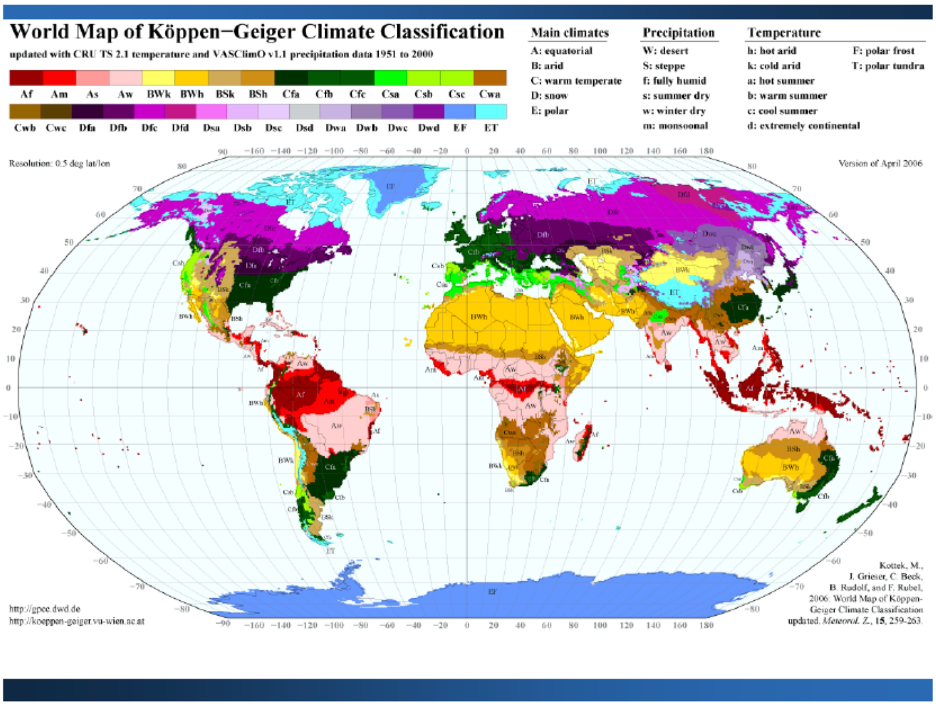
Picture 2. Navotas City Hall.(www.panoramio.ph)

The mangrove park is situated on the Tanza Barangay. The name of the park is marine Tree Park. The Park occupies 20Ha along the coast. The coast of the mangrove is situated in Manila Bay. There is a small community living beside mangrove forest. The people are mostly fishermen who are dedicated to produce shrimps in small fishponds and fishing.

Picture 3. Placard at the entrance of the Marine Tree Park, Tanza, Navotas.

1.2 Climatology

The Philippines are situated between the parallels 10 and 20 in the northern hemisphere. The islands belong to Equatorial climate, with monsoonal precipitations on the west part of the Philippines, and fully humid on the east part. We can observe the climate characteristics on the map 3 : World Map of Köppen-Geiger Climate Classification.



Map 3 . World Map of Köppen-Geiger Climate Classification. (www.tiempo.com)

Manila Bay is situated on the west part of the Philippines where is characterized by monsoonal precipitation. In this part there are two different season: the wet season (from May to November) and the dry season (from December to May).

In the table below we can see more clearly the different season of the Philippines, taking into account the rainfall and the temperature along one year.

Month	December-February	March-May	June-August	September-November
Rainfall	DRY		RAINY	
Temperature	COOL	HOT		
Season	Cool Dry	Hot Dry	Rainy	

Table 1 . Climate Season Table of the Philippines. (en.wikipedia.org)

In the follow table are showed the average temperatures and the precipitation of Manila City. The coolest month is January, and the warmest moths are April and May. As to precipitation, the wettest months are July, August and September; all of them have more than 300 mm of precipitation per month.

Climate data for Manila

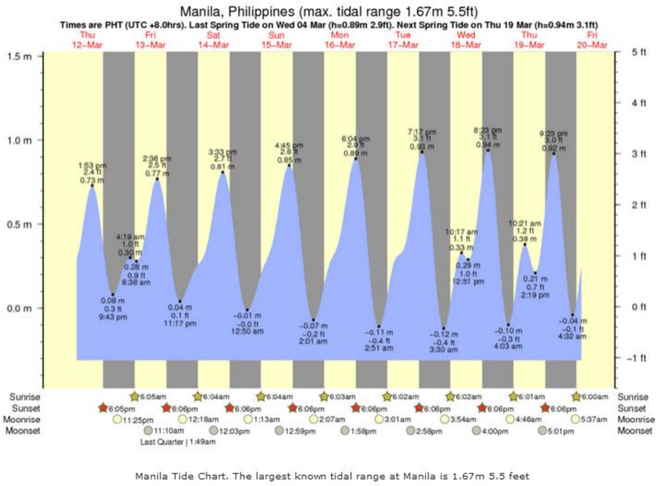
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C (°F)	30.1 (86.2)	31.1 (88)	32.8 (91)	34.3 (93.7)	34.2 (93.6)	32.4 (90.3)	31.3 (88.3)	30.8 (87.4)	31.1 (88)	31.2 (88.2)	31.0 (87.8)	30.3 (86.5)	31.72 (89.08)
Daily mean °C (°F)	25.6 (78.1)	26.1 (79)	27.6 (81.7)	29.1 (84.4)	29.5 (85.1)	28.4 (83.1)	27.7 (81.9)	27.4 (81.3)	27.6 (81.7)	27.3 (81.1)	26.9 (80.4)	26.0 (78.8)	27.43 (81.38)
Average low °C (°F)	20.9 (69.6)	21.1 (70)	22.5 (72.5)	24.0 (75.2)	24.8 (76.6)	24.4 (75.9)	24.1 (75.4)	24.0 (75.2)	24.0 (75.2)	23.5 (74.3)	22.8 (73)	21.6 (70.9)	23.14 (73.65)
Precipitation mm (inches)	6.3 (0.248)	3.3 (0.13)	7.1 (0.28)	9.3 (0.366)	100.4 (3.953)	272.7 (10.736)	341.2 (13.433)	398.3 (15.681)	326.0 (12.835)	230.0 (9.055)	120.4 (4.74)	48.8 (1.921)	1,863.8 (73.378)
Avg. rainy days	1.0	1.0	1.0	1.0	7.0	14.0	16.0	19.0	17.0	13.0	9.0	5.0	104

Source: Hong Kong Observatory[8]

Table 2. Climate data of Manila. (en.wikipedia.org)

Finally in Manila Bay the tide is predominantly diurnal with an average tidal range of 1.2 meters during spring tide and 0.4 meter during neap tide.

Seasonal wind systems (i.e., the monsoons) and diurnal breezes affect the current pattern especially in shallow water. On the graphic below we can see the tide chart which shows the height and times of high tide and low tide for Manila, Philippines.

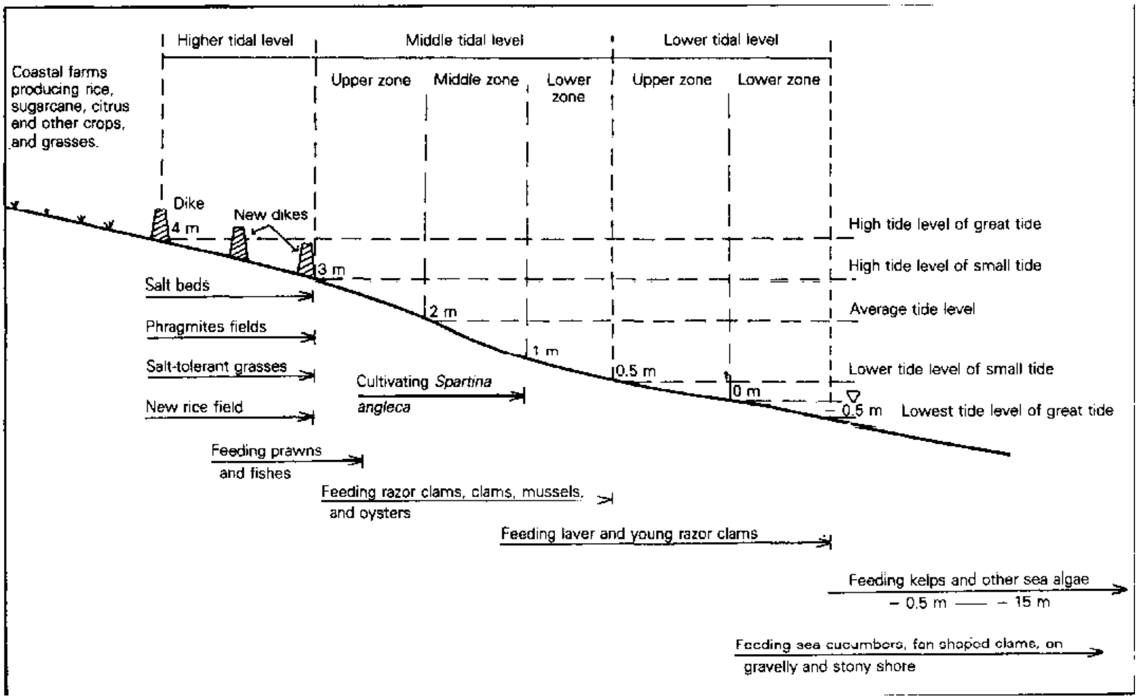


Graphic 1. The tide chart above shows the height and times of high tide and low tide for Manila, Philippines.

1.3 Biodiversity of intertidal zone

The intertidal zone, also known as the littoral zone, in marine aquatic environment is the area of the foreshore and seabed that is exposed to the air at low tide and submerged at high tide. . This would be a simple definition, but it can be explained better.

According to Karleskint the intertidal zone is the part of the marine environment that is between the highest high tide and the lowest low tide. It is therefore alternately submerged and exposed to air. This is a stressful environment with large daily fluctuations in such factors as temperature, salinity, moisture, and wave action. Organisms must have specific adaptations to survive in these environmental extremes. Most organisms in the intertidal zone are marine in origin and therefore prefer to remain in seawater, so exposure at low tide is physiologically stressful to most. (Karleskint, 1998)
On the next picture picture 4 we can see the distribution patters of the intertidal zone. The intertidal zone is split up in 3 different regions: higher tidal level, middle tidal level and low tidal level. The higher tidal level is submerged just during the high level, and it is where we can find the mangroves forests, like in Navotas. It is characterized by arthropods and molluscs which live attached to the roots of mangroves. The middle tide zone, is the true intertidal and it is the transition between the high and the low tide. Moisture reaches the zone of drying sand during the highest tides and gradually evaporates. In this area of saturation is constantly moist and supports the greatest diversity of organisms, including polychaetes, amphipods, isopods and bivalves. Finally the low tidal level, which is always flooded, is a proper marine habitat. It is dominated by marine sea grass, with bivalves, snails, urchins and fishes.



Picture 4. Ditribution patters of intertidal zone (The New Zealand Digital Library http://www.nzdl.org)

There are two different intertidal zones: intertidal rocky shores or sandy shores. They are very different between themselfs due to the kind of organisms which can be found and the physical factors that predominate. These organisms have to be very well adapted to strength of the waves, particle size and slope.

In Navotas Mangrove is characterized by an intertidal sandy shore. The sandy shores are not as rich as rocky shores in biodiversity. Sandy shores form in areas of lower wave action, where loose sediment accumulates. This loose material commonly includes quartz grains, black volcanic sand, pulverized carbonate plant and animal skeletons. Competition does not appear to be as important as in rocky shores, as is suggested by the sparse populations, three-dimensional space and abundance of food. There also appear to be fewer predators on sandy shores. The physical factors of wave action, particle size and beach slope may be more important than biological factors in determining the distribution patterns on sandy shores. (Karleskint, 1998)

The distribution and abundance of the fauna is mostly controlled by complex interactions between the physicochemical and biological properties of the sediment.

The **physicochemical** properties are:

- Grain size
- Water content
- Flushing rate of water through the sediment
- Oxidation-reduction state
- Dissolved oxygen
- Temperature
- Light
- Organic content

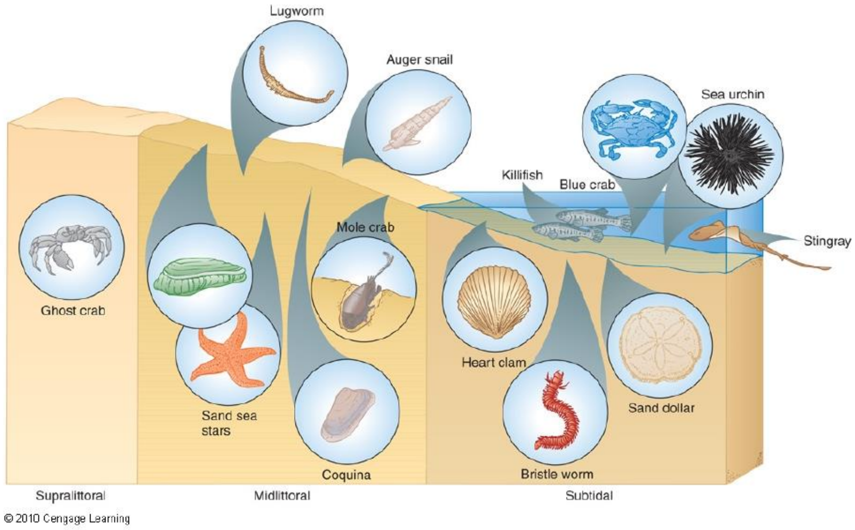
The **biological** properties are:

- Food availability and feeding activity
- Reproductive effects on dispersal and settlement
- Behavior that induces movement and aggregation
- Intraspecific competition
- Interspecific competition and competitive exclusion
- Predation effects

Most invertebrate phyla are represented on sandy beaches, either as interstitial forms or as members of the macrofauna. The macrofauna of sandy beaches includes most major invertebrate taxa like molluscs, crustaceans and polychaetes are the most important. The macrofaunal forms are by far the better known. Some of them are typical of intertidal sands and their surf zone, while others are more characteristic of sheltered sandbanks, sandy muds or estuaries and are less common on open beaches of pure sand. (Marine Biodiversity Wiki)

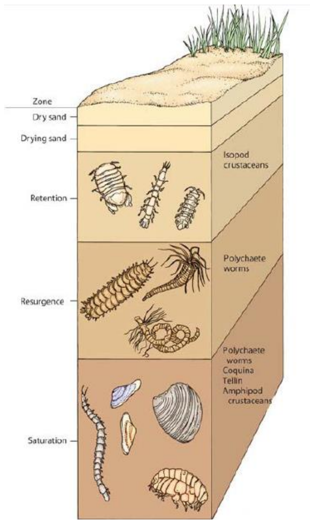
Also the meiofuana is a very important part of sandy shores due to the three-dimensional system. They use to burrow into the sediment. According to Marine Biodiversity Wiki: *Meiofauna or meiobenthos are small* benthic *invertebrates that live in both marine and fresh water environments. The term meiofauna loosely defines a group of organisms by their size, larger than microfauna but smaller than macrofauna, rather than a taxonomic grouping. In practice these are organisms that can pass through a 1 mm mesh but will be retained by a 45 µm mesh, but the exact dimensions will vary from researcher to researcher. Whether an organism will pass through a 1 mm mesh will also depend upon whether it is alive or dead at the time of sorting.* So definitely the miofauna for sandy shores are the organisms which live between the sandy grains.

On the picture below we can see the horizontal zonation and the fauna which we will find in and on a sandy shore.



Picture 5. Horizontal sandy shore zonation (Karleskint, 1998)

And on the picture below we can observe the vertical zonation of a sandy shore. This zone is dominated by, with animals such as bivalves, snails, heart urchins and sand dollars.



Picture 6.Vertical sandy shore zonation (Karleskint, 1998)

1.4 Biology and ecology of Mangroves forest

"The word *mangrove* comes from the Portuguese *mangue* which means "tree" and the English *grove* and is used to refer to trees and shrubs that are found in shallow, sandy or muddy areas." (Karleskint, 1998).

The mangroves forests are found in the coasts of Caribbean Sea, Atlantic Ocean, Indian Ocean and Western Pacific Ocean, therefore the mangroves forest are associated with tropical climate. They inhabit the coastal intertidal zone. The mangroves are adapted to salty, anaerobic and flooding environment, as they are covered by the tides every day.

Picture 7. Worldwide distribution of Mangrove Forests (mangroveactionproject.org)

The Philippines is one of the 15th mangrove-rich countries in the world, like we can see in the Table. The Philippines have 263,137 ha of mangrove forests, which represent the 1.9 % of the global mangroves forests.

Status and distributions of global mangroves

SN	Country	Area (ha)	% of global total	Cumulative %	Region
1	Indonesia	3,112,989	22.6	22.6	Asia
2	Australia	977,975	7.1	29.7	Oceania
3	Brazil	962,683	7.0	36.7	South America
4	Mexico	741,917	5.4	42.1	North and Central America
5	Nigeria	653,669	4.7	46.8	Africa
6	Malaysia	505,386	3.7	50.5	Asia
7	Myanmar (Burma)	494,584	3.6	54.1	Asia
8	Papua New Guinea	480,121	3.5	57.6	Oceania
9	Bangladesh	436,570	3.2	60.8	Asia
10	Cuba	421,538	3.1	63.9	North and Central America
11	India	368,276	2.7	66.6	Asia
12	Guinea Bissau	338,652	2.5	69.1	Africa
13	Mozambique	318,851	2.3	71.4	Africa
14	Madagascar	278,078	2.0	73.4	Africa
15	Philippines	263,137	1.9	75.3	Asia

Table 3. The 15 most mangrove-rich countries and their cumulative percentages. (*Status and distribution of mangrove forests of the world using earth observation satellite data; Global Ecology and Biogeography, (Global Ecol. Biogeogr.)* (2011) **20**, 154–159*)*

There are different species of mangroves, but the most common are the red mangrove (*Rhizophora*), black mangrove (*Avicennia*), buttonwood (*Conocarpus*) and white mangrove (*Laguncularia*).

Picture 8. *Avicennia* sp (Wikipedia.org)

Picture 9. *Rhizophora* sp. (www.mangrovesforthefuture.org)

Mangroves present different adaptations to the environmental conditions in which they live and which have been described above.

The most important adaptation is that "the leaves are thick and leathery. The epidermis of the leave is covered with a thick cuticle, and the stomata, openings in the leave for gas exchange and water loss, are sunken and confined to the undersurface." (Karleskint, 1998) This adaptation reduces the water loss by evaporation. And another adaptation is that the leaves have salt glands to remove the excess of salts which are taken by roots.

Also the roots present another adaptation to the muddy sediment in which mangroves grow. The roots do not penetrate deep into the soil to anchor the plant. They are exposed to the atmosphere due to the exchange gas system and they also serve as a structural support.

Finally the seeds present an extraordinary adaptation. "The embryo begins to germinate while the seed is still attached to the parent plant. That allows developing a root (…) quickly after the seed, seedling, or fruit is dropped from the tree, allowing to the embryonic root attach to the sediment, preventing it being washed back out to sea" (Karleskint, 1998

1.5 Importance of Mangroves Forest (social, economic and ecological)

According to the World Wilde Foundation (WWF) the mangrove forest are "extremely productive ecosystems that provide numerous good and services both to the marine environment and people**".**

Four of the most important services are:

- **Fisheries:** Mangrove forests are home to a large variety of fish, crab, shrimp, and mollusk species. These fisheries form an essential source of food for thousands of coastal communities around the world. The forests also serve as nurseries for many fish species, including coral reef fish. A study on the Mesoamerican reef, for example, showed that there are as many as 25 times more fish of some species on reefs close to mangrove areas than in areas where mangroves have been cut down. This makes mangrove forests vitally important to coral reef and commercial fisheries as well.

- **Timber and plant products:** Mangrove wood is resistant to rot and insects, making it extremely valuable. Many coastal and indigenous communities rely on this wood for construction material as well as for fuel. These communities also collect medicinal plants from mangrove ecosystems and use mangrove leaves as animal fodder. Recently, the forests have also been commercially harvested for pulp, wood chip, and charcoal production.

- **Coastal protection:** The dense root systems of mangrove forests trap sediments flowing down rivers and off the land. This helps stabilizes the coastline and prevents erosion from waves and storms. In areas where mangroves have been cleared, coastal damage from hurricanes and typhoons is much more severe. By filtering out sediments, the forests also protect coral reefs and seagrass meadows from being smothered in sediment.

- **Tourism:** Given the diversity of life inhabiting mangrove systems, and their proximity in many cases to other tourist attractions such as coral reefs and sandy beaches, it is perhaps surprising that only a few countries have started to tap into the tourism potential of their mangrove forests. Places as diverse as Bonaire and offer snorkelling expeditions in and around mangroves to witness a marvellous variety of baby fish, jellyfish, and urchins against a magical background of interwoven roots delving deep into the sandy substrate. Great potential exists elsewhere for revenue generation in this manner, which values the mangroves intact and as they stand.

1.6 Consequences of Mangroves loss

As we have seen above, the mangrove forests produce a great quantity of services for the local people, but in the last years they have been destroyed to convert them into fishponds or roads.

Asia suffered the largest net loss of mangroves since 1980, with more than 1.9 million ha destroyed, mainly due to changes in land use (FAO)

And FAO cited high population pressure, the large-scale conversion of mangrove areas for shrimp and fish farming, agriculture, infrastructure and tourism, as well as pollution and natural disasters as the major causes for the destruction of mangroves.

Mangroves in the Philippines were reduced from an original area of about 500,000 ha to approximate 288,000 ha. in 1970, and further to 123,400 ha. in 1993. One of the major threats to mangroves is the rapidly growing aquaculture industry. (RON JANSSEN1 and JOSE E. PADILLA2; Preservation or Conversion? *Valuation and Evaluation of a Mangrove Forest in the Philippines*)

The maricultural practices are responsible for the bulk of the increasing losses of mangrove swamps worldwide. Pond culture has been reported to be responsible for 50% of the loss of mangrove environments in the Philippines (Primavera 1991)

The mangrove forests loss produce several ecological, economic and social problems.

First of all, if the mangroves are destroyed, the biodiversity of the forest will be reduced. Some of the common problems that affect the mangroves forest are the deforestation, contamination of the water and soil and the loss of biodiversity.

This problems produce that some species of fish, birds, frogs, mollusks, snakes and insects disappear. These species are used by the inhabitants for feedeing themselves and for fishing. So, the loss of these species produces an impoverishment of the people.

Moreover, the mangroves forests act like a protected barrier for the waves and for the typhoon that take place in the tropical and subtropical areas. If they are deforested, the villages become more vulnerable to these atmospheric phenomena, destroying the houses and business.

In the end, the mangroves forests are a reclaim for tourism, because we can observe wild animals like monkeys, big lizards and birds. The tourism is a source of income for the local people.

The director of FAO's Forest Products and Industry Division, on the occasion of World Wetlands Day (2 February 2008), Wulf Killman said: "The loss of these coastal forests (Mangroves Forest) remains alarming. The rate of mangrove loss is significantly higher than the loss of any other types of forests. If deforestation of mangroves continues, it can lead to severe losses of biodiversity and livelihoods, in addition to salt intrusion in coastal areas and siltation of coral reefs, ports and shipping lanes. "

1.7 Intertidal molluscs

Mangroves are inhabited by a variety of benthic invertebrates, such as brachyuran crabs, gastropods, bivalves, hermit crabs, barnacles, sponges, tunicates, polychaetes and sipunculids.

Mangrove invertebrates often show marked zonation patterns, and colonise a variety of specific micro-environments. While some species dwell on the sediment surface or reside in burrows, others live on pneumatophores and lower tree trunks or prop-roots, burrow in decaying wood, or can even be found in the tree canopies. Macrobenthos may be operationally separated in two groups, i.e., epifauna and infauna. Epifauna refers to those invertebrates that live on various substrates such as lower tree trunks and the sediment surface, but which do not burrow in it. A range of gastropods, crabs, and bivalve species are typical representatives of epifauna. Infauna refers to burrowing invertebrates which live within the sediment, and includes crabs, pistol prawns, polychaetes, and sipunculids (*Nagelkerken a,*, S.J.M. Blaber b, S. Bouillon c,d, P. Green e, M. Haywood f, L.G. Kirton g, J.-O. Meynecke h, J. Pawlik i, H.M.Penrose j,A. Sasekumar k, P.J. Somerfield l, 2007)*

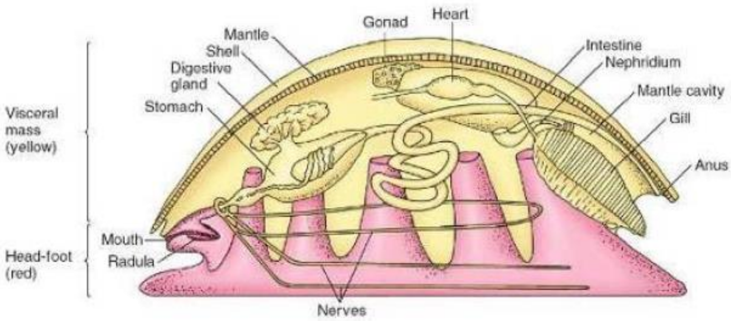
In this study we are going to talk about the molluscs species that we can find on mangrove forests, and like it is mentioned above they are representatives of the infauna.

Molluscs are a very diverse phylum of organisms. The molluscs compose the large phylum of invertebrate animals known as the Mollusca. Around 85,000 extant species of molluscs are recognized. Molluscs are the largest marine phylum, comprising about 23% of all the named marine organisms. The phylum is divided into 8 classes: Aplacophora, **Bivalvia**, Cephalopora, Polyplacophora**, Gastropoda ,**Monoplacophora, Pleistomollusca, and Scaphopoda. (Wikipedia)

But in the intertidal zone and mangroves roots the most common classes are Bivalvia (mussels, oysters, clams…) and Gastropoda (snails).

Mollusks are a large and varied group of animals that have a soft body and are most often covered with a calcium carbonate shell. Their body is divided into two major parts.

The head-foot region includes the head, mouth, sensory organs and the foot, which is usually used for locomotion. The visceral mass includes all the other organ systems. Themantle of mollusks covers the visceral mass and hangs from the sides of the body. Themantle produces the shell and in some groups is used in locomotion or gas exchange. Allmollusks except bivalves have a radula, a ribbon of tissue that contains teeth, used for scraping, tearing, piercing and cutting. (Karlestin 1998)



Picture 10. Hypothetical mollusk showing the head-foot region, visceral mass and mantle. (Karlestin, 1998)

The gastropods and bivalves are filter-feeders, scavengers or deposit-feeders. They feed on phytoplankton primary. They inhale water with oxygen and food particle through the gills. For this reason the bivalves and the gastropods are really vulnerable to the water contamination.

Based on the work of Joan Pérez Cremades on Prof. Severino Salmo (*Assessment of the displacement of mangrove species Avicennia sp. On mud clam Polymesoda erosa (Solander, 1876) in planted Rizhosphora mangroves*), on Navotas Mangrove we should fine at least some of the next molluscs: *Cerithidea sp., Gafrarium pectinatum, Isogriomon ephippium, Nassarius sp., Nerita planospira, Perna viridis, Polymesoda erosa, Terebralia sulcata* and *Telescopium telescopium*.

Most of these species are on mangroves forest and in brackish water, so it is logical to think that they can be on Navotas Mangrove.

Picture 11. *Polymerosa erosa* Picture 12. *Telescopium telescopium*

Additionally, these molluscs species are the most common on rehabilitated mangrove. These were the species founded on Bangrin (Bani) and Pilar (Lucero) mangroves, which are 280 km from Navotas.

The Navotas mangroves are being rehabilitated by the Universities of Philippines with *Rizosphora* sp. and some coconuts palms. This rehabilitation contributes to increase the malacofauna. Moreover, on Navotas the natural mangrove species is *Avicennia* sp., which is also very common and it can be full of molluscs species.

1.8 Economic and Social development of Manila Bay

According to the PEMSEA (*Manila Bay coastal Strategy, 2011*), around 30% of the country's population is found in the Manila Bay area. As of May 2000 (NSO, 2001), there are 23,045,442 persons living in this area. About 42.6% of this population or 9,826,622 live in the coastal areas, which include Manila, Las Piñas City, Parañaque City, Pasay City, Navotas, Bataan, Bulacan, Pampanga and Cavite. The noncoastal population is 13,218,820 persons.

The high population growth rates in the provinces create pressure on resources — opening up of marginal lands for cultivation and application of additional fishing effort or destructive fishing methods in order to put food on the table. Ultimately, such practices impair agricultural and fishing productivity resulting in low earnings for rural households.

Like we can observe on the table below, most of the people are working both as fishermen in fishponds (aquiculture) or as farmer, and there is also a big industrialized zone in Manila bay, which give work to a lot of people in manufacturing companies.

In spite of the jobs that there are around Manila Bay, the annual per capita poverty threshold level for 1997 was PhP 11,319.00. Poverty incidence in the Philippines was 31.8%, with 44.4%

found in rural areas and 17.9 % in urban areas (NSO-FIES, 1997). The poverty incidence in the NCR in 1994 was 8.0% (NSO, 2001).

The coastal character of Manila Bay

Zone	Location	Description
1. Brushland/Industrial	Southern Bataan (Mariveles & vicinities)	• coral reefs, seagrass and seaweeds • special economic zone
2. Urban/Aquaculture/ Agricultural	Bataan (from Limay & northwards)	• urban centers amid agricultural & aquaculture activities
3. Aquacultural and agricultural env't	Coastal Pampanga (Pasac River & environs)	• main drainage system for Central Luzon
4. Extensive aquacultural and agricultural env't	Coastal Bulacan (Tibaguin & Pamarawan River & environs)	• natural spawning area • large tracts of fishponds • large agricultural areas inland
5. Aquacultural/ Industrial	Eastern Bulacan (Meycauayan & eastward)	• natural spawning area • extensive aquaculture • industrial areas
6. Highly urbanized and industrialized areas	NCR •Navotas and environs •Pasig River area •Paranaque River area	
7. Extensive open-water aquacultural & urbanized environment	Northern Cavite (Bacoor and vicinities)	• productive aquaculture • commercial and residential areas
8. Limited aquacultural/ Extensive agricultural/ tourism	Southern Cavite (Rosario to Ternate)	• limited aquacultural activities • highest population of fisherfolk
9. Natural environment	Southernmost Cavite	• mountainous terrain
10. Island environment	Corregidor	• coral reefs, seagrass and seaweeds

Table 4. The Coastal character of Manila Bay. (*Manila Bay Coastal Strategy, PEMSEA, 2011)*

Manila Bay is the most important economic region of Philippines. Today, the National Capital Region (Metro Manila), consisting of 12 cities and 5 municipalities, is a bustling metropolis. There are about 39 special economic zones and technological parks located in the provinces, alongside prime agricultural lands.

Financial and business centers are also concentrated in this area. Considered as the best natural harbor in East Asia, the country's biggest shipping ports as well as ferry terminals, fish port, and yachting marina are found around the Bay. Its orientation towards the South China Sea allows the country to benefit from the current trend of transboundary development and trade with the rest of Asia and the world. (*PEMSEA, 2011*)

Now it is going to be described the main economic activities which take place in Manila Bay, according to PEMSEA.

- **Fisheries and Aquiculture:** Fisheries and aquaculture are among the major sources of livelihood in Manila Bay. Commercial, municipal and artisanal fisheries are common in the Bay
- **Manufacturing industries:** Manufacturing industries are found in industrial parks both in coastal and noncoastal areas of the Bay. Manila Bay area is home to oil refineries, tanneries and jewelry manufacturing, food and beverage, textile, electronics, pharmaceutical, and plastics industries.

- **Shipping and ports:** Shipping is the major avenue for trade and commerce in the Bay. An average of 30,000 ships arrive and depart from these ports annually, transporting passengers, manufactured goods and raw materials. The Bay includes international ports, fish ports, a container terminal and several major terminals servicing industries in the area.
- **Agriculture:** The surrounding inland area of Manila Bay area is predominantly agricultural. They produce rice, corn, vegetables and other crops, as well as livestock and poultry.
- **Commercial areas:** Commercial and business areas abound in the NCR, being the center of trade, commerce and finance. Most cities have shopping malls, business and commercial centers.

The increment of the population in Manila Bay and the rapid economic development of the region is producing a lot of environmental problems which are affecting the natural resources on Manila Bay, like the wetlands, ocean and mangroves forests. In the next paragraph is developed the environmental problems which the pollution is producing in Manila Bay.
In the next paragraph is developed the environmental problems which the pollution is producing in Manila Bay.

1.9 Pollution on Manila Bay

The most important environmental problems in Manila Bay are caused by the water pollution and by the plastic wastes which are produced by the population and the industries.

Water pollution

Based on the PEMSEA report, the water quality of Manila Bay has continuously deteriorated due to increasing discharges from domestic and industrial sources, as well as urban and agricultural runoff. Sea-based activities (e.g., ports, ships, aquaculture) also contribute to the increasing pollutant load to the Bay.

- Domestic sewage discharged to Pasig River
- Nitrate, nitrite, ammonia and phosphate concentrations are increasing in the eastern part of the Bay, due to pesticides used in agriculture.
- Heavy metals like copper, cadmium or zinc. They came from industries of Manila Bay and from the ports.

- Oil and grease from land– and sea-based sources fouls shorelines, vessels and equipment and inhibits living resources.

These pollutants produce a contamination of the seafood and consequently produce several diseases to the Manila Bay population. Moreover, the pollutant affect to the health and the reproduction of the marine life. These pollutants increase the mortality rate of the marine life and decrease their reproduction rate. Due the decrease of the population marine life the economic and the food supply of the locals it has been affected.

Moreover the water contamination affects to tourism because the Manila Bay is not appropriate for recreational uses like diving, swimming or skin diving. Also this reduces the incomes for local people.

Solid wastes

The solid waste is big problem in Manila Bay. The population and the industries produce thousands of tons of solid wastes dairy. Moreover these wastes are not managed adequately. They are not separated and recycled, and most of them end on the rivers (Pasig and Pampanga rivers), which fall into Manila Bay. Most of these wastes are plastic. So they take thousands of years to degrade and they produce several ecological problems on the marine environment and on the coast. For example they are dragged with the tides and waves to the beaches, degrading the coastal ecosystems.

Solid wastes are capable of impairing ecosystems, blanketing habitats, degrading aesthetics, and posing public health risks.

The amount of wastes production is a direct consequence of the Filipino population consumerism. For example the Filipino people use to go to fast food restaurant, where is produced a lot of plastic and paper waste. And another problem is that the people can buy everything (body lotion, detergent, deodorant…) in individual size. These products generate a big amount of plastics which could be reduced just using big containers for these products.

The solid wastes as the water pollution produce economic losses for local people because they contaminate the ecosystem, this reduce the population of marine life and also decrease the soil efficient of the fields which are around Manila Bay.

On 13th of February of this year was published on the Rappler magazine that Philippines is one of the top countries on the world who more waste throw into the sea. Exactly 0.28-0.75 MMT (millions metric tons) annually.

Picture 13. A rubbish collector gathers floating plastic garbage in Manila Bay on 'Fifth International Plastic Bag-Free Day' in Manila, Philippines, July 3, 2014. Ritchie B. Tongo/EPA

2. HYPOTESIS

In this study we expect that the number of mollusk species is higher in non-polluted mangroves than in polluted mangroves. Therefore we will considerate as bioindicators of the contaminated mangroves the mollusk species found in the polluted mangrove *(Navotas, Manila Bay).*

3. OBJECTIVES

MAIN OBJECTIVE: To make a study of the mollusk species which survive on a polluted mangrove (Navotas, Manila Bay). Therefore we will be able to use those species as bioindicators of contaminated mangroves.

SECONDARY AIMS:

- Study of the currently physico-chemical parameters (pH, light, EC, Redox, Soil Temperature and salinity) of the soil in the mangrove forest of Navotas.
- Study of intertidal mollusk communities.
- Compare the number of mollusk species of the Navotas Mangrove, which is the contaminated mangrove, to the Pilar and Bangrin mangrove forests, which are the non-polluted mangroves.

4. MATERIALS AND METHOD

4.1 Experimental design/ Sampling

We delimitate 10 random study plots of 1 x 1 meter each one on the area of Navotas mangrove. We take the coordinates with a GPS to place them on a map.

After that we measure the soil physic-chemical parameter of these random plots using the appropriate material. In the next table we can observe which material we use for each parameter. We will do three repetitions of each parameter to decrease the error of the data.

Ph	Ph- meter
Light reflexion	Luxmeter
Redox	Oxygen meter
Soil Temperature	Scientific thermometer
Salinity	Refractometer
Electroconductivity	Conductivity tester

Table 5. Instruments and parameters used for the study

Once we have all the physico-parameters collected, we start collecting the bivalves and gastropods which we find on the plots. Then we will describe them and identify the species of each one using a guide of molluscs of the Philippines. In this way we will know the molluscs biodiversity of the mangrove. Also we will take photographs of the different species as a visual prove of them. Finally we will weight them to calculate the biomass. We will separate them on species, to know the biomass of each one. We will weigh them on the mangrove to avoid taking them to the laboratory and causing them the die.

4.2 Data analysis

Once we have the field data, we will study the correlation of the data using the Excel program. In which we will know the correlation between the data. We will meanly focus on biomass biodiversity.

Finally, we will compare our data filed to the data from the study of "**Assessment of the displacement of mangrove species *Avicennia sp*. on mud clam *Polymesoda erosa* (Solander, 1876) in planted *Rhizosphora* mangroves**", carried out by Joan Pérez Cremades and supervised by Prof. Severino G. Salmo III from Ateneo de Manila University.

5. RESULTS

The expected results for this work were to find less biodiversity and biomass of molluscs in Navotas mangrove than in Pilar and Bangrin mangroves, due to the pollution of the water and the area.

But when we went to collect the data, we did not find any species of mollusc. So, in return, there was zero species of molluscs per square meter.

So: $$Biomass = \frac{weight\ of\ organisms}{area} = \frac{0\ kg}{1\ m2} = 0\ kg/m2$$

And: $$Biodiversity = n^{o}\ of\ species = 0$$

We could not find any mollusc due to the pollution that was evident in the mangrove. It was totally covered by wastes (plastics, clothes…), which come from the tides of the Manila Bay. On the pictures below we can observes the great amount of wastes which we found there. And on the Annex 2 there are more pictures of the wastes pollution of Navotas Mangrove.

Picture13. Tanza, Navotas beach

Picture 14. People collecting on Navotas Manfgrove

Picture 15. Navotas Mangrove

Definitely, there are more biodiversity and biomass on non-polluted mangroves than in polluted mangroves. And we can safely say that the pollution is the cause of the lack of molluscs in Navotas mangrove.

6. CONCLUSION

In conclusion, the great population who is living in Manila Bay and the huge amount of solids wastes that this population produces are affecting to the marine environment and its organisms. These factors are blocking the social and economic development of the community, because the principal working and feeding resources have been affecting by the pollution: the water and the food.

The pollution is decreasing the fish population, crustaceans and molluscs population as well as it affects the income of the locals, because they cannot fish. Also they cannot feed on them due to the fact that the marine organisms are contaminated and are causing diseases to the locals.

So to avoid the problems which the pollution causes, first of all, it must have a decrease of the plastic consumption and then it should have a good management of the solid wastes.

In the case of Navotas Mangrove, the plastics must be removed from the mangrove. They can be used for building and to get some income for the locals. On the Annex 1, it is explained how to make a house using plastic bottles and plastic wastes.

Then if all the plastics are removed, in the future, the fauna would come back to the mangrove ecosystem and the forest would be recovered.

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8. ANNEXES

ANNEX 1

PROPOSAL OF PLASTIC WASTES RECYCLING FOR NAVOTAS MANGROVE

The first thing that has to be done is to remove all the plastics that we find on the Navotas mangrove.

If the plastic wastes are removed, the soil could be recovered because the water of the high tide would bring nutrients and organisms from the sea, among them the intertidal mollusk. Moreover the mangrove trees could grow up and reproduce, making up a real mangrove forest which would attract the typical fauna that we can find on a mangrove.

The mean problem is that the government is not investing money to keep the mangrove clean, in spite of being a protected area. For this reason in this document we are going to find different proposals to recycle and reuse these plastic wastes.

The main objectives of these proposals are to remove the wastes and turn them into an income for the population of Tanza. This way, we get to involve the locals and to create steady jobs.

The first proposal is the **Ecobrick**.

An **ecobrick** is a plastic bottle stuffed solid with non-biological waste to create a reusable building block. Ecobricks are used to make modular furniture, garden spaces and full scale buildings such as schools and houses. Ecobricks are a collaboration powered technology that provides a zero-cost solid waste solution for individuals, households, schools and communities. Also known as an **Eco-Brick**, a **bottle brick**, and **Ecoladrillo** this local waste solution has come to be known as 'Ecobricks' (non-hyphenated) by a growing movement of communities around the world. (Wikipiedia)

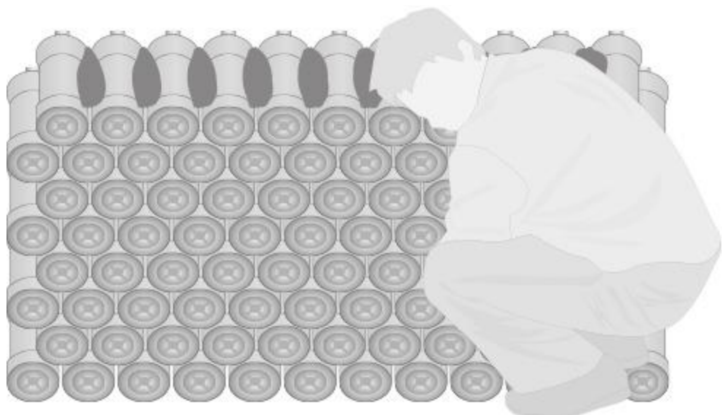
Ecobricking is characterized by these general principles:

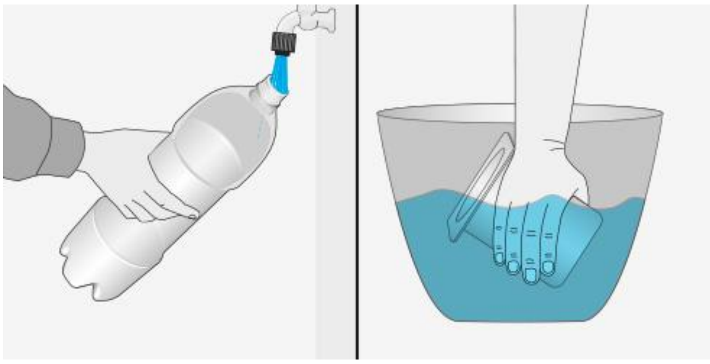
- Reduce the environmental pollution
- It is an easy recycling technology
- It is easy to store and transport
- It is a technology which use the human energy
- Use all the plastics wastes
- It is an insulating material
- It is earthquake resistant

Ecobricking plastic waste into bottles is a method for dealing with waste that has popped up organically around the world. Various simultaneous pioneers have helped shape the global movement and refine the technology. Susana Heisse an environmental activist around Lake Atitlan in Guatemala in 2004. Alvaro Molina began on the island of Ometepe in 2003. The technique builds upon the bottle building techniques developed by German architect Andreas Froese (using sand filled PET bottles) in South America in 2000.

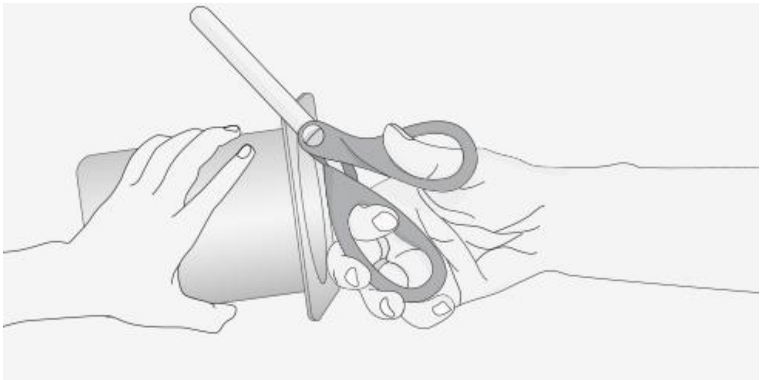
In 2010, in the Northern Philippines, Russell Maier and Irene Bakisan developed a curriculum guide of simplified and recommended practices to help local schools integrate ecobricks into their curriculum. Applying the ancestral ecological principles of the Igorots for building rice terraces, they integrated Cradle-to-cradleprinciples into Ecobrick methodology: ensuring that Ecobricks can reused at the end of the construction they are used in. Through the Department of Education the guide was distributed to 1700 schools in 2014.

How to make an ecobrick? (Austral University of Chile)



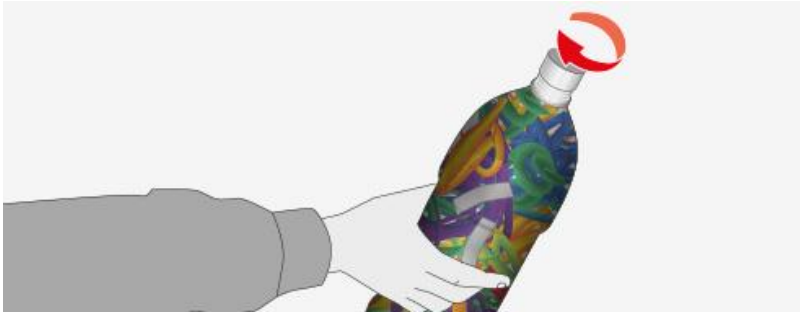


1. Clean the bottles and the plastics wastes which we are going to put inside it. It is better clean them with water and soap. This allows us to remove any organic waste. It is important to keep the cap.



2. In order that every waste fits inside the bottle, we can cut them with the scissors.

3. When we have all the wastes cut and cleaned, we have to put into the bottles. We should use something to press the plastics because they have to be very compacted.



4. Finally it is very important to close the bottle, to keep them compressed.

With these Ecobricks the locals can build up houses, schools, park benches, fences…almost every kind of constructions.

Picture. Ecobricks

When we have the Ecobricks done, we can use them to build up a house.

In this example we are going to explain how to build up a simple squared house, with four walls. The dimension for this house are: 36 m^2 with 24 linear meters and 2,4 height, and we don't take into account the roof.

To build up this house we will need:

- 5,184 Ecobricks of 1,5 L. (If the bottles are bigger we will need less, but it is advisable that the bottles have the same size)
- 48 concrete bags
- 10 bucket of sand
- 5 bucket of gravel
- 2 wheelbarrow
- 4 shovels
- Water

1. To make all the Ecobricks, like it has been described above, which are going to be used.
2. Start making the cement mixture. We will mix 1 shovel of concrete with 1 of gravel and 2 of sand. Rake over with the shovel and add water until all is well mixed.
3. When we have the mixture done, we put the first layer of concrete on the floor. Then we are going to put the first layer of Ecobricks. We must leave 2 cm between the bottles to make sure that the concrete fills up the space.

Picture. People building up a house with Ecobricks

4. Now we can put the second layer of bottles. We have to make sure that this layer is fitted in the spaces that we leave between the bottles of the first layer.

5. Repeat this process until the last layer. On the last layer we are going to change the concrete mixture. We will put 1 shovel of concrete per 2 of the sand. We don't put gravel for the last layer. On the last layer we will put two layers of concrete mixture, for endurance it.
6. Finally we are able to use the construction when the concrete is totally dried.

Picture. House made out of Ecobricks

There are different ways to build up a house with Ecobriks. For example the one below is build it without using concrete, just metal net and wood.

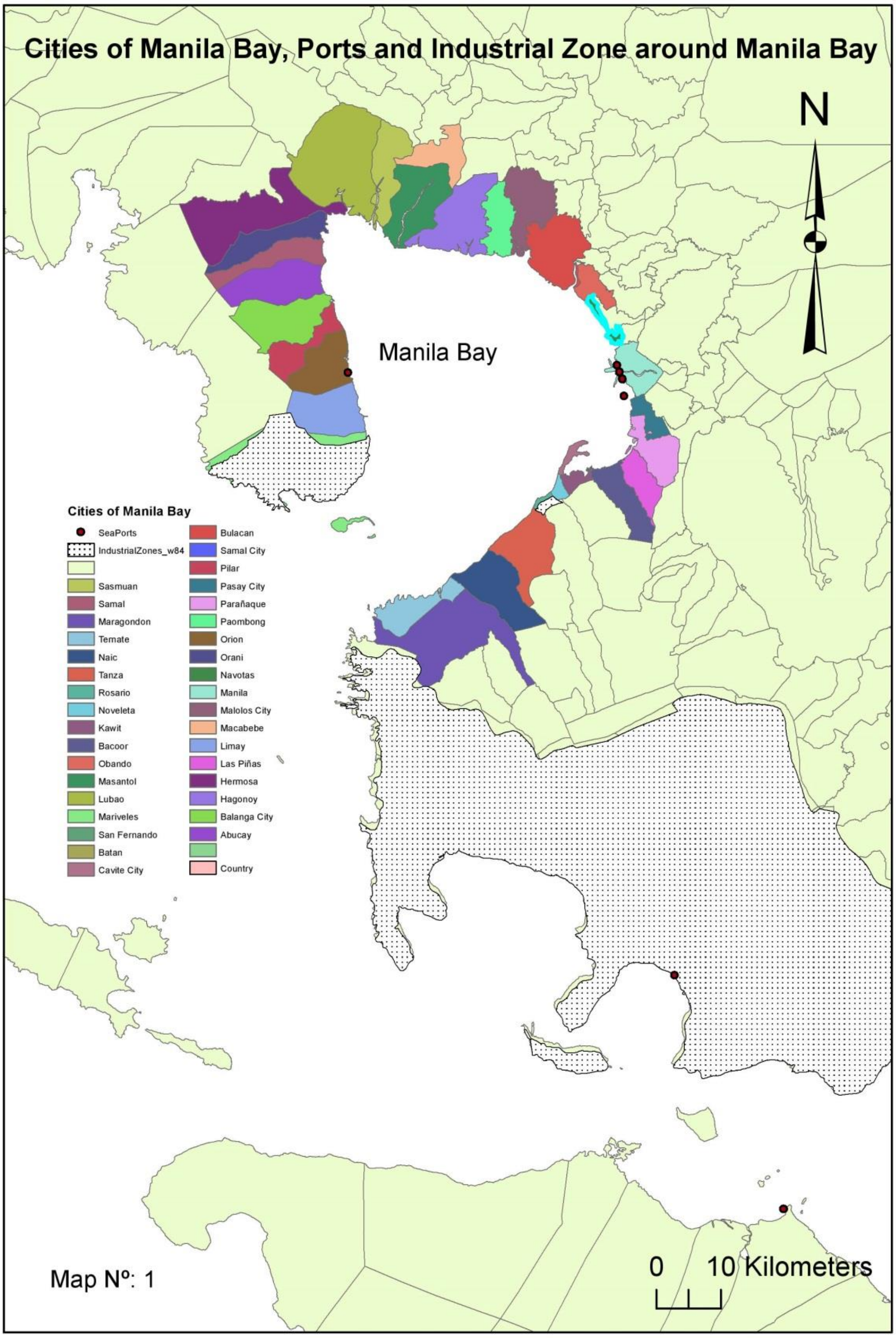
Picture. House made out of Ecobricks

Building this house using bottles of 1.5 L, we would remove 7.776 m^3 of plastics of the Navotas Mangrove. This example shows that building the construction with Ecobricks could help to remove all the plastics and to recover the Navotas mangrove. Moreover the cost of this kind of building is low for the locals and at the same time create stable jobs for the people.

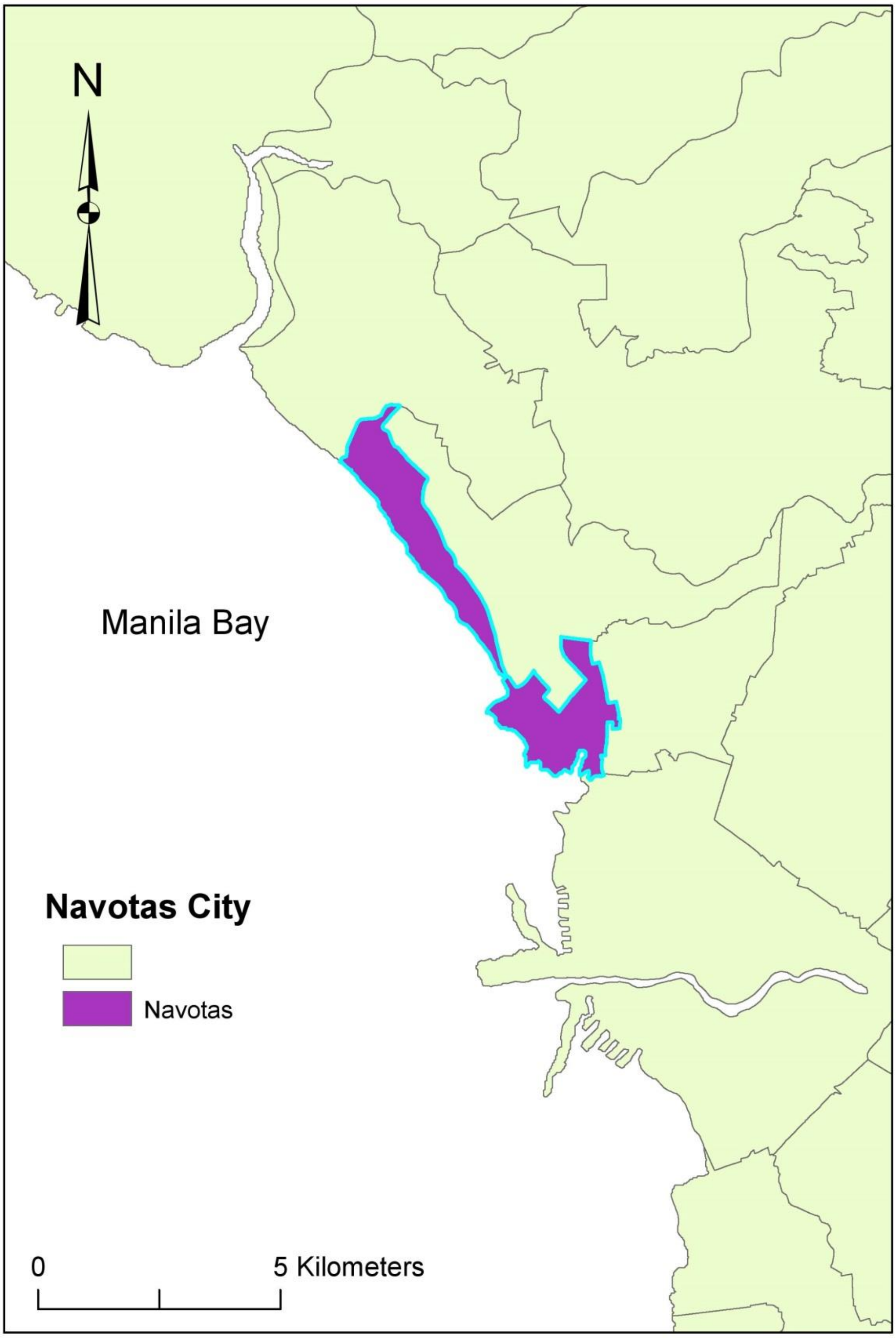
ANNEX 2

Navotas Mangroves Photographies

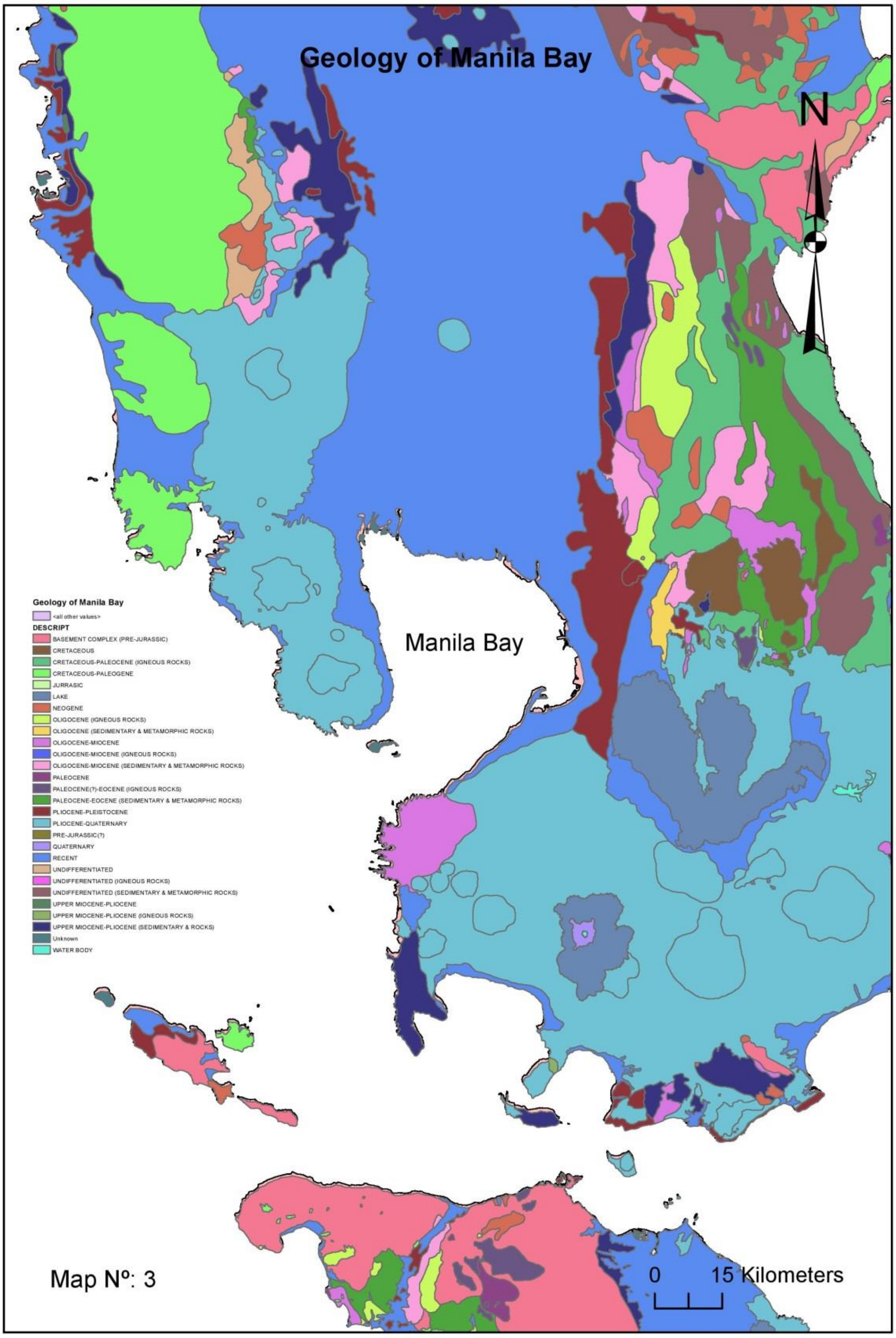
ANNEX 3 MAPS



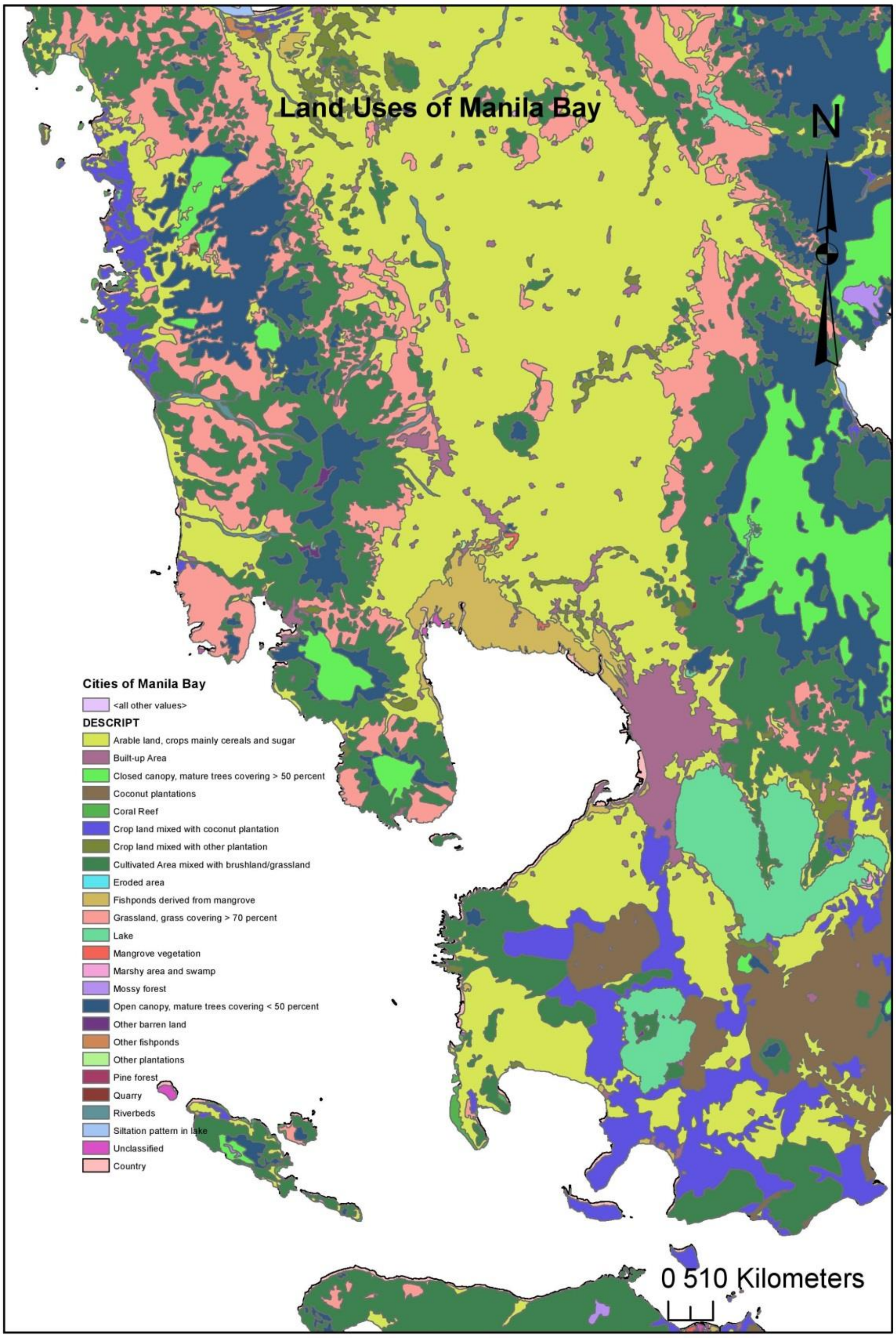
Map 1. Manila Bay



Map 2. Navotas City



Map 3. Geology of Manila Bay



Map 4. Land uses of Manila Bay