REHABILITATION & ECOLOGICAL RESTORATION R & D FOR MARGINAL & DEGRADED LANDSCAPES AND SEASCAPES

A Research Compendium
FOR DAMAGED URBAN AREAS

Department of Environment and Natural Resources
Ecosystems Research and Development Bureau

A RESEARCH COMPENDIUM FOR DAMAGED URBAN AREAS

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FOREWORD

The urban ecosystem had been pressured by rapid rate of air, water and land pollution coupled by thermal heat, hazardous waste generation and reduced greenery areas. This was brought about by accelerated urbanization giving rise to industrialization, population influx and increased infrastructure development. These besetting problems in urban ecosystem contributed a high percentage in the so-called climate change or global warming. This compendium therefore has been designed for urban environmental managers who are in search for solutions in addressing these various problems.

Information on the most appropriate rehabilitation techniques however, is scanty. The much-needed research-based data are generally scattered in different government agencies, private organizations, colleges and universities. There is only a need to gather, integrate, and consolidate these large bodies of scientific knowledge and verify the technologies under certain environmentally-stressed site conditions.

Hence, it is envisioned that the application of the technologies presented in this compendium will be instrumental in the recovery and management of the damaged urban ecosystem for the provision of a safe and productive environmental life for urban people.

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PREFACE

This Research Compendia on Rehabilitation and Ecological Restoration R & D Technologies for various Ecosystems was published through the efforts of the Ecosystems Research Development Bureau and its regional research field counterparts, *i.e.* Ecosystems Research and Development Sectors. Research information was gathered from all Regions including those from recent books and the internet. Ecosystems studied include: critical watersheds, degraded mine waste areas, volcanic debris laden areas, marginal grasslands and uplands, damaged urban and coastal sites.

While research and technology information generated in the past years have proliferated, the changing needs of time require that recent technologies be collated, integrated, analyzed and synthesized as a basis of decision-making in verifying the effectiveness and efficiency of said technologies. Managers and developers particularly in degraded areas need vital source of broad set of information from which to choose from. This manual hopes to be a meaningful guide to hasten rehabilitation efforts in these areas.

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INTRODUCTION

Urban areas are characterized by their high concentration of population and intensive human activities in a relatively small land area particularly, in big towns and cities. The urban ecosystem has very high economic, political and social importance. Urban areas play a major role in transforming resources into useful goods and services that contribute to national economic production. They affect both local and regional environments because of the concentration of consumption of goods and generation of wastes in one area. Urbanization invariably results in high per capita consumption rates that, in turn, cause higher demand for natural resources and more environmental risks.

In the process of development, urban areas are the first to be industrialized. As factories and manufacturing firms are established, more people are attracted to converge in these areas for employment and for improvement of socio-economic status.

The build up of transportation facilities in urban areas grow rapidly thru the years. Metro Manila has an estimated close to a million motor vehicles operating which spew tons of carbon monoxide and carbon dioxide daily into the air, aside from the noise pollution produced by engines and horns. The 8 million commuters who use up space and litter into streets aggravate the stressed environment.

In the 20th century the ever-increasing population of major cities in the Philippines, particularly Metro Manila, placed greater pressures on the environment. Metropolitan Cebu is another crowded city which has more than 18,000 registered business establishments (DENR, 1990). Today, there are about 15,000 industrial firms in the country and 69% of these are situated in Metro Manila. The transport and industrial sectors both contribute approximately 40% to 60% of pollution load.

Inefficient sewage collection and water pollution aggravate the environmental problems as huge discharge of untreated wastewater from domestic and industries have rendered major rivers in the metropolis biologically dead. At present, an average Filipino generates 35-70 g of sewage per day and 640-1,600 g/person of solid waste per day. In Metro Manila alone, 6,169 tons of wastes are generated every day (Reyes 2007) which is enough to fill 1,500 dump truck trips per day. From the total volume of trash generated 1,500 tons daily is dumped illegally on private lands, rivers, creeks, and in Manila Bay, while other wastes are openly burned. In Rodriguez and Payatas waste sites, 76 kgs of arsenic are released annually into water bodies surrounding Metro manila.

A major problem besetting the inland waters is the infiltration of the leachate or "garbage juice" brought about by open and controlled dumping. Leachate emanates from bacterial decomposition of garbage eventually contaminating bodies of water used for fishing, swimming, drinking, agriculture, industry and other domestic needs.

Likewise, groundwater can also pose serious threats, in terms of its quality and quantity. Since 1995, the groundwater table in Metro Manila was estimated to recede at an accelerating rate of 5-12 m/year which has led to saltwater intrusion in a two-kilometer coastal strip extending from Cavite to Navotas-Malabon (DENR-MEIP, 1992 as cited by World Bank 2000).

Flooding also affects about 1.9 million people and inflicts losses of about PhP900 million per year. Almost 7% of Metro Manila (about 44 km2) is prone to flooding. Mostly affected are medium and highly dense residential districts. Flooding occurs as a result of poor drainage system. In river systems, easement of encroachment is a common problem. This is aggravated by the presence of informal settlers and business establishments along riverbanks.

Air quality of Metro Manila and its vicinities are alarming. Fine particulate emissions result in about 2,000 premature deaths and 9,000 cases of chronic bronchitis in the country's four largest urban areas annually. Emissions of pollutants were largely blamed on public buses, jeepneys, utility vehicles, trucks, and motorcycles; 70% of air pollutants are attributed to motor vehicles (Reyes, 2007) and 30% to stationary sources (industries).

Likewise, persistent organic pollutants (POPs) pose a risk on human beings and the environment. Pesticides, industrial chemicals, and unintentional by-products from the emissions of incinerators from hospital wastes, municipal wastes and from dioxins as by-products of processes used by metal smelters, refineries and cement kilns were found to cause cancer and tumor. Pesticides have been demonstrated to cause a variety of serious health effects on the human immune, reproductive, nervous and endocrine systems.

The influx of people and overcrowding into the metropolis exacerbate an already stressed situation in sidewalks, canals, and estuarines. Urban areas suffer from pollution coming from various sources. Before anyone realizes it, urban centers have already choked up because of pollutants spewed by factories, fumes, and toxic gasses into the air, and chemical pollutants into the waterways. All these pose immediate health hazards to the population.

PROBLEMS IN URBAN ECOSYSTEMS

Urban Greening

Urban greening or forestry in the Philippines, just like in any other countries, has evolved due to the need to maintain and sustain wholesome and habitable environment of the communities for the benefit of the urban society. Most urban areas, especially Metro Manila, are experiencing environmental problems whose mitigating measures are connected with the restoration of greeneries, green spaces or urban forests.

There are two main groups that play critical role in the green space health of the gateway to the Philippines from NAIA to the mouth of Pasig River via Roxas Boulevard. These are the settlers and the business people. The settlers or squatters found refuge in the area by building their camps and shanties. The business sectors are the legitimate, highly commercialized businesses such as hotels, restaurants, banks and commercial enterprises.While the illegitimate businesses are the peddlers, sidewalk vendors and scrap collectors.

The proliferation of mendicants, unregulated increase of vendors and peddlers and stubborn pedestrians were identified as the primary cause of littering, trampling and destruction of plants along island and corridor plantings in Roxas Boulevard, and other green spaces in Metro Manila.

Efficient and effective management of urban vegetation is essential to the environment and the welfare of the residents.

More sectors of the society, however, are now becoming aware of the vital roles of trees/green spaces/forests in enhancing the environment and in sustaining ecological stability aside from the socio-economic, aesthetic and amenity benefits.

Hence, efforts to develop, conserve and preserve the green spaces are still being initiated to save the environment and to have clean, sustainable cities in the country. Though some of the practices of urban greening had been employed for quite a long time, the knowledge and technologies have yet to be fully generated with some scientific basis. The following are identified areas with urban greening problem:

1. Open Areas

Open areas are those areas left abandoned for a time. Some of these are mining sites, municipal and industrial dumpsites and farmlands. These lands

are contaminated with toxic metal like Cadmium (Cd), Copper (Cu), Nickel (Ni), Zinc (Zn), Barium (Ba), Lead (Pb), and etc.

2. Roads and Highways

Generally all roads and highways are not provided with spaces for planting. Even sidewalks are occupied illegally for other purposes, mostly vendors. Roads are often subjected to widening or renovation. Utility services for the cities are generally provided by overhead cables, suspended transformers or varied pipes and other services along sidewalks. These restrict planting or greening.

3. Parks

Parks are areas where people usually converge and hold social gatherings or celebrations. National parks include areas of the public domain essentially of primitive or wilderness character which have been withdrawn from settlement or occupancy and set aside as such, exclusively to preserve the scenery, the national historic objects, the wild animals or plants that contain and provide enjoyment of these features in such manner as will leave them unimpaired for future generations. Many of our parks today need restoration strategies, intensive maintenance and inputs, protecting from pest and diseases to keep them healthy. Parks could take advantage of natural processes such as nutrient and water cycling.

4. Green Belts

Green belts are public plazas, subdivision, schools, and public grounds. Some of these areas are still open and when planted, will serve as environmental pollution buffer or filters.

Water Pollution

The principal sources of water pollution in urban areas are sewage, domestic, industrial wastes, garbage, refuse pesticides and other chemicals (Fig. 1).

Fig. 1. Polluted river due to illegal waste dumping and inefficient sewage collection along the coastal road in Parañaque, Metro Manila.

The inefficient sewage collection and water pollution caused by discharge of untreated wastewater from domestic and industries render major rivers in the metropolis biologically dead. The siltation of the riverbanks is also due to vegetation losses. Some of our riverbanks are also occupied by squatters wherein their waste matters go directly to rivers. In addition, numerous industries situated along the river systems discharge their toxic wastes directly unto the rivers (Fig. 2).

Fig. 2. The presence of numerous illegal settlers as shown through their houses and factories built along the riverbanks of Manila Domestic Airport is a problem that needs to be addressed by the government. Their wastes go directly to the river causing water pollution.

Fig. 3. Dirty sewage coming from the wet market and eatery section along the Coastal Road in Parañaque, Metro Manila.

Polluted wastewaters from the wet and eatery sections of the market and public toilets drain into creek leading to the lake [Fig. 3]. Untreated leachates from landfills also pollute water bodies.

The leather industry, on the other hand, is traditionally associated with bad odors and pollution. Tanneries are generally located close to a river to ensure plentiful water supply for processing and effluent disposal. Tannery effluent includes proteins, hair salt, lime sludge, sulfides, acids, dyes, oils, and tanning agents.

Water is often drawn from rivers, lakes, or the ocean for use as a coolant in factories and power plants. The water is usually returned to the source warmer than when it was taken. Even small temperature changes in a body of water can drive away the fish and other species that were originally present, and attract other species to take their place. Thermal pollution can accelerate biological processes in plants and animals or deplete oxygen levels in water. The result may be fish and other wildlife deaths near the discharge source. Thermal pollution can also be caused by the removal of trees and vegetation.

Water pollution can also be caused by other types of pollution. For example, sulfur dioxide from a power plant's chimney begins as air pollution. Because polluted air mixes with atmospheric moisture to produce airborne sulfuric acid, it falls to the earth as acid rain. In turn, the acid rain can be carried into a stream or lake, becoming a form of water pollution that can harm or even eliminate wildlife. Similarly, the garbage in a landfill can create water pollution if rainwater percolating through the garbage absorbs toxins before it sinks into the soil and contaminates the underlying groundwater (water that is naturally stored underground in beds of gravel and sand are called **aquifers**).

Water pollution from non-point sources are more difficult to recognize. Pollutants from these sources may appear a little at a time from large areas, carried along rainfall. For instance, the small oil leaks from automobiles that produce discolored spots on the asphalts of parking lots become non-point sources of water pollution when rain carries the oil into local waters.

Hence, with the country's fast pace of urbanization, our water environment is the first one to suffer amidst the reward of growth.

Waste Management

Solid waste or "basura" has emerged as the most visible environmental problem in the cities and municipalities of the Philippines. Generation of waste is increasing rapidly as consumption rises, while collection efficiencies are dropping as service levels deteriorate. Treatment and disposal facilities are facing closure because of improper setting, management, and growing public opposition. The problem is more pronounced in Metro Manila, where it is common sight to see uncontrolled garbage piling up or being burned. In the meantime, human health expenses continue to rise as a result of improper handling and disposal of household, hospital and industrial wastes.

It has been observed that some of the households, owners, operators, and tenants of businesses and commercial establishment and institutions indiscriminately put their garbage outside their fences or within their immediate premises. This serves as the feeding ground for cats and dogs thereby causing garbage to spill and scatter, attracting insects, pests and vermins in the area.

The indiscriminate dumping of wastes contaminates surface and ground water supplies. In urban areas, solid wastes clog drainage systems, creating stagnant water for insect breeding and floods during rainy season.

Metro Manila can generate 6,000 tons of garbage daily. About one-half of this garbage remain uncollected and continue to litter the streets (Fig. 4), which can cause clogging of esteros and river tributaries. Some are dumped in vacant lots. Even garbage collected which reaches dumpsite is not properly controlled. Uncontrolled open dumps have no environmental safeguard and will impose public health problem and affect the landscape of the place.

Fig. 4. A sample of illegal waste dumping on the street in Las Piñas, Metro Manila.

Wastes in highly urbanized areas can be categorized into the following:

1. Industrial wastes– those generated from the production of plastics, pesticides, medicines, paints, oil and petroleum products, metals and biodegradable wastes from fisheries and others.

2. Municipal wastes– those that come from garbage and other waste materials produced from households, public markets, restaurants, office buildings, commercial establishments, etc.

Air Pollution

In urban areas particularly in Metro Manila, the sky is always hazy with the thick layer of smog, mainly due to build-up of pollutants from large vehicular population. Dust pollution or particulate matter is aggravated by the exposed earth in most open areas due to lack of turfs or grasses.

Significant contributory factors to urban air pollution are activities which arise from uncontrolled burning of waste and improper incineration.

Meanwhile, in landfill areas, odors caused by gases are created by microorganisms as they breakdown organic material. Landfill Gas (LFG), if left uncontrolled, will migrate into the atmosphere creating odor and environmental problems. LFG is composed of methane (50-55%), carbon dioxide (45-50%) and trace amounts of other gases such as O2, N2, and hydrogen sulfate.

Odors in landfill occur because most sanitary landfills do not incorporate any significant provisions to prevent air pollution from gaseous emissions.

Aggravation of air pollution also results from the expansion of industries. However, while most industries provide anti-pollution safeguards, a significant number of established anti- pollution safeguards were not effective.

REHABILITATION TECHNOLOGIES

Urban Greening Problem

1. Rehabilitation Schemes for Open Areas

a. The use of **hyper-accumulator** or metal scavenging plants which could extract and sequester toxic heavy metals from contaminated soil is one of the technologies that may be used. These metal scavenging plants are capable of accumulating metals 100 times greater than those of the common non-accumulator plants. *Amaranthus* and pechay baguio are some of the plants which can survive high concentration of cadmium, chromium, copper, nickel and zinc.

On the other hand, vetiver grass is being used to remove boron, cadmium and lead from soils contaminated by sludge coming from the textile industry while radish is the best known hyper-accumulator of copper, lead, cadmium and zinc.

These plants not only tolerate the presence of heavy metals but they also have strong appetite to take them up through their roots and transport them to their stems or leaves where these contaminants could be easily removed by harvesting. If the land is needed for growing crops, particularly food crops, the hyper-accumulators must be removed. The leaves of these plants should not be used as mulch or green manure, because the heavy metals will be returned back to the soil. The best way is to dry them, burn and then bury the ash.

b. The use of **non-food** crop such as **flowering** and **ornamental** plants for contaminated lands are also recommended to make the land attractive and colorful. Some of these species are: chichirica, false bird of paradise, *Wedelia*, cucharitas, carabao grass, luha ng dalaga, rose moss and lantana.

c. **Tree** species are usually planted on open areas such as: rain tree or acacia, banaba, kamagong, pili, balete and fringon.

2. Urban Greening Schemes for Roads and Highways

a. **The species usually chosen for expressways and highways are:** mahogany (large-leaf and small-leaf), narra, rain tree, banaba, kamagong, mangium, auri, neem, balete and fringon. Urban greening of roads and highways utilizes species of bigger trees and are usually planted at 10m x 10m spacing. To provide visual variety, species differed at least every kilometer during long distance travels and to prevent potential attacks of pests or diseases.

b. ***For Center Islands (medium roads)*** with the width of more than 2 meters, shade trees and trees with colorful flowers can be planted. All center islands can be turfed or landscaped. However, if there are possible expansion to ease the traffic in the future, thick shrubs can be planted; they can be easily removed in case of road widening. Trees can be planted at 8m x 8m spacing. Species recommended for center islands are: agoho, mangium, banaba, pink tecoma, golden shower, Palawan cherry, royal palm, anahaw, Mc Arthur palm and bunga de China.

c. ***For narrow and median roads and verges,*** the following shrubs can be used: adelfa, caballero, melendres, yellow bell, bougainvilla, dwarf calachuchi and Shanghai beauty.

d. ***For Rotunda or Runabout roads,*** the recommended species are: Golden shower, Acacia, Palawan cherry, Dapdap, Palosanto and Fringon.

e. ***For road shoulder (near beach),*** the recommended species are: Talisai, Botong, Bitaog, Agoho and Coconut.

f. ***For flyovers, pedestrian and overhead bridges***, palms and shrubs can be planted along the sides of the flyovers. Land is provided around columns, staircases, etc. for this purpose. The bare surfaces of the pedestrian overhead can be planted with creepers and climbers.

Small trees can be planted along roads which are close to buildings and congested areas with overhead bridges to reduce the necessity of constant pruning of branches. Trees should be planted 1 meter away from traffic signs.

3. Urban Greening Strategies for Parks

Species that should be planted should provide shade and improve their aesthetic value. The relative position of the individual trees and shrubs has to be varied as much as possible. They may be

single trees neighboring small groups of the same species. An intimate mixing of single trees and shrubs species has to be discouraged. This can be planted at irregular spacing or 1 tree for every 40 sq. m.

a. ***For recreational parks*** whether public or private, the practice was planting of fire tree, acacia, African tulip, narra, golden shower, pink shower, yellow shower, Palawan cherry, fringon, dapdap, Ilang-ilang, champaca, balitbitan, S*araca*, *Amherstia*, royal palm, champagne, red palm and blue palm.

b. ***For open car parks*** whether public or private, trees with a wide awn can be planted to provide shade. Aeration slabs can be provided and turfed with grasses. All the void areas can also be planted to maintain aeration, drainage and greenery. Trees can be planted at 10m x 10m spacing and provided with tree guards to prevent damage from careless drivers. Some of the species used are: narra, dapdap, mahogany and raintree or acacia.

4. Greening Strategies for Greenbelts

Presidential Decree No. 953 dated July 6, 1976, requires subdivision owners-developers to allocate 30% of the area of subdivision, exclusive of roads, service streets and alleys, as open spaces for parks and recreational areas. All open spaces should be planted with species that will improve the aesthetic value, provide shade, abate noise, glare control and traffic control.

Species recommended for planting are: rain tree or acacia, narra, fire tree, golden shower, banaba, katmon, alibangbang, botong, akle, molave, *Saraca*, *Amherstia*, royal palm, traveller's palm and fringon.

Some fruit trees planted in schools, hospitals, private residential houses and other private open spaces are: guyabano, mango, avocado, caimito, datiles, sampaloc, langka, guava, kamias, santol, chico, manzanitas, mabolo or kamagong and atis.

Shrubs for ground covers include: chichirica, false bird of paradise, *Wedelia*, cucharitas, spider lily, carabao grass, luha ng dalaga, rose moss, and lantana.

The recommended shrubs for landscaping are: yellow trumpet, Yellow caballero, Yellow santan, Singapore bush, poinsettia, red santan, Doña Luz, Doña Trining, Doña Aurora, rosal, and white santan.

Recommended vines for landscaping are: Honey suckle, Cadena de Amor, Garlic Vine, Jasmine and Drunken sailor.

5. Restoration and Greening of a Closed Dumpsite

Figures 5 to 9 shows a step by step greening program undertaken by the municipality of San Juan, Rizal to ecologically restore a closed dumpsite. The dumpsite now becomes a mini-botanical garden.

Fig. 5. Before, this bare area which was more or less 1,000 m2 in size was once upon a time a dumping site of garbage materials in San Juan, Rizal.

Fig. 6 Squatters living in the surrounding area were relocated and wastes were removed prior to the starting of the project.

Fig. 7, For initial planting the perimeter areas were planted with Bandera española. Used vehicle tires were utilized as tree guards or pots for ornamentals.

Fig. 8. This was how the used tires were utilized.

Fig. 9. The former dumpsite now becomes a mini-botanical garden.

The conversion of a former dumpsite into a mini botanical park is only one example of urban restoration or rehabilitation. There are however, other potential sites and projects for restoring the urban ecosystem, the following are examples: (1) the establishment of under story plant species in school yard to promote wildlife species; (2) the eradication of invasive plant species which is eliminating much of the understory biodiversity; (3) the clean-up of a vacant public or private-owned lot or abandoned site and the establishment of a park; and (4) the re-design of a small water retention pond which could be restored with wet land species.

6. Planting and maintenance

Generally, plant materials that will be used for urban greening should be healthy, well-rooted, free from pests, diseases and physical deformities. The size and species in a given site should be in accordance with approved assessment plans and specifications.

The most neglected part of urban greening is on the proper planting. To achieve a successful greening program the following should be pursued by all involved in planting.

Maintenance should be carried out for 2-3 years after planting.

a. The minimum size of tree planting holes especially on adobe soil is 1.0 m x 1.0 m x 1.0 m.

b. Every planting hole or bed should be backfilled with a mixture of good top soil and compost at a ratio of 3 parts topsoil to 1 part compost.

c. All plantings, particularly trees should be watered regularly especially during first two years and during the occurrence of drought.

d. All tree saplings, poles and big trees planted should be provided with stakes and tied on guy lines so that they will grow upright and be protected from strong winds or typhoon.

e. The stakes or guy lines should be removed as soon as the tree can stand on its own. This is usually one year after planting for most trees, in order not to girdle the tree.

f. Weeding of undesirable plant materials must be carried out regularly.

g. Application of environment-friendly technologies -biofertilizer during initial establishment, periodic organic fertilizer application (every 6 months) and liming if soil acidity occurs. In case inorganic fertilizer is employed, this should be made usually 6 months after planting and every 6 months thereafter for 2-3 years.

h. Constant monitoring for pest and diseases on the plants must be carried out regularly. When necessary, appropriate chemicals must be applied.

i. All dead parts of the plants must be removed and low branches of trees which cause obstructions must be pruned.

j. All overgrown plants should be trimmed/pruned to reduce foliage.

k. All turfed areas must be maintained regularly by grass-cutting, cleaning and weeding of undesirable plants.

l. The minimum depth of all planting beds for shrub ground covers is 0.6 meter.

m. The minimum size of shrub planting holes is 0.6 m x 0.6 m x 0.6 m.

Fig. 10. For urban greening, shrubs, vines and grasses were employed in the concrete structure of the building at

Fig. 11. Vines and climbing plants were used to rehabilitate and to beautify open walls in NCR.

Fig. 12. Palms, ornamental plants and grasses were used to landscape roadsides in NCR.

Fig. 13. Ornamental plants and grasses were used to landscape the façade and walkway in South Luzon Expressway.

Rehabilitation Schemes to Abate Water Pollution

Effective pollution control systems depend on policies that combine technical, economic, social and aesthetic considerations.

There are several ways in which water pollution can be combated. First, make wastewater reusable and of high quality. Second, enact and enforce governmental regulations prohibiting and limiting pollution of waters. Third, develop practices and techniques that will prevent or limit the natural runoff of pollutants [Fig. 14].

Fig. 14. Garbage trap for collecting waste materials along the river in NCR.

1. Major treatment stages used for waste water disposal (sewage)

Sewage treatment, or domestic wastewater treatment, is a process of removing contaminants from wastewater, both runoff (effluents) and domestic. It includes physical, chemical and biological processes to remove physical, chemical and biological contaminants. Its objective is to produce a waste stream (or treated effluent) and a solid waste or sludge suitable for discharge or reuse back into the environment.

Sewage is created by residences, institutions, hospitals and commercial and industrial establishments. It can be treated close to where it is created (in septic tanks, bio-filters or aerobic treatment systems), or collected and transported via a network of pipes and pump stations to specialized treatment processes.

Typically, sewage treatment involves three stages, called primary, secondary and tertiary treatments. First, the solids are separated from the waste water stream. Then dissolved biological matter is progressively converted into a solid mass by using indigenous, water-borne microorganisms. Finally, the biological solids are neutralized then disposed of or re-used, and the treated water may be disinfected chemically or physically (for example by lagoons and micro-filtration). The final effluent can be discharged into a stream, river, bay, lagoon or wetland, or it can be used for the irrigation of a golf course, green way or park. If it is sufficiently clean, it can also be used for groundwater recharge.

Raw influent (sewage) includes household waste liquid from toilets, baths, showers, kitchen, sinks, and so forth that is disposed via sewers. In many areas, sewage also includes a liquid waste from industry and commerce. The draining of household wastes into grey water are being permitted to be used for watering plants or recycled for flushing toilets. A lot of sewage also includes some surface water from roofs or hard-standing areas. Municipal wastewater, therefore, includes residential, commercial, and industrial liquid waste discharges, and may include storm water runoff.

Sewage systems capable of handling storm water are known as combined systems or combined sewers. During dry weather, when combined sewers are handling only the normal amount of waste water, all of it is carried to the waste treatment plant. But during a storm when combined sewers have to carry a much larger amount of water, part of the water, including varying amounts of raw sewage, often by-pass the treatment plant and flow directly into receiving streams. Such systems are usually avoided since they complicate and thereby reduce the efficiency of sewage treatment plants owing to their seasonality. The variability in flow also leads to often larger than necessary, and subsequently more expensive, treatment facilities. In addition, heavy storms that contribute more flows than the treatment plant can handle may overwhelm the sewage treatment system, causing a spill or overflow. It is preferable to have a separate storm drain system for storm water in areas that are developed with sewer systems.

As rainfall runs over the surface of roofs and the ground, it may pick up various contaminants including soil particles and other sediment, heavy metals, organic compounds, animal waste, and oil and grease. Some jurisdictions require storm water to receive some level of treatment before it is directly into waterways. Examples of treatment processes used for storm water include sedimentation basins, wetlands, buried concrete vaults with various kinds of filters, and vortex separators (to remove coarse solids).

The site where the raw waste water is processed before it is discharged back to the environment is called a **wastewater treatment plant** (WWTP). The order and types of mechanical, chemical and biological systems that comprise the wastewater treatment plant are typically the same for most developed countries.

a. Primary or Mechanical treatment

Primary treatment removes the materials that can be easily collected from the raw wastewater and disposed. The typical materials that are removed during primary treatment include fats, oils, and greases (also referred to as FOG), sand, gravels and rocks (also referred to as grit), larger settle-able solids including human wastes and floating materials. This step is done entirely with machinery, hence the name mechanical treatment.

a.1. Removal of large objects from influent sewage

In the mechanical treatment, the influent sewage water is strained to remove all large objects that are deposited in the sewer system, such as rags, sticks, condoms, sanitary towels (sanitary napkins) or tampons, cans, fruits, etc. This is most commonly done with a manual or automated mechanically raked screen. This type of waste is removed because it can damage or clog the equipment in the sewage treatment plant.

a.2. Sand and grit removal

Primary treatment typically includes a sand or grit channel or chamber where the velocity of the incoming wastewater is carefully controlled to allow sand grit and stones to settle, while keeping the majority of the suspended organic material in the water column. This equipment is called **detritor** or sand catcher. Sand grit and stones need to be removed early in the process to avoid damage to pumps and other equipment in the remaining treatment stages. Sometimes there is a sand washer (grit classifier) followed by a conveyor that transports the sand to a container for disposal. The contents from the sand catcher may be fed into the incinerator in a sludge processing plant, but in many cases, the sand and grit are sent to a landfill.

a.3. Sedimentation

Many plants have sedimentation stage where the sewage is allowed to pass slowly through large trunks, commonly called “primary clarifiers” or “primary sedimentation tanks”. The tanks are large enough that fecal solids can settle and floating materials such as grease and oils can rise to the surface and be skimmed off. The main purpose of the primary stage is to produce a generally homogenous liquid capable of being treated biologically and a

sludge that can be separately treated or processed. Primary settlement tanks are usually equipped with mechanically driven scrapers that continually drive the collected sludge towards a hopper in the base of the tank from where it can be pumped to further sludge treatment stages.

b. Secondary Treatment

Secondary treatment is designed to substantially degrade the biological content of the sewage such as those derived from human waste, food waste, soaps and detergent. Majority of municipal and industrial plants treat the settled sewage liquor using aerobic biological processes. For this to be effective, the biota requires both oxygen and a substrate on which to live.

There are a number of ways in which this is done. In all these methods, the bacteria and protozoa consume biodegradable soluble organic contaminants (e.g. sugars, fats, organic short -chain carbon molecules, etc.) and bind much of the less soluble fractions into **floc**.

Secondary treatment systems are classified as fixed film or suspended growth. Fixed -film treatment process including trickling filter and rotating biological contractors where the biomass grows on media and the sewage passes over its surface. In **suspended growth systems** - such as activated sludge - the biomass is well mixed with the sewage and can be operated in a smaller space than fixed-film systems that treat the same amount of water. However, fixed-film systems are more able to cope with drastic changes in the amount of biological material and can provide higher removal rates for organic material and suspended solids than suspended growth systems.

Roughing filters are intended to treat particularly strong or variable organic loads, typical industrial, to allow them to be treated by conventional secondary treatment process. These filters are typically tall, circular filters filled with open synthetic filter media to which wastewater is applied at a relatively high rate. They are designed to allow high hydraulic loading and a high flow-through of air. On larger installations, air is forced through the media using blowers. The resultant wastewater is usually within the normal range for conventional treatment processes.

b.1. Surface-aerated basins

Most biological oxidation processes for treating industrial wastewaters have in common the use of oxygen (on air) and microbial action. **Surface-aerated basins** achieve 80 to 90% removal of biochemical oxygen demand (**BOD)** with retention times of 1 to 10 days. The basins may range in depth from 1.5 to 5.0 meters and utilize motor-driven aerators floating on the surface of the wastewater.

In an aerated basin system, the aerators provide two functions: they transfer air into the basins required by the biological oxidation reactions, and they provide the mixing required for dispensing the air and for contacting the reactants (that is, oxygen, wastewater and microbes). Typically, the **floating aerators** are rated to deliver the amount of air equivalent to 1.8 to 2.7 kg O_2/kW.h. However, they do not provide as good mixing as is normally achieved in activated sludge systems and therefore aerated basins do not achieve the same performance level as activated sludge units.

Biological oxidation processes are sensitive to temperature and, between 0^{o}C and 40^{o}C, the rate of biological reactions increase with temperature. Most surface aerated vessels operate at between 4 ^{o}C and 32 ^{o}C.

b.2. Fluidized bed reactors

The carbon adsorption following biological treatment is particularly effective in reducing both the BOD and chemical oxygen demand (COD) to low levels. A fluidized bed reactor is a combination of the most common stirred tank packed bed, continuous flow reactors. It is very important to chemical engineering because of its excellent heat and mass transfer characteristics. In a fluidized bed reactor, the substrate is passed upward through the immobilized enzyme bed at a high velocity to lift the particles. However, the velocity must not be so high that the enzymes are swept away from the reactor entirely. Since this causes low mixing; these type of reactors are highly suitable for the exothermic reactions. It is most often applied in immobilized enzyme catalysis.

b.3. Filter beds (oxidizing beds)

In older plants and plants receiving more variable loads, **trickling filter** beds are used where the settled sewage liquor is spread onto the surface of a deep bed made up of **coke** (carbonized coal), **limestone** chips or especially fabricated plastic media. Such media must have high surface areas to support the bio-films that form. The liquor is distributed through perforated rotating arms radiating from a central pivot. The distributed liquor trickles through this bed and is collected in drains at the base. These drains also provide a source of air which percolates up through the bed, keeping it aerobic. Biological films of bacteria, protozoa and fungi form on the media's surfaces and eat or otherwise reduce the organic content. This bio-film is grazed by insect larvae and worms, which help maintain an optimal thickness. Overloading of beds increases the thickness of the film leading to clogging of the filter media and ponding on the surface.

b.4. Biological aerated filters

Biological Aerated (or Anoxic) Filter (BAF) or Biofilters combine filtration with biological carbon reduction, nitrification or denitrification. BAF usually includes a reactor filled with a filter media. The media is either in suspension or supported by a gravel layer at the foot of the filter. The dual purpose of this media is to support highly active biomass that is attached to it and to filter suspended solids. Carbon reduction and ammonia conversion occurs in anoxic mode. BAF is operated either in upflow or downflow configuration depending on the design by its manufacturer.

b.5. Membrane biological reactors

Membrane biological reactors (MBR) combine activated sludge treatment with a membrane liquid-solid separation process. The membrane component utilizes low pressure micro-filtration or ultra filtration membranes and eliminates the need for clarification and tertiary filtration. The membranes are typically immersed in the aeration tank (however, some applications utilize a separate membrane tank). One of the key benefits of a membrane bioreactor system is that it effectively overcomes the limitations associated with poor settling of sludge in **conventional activated sludge (CAS)** processes. The technology permits bioreactor operation with considerably higher **mixed liquor suspended solids (MLSS)**

concentration than CAS systems, which are limited by sludge settling. The process is typically operated by MLSS in the range of 8,000-12,000 mg/L, while CAS is operated in the range of 2,000-3,000 mg/L. The elevated biomass concentration in the membrane bioreactor process allows for very effective removal of both soluble and particulate biodegradable materials at higher loading rates. Thus increased **Sludge Retention Times (SRTs)**--usually exceeding 15 days---ensure complete nitrification even under extreme cold weather operating conditions.

b.6. Rotating biological contactors

Rotating biological contactors (RBCs) are mechanical secondary treatment systems, which are robust and capable of withstanding surges in organic load. The rotating disks support the growth of bacteria and micro-organisms present in the sewage, which breakdown and stabilize organic pollutants. To be successful, micro-organisms need both oxygen to live and food to grow. Oxygen is obtained from the atmosphere as the disks rotate. As the micro-organisms grow, they build up on the media until they are sloughed off due to shear forces provided by the rotating discs in the sewage. Effluent from the RBC is then passed through final clarifiers where the micro-organisms in suspension settle as sludge. The sludge is withdrawn from the clarifier for further treatment.

c. Tertiary Treatment

Tertiary treatment provides a final stage to raise the effluent quality before it is discharged to the receiving environment (sea, river, lake, ground, etc.). More than one tertiary treatment process may be used at any treatment plant. If disinfection is practiced, it is always the final process. It is also called **"effluent polishing"**.

c.1. Nutrient removal

Wastewater may contain high levels of the nutrients nitrogen and phosphorus. Excessive release to the environment can lead to a build up of nutrients, called **eutrophication** (blue-green algae). This may cause an algal bloom, rapid growth in the population of algae. The numbers of algae are sustainable and eventually most of them die. The decomposition of the algae by bacteria uses up so much of oxygen in the water that most or all of the animals die, which creates more organic matter for the bacteria to decompose. In addition to causing de-oxygenation, some algal species produce

toxins that contaminate drinking water supplies. Different treatment processes are required to remove nitrogen and phosphorus.

c.1.1 Nitrogen removal

The removal of nitrogen is effected through the biological oxidation of nitrogen from ammonia, **nitrification**, the reduction of nitrate to nitrogen gas. Nitrogen gas is released to the atmosphere and thus removed from the water.

Nitrification itself is a two-step aerobic process, each step facilitated by a different type of bacteria. The oxidation of ammonia (NH_3^-) to nitrite (NO_2^-) is most often facilitated by *Nitrosomonas* spp. (nitro referring to the formation of a nitro functional group), is now known to be facilitated in the environment almost exclusively by *Nitrospira* spp. **Denitrification** requires anoxic condition to encourage the appropriate biological communities to form. It is facilitated by a wide diversity of bacteria. Sand filters, lagooning and reed beds can all be used to reduce nitrogen, but the activated sludge process (if designed well) can do the job most easily. Since denitrification is the reduction of nitrate to dinitrogen gas, an electron donor is needed. This can be, depending on the wastewater, organic matter from feces, sulfide, or an added donor like methanol.

Sometimes the conversion of toxic ammonia to nitrate alone is referred to as **tertiary treatment**.

c.1.2 Phosphorus removal

Phosphorus can be removed biologically in a process called **enhanced biological phosphorus removal**. In this process, specific bacteria, called **polyphosphate accumulating organisms**, are selectively enriched and accumulate large quantities of phosphorus within their cells (up to 20% of their mass). When the biomass enriched in these bacteria is separated from the treated water, these bio-solids have a high fertilizer value.

c.2. Disinfection

The purpose of disinfection in the treatment of wastewater is to substantially reduce the number of microorganisms in the water to be discharged back into the environment. The effectiveness of disinfection depends on the quality of the water treated (e.g., cloudiness, pH, etc.), the type of disinfection being used, the

disinfectant dosage (concentration and time), and other environmental variables. Cloudy water will be treated less successfully since solid matter can shield organisms, especially from ultraviolet light or if contact times are low. Generally, short contact times, low doses and high flows all militate against effective disinfection. Common methods of disinfection include ozone, chlorine, or ultraviolet light.

Chlorination remains the most common form of wastewater disinfection due to its low cost and long-term history of effectiveness. One disadvantage is that chlorination of residual organic material can generate chlorinated-organic compounds that may be carcinogen or harmful to the environment. Further, because residual chlorine is toxic to aquatic species, the treated effluent must also be chemically dechlorinated, adding to the complexity and cost of treatment. **Ultraviolet** (UV) light can be used instead of chlorine, iodine, or other chemicals. Because no chemicals are used, the treated water has no adverse effect on organisms that later consume it, as may be the case with other methods. UV radiation causes damage to the genetic structure of bacteria, viruses, and other pathogens, making them incapable of reproduction. The key disadvantages of UV disinfection are the need for frequent lamp maintenance and replacement and the need for a highly-treated effluent to ensure that the target microorganisms are not shielded from the UV radiation (i.e., any solids present in the treated effluent may protect the microorganisms from the UV light).

Ozone, O_3, is generated by passing oxygen, O_2, through a high voltage potential resulting in a third oxygen atom becoming attached and forming O_3. Ozone is very unstable and reactive, and oxidizes most organic material it comes in contact with, thereby destroying many pathogenic microorganisms. Ozone is considered to be safer than chlorine because, unlike chlorine which has to be stored on site (highly poisonous in the event of an accidental release), ozone is generated onsite as needed. **Ozonation** also produces fewer disinfection by-products than **chlorination**. A disadvantage of ozone disinfection is the high cost of the ozone generation equipment and the requirements for highly- skilled operators.

d. Sludge treatment and disposal

The sludge accumulated in a wastewater treatment process must be treated and disposed of in a safe and effective manner. The purpose

of digestion is to reduce the amount of organic matter and the number of disease-causing microorganisms present in the solids. The most common treatment options include **anaerobic digestion, aerobic digestion** and **composting**.

The choice of a **wastewater solid treatment method** depends on the amount of solids generated and other site-specific conditions. However, in general, **composting** is most often applied to smaller-scale applications followed by **aerobic** digestion and then lastly **anaerobic** digestion for the larger-scale municipal applications.

d.1. Anaerobic digestion

Anaerobic is a bacterial process that is carried out in the absence of oxygen. The process can either be **thermophilic** digestion, in which sludge is fermented in tanks at a temperature of 55^{o}C, or **mesophilic**, at a temperature of around 36^{o}C. Though allowing shorter retention time (and thus smaller tanks), **thermophilic digestion** is more expensive in terms of energy consumption for heating the sludge.

One major feature of **anaerobic digestion** is the production of **biogas** which can be used in generators for electricity production and/ or in boilers for heating purposes.

d.2. Aerobic digestion

Aerobic digestion is a bacterial process in the presence of oxygen. Under aerobic conditions, bacteria rapidly consume organic matter and convert it into carbon dioxide.

d.3. Composting

Composting is also an aerobic process that involves mixing the sludge with sources of carbon such as sawdust, straw or wood chips. In the presence of oxygen, bacteria digest both the wastewater solids and the added carbon source and in doing so, produce a large amount of heat.

e. Sludge disposal

When a liquid sludge is produced, further treatment may be required to make it suitable for final disposal. Typically, sludges are thickened (dewatered) to reduce the volumes transported off-site for

disposal. There is no process which completely eliminates the need to dispose bio-solids. There is, however, an additional step some cities are taking to superheat the wastewater sludge and convert it into small pelletized granules that are high in nitrogen and other organic materials. This product is then sold to local farmers and turf farms as a soil amendment or fertilizer, reducing the amount of space required to dispose sludge in landfill.

2. Land Sewage Disposal System reduces stream water pollution, conserve and recycle water, and allow nutrients to be recycled for further use. Waste water from residential areas can generally be used for this purpose. Industrial waste water may require some treatment to remove toxic substances that could affect biological systems.

Industrial waste from food processing plants and pulp mills are usually well-suited for land disposal.

Fig. 15. Early stage of bamboo planting to rehabilitate various rivers in NCR (Sagip-ilog Project).

Fig. 16. Full grown species of bamboo could be seen along the riversides in NCR as a phytoremediation technology in their Sagip-ilog Project.

3. ***Phytoremediation Technology For Stream and Riverbank Stabilization*** can be done to minimize and delay further degradation of these waterways. The technology prevents soil erosion, serves as site barriers, prevents contamination from spreading into surface water or ground water and provides aesthetic value. Some species recommended are: bamboo, bitaog, palosanto, akle, anchoan dilao, acacia, african tulip, antipolo, moluccan sau, bangkal, batino, bitaog, balsa, balobo, cinchona, niyog, dita, dao, yemane, gubas, ipil, ipil-ipil, ilang-ilang, kalumpang, kaatoan bangkal, kakawate, kalantas, katurai, lanete, lumbang, lamio, mahogany, marang, malunggay, narra, palosanto, santol, supa, teak, tibig, tIndalo, tuai, para rubber, talisai and bani. Depending on the species, it could be planted at 4m x 4m distance from each other and at

16 – 18 m away from the water level. Figs.15 and 16 are bamboo species used as phytoremediation technology to rehabilitate rivers in NCR.

4. Bioremediation Technology for Lakes, Ponds and Streams

4.1 **Aquamedix** is an environmentally-friendly biocatalyst liquid for the bioremediation of polluted bodies of water. Our world ecosystem depends on algae blooms. Algae provide oxygen for the largest and smallest creature on earth. However, when algae blooms go unchecked in our lakes, ponds, and streams, it has adverse effect on animals, fish, plants, and all living things. Algae pollute bodies of water produce obnoxious odors, become unsightly, and are considered "sick" or "dead". Aquamedix when used as directed will increase the metabolism of naturally occurring bacteria to its maximum rate and maintain that activity level for as long as Aquamedix is added. In addition to the water itself, everything the water comes in continuous contact with, is also cleaned.

4.2 **Eutro-Clear** is a pro-biotic formula for the bioremediation of ponds. It is standardized at a total endospore count of 5 billion CFU /gm, which will multiply in a bucket to 150 billion CFU/gm in 18 hours (http://www.liftstationdegreasers.com).

Two (2) lbs. of this microbial formulation, hydrated in water, will inoculate a 1 acre pond to many thousand times more than the bacterial biota normally found in a water column and out compete all the naturally occurring bacteria, including pathogenic gram- negative *E.coli.*

Augmented facultative heterotrophic bacteria settling into these benthic regions will speed up sludge digestion and reduce odors by using an alternate electron acceptor other than oxygen. Overall, bio-augmentation will reduce nutrient levels, thus reduce the risk of eutrophication and algal blooms.

4.3 **Plantex Biozyme Micro Aid Power Activator** can be utilized as an effective and economical way of treating either open water or wastewater in treatment system. The potent enzymes and microorganisms present in the activator breaks and degrades any organic and inorganic substance present in the wastewater (Trevis Internationale Corp., undated).

It decomposes solid substances and digests oil and grease, thereby preventing the accumulation of sludge. The result is the reduction of both biological oxygen demand (BOD) and chemical oxygen demand (COD).

The putrid odor coming from the fermentation and decomposition of indol, eskatol, mercaptants and others are eliminated.

It is strongly advised that Plantex All-In-One Solution be applied on the wastewater for thorough disinfection.

Methods of Application

Initial Application (Shock Treatment) - Five (5) L of concentrated Plantex All-In-One Solution is applied to every 15,000 gals. of wastewater influent in the first treatment chamber or equalization tank. This results to the removal of the foul odor and digestion/ degradation of organic and inorganic substances.

Thirty (30) kilos of Plantex Biozyme Micro Aid Activator is broadcast to every sixty thousand (60,000) gals. of wastewater in the aeration chamber/tank preferably at noon time to allow the micro-organisms to multiply faster and produce more enzymes.

After the first week of initial application, 1.5 kilos of Plantex Biozyme should be broadcast once again. For maintenance, broadcasting of 1.5 kilos into the aeration pond every 2-3 days (at noon time) is suggested.

Application on Septic Tanks - One (1) L of concentrated Plantex All-In-One Solution for every cubic meter is poured directly into the septic tank. After 30 minutes, two (2) kilos of Plantex Biozyme should be broadcast into the septic tank as well.

5. The Muntinlupa City Waste water treatment facility as model

The Muntinlupa City government has developed a technology based on the above order and types of mechanical, chemical and biological systems that comprise the waste water treatment plant. However, the waste water treatment system that has been developed is less complicated, low-cost and has low-maintenance.

The wastewater treatment system is an **aerobic** and **anaerobic** combination coupled with **filtration** using coco peat media to meet local discharge standards. It also includes a water recycling system that allows re-use of the treated effluent for flushing toilets, watering plants and street cleaning. This technology is being applied elsewhere in the Philippines and is suitable for other locations in the region.

The treatment facility will bring the biochemical oxygen demand (BOD) from more than 600mg/l to less than 30mg/l. It utilizes a hybrid design using non- mechanized and mechanized systems, particularly grit screens septic tanks and an **aerobic baffled reactor** (ABR) for the **primary** and **secondary** treatment. This can treat more than 200 cubic meters of wastewater daily. A **sequencing batch reactor** (SBR) is also a part of the secondary treatment. A multimedia filter was used for the **tertiary treatment**, which will allow re-use of the treated water. The facility is built below ground and covered with reinforced concrete, so that the place can be used as a parking lot and a loading/unloading bay. Figure 17 shows the system flow of the Muntinlupa public market wastewater treatment facility.

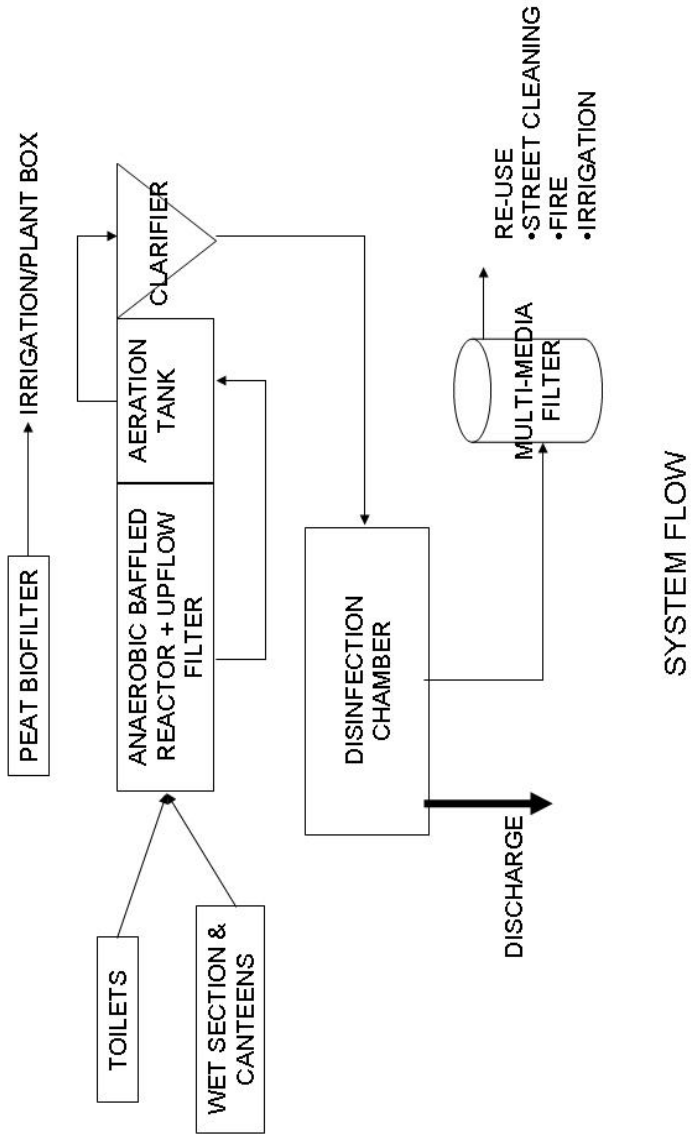

Fig. 17 MUNTINLUPA PUBLIC MARKET WASTE WATER TREATMENT SYSTEM (WWTS)

6. Technology to Study Water Quality of Surface Water Bodies

A reconnaissance survey was conducted along Navotas-Malabon-Tullahan-Tinajeros (NMTT) river system and its tributaries. Data were gathered to delineate location and identify its physical features such as land use, industrial pollution source, etc. as well as hydrological features.

Four samples for water and three samples for sediments taken at different points were collected every month for analyses. Temperature, pH, dissolved oxygen (DO), chlorides, biological oxygen demand (BOD), chemical oxygen demand (COD), organic and inorganic ratio were determined for physical and chemical analyses. For biological analyses, microorganisms found in the samples were identified. A sequential batch/ bench scale treatability method was applied on water samples obtained from the river system. The same treatability method was applied in the field. This method used two chambers with three test tanks each. One chamber served as control for treatment.

Enzymes were added to the treated tank until a maximum percent reduction in CO was obtained. Results showed that after the 12^{th} day, pH was reduced from 7.8 to 6.5; dissolved oxygen from 0 to 4.0 mg/l; biological oxygen demand from 56 to 20 mg/l at 20 degrees Celsius and suspended solids from 40 to 10 mg/l.

7. Bioassay of Textile Effluent

The research examined the toxicity of the effluent and influent wastes of a textile plant in the vicinity of the Cabuyao River on commonly grown fishes using bioassay method. The particular textile plant investigated used activated sludge treatment to eliminate or reduce the pollutants to maximum level. The study correlated the results of the physico-chemical procedures and bioassay examination. Specifically, the level of toxicity of textile effluent discharged and lethal concentrations of the treated effluent discharged after 24 and 96 hours, respectively, were studied.

Bioassay Procedure:

Six 10-gallon capacity aquaria were used per bioassay test which contained effluents/river water concentrations of 10, 20, 40, 60, 80, 100 percent respectively. Ten tilapia fingerlings per aquarium were used for the bioassay test. The fingerlings were acclimatized in the aquarium condition for seven (7) days using dechlorinated tap water and fed with

commercial fish food. The cessation of operculum movement and visible upturned floating of bodies of fish samples were observed after 24-96 hours for fish mortality. Lethal concentration (LC) of effluent and river water was set when it caused the death of five (5) out of ten (10) fish per aquarium (Capino, 2002).

Waste Management Schemes

1.Industrial waste management schemes

Industries in general, have tried to convert waste products into profitable energy. There are a number of emerging technologies that are able to produce energy from waste and other fuels without direct combustion. Many of these technologies have the potential to produce more electric power from the same amount of fuel than would be possible by direct combustion. This is mainly due to the separation of corrosive components (ash) from the converted fuel, thereby allowing a higher combustion temperature in e.g. boilers, gas turbines and internal combustion products. Some are able to efficiently convert the energy into liquid or gaseous fuels.

a. Thermal Technologies

a.1. Gasification is a process that converts carbonaceous materials, such as coal, petroleum, or biomass, into carbon monoxide and hydrogen by reacting the raw material at high temperatures with a controlled amount of oxygen.

a.2. Pyrolysis is the chemical decomposition of organic materials by heating in the absence of oxygen or any reagents, except possibly steam. Extreme pyrolysis that leaves only carbon as the residue is called **carbonization**. The application of **pyrolysis** to waste management is well established with other advanced waste treatment technologies. **Pyrolysis** is used as a form of **thermal treatment** to reduce waste volumes and produce liquid or gaseous fuels as a byproduct. Low temperature pyrolysis can also be used to produce a synthetic diesel fuel from waste film plastic, through systems such as **thermofuel**.

b. Non-thermal technologies

b.1. In **anaerobic digestion**, a bacterial process that is carried out in the absence of oxygen, the process can either be thermophilic

digestion, in which sludge was fermented in tanks at a temperature of 55°C, or mesophilic, at a temperature of around 36°C. Though allowing shorter retention time (and thus smaller tanks), thermophilic digestion was more expensive in terms of energy consumption for heating the sludge.

One major feature of anaerobic digestion was the production of biogas, which can be used in generators for electricity production and/or in boilers for heating purposes.

b.2. In **Aerobic digestion,** a bacterial process occurs in the presence of oxygen, bacteria rapidly consume organic matter and convert it into carbon dioxide.

b.3. In **Composting,** an aerobic process is involved while mixing the wastewater solids with sources of carbon such as sawdust, straw or wood chips. In the presence of oxygen, bacteria digest both the wastewater solids and the added carbon sources and in doing so, produce a large amount of heat.

b.4. In **MixAlco process,** a bioconversion of biomass to mixed alcohol fuels can be accomplished. Through this bioconversion, more energy from the biomass will end up as liquid fuels than in converting biomass to ethanol by yeast fermentation.

The process involves a biological/chemical method for converting any biodegradable material (e.g., urban wastes, such as municipal solid waste, biodegradable waste and sewage sludge, agricultural residues such as corn stover, sugarcane baggasse, cotton gin trash, manure) into useful chemicals, such as carboxylic acids (e.g., acetic, propionic, butyric acid), ketones (e.g., acetone, methyl ethyl ketone, diethyl ketone) and biofuels, such as a mixture of primary alcohols (e.g., ethanol, propanol, butanol) and/or a mixture of secondary alcohols (e.g., isopropanol, 2-butanol, 3-butanol, 3-pentanol). Because of the many products that can be economically produced, this process is a true **biorefinery**.

The process uses a mixed culture of naturally occurring micro-organisms found in natural habitats such as the rumen of cattle, termite guts, marine and terrestrial swamps to anaerobically digest biomass into a mixture of carboxylic acids produced during the acidogenic and acetogenic stages of anaerobic digestion, however with the inhibition of the

methanogenic final stage. The more popular method for production of ethanol and cellulosic ethanol is the use of enzymes that must be isolated first to be added to the biomass and thus convert the starch or cellulose into simple sugars, and then followed by yeast fermentation into ethanol.

2. Municipal Waste Management Schemes

Waste management or solution for municipal wastes consists of four options:

a. Waste reduction – reducing waste requires cutting the number and volume of discarded products. Consumers can reduce households waste by buying high quality long lasting items that can be repaired, instead of buying short-lived "disposal" alternatives. The consumer typically pays a much higher price per unit for such convenience item.

Many advocates of waste reduction use the term **precycling.** This concept refers to a consumer making environmentally-sound choices at the point of purchase. It includes avoiding products with extra packaging such as canned or mixed vegetables instead of fresh, unbagged ones.

b. Landfilling - this is the least expensive and easiest method of disposal. This corresponds to the common sanitary landfill used for municipal garbage. The waste remains essentially unchanged and because of frequent soil cover, the site soon becomes exhausted.

c. Incineration - this waste management option uses an incinerator machine which is quite expensive. Mixed trash is burned in the incinerator in a single combustion. The heat generated from the burning material in the heat chamber is converted into usable electricity. The temperature in the chamber reaches 2,000^{o}F. The by-products are ash, which are sent to landfills.

d. **Ecological solid waste management** is also known as recycling, reusing and composting. It aims to use waste to its fullest in order to maintain round-the-clock cleanliness of the surroundings. Ecological solid waste management should start at the household level.

Basically, there are three ways to tackle waste – **Reduce, Re-use,** and **Recycle**. Reduce the amount of material we use so we generate less waste. Re-use the things we already have instead of buying them anew. Recycle the things we can't re-use. The steps are as follows:

1. Sort out your garbage properly by setting up two trash cans in the kitchen – one for wet garbage, another for dry.

2. For wet garbage, you may use an empty can of cooking oil or ice cream container as your trash can. Wet garbage includes leftover food, fruit and vegetable peelings, and even animal excreta.

3. For dry garbage, you may use an old bayong, a large plastic bag, or a box. Dry garbage includes paper, cartons, bottles, cans, plastic containers (for toothpaste, shampoo, and other cosmetic items), shopping bags, metals, used-up batteries, ballpens, and others.

4. Wet garbage is biodegradable; that is, it can naturally blend with the earth once it is composted. It can also be used as soil fertilizer, poultry or pig feed, or methane gas for cooking. Composting can take place in centralized facilities or individual backyards.

5. Dry garbage is often non-biodegradable. It is best for re-use or re-cycling. This requires dry garbage to be sorted out further into two groups – one for re-use, and the other for re-cycling.

6. Remember what they say about "money in junk"? It's quite true. Collect all items that cannot be re-used and sell to recycling stores. These include old newspapers, magazines, and other papers; bottles, cans and even plastic containers; and metal or steel items. The neighborhood magbobote't bakal will only be too happy to buy all these from you. You earn a few extra bucks on the side while sparing the environment.

7. Wash and clean the things for re-use and keep them where they can easily be located when needed. These include gift wrappers and ribbons, boxes, plastic or brown bags from department stores or supermarkets, and wide-mouthed bottles or plastic containers which can be used as canisters.

Aside from observing the steps above, waste management requires some adjustments in our lifestyle to enable us to reduce the amount of waste we generate.

* Don't buy anything you don't need. Corollary to this, don't buy more than you need.

* When you go to market, bring your own brown or plastic bag, so you don't have to buy from the vendors. Better yet, bring your good old bayong or basket.

* Same thing when you go shopping. Bring along your own plastic bag/s and graciously refuse counter girls who offer you new plastic bags.

* Avoid eating in fast food outlets that serve food in Styrofoam. When ordering for take-out food, bring your own food container and ask the food outlet to use it for your order.

* Avoid using disposable items made of non-biodegradable materials.

* Avoid using a straw when drinking soft drinks. Use a glass instead.

* Avoid incinerating garbage. In crowded neighborhoods, this is a potentially hazardous practice. Besides, plastics consumed by fire emit hazardous elements to the atmosphere, contributing to the ozone depletion and break-out of various diseases.

* Support recycling. Buy recycled materials, even if they may cost higher.

These simple ways of reducing, re-using, and re-cycling our trash will go a long way in helping preserve our planet earth. We don't even need to learn or master them. With a little earth consciousness and some practice, these earth-friendly ways to manage our garbage properly are easy habits to acquire.

3. Managing Solid Wastes Through Advanced Pyrolysis System

An existing unique technology that can solve the growing problem of solid waste disposal is the continuous feed pyrolytic thermal waste treatment system, better known as the International Environment Solutions (IES) advanced pyrolysis system. The system treats all types of wastes-whether municipal, industrial or agricultural – as enormous mine of wealth. This is because in the process of pyrolysis, wastes are being converted into raw materials to generate electricity, produce charcoal and charcoal briquettes, and manufacture high-quality building materials.

In this process, solid wastes are delivered to the plant site where they are first weighed, then dumped into the receiving area and sent to the sorting floor. Materials that can be recycled are separated and collected in roll-off bins to be sent into recycling facilities.

Other materials not suited for pyrolysis such as large rocks and chunks of concrete are separated in roll-off bins for shipment back into the landfill site.

Those materials suitable for pyrolysis are then sent to a high temperature air dryer, or are temporarily stored. The dried wastes are then fed into a high-speed shredder that cuts them into small pieces, which are sent to the blender to combine with several other materials. The mixture is then fed into an oxygen-free chamber and an intense indirect heat is applied to reduce the waste material into combustible gases and benign residual char in the form of small granules similar to coarse black sand. The gases are recycled in the plant and cleaned in the system.

In the Philippines, a small-scale biomass pyrolyser for farm irrigation was locally developed by the Forest Products Research and Development Institute (FPRDI), an agency of the Department of Science and Technology. The pyrolyser produces combustible gas and carbon from agroforestry wastes such as pili, peanut, coconut shells, rice hulls, and wood chips. The gas can be used to fuel an internal combustion engine for irrigation pumps. The pyrolyser can pump about 30,000 gallons of water per hour compared with the traditional diesel engine that can pump 12,000 gallons per hour. It can supply the irrigation requirements of a 9.3 – ha farm for eight hours (Rimando & Rimando, 2003).

Aside from extracting pyrolysis gas, the system can also produce char, which can be converted into charcoal briquettes. As a whole, the biomass pyrolyser is economically significant since it lessens the cost of irrigating rice field and minimizes the problem of disposing agroforestry wastes.

However, unlike the IES advanced pyrolysis system, the biomass pyrolyser developed by FPRDI releases into the environment toxic fumes and liquid effluents during the operation. For this reason, it has been suggested that FPRDI improves its biomass pyrolyser system that it can operate in a large scale and in a closed-loop system to avoid the hazardous by-products of combustion.

4. The Quezon City Controlled Waste Management Facility as Model

In compliance with the Ecological Solid Waste Management Act of 2000 (RA 9003), the Quezon City government embarked on the conversion of the Payatas open dumpsite into a controlled disposal facility [Figure 18).

Fig. 18. The Quezon City controlled waste management facility.

This is being managed by the Payatas Operations Group which covers an area of 9.70 ha. The New Payatas Disposal Facility strictly implements a comprehensive waste disposal plan in order to extend the life of the waste facility. The plan includes the application of earth cover material to expose garbage from previous open dumping operation (Figures 19 and 20). At least 0.6 m of top soil is being applied to the wastes [Fig. 21]. This will minimize the production of leachate, control odor and prevent the proliferation of flies, rats and other insect pests.

Fig. 19. **Before** this was how the streets along the Payatas open dumpsite in Quezon City, Metro Manila looked like. Wastes were dumped every-where.

Fig. 20. **After** the conversion program, a perimeter fence was put up, so that the wastes are controlled within the perimetered area.

Fig. 21. At least 0.60 m of soil is being applied to the wastes at the end of each working day. The soil is then compacted to minimize the production of leachate, to control odor and to prevent the proliferation of flies, rats and other vermins.

A pond was constructed to separate storm water from leachate. The leachate canals and collection ponds prevent the accumulation of leachate along the foot of the active disposal cell. The leachate collected was sprayed in the compacted waste to speed up the decomposition process. Run-off and drainage canals were constructed to prevent water run-off coming in contact with the waste. Fig. 22 summarizes the before, during and after waste conversion program.

Fig. 22. Various processes of the conversion.

5. The Payatas Methane Gas Generation Technology

To effectively manage the wastes in Payatas dumpsite, a methane gas generation technology (a non-thermal technology type of generating energy) as described above was employed.

Greenhouse gases such as methane and carbon dioxide which were produced during the process of anaerobic biodegradation of organic material were extracted and utilized. Hence, a 100-KW pilot methane power plant was built to supply the power for the composting plant and perimeter lights of the dumpsite. This was Quezon City's humble contribution to the mitigation of global warming and climate change.

6. Phytoremediation technology on dumpsites

The recommended species are: McArthur palm, bunga de china, dapdap, balete and palosanto. These plants maybe planted around the perimeter of landfills. Application of this technology prevents contamination from spreading into surface water and or groundwater.

In Payatas dumpsite, phytoremediation was also practiced in the area not used for dumping wastes. Mongo beans were planted to enrich and condition the soil before vetiver grass is planted along the steep slope area for stabilization. Shrubs were also used to improve the landscape of the dumping site. Shrubs were planted on the reprofiled slopes. Such vegetative cover (or vegetative cap) is a long- term, self-sustaining cap composed of soil and plants growing in and/or over waste in a landfill. This type of cover is an alternative to composite clay or plastic layer caps. Plants control erosion and minimize seepage of water that could otherwise percolate through the landfill and form contaminated leachates. In addition, a vegetative cap can be designed not only to control erosion and seepage by water, but also to enhance the degradation of underlying materials in the landfill.

7. The MMDA's Unified Approach on Solid Waste Management

In order to ensure an efficient and effective system of solid waste and garbage collection and disposal, and prohibit littering and the placing or throwing of garbage, refuse and other waste, the MMDA passed an ordinance for a unified approach on Solid Waste Management.

Description of Technology

a. **Education and information Campaign**. The MMDA understands the difficulty in giving proper instruction to the people on the proper waste disposal and management. They realized that the best way to address the problem is by maximizing the use of mass communication thru radio, TV, and print media.

   The city government, in cooperation with the MMDA thus, conducted a massive public awareness campaign to inform and instruct the people and all stakeholders on the matters relative to the implementation of the unified approach on solid waste management.

b. **Storage of wastes**. Basically, any wastes should be left in the place of purchase or in the household. No other person or individual in between has the obligation to keep those wastes. Hence, all stores, establishments and households were required to have suitable trash receptacle to keep one's garbage to be kept inside its premises and not along the sidewalks except during collection days.

Wastes were required to be stored and set out for collection in a closed plastic bag or any appropriate container to avoid the entry of insects, pests and vermins; escape of bad odor; and spillage of leachate. Unpacked, improperly packed and spillage of garbage were not collected.

The owner were also made responsible in sweeping, cleaning and repacking of the spilled garbage and to clean the mess caused by it.

Household toxic wastes were required to be disposed in a specified manner in accordance with RA 6969. Broken glasses or lamps and other sharp objects are required to be securely enclosed in hard cardboards with tie to prevent injury to handlers and rip and tear bags or containers.

c. Waste Collection System. The city government shall be responsible in collecting the garbage door to door on specified collection day. The city shall share this responsibility with the barangays.

Households, commercial establishments and institutions shall bring their wastes conspicuously only in front of their premises during the designated collection day. Bulky wastes shall be collected separately subject to special arrangement with the local government units.

No burning shall be allowed at source. Only the authorized garbage collection shall be allowed to handle the waste from the generators. Selling, scavenging and sorting by the garbage collection crew shall not be allowed. Junk dealers are not allowed to collect recyclable materials during the scheduled date of collection.

Collection equipment were required to be registered with the city government to ensure the proper markings, safety and sanitation of the vehicle. All collection trucks should be in good

body condition and properly equipped with tools and spare tires. Trucks must be properly covered to prevent spillage of garbage and escape of odor when traveling. Owners and operators must sanitize, disinfect and deodorize the collection trucks before leaving the dispatching area and after its disposal.

d. Disposal of wastes. A sanitary landfill is an engineered disposal site for solid wastes. It should be designed, constructed, operated and maintained in such manner as to allow engineering control over significant potential impacts that could arise from the development and operation of the facility.

Compared to open dumping, a sanitary landfill system has the built-in advantage of preventing harmful materials such as leachate and landfill gas from contaminating the environment. After filling its intended use and after closure, a sanitary landfill also makes possible the extraction to landfill gas for possible use in power generation and other uses.

e. **Imposing of Fines**. The imposition of tickets and fines to violators of the ordinance were proposed to be made. In case the violator is a corporation, firm, institution or corporate entities, its president, manager or person responsible for its operation shall be held liable. The head of association or owner of malls, condominium and household shall be made responsible in case of violation of ordinances.

8. Management of Wastes in Barangay Molino V, Bacoor, Cavite.

This community started by maintaining a waste management project aimed at reducing waste through recycling. Unsegregated garbage were not collected to impose and enforce their sorting and for people to learn to do it on their own.

Majority of the people in the community worked together for the closure of the dump site. All the wastes were removed and the dumping area was converted into a garden. They planted vegetables and maintained it everyday.

The project encouraged the majority of the residents to segregate wastes and establish a Material Recovery Facility (MRF), which served as a depository and sorting area of the recyclable waste materials. An MRF was encouraged to be located even inside a residential lot, because it does not

give a disgusting odor. The MRF had a shredder machine and engine, which transformed biodegradable wastes into organic fertilizers used for the garden.

The project started with donations from residents. When the municipal government found that the waste management project was successfully working, it provided P300,000.00 grant and a garbage truck.

The project was somehow costly, because they have to hire an "Eco-boy" who would collect the household's garbage everyday. The worker was given P250.00/day plus meal allowance from the P40.00 monthly fees of the members and the money from the sold recyclable wastes. They were able to save P10.00 per sack of garbage which the barangay used to collect. The whole community also earned P7,000.00 from recyclable wastes every three months. This project also reduced the risk of illnesses caused by insects and other vermins.

Education of the People

It was highly encouraged in this project that the education about proper waste management and disposal must start with the family because not everyone in the family can fully understand the importance of the project.

9. The Kleensmoke Burner Technology is an inverted pile incinerator for waste disposal and energy production.

The burning chamber is a large cylindrical pipe of refractory concrete, lying either horizontally or a slight upward angle. The present model, now in prototype setting is 10 m by 1.5 m size (James, 1979). Longitudinal channels are cast into the wall of the burning chamber, and combustion air is preheated in these channels before it enters the chamber. The concrete walls can withstand temperatures up to 160 degrees centigrade and the ends of the burning chamber are closed by refractory concrete plates, which have penetrations for fuel addition at the bottom of one end. The primary fuel for the burner are wood- logging or brush clearing wastes, saw dust and other lumber mill wastes, and woody agricultural wastes such as orchard or vineyard prunings.

Air Pollution Rehabilitation Schemes and Technology

1. ***Scrubber System Air Pollution Control Devices.***

These devices remove particulates and/or gases from industrial exhaust streams. Traditionally, the term "scrubber" has referred to pollution control devices that used liquid to "scrub" unwanted pollutants from a gas stream. Recently, the term is also used to describe systems that inject a dry reagent or slurry into a dirty exhaust stream to "scrub out" acid gases. **Scrubbers** are one of the primary devices that control gaseous emissions, especially acid gases.

The exhaust gases of combustion may at times contain substances considered harmful to the environment, and it is the job of the scrubber to either remove those substances from the exhaust gas stream, or to neutralize those substances so that they cannot do any harm once emitted into the environment as part of exhaust gas stream.

In wet scrubbing, a wet scrubber is used to clean air or other gases of various pollutants and dust particles. Wet scrubbing works via contact of target compounds or particulate matter with the scrubbing solution. Solutions may simply be water (for dust) or complex solutions of reagents that specifically target certain compounds.

Removal efficiency of pollutants is improved by increasing residence time in the scrubber or by the increase of surface area of the scrubber solution using a spray nozzle, packed towers or an aspirator. Wet scrubbers will often significantly increase the proportion of water in waste gases of industrial processes which can be seen in a stack plume.

In dry scrubbing, a dry or semi-dry scrubbing system, unlike the wet scrubber, does not saturate with moisture the flue gas stream that is being treated. In some cases, no moisture is added; while in other designs only the amount of moisture that can be evaporated in the flue gas without condensing is added. Therefore, dry scrubbers do not have a stack steam plume or wastewater handling/disposal requirements. Dry scrubbing systems are used to remove acid gases (such as SO_2 and HCL) primarily from combustion sources.

There is a number of dry type scrubbing system designs. However, all consist of two main sections or devices: a device to introduce the acid gas sorbent material into the gas stream, and a particulate matter control device to remove reaction products.

Dry scrubbing systems can be categorized as dry sorbent injections (DSIs) or as spray dryer absorbers (SDAs). Spray dryer absorbers are also called semi-dry scrubbers or spray dryers.

a. **In dry sorbent injection,** an alkaline material (usually hydrated lime or soda ash) is added into the gas stream to react with the acid gases. The sorbent can be injected directly into several different locations: the combustion process, the flue gas duct (ahead of the particulate control device), or an open reaction chamber (if one exists). The acid gases react with the alkaline sorbents to form solid salts which are removed in the particulate control device. These simple systems can achieve only limited acid gas removal efficiencies. Higher collection efficiencies can be achieved by increasing the flue gas humidity (i.e., cooling using water spray). These devices have been used on medical waste incinerators and a few municipal waste combustors.

b. **In spray dryer absorbers**, the flue gases are introduced into an absorbing tower (dryer) where the gases are contacted with finely atomized alkaline slurry. Acid gases are absorbed by the slurry mixture and react to form solid salts which are removed by the particulate control device. The heat of the flue gas is used to evaporate all the water droplets, leaving a non-saturated flue gas to exit the absorber tower. Spray dryers are capable of achieving high (80+%) acid gas removal efficiencies. These devices have been used on industrial and utility boilers and municipal waste combustors.

c. **Scrubber waste products** - One side effect of scrubbing is that the process only moves the unwanted substance from the exhaust gases into a solid paste or powder form. If there is no useful purpose for this solid waste, it must be either contained or buried to prevent environmental contamination. **Limestone - based scrubbers** can produce a synthetic gypsum of sufficient quality that can be used to manufacture drywall and other industrial products.

Mercury removal results in a waste product that either needs further processing to extract the raw mercury, or must be buried in a special hazardous wastes landfill that prevents the mercury from seeping out into the environment.

2. Mitigating odors in landfill and garbage dumps

a. **Deodorizer floating natural citrus odor counteractant** is a floating odor counteractant to control odors in drains, manholes, sewage treatment plants, lagoons, garbage dumps, landfills and outside dumpsters. Its coating action creates a "seal" that floats on the surface of water. As foul odor seepage rises from below, it must pass through this 'natural seal' which counters the malodors on contact. This coupling of odors results in a pleasant, positive effect. It regreases as it deodorizes. It is biodegradable.

b. **Volcanic deodorizing minerals** are all natural odorless, non-toxic volcanic crystals which capture unpleasant odors through its "negative ionic charge". Generally all odors are positively charged gases that float in the air like dust particles. The negative charge of the volcanic minerals "traps" the positively charged undesirable odor particles. This particle is similar to a piece of metal being attracted to a magnet. The minerals attract and hold foul odor making the air smell fresh.

c. **Dumpsite delight** - is a granular solid odor control system, formulated with citronella oil which eliminates obnoxious odors. Just sprinkle or broadcast the super absorbent "dumpsite delight" which filters out malodors, eliminating them, not covering them up. It is biodegradable and can be used in trash composters, sewage treatment plants, landfill sites, garbage trucks, municipal dumps, hospital waste, manure piles, urine, decaying carcasses, all kinds of food wastes including meats, fish and poultry.

d. BIO-CURE is a liquid biochemical organic formulation, which contains a blend of several species of bacteria and organic nutrients to ensure maximum degradation of organic substances and to enhance the rapid multiplication of enzyme-producing bacteria. It removes foul odor in actively decomposing organic waste and decontaminates polluted waste water in processing plants.

It converts harmful disease-producing organisms into useful elements and eliminates sulfuric odor (H_2S) coming from stagnant water and decaying matter. It lowers the acidity level and gets rid of organic contaminants in water. It is undoubtedly a non-toxic and environment-friendly alternative in the preservation of nature.

To remove garbage odors in landfills and dumpsites, dilute 1 liter of BIO-CURE in 100 liters of water and spray.

3. Phytoremediation technology to minimize air pollution

Trees, shrubs and other forms of vegetation, planted in highly urbanized areas are nature's own way of minimizing and controlling air pollution. The trees give off oxygen and take in CO_2. The oxygen the tree gives off stabilizes the ozone layer, which is made up of pure oxygen that filters the carcinogenic ultraviolet rays of the sun. The carbon dioxide and industrial gases that trees absorb reduce the pollutants in the atmosphere. Scientists have estimated that a tree uses about 5 tons of CO_2 for every cubic meter of wood that it produces through the process of photosynthesis.

In addition, the tree's stem, branches and foliage could trap dust particles and other particulate matters in the air. The leaves could also absorb other toxic gases in the atmosphere. Broadleaved tree species with dense open crown proved to be more favorable in controlling air pollution than needle-shaped leaves. Gases and particulates are either absorbed or trapped more by large leaves rather than by the needle-shaped ones.

Plants with irregular surfaces are more capable of removing gaseous pollutants from the air. The presence of trichomes increase the absorptive area of the leaves and trap sulfur dioxide.

Some of the locally–grown plants that have the ability to contain air pollutants such as sulfur dioxide and nitrogen oxide(s) are: ipil-ipil, mollucan sau, caballero, lumbang, African tulip, and yemane. Plants recommended for planting near factories, power stations, areas with congested and heavy traffic to help contain sulfur and nitrogen dioxide are: yellow bell, Chichirica, San Francisco, bandera española, mayana, and Zigzag plants.

Other pollution-resistant plant species recommended for urban areas are adelfa, African tulip, bandera española, bougainvilla, bunga, caballero, campanilla, giant Ipil-ipil, lumbang, mayana, molave, moluccan sau, pandan, San Francisco, chichirika, yellow bell and Zigzag plant. These plant species are found in high traffic density areas but they exhibit zero or almost zero percent injury and are naturally growing well.

4. *Technology to Determine the Concentration of Lead in Blood of Individuals Regularly Exposed to Motor Vehicle Emissions.*

The study sites identified were at the high traffic density areas near the Ermita Air Quality Monitoring Station along Taft Avenue. This site encompasses the side streets of T.M. Kalaw, U.N. Ave., Padre Faura, Pedro Gil, Gen. Malvar, Julio Nakpil and Remedios. According to DOTC 1990 record, 47,500 vehicles were passing by the area during peak hours (Ramallosa, 1995).

Blood was extracted from 51 subjects comprising juice and cigarette vendors, policemen, newsboys, car watchers and street cleaners for blood lead determination. Medical history of each of the said subject was also determined by the use of pre-tested interview schedule. Air sampling was also conducted daily for the lead analysis in ambient air within the area with the use of high volume sampler. Results of the blood lead analysis were correlated with the medical history of the subjects to determine whether the concentration of lead in blood can be attributed to lead emissions from motor vehicles or from other sources. Correlation was also determined with the mean of lead concentrations in air and human blood and the seasonal variation.

From the data, it was found that seasons, age, sex, smoking, allergies, gastro intestinal problems and exposure to fumes had no effect on the concentration of lead in blood.

5. *Technology to Analyze the Pollution Uptake of A. mangium and A. auriculiformis.*

In NCR, included were 36 and 14 total sampling sites for *A. auriculiformis* and *A. mangium*, respectively. Leaf samples were collected from 4 to 5 trees from each study site. Leaves were taken from top, middle and lower portions of the trees. These were mixed together in plastic bags and were analyzed for SO_2 and Pb content at the Bureau of Plant Industry (BPI) and UP National Science Research Institute (NSRI) laboratories. Same activity was conducted in non-pollutive areas like La Mesa Dam in Quezon City and UP Los Baños.

Comparisons of the laboratory result analysis for SO_2 and Pb in leaf samples were done for pollutive and non-pollutive areas.

Result of the study showed that leaf samples of *A. auriculiformis* and *A. mangium* collected at pollutive areas were high in SO_2 and lead content when compared to those at non-pollutive areas. Both tree species therefore, can be potential absorbers of SO_2 and lead in the atmosphere. Planting of these trees could be one of the solutions to the heavily polluted air in the National Capital Region (NCR) and other highly urbanized areas in the country (Ramallosa, 1995).

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APPENDICES

Appendix Table 1. COMMON AND SCIENTIFIC NAMES OF RECOMMENDED PLANT SPECIES FOR URBAN AREAS

Common Name	Sciencitific Name
Acacia	*Samanea saman*
African tulip	*Spathoda campanulata*
Akle	*Serialbizia acle*
Adelfa	*Nerium oleander*
Agoho	*Casuarina equisetifolia*
Amherstia	*Amherstia nobilis*
Aratiles	*Muntigia calabum*
Atis	*Anona sqamos*
Anahaw	*Livistonia rotundifolia*
Avocado	*Persia Americana*
Bitaog	*Callophyllum inophyllum*
Balete	*Ficus Benjamin*
Balitbitan	*Cynometra ramiflorea*
Banaba	*Lagerstroemia speciosa*
Blue palm	*Neodyosis decaryi*
Botong	*Barringtonia asiatica*
Bunga de China	*Adonidia bluescens*
Bougainvilla	*Bougainvilla sp*
Caballero	*Caesalpinia pulcherrima*
Caimito	*Chrysophyllum caimito*
Carabao grass	*Paspalum conjugatum*
Champaca	*Michelia champaca*
Champagne	*Mascarena lagenicaulis*
Chichirica	*Altemanthera amoena*
Chico	*Achras zapota*
Coconut	*Cocos nucifera*
Cucharitas	*Altermanthea ficoidea*
Dapdap	*Erythrina indica*
Dwarf calachuchi.	*Adenum obesum*
False bird of paradise	*Heliconia psittacorum*
Fire tree	*Delonix regia*
Fringon	*Bauhinia purpurea*
Golden shower	*Cassia fistula*
Guava	*Psidium guajava*
Guyabano	*Anona muricata*
Ilang-ilang	*Cananga odorata*
Kamagong	*Diospyros discolor*
Kamias	*Averhon balimbi*
Katmon	*Dillenia philippinensis*

Langka	*Artocarpus heterophylla*
Luha ng dalaga	*Pedilanthus tithymaloides*
Lantana	*Lantana camara*
Mc Arthur palm	*Ptychospera macarthurii*
Mabolo	*Diospyros dioscolor*
Mahogany	*Swietenia macrophyla*
Mango	*Acacia mangium*
Mangium	*Mangifera indica*
Manzanitas	*Zizipus mauritians*
Melendres	*Lagerstroemia indica*
Molave	*Vitex parviflora*
Narra	*Pterocarpus indicus*
Palawan cherry	*Cassia rodosa*
Palmera	*Chrysalidocapus bluesens*
Palosanto	*Triplaris cumingiana*
Pili	*Canarium ovatum*
Pink tecoma	*Tabebuia rosea*
Pink shower	*Cassia javanica*
Rain tree	*Samanea saman*
Red palm	*Cystotachys renda*
Rain Tree	*Samanea saman*
Rose moss	*Portulaca grandiflora*
Royal palm	*Roystone regia*
Santol	*Sandoricum koetjape*
Saraca	*Saraca declinata*
Sampaloc	*Tamarindus indica*
Shanghai beauty	*Janthropha panduriflora*
Talisai	*Terminalia catappa*
Traveller's palm	*Ravenada madagascariensis*

Appendix Table 2. Biophysical Requirements of Species Suitable for Urban Rehabilitation

PLANT NAME	MORPHOLOGICAL	CLIMATE		TOPOGRAPHY	
Scientific Name /	Description	Temperature	Rainfall	Elevation	Slope
Common Name					Gradient
Acacia auriculiformis/Auri	Medium-sized tree; fast growing; ever green with dense foliage and an open spreading crown.	17-34 C	900—2000mm	220-300mm	5-15%
Acacia mangium Willd/ Mangium	The species is a tall tree reaching a height of 30m (average 15m) and a diameter of 90cm. It has a straight bole and a slightly fluted at the bottom. Leaves flattened leaf stalk called phyllodes, oblong, entire, parallel veined; 25-30cm x 8-10cm wide. Newly germinated seedlings have compound leaves like Leucaena and Albizia. Like other legume species, the species can fix Nitrogen and has symbiotic relationships with the mycorrhizal fungi thus providing soil fertility.	12-34 C	Range: 1000-4500mm Normal: 2000 mm Best growth 500-3000mm		
Adenium obesum(Forssk.) Roem. & Schult./Dwarf calachuchi	Succulent shrub or small tree, sometimes with a fleshy taproot; stem swollen at the base upto 1-2m in diameter; bark pale greyish-green,grey or brown, smooth, with sticky, clear or white latex, leaves arranged spirally, clustered at the end of branclets, simple; flowers bisexual, showy, usually appearing before the leaves.	warm temperature preferably above 30 o C		up to 2100 altitude	
Amherstia nobilis Wall. Amherstia	Amherstia is a stunning evergreen tree that grows up to 12 m high. Its 90 cm long leaves are pinnately compound. Its 30 cm long, oblong leaflets, have long acuminate tips, red or pink, that droop when young and turn green at maturity. Its 10 cm racemes are hanging. Its extravagant flowers hang from the long inflorescence with bright crimson red at the end. Its flower has two minute and three unequal crimson petals. The tip of its two medium-sized petals are yellow. The large petal is about 7.5 cm long and over 4 cm wide at the end. Its largest petal is broad and fan-shaped with a wavy upper margin and a yellow triangle of color extending from the tip down to the flower. There are 9 or 10 stamens of different lengths, partly fused into a pink sheath	The species requires a warm and moist climate, shade and protection from severe wind.			

PLANT NAME	MORPHOLOGICAL	CLIMATE		TOPOGRAPHY	
Scientific Name / Common Name	Description	Temperature	Rainfall	Elevation	Slope Gradient
Antigonon leptopus Cadena de Amor	This is a lovely vine of fast to moderate growth, wide spreading tendril, climbing creeper and quite herbacious. It looks quite fragile but is a very persistent vine, ascending from a tuberous root stock, bears masses of small bright pink or cense flowers in feathery trails of lacket shaped blooms borne in sprays ending in tendrils that tighten around any support, spreading out their small shaped leaves.	Requires full sun, but is okay in partial 65-70^{o} F (19-21oC)			
Areca catechu L. Bunga	Areca nut is a slender, delicate, erect tropical palm reaching a height of about 10 m and lives from 60 up to 100 years. Adventitious roots are produced from the bole; primary roots, about 1.5 cm in diameter, branched out to form secondary and tertiary roots. Roots are mostly confined within a radius of 1 m from the bole and at the top 60 cm of soil. The stem is unbranched cylindrical, straight, 25-40 cm in diameter, about 25 m tall, ringed with leaf scars and has a crown of leaves at the top. The crown is about 2.5 m in diameter; leaves, 1.0 to 1.5 m long with a smooth sheathing base completely encircling the stem. Leaves are retained for about two years after unfurling; mature crown contains about 12 functional leaves. The spadix is enclosed by a double boat-shaped spathe about 60 x 18 cm. The rachis is 30-60 cm long with 20-25 secondary branches. Flowers are unisexual; male flowers are numerous, minute and deciduous and borne at the base of secondary and tertiary branches, 200-500 per spadix	16 to 35^{o}C	1000-5000 mm annual rainfall	900 m asl	
Averrhoa bilimbi L. Kamias	Kamias is a small tree which grows from 5-12 m high. The leaves are pinnate, 20-60 cm long, with hairy rachis and leaflets. The leaflets are opposite; 10-17 pairs; oblong and 5-10 cm long. The panicles growing from the trunk and large branches are hairy and approximately 15 cm long. The flowers are about 1.5 cm long and are relatively fragrant.			500 m	

PLANT NAME	MORPHOLOGICAL	CLIMATE		TOPOGRAPHY	
Scientific Name / Common Name	Description	Temperature	Rainfall	Elevation	Slope Gradient
Barringtonia asiatica (Linn.) Kurtz Botong	A tree reaching of height of 8-15 m. Leaves are large often alternating with smaller ones attached directly to a branch or stem without an intervening bulkj, 20-40 cm long; thick and shiny; apex obtuse; base is rounded truncate, petiole is absent. The bark is pinkish to greenish, not scaly or ridged; inner bark is thick, white with pale yellowish streaks. Flowers are very large with white color, borne in short, erect, few- flowered racemes. Calyx tube is about 1 cm long. The lobes number 2 or 3, with an oblong shape. There are 4 deciduous, thin petals, first white and then brownish, oblong, 7 to 8 cm long and 3 to 4 cm wide. The stamen are numerous and slender, united at the base, 10 to 12 cm long, white below and shading to purple above. The anthers are small and yellow.				
*Brassica rapa/*Pechay Baguio	Chinese cabbage is a Chinese leaf vegetable commonly known in Chinese cuisine. The vegetable is related to the western cabbage and of the same species as the common turnip.	45 -85 ^{o}F		sea level to high alti-tudes	
Canarium ovatum Engl./ Pili	Pili is a large tree reaching a height of about 35 m and 1 m or more in diameter at breast height. The leaves are alternate, pinnate, about 30 cm long, with usually three pairs of opposite leaflets. The flowers are clustered and borne on large compound inflorescence.	warm temp.	well distributed throughout the year.	low elevation but could also thrive in areas which are 300-400m. Absl.	
Champagne lagenicaulis Mascarena	This little dwarf of a palm will grow slowly to a height of 10-12 ft. The solitary trunk is grotesquely swollen and looks as if were cast in a smooth grey concrete. The trunk is a rounded bulge in young speci-mens and gradually elongates and flattens somewhat as the palm matures. Flowers are found in the lowest leaf in a single panicle.	61-63 ^{o}F			

PLANT NAME	MORPHOLOGICAL	CLIMATE		TOPOGRAPHY	
Scientific Name / Common Name	Description	Temperature	Rainfall	Elevation	Slope Gradient
Cocos nucifera (Linn.) Coconut	Thick, erect, unbranched, continously growing stem, with a crown of fully and partially opened leaves, each 6 m long and containing about 200 leaflets of 90-135 cm length. The root-producing bole is about 90cm long, there are about 7000 roots for adult palm, the palm is described as "the tree of heaven" and one of the world's greatest gift to man. The coconut tree grows to 30m (98ft) in height and may live 100 years. It has a single growing point that produces huge pinnate leaves, or fronds, and yellow or white flowers that form the fruit bunch.	mean annual temp. is bet. 27- 35^{o}C	1,300-2,300mm	600m is the limitation.	
Ficus benjamina Balete	Balete can grow into a large tree with wide spreading, conical crown of drooping slender branches. The 6 to 9 cm long leaves are oblong ovate, leathery, with prominent and slender point, rounded base, entire margins, green, smooth and shiny; the nerves are slender, spreading and not prominent. The petioles are 5 to 10 mm long.	45 -85 ^{o}F		1,500 m asl	
Helliconia psittacorum/ False bird of paradise	The leaves of these plants are 15-30 cm long, oblong, opposite one another on non-woody petioles, often longer than the leaf, often forming large clumps with age. Their flowers are pro- duced on long, erect or drooping panicles, and consist of brightly colored waxy bracts, with small true flowers peeping from the bracts. The growth habit of Helli- conia is similar to Conna, Strlitzia and banana to which they are related.	As a potted plant, main- tain temp. above 65 degrees			
Lagerstroemia indica/ Melendres	Medium to large vase-shaped shrub; 4-20 ft., leaves are simple, oval to lanceolate, glossy green, sometimes bronze-tinged, attractive, wide variation in all color. In some plants the leaves stay green until droop- ing, in others they turn crimson or yellow. Flowers are large clusters on branch terminals, color varies from white, pink and lavender, red hues ;blooms from early summer. With a height of about 3m and 1m or more in diameter at breast height. The leaves are pinnate, about	Requires full sun	Evenly distributed throughout the year	low elevation but could also thrive in areas 300-400m asl	

PLANT NAME	MORPHOLOGICAL	CLIMATE		TOPOGRAPHY	
Scientific Name / Common Name	Description	Temperature	Rainfall	Elevation	Slope Gradient
Lagerstroemia indica/ Melendres	30 cm long with usually three pairs of opposite leaflets and a terminal leaflet. The leaflets are smooth, ovate-oblong 12 to 20cm long, 3 to 7 cm wide, smooth and shiny on both sides, pointed at the apex and rounded or obtusely pointed at the base. The flowers are clustered and borne on large compound inflorescence.				
Lantana camara L. Lantana	Lantana is a small thorny flowering shrub with square stems. It is an angiosperm with rings of eight or more tubular flowers. It can grow to a maximum height of 6 ft and may spread 8 ft across the ground. It has an erect or subscandent, square-sectioned, prickly stem. Its young leaves are usually pale in color, while older ones are darker such as red or orange. The leaves are ovate, coarsely serrated and deeply veined measuring 5-12.7 cm x 2.5 cm with rounded tooth edges and a textured surface. The small flowers are arranged in dense flat-topped heads and held in clusters (called umbles), typically 2.4 - 5.1 cm in diameter. Color of flowers ranges from white to yellow, orange to red, pink to rose in unlimited combinations, usually changes in color as they age.	It can tolerate both humid and dry heat but cannot live below 28oF.			
Michelia champaca (Linn)/ Champaca	This is a small tree, growing to a height of 6m. or more. The bark is grey and smooth. The wood is soft, with white sapwood and white olive-brown hearthwood. The young shoots are silky and the branchlets are oppressed-pubescent. The leaves are ovate- lanceolate to oblong-lanceolate, 12 to 20 cm long, and 2.5 to 6.0 cm wide, gradually narrowiing upward to a long pointed apex. The flowers are pale yellow or orange, very fragrant, and 4-5 cm long. The perianth segments are usually 15-20, decidous in whorls of 3, the outer ones being oblong, and the inner,linear in shape.	Full sun to partial shade			

PLANT NAME	MORPHOLOGICAL	CLIMATE		TOPOGRAPHY	
Scientific Name / Common Name	Description	Temperature	Rainfall	Elevation	Slope Gradient
Mussaenda sps.	The Rubiaceae are trees, shrubs, or infrequently herbs. Leaves are simple, opposite or sometimes whorled. Stipules are present and interpetiolar. The flowers are nearly always bisexual and actinomorpic, is variable, some- times forming multiple flower bloom. Doña Luz has large dark pink bracts, peach or pink bracts.	66-75 ^{o} F		0-2490 m	
Pongamia pinnata (Linn.) Merr. Bani	Bani is a gnarly tree reaching a height of 6 to 25 m and 45 cm in diameter. Its bark has a dull gray to pinkish- brownish color, smooth but becoming shallowly fissured; the inner bark has a strong smell of crushed bean-pod. Leaves are compound 20-25 cm long; leaflets ovate, 6-15 cm long. The terminal one is larger than the other and pointed at the tip; usually with a round base thickly coriaceous, purplish, pink white, about 1.5 cm long. Calyx is companulate nearly truncate; corolla is much exerted. The banner is broad; keel obtuse, the petals are cohering at the tip; style, incurred glabrous; stigma, capitate.				
Psidium guajava Linn./ Guava	It is a small tree reaching a about 8 m. in height. Young branches are four-angled. The 12 cm long, apex pointed, base usually rounded. Peduncles are 1 to 3- flowered. Flowers are white, 3 to 3.5 cm across, solitary or 2-3 together cottony white. The numerous stamens form the attractive parts of the flower.				
Quisquialis indica Linn./ Drunken sailor	It is a free branching perennial climber, erect and shrub like in youth, it can reach up to 70 ft tall or more. Leaves are dark and green and elliptic with distinguished veination. The slender 5 lobed fragrant flower blooms white and change to pink and then brightened on a 3-day bloom period.	Full sun to partial shade			

PLANT NAME	MORPHOLOGICAL	CLIMATE		TOPOGRAPHY	
Scientific Name / Common Name	Description	Temperature	Rainfall	Elevation	Slope Gradient
Roystonea regia/ Royal Palm	Roystonea species are single- stemmed trees. Trunks are grey to white, often bulging either at the base or the central portion. The leaves are pinnate, 1-7m long with numerous pinnate up to 1 m long and 2-4 cm broad, the leaves also have a distinctive green basal sheath extending 2-5 m down the the trunk. These plants have the ability to easily release their leaves in strong winds. Inflo- rescence occur beneath the crown shaft, emerging from a narrow horn-shaped shaft. The flowers on the branches panicles are usually white, unisex- ual and contain both sexes.	26-28^{o}F			
Samanea saman(Jacq.) Merr./ Rain Tree	The species is a large tree reaching a height of 50m and a dbh of abot 50m in very old tree. It has a wide spreading and umbrella shaped feathery foliage. The tree is decidous in decidous forest and evergreen in rainforests. Flowering and defoliation are synchronized. The bole is irregular and twisted. Leaves are compound, alternate, bipinnate, paripinnate, 12 to 36 long and 13 to 34cm wide.	Range: 18-380^{o}C Extreme tol. 380^{o}C	600-3000 mm	0-700m	
Saraca declinata	It is an evergreen shrub or tree about 20 m tall. Its poorly- shaped bole is about 40 cm in diameter, without buttresses but with many fine roots that stretch out from the butt. It has smooth and dark brown bark. Its spirally arranged leaves hang limp, with grayish-pink or purple-red tassels.	It thrives best in sheltered shady sites, especially near water, in wet or mon- soonal low- lands	900 m		
Tabubea rosea/ Pink tecoma	Pink tecoma is a medium to large deciduous tree up to 23m in height. Flowers are purplish pink to nearly white up to 8 cm long. It has com- pund leaves, opposite with 3-5 ovate leaflets, often leafless at flower- ing, the beautiful pink flowers are trumphet-shaped, in large clusters.	22-27^{o}C	1,250-2,500mm	up to 1,200m	

PLANT NAME	MORPHOLOGICAL	CLIMATE		TOPOGRAPHY	
Scientific Name / Common Name	Description	Temperature	Rainfall	Elevation	Slope Gradient
Vigna radiata L. Witzeck Mungo	Mungo is is a bushy aannual that grows about 2 1/2 to three feet tall, and has many branches with typical, hairy, beanlike leaves. The flowers are yellowish- green with purple streaks and produce long, thin, hairy pods containing nine to 15 small, yellow seeds. The seeds are used to produce bean sprouts.		Best results are expected during the dry season		

Appendix Table 2. Biophysical Requirements continued……

PLANT NAME	GEOLOGY/SOILS			
Scientific Name /Common Name	Physical/Chemical Condition	Texture	pH	Microbial Status
Acacia auriculiformis/Auri	can thrive in a wide range of soil condition including clay to limestone soil. Often survive in soils of low nitrogen and organic matter.	Deep shallow limestone to lateritic clay	3-9.5 Best growth in 5.5-6.0	The tree can fix N thru Rhizobial association with root nodules, the bacteria infect the root system forming nodulation.
Acacia mangium Willd/ Mangium		Grows in a variety of soil form: eroded, rocky mineral or alluvial soil	Prefer acidic soil pH 4.5. Medium to low fertility and can be poorly drained and low P.	The tree can fix N thru Rhizobial association with root nodules. The bacteria infect the root system forming nodulation.
Adenium obesum(Forssk.) Roem. & Schult./Dwarf calachuchi		can thrive in rocky or sandy soil.		
Amherstia nobilis Wall. Amherstia				
Antigonon leptopus Cadena de Amor	Tolerates moist soils, but better in prepared soils. Requires full sun but is okay in partial.	easily grown in average, medium soil	6.1-7.8	
Areca catechu L. Bunga	It thrives in well-drained laterite or reddish soil, fertile clay loam and alluvial soils. It grows very poorly in ill-drained soil.	Clay loam reddish soil, alluvial soils		
Averrhoa bilimbi L. Kamias	Can thrive in well drained soil types			
Barringtonia asiatica (Linn.) Kurtz Botong				

PLANT NAME	GEOLOGY/SOILS			
Scientific Name /Common Name	Physical/Chemical Condition	Texture	pH	Microbial Status
Brassica rapa/ Pechay Baguio	Grows vigorously in soils rich in organic matter.	Good loam or sandy soil rich in Nitrogen	6-7.5 can tolerate slighly alkaline soil	
Canarium ovatum Engl./ Pili	Rich porous and well-drained soil	medium to heavy soil	neutral to alkaline	
Champagne lagenicaulis/ Mascarena	can adopt to many soils as long as they were well drained; feed with fertilizer three times a year if not grown in rich soil.	sandy loam to loam	4.5- 6.5	
Cocos nucifera (Linn.)/ Coconut	Prefers fertile and adequately drained soil and with a high water holding capacity	sandy or sandy loam	5.0-8.0	
Ficus benjamina Balete	It is best suited in moist and well-drained sites. It can thrive in almost all kinds of soil and site conditions.			
Helliconia psittacorum/ False bird of paradise	Helliconia is frost tender. They should be planted in well-drained soil in a sun or partial shade.	sand, loam, clay	acidic-alkaline	
Lagerstroemia indica/ Melendres	Like moist soil, but tolerates dry conditions once established. rich porous and well drained soil	light soil and volcanic soils		
Lantana camara L. /Lantana	Grows well in dry areas because it prefers well drained soil and it can tolerate drought.			
Michelia champaca (Linn)/ Champaca			6.1-6.5 (mildly acidic)	
Mussaenda sps.	requires well drained soil	Thrives well in sandy soil		
Pongamia pinnata (Linn.) Merr. Bani	It thrives well on sandy to clay loam soil as well as in areas with limestone formation	Sandy to clay loam soils		

PLANT NAME	GEOLOGY/SOILS			
Scientific Name /Common Name	Physical/Chemical Condition	Texture	pH	Microbial Status
Psidium guajava Linn./ Guava	It can withstand water logging and drought. It grows well in poor soil with good drainage.	from open sand to compact clay	5-7	
Quisquialis indica Linn./ Drunken sailor				
Roystonea regia/Royal Palm	The Royal palm are not particular about soil. Like water and look their best when given in adequate amount. It is somewhat drought resistant.	clay, loam, sand	Prefers acidic soil. High alka-line soil should be avoided.	
Samanea saman (Jacq.) Merr./ Rain Tree	Thrives in poor to fertile soil.	Light to gray in color	neutral to acid soil	The tree fixes Nitrogen thru the Rhizo-bial infection in the root system
Saraca declinata	Thrives in well-drained areas like hill slopes	Wide varieties of soils including limestone.		
Tabubea rosea/ Pink tecoma	grows well in deep rich soil	sand, loam, clay	acidic-alkaline	
Vigna radiata L. Witzeck Mungo	Mungo is fairly drought tolerant and can thrive fairly well in relatively dry soil.	clayloam to silty loam	5.8-6.5 slightly acidic	It has root nodules formed by Rhizobia that can fix Nitrogen.

Appendix Table 3. Seed Technologies for Various Species Suitable for Rehabilitation of Urban

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Acacia auriculiformis auri	The fruit is a twisted pod, flat and undulating when ripe. The small black seed, 4-6 mm long and 3-4mm wide are encircled by a long red orange funiculus string from which are suspended after the pods open; each pod contains up to 15 seeds.	Dec- April	Climb the tree collect pods before seeds are released. Use of bamboo pole with scythe to cut branches with ripe pods.	Orthodox	49,000/ kg; 60,000-63,000/ kg	Sun drying of pods to open then extract the seeds manually. Dry the seeds under the shade to reduce moisture content up to 7%
Acacia mangium Willd. mangium	The fruit is dark brown, crinkled and soiled pod; it partially opens when ripe, the seeds are small 2.5mm x 4mm wide and hang by orange fleshy funicles.	Dec-May; June-September	Climb the tree & handpick the fruit; clip the fruit from the tree using pruning pole when the color change to dark brown and begins to crack open.	Orthodox	130353 seed/kg (Dayan, et.Al, 2005)	sun dry the pods for 6 days then place the pods in a sack then beat it using a bamboo stick (Sadjad, 19930 Air dry the seeds under the shade to reduce MC to 7% (dayan, et.al 2005)
Anona squamosa Linn Atis	Fruits are borne on thick stalks, ovoid 5-8 cm in diameter, pale green or glaucous when mature; the out- side is roughened by rounded ends of carpels which are light yellowish-green when ripe. Seeds indefinite, smooth, brownish, embedded in very soft, creamy- white, sweet and juicy fleshly meat.	June and August	Collect the seeds from superior mother trees.		4850 seeds per kilo (2.2 lbs)	Extract the seeds from ripe fruits. Clean in tap water and allow to dry.
Amherstia nobilis Wall Amherstia	Its 11-12 cm similar-shaped. Fruits or seed- pods have woody outer cases.					

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Antigonon leptopus/ Cadena de Amor	Dark seed encased in papery, staw-colored sheath.					
Areca catechu L. Bunga	The fruits mature 8-10 months after pollination. Female flowers do not set fruits but once spadix produces 50-400 fruits. The fruits are fibrous drupe and vary in size and shape. They are green when ripe. The seed, wrongly called "nut", is ovoid or ellipsoidal and weighs 10-20 g. The endosperm, which is the edible portion, has a hard texture and pole brown color.	July to December, December to May	Climb the tree and handpick the fruits			
Averrhoa bilimbi L. Kamias	The fruit is subcylindrical, broad, rounded and longitudinal in shape	Through out the year	Manual picking of the fruits when they turn yellowish green			Seeds are extracted from the ripe fruits. They are thoroughly cleansed with water to remove the slimy covering and allowed to dry under room conditions
Barringtonia asiatica (Linn.) Kurtz. Botong	pyramidal, obtuse, angular, 8 to 12 by 8 to 14 cm; thick pericarp, brown, with a tough corky-fibrous husk, 1 seed					
Brassica rapa/ Peachay Baguio					1,600/ pound	

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Canarium ovatum Pili	The fruit is ovoid, 4-5 cm long, 2-2.5 cm wide, entirely smooth. The rind is greenish when young and turns black when ripe. It contains a brown, hard-shelled triangular in shape nut pointed at both ends where the edible flesh is embeddded.	June to December	The fully ripe fruits should be collected from outstanding trees.	Recalcitrant	50-200 seeds/kg	Newly harvested fruits should be soaked in tap water from 24- 48 hours. Until then, the pulp becomes soft and can be readily separated from the seed by hand. Seeds that float should be discarded because they are either empty or has undeveloped embryo.
Cocus Nucifera/ Coconut	The fruit is a large, single -seeded drupe with a hard stony "shell" and a fibrous husk. The liquid inside the shell becomes solid and oily to form the coconut meat, which is subsequently dried to make commercial copra.		Mature nuts can be picked by hand from the tree or collected from the ground.		single-seeded	
Ficus benjamina Balete	The 1 cm in diameter fruit is solitary, axillary, stalk less, dark purple and fleshy when mature and spherical					
Helliconia pssiticorum/ False bird of paradise	The fruit is a trilocular drupe and has an obcomic shape with about 2.5 cm length. In the young stage, the epicarp had a greenish color, smooth and thin. The endocarp becomes lignified as the fruit develops.		Select ripe and young fruits.			Remove the fleshy part.
Lagerstroemia indica/ Melendres	The fruits are brown or black. When mature they dry and split releasing dish-shaped seeds.					

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Lantana camara L. Lantana	The fruit is an ovoid drupe 4-6 mm in diameter, on a thickened, freshly receptable, colored green initially, but turning black or purple at maturity. The seed is 2-seeded, a nutler, about 1.5 mm long					
Livistona rotundifolia (Lam.) Mart. Var. *luzonensis* Becc. Anahaw	The fruit is 1.5 cm in diameter, globose, fleshy and yellow with a hard, round, brown seed inside		By climbing and chipping off the branchlet using an extension pruner or a pole with a Scythe			The fruits are macerated by putting them in a basin of water to soften the pulp. Remove decayed pulp to extract the seeds. Immediately after de- pulping, soak the lean seeds in water to minimize loss of moisture.
Mascarena lagenicaulis/ Champagne			Allow seedheads to dry on plants, remove and collect seeds.			Pick the seeds from the plants.
Michelia champaca Linn./ Champaca	Seeds are blackish, angular and covered with thin, pink-orange pulp.	August to September	Collect only fresh seeds. Collection may be done by plucking the fruit.		12,000/ kg	Allow unable mish fruit to ripen. Clean and dry the seeds before sowing.
Muntingia calabura Linn. Datiles	The fruit is a berry type; globose green when still immature but turns to yellow to deep red when ripe and measures 1.0 to 1.5 cm in diameter, smooth, fruit soft brown, pulp somewhat sweet and filled with tiny, tan seeds.	All year round	Climbing of the tree and hand-pick the fruits. Use bamboo pole with scythe to cut the branchlets with fruits	Probably recalcitrant	26M/kg seeds	Soak the fruits in a basin of water to soften and macerate it over a fine mesh to separate the pulp from the tiny seeds.

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Mussaenda sps.	The fruit is small (to 3/4"), fleshy, some- what elongated berry.					
Pongamia pinnata (Linn.) Merr/ Bani	Pod is woody, smooth, oblong 5-7 cm long, 5-6 mm thick, beaked at the apex, contains 1 seed which is 3.5-5 cm long.	April to May, July to September	By climbing or by using a light pole with a hook attached to its end			In extracting the seeds, fruits are dried under the sun to let the pods open. Another method is by using a hard object or knife to open the pods and for the seeds to come out.
Psidium guajava Linn/ Guava	The fruit is rounded, ovoid or ovo-void, 4-9 cm. long, green or yellow-green when ripe, contains many seeds embedded in aromatic, pink, edible pulp.	Throughout the year	Allow tree to ripen on the tree; or pick green mature fruit and allow to ripen at room temp.			Extract the seed from ripen fruits.
Quisquialis indica/ Drunken sailor	Coherent at the base, opening by longitudinal slit, many seeded, seeds are pale brown, slightly rough, with tuts of long, dirty white hairs.					
Roystonea regia/ Royal palm	The fruit is an oblong or globose drupe, 1-2 cm long, and deep purple when ripe.	Seed can be collect when the fruit is completely ripe or as soon as it falls from the ground.				Palm seeds are enclosed by a fleshy or fibrous fruit wall that must be removed prior to storage or planting. It can be cleaned by hand using a knife to away the fruit tissue.

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Samanea saman/ Rain Tree	It is a pod, indehi- scent, woody, flat to 25cm long, straight or curved. 2.5-3.5cm wide and almost 1 cm thick (Vozzo,2000; Dayan, et.al.,2003). The seed is oblong, glossy, dark brown, laterally compressed, 0.8-1cm long; 0.7-0.8cm wide and 0.4-0.5cm thick (Dayan,2005) . It has very hard seed coat.	August-September	Collection from the ground of newly fallen fruits.	Orthodox	4,798/kg (Dayan, et.al., 2005); 4000-5000/kg (Vozzo, 2000) 4000-7700 seeds/kg (Heinsleigh & Hollway, 1988)	Manual extraction by hand and washed in running water to remove the stucking substance, then dry and expose in full sunlight (Vozzo, 2000) Sundry the pods for 2-3days, extract the seeds manually then air dry the seeds for two weeks to attain 7-8% MC (Dayan et. al., 2006)
Saraca declinata Saraca	Its flattened and valved fruits, with dehiscing pod and containing 1-8 seeds each, twist or coil upon drying,					
Tabubea rosea/ Pink tecoma	Fruit is linear, dehiscent containing many winged seeds.				42,000 seeds/kg	
Tamarindus indica L. Sampalok	The fruit is 6-15 cm long, 2-3 cm wide, sometimes round or flattened. The pod does not split when mature	June to October	Mature fruits are collected from healthy mother trees			Seeds are extracted by mac-erating and eating the pulp.
Vigna radiata Mungo			Harvesting is done by priming or hand picking as the pods mature. On a sizeable operation, harvesting can be done by a continued har-vester- tresher machine.			Mungo pods are first dried in the sun until they are brittle before threshing by foot or by beating the pods inside the jute sack or with a me-chanical thresher if available.
Zizyphus jujuba (L.) Lam and Mill. Mansanitas	The fruit is smooth, shiny, fleshy and ovoid or subglobose berry. Light green to yellow which measures 1.5 to 2 cm in diameter, with a bony irregular furrowed stone/ seed inside	November to February	Use bamboo pole with scythe to cut branchlets with ripe fruit	Orthodox	15,000	By eating the pulpy part of the fruit. The extracted seeds are washed in running water to clean thoroughly.

Appendix Table 3. Seed Technologies continued….

PLANT NAME	FRUIT			
Scientific Name / Common Name	Media	Germination Treatment	Sterilization	Method of Sowing
Antigonon leptopus/ Cadena de Amor	soil mix consisting of 2 parts loam to 1 part peat moss to 1 part sand	Pre soak seeds for 12 hours		Seeds should be showing a well drained soil mix and barely covered. Plant 3/4" depth
Areca catechu L. Bunga				Prepare raised nursery- beds and directly sow the seeds in shallow holes 10-20 cm apart.
Averrhoa bilimbi L. Kamias	Fine river sand, garden soil			Seeds are sown in seed boxes or shallow pots containing fine river sand or a mixture of two parts fine sand and one part garden soil. They are planted about 2 cm between rows and 1 cm between seeds in a row at about 0.5 cm deep. The bed is leveled to cover the seeds and watered to saturation.
Barringtonia asiatica (Linn.) Kurtz. Botong				
Brassica rapa/ Peachay Baguio		Soak in hot water 925-30min., then quickly cooled and dried.		In seedbed, sow the seeds directly in rows 2 feet apart.
Canarium ovatum Pili	Fine sand and ordinary garden soil	If extracted are to be planted in another place, they should be contained in moist jute sacks during transport and should be sown immediately upon arrival.		Seeds should be laid flat in pre- pared shallow trenches 15-18cm between rows and 8-10cm between seeds in a row. Completely cover the seeds with approximately 1 cm thick of the germinating media.
Cocus Nucifera/ Coconut		Soak the seed nuts in water for two weeks before sowing.	not required	Seednuts are buried two-third of their length in coarse soil to reduce the loss of nut water through evapo- ration.

PLANT NAME	FRUIT			
Scientific Name / Common Name	Media	Germination Treatment	Sterilization	Method of Sowing
Helliconia pssiticorum/ False bird of paradise			Sterilize the seeds in 10% sodium hypochlorite for five minutes; then wash in distilled water.	
Livistona rotundifolia (Lam.) Mart. Var. *Luzonensis* Becc. Anahaw				Sow freshly depulped seeds evenly on previously prepared seedbeds. Press the seeds lightly in the seed beds and cover them with Soil
Michelia champaca Linn./ Champaca	Ordinary garden soil	The red pulp around the seed should be removed before sowing because de-pulped got significantly higher percentage of germination compared to seed sown with pulp.	not required	Sow as soon as possible.
Muntingia calabura Linn. Datiles	Air dry before sowing the seeds. Fine sand in trays can be used in germinating datiles seeds.	Pre- treatment not required	not required	Broadcast the seeds in the sowing medium, cover the seeds thinly with the medium,
Pongamia pinnata (Linn.) Merr Bani				Sow the seeds in drills 3 cm deep and 15 cm wide with a distance of 4 cm
Psidium guajava Linn/Guava	equal mixture of sand and top soil	Boil for 5 minutes or soak for two weeks.		Sow the seeds and lightly cover with soil 0.5-1.0 cm deep.
Roystonea regia/ Royal palm	A 1:1 mixture of peat and sand.	Soak seed in water for 1 to 7 days. It is advisable to change the water daily. Scarification by soaking the seed in diluted H2SO4 for 30-40 min.		Sow in 6 cm. pot filled with germination media with a layer of drainage at the bottom of the pot. Do not water too much, the seeds could rot. You can cover the pot with a pane or sachet of

PLANT NAME	FRUIT			
Scientific Name / Common Name	Media	Germination Treatment	Sterilization	Method of Sowing
Samanea saman/ Rain Tree	1:1:1 top soil, sand and dried organic matter	Nic or cutting of the seedcoat and soak in tap water overnight or in 0.02% fungicide solution (small volume of seeds). Soak the seeds in con. H2SO4 for 30 minutes then wash in running water, then soak in tap water overnight or 0.02% fungicide.	Sterilize the medium for four hours at 80-90 C in sterilizing pad. Let the medium cool off then place in trays for sowing of seeds.	Seeds are sown in greenhouse beds with sand, or in bags with sand or directly in the soil (Vozzo, 2000). Seeds are sown in trays with 1:1:1 topsoil sand and dried organic matter or in trays with moistened paper towel (Dayan et. al., 2005)
Tabubea rosea/ Pink tecoma		desiccation to 71% MC		
Tamarindus indica L. Sampalok	Sandy soil or fine sand			Seeds can be sown in seed-boxes or in seed- beds with sandy soil or fine sand about one cm deep and a distance of 2.3 cm
Zizyphus jujuba (L.) Lam and Mill. Mansanitas	1:1:1 OGS, dried OM and coir dust in trays	Cracking of the stone and soaking in tap water overnight		Drill the seeds in seed bed or in trays with the sowing medium

Appendix Table 4. Nursery Techniques and other Cultural Management Practices of Species Suitable for Rehabilitation of Urban Areas.

PLANT NAME	PRICKING		POTTING		INOCULATION	
Scientific Name /Common Name	Method	Time	Container size	Medium/Ratio	Micro-organism	Dosage
Acacia auriculiformis/ Auri	Lift the seedlings from the potting medium when a pair of false leaves (similar to ipil-ipil) is already formed 2-3 weeks after emergence or when few lateral roots arises. Pricking of germinants should be done in the shaded areas to prevent drying of seedlings.	Anytime of the day in a shaded area.	4x6 polyethylene bag with holes	Sterilized medium of the same ratio 1:1:1 OGS; 5x6 plastic bag with 7:2:1 top soil, sand and organic Fertilizer	VAM mycorrhiza; Rhizobial inoculation Mycovam & Rhizobium	5g (1 full softdrink cap) placed halfway in the bag with the medium; 5cc per germinants (2 leaves) prepared by mixing 15g inoc. to 1 li water; 5g capitulated & rhizobial Inoculants
Acacia mangium Willd./ Mangium	Prick the germinant when a pair of leaves are already developed.	3 weeks after emergence.	4x6 plastic bag	1:1:1 OGS coir dust and dried organic Matter	Mycovam and Rhizobial inoculants	5 g and 1 pellet inoculants place in the center of the bag halfway with the potting mixture before transferring
Anona squamosa Linn./ Atis						
Antigonon leptopus/ Cadena de amor				2 parts loam: 1 part peat moss: 1 part sand		
Areca catechu L./Bunga						
Bambusa blumeana/ Kauayan tinik			8"x12"x .003 plastic bag	sandy loam soil		
Canarium ovatum Engl./ Pili	Carefully uproot and transplant germinated seeds.		6" x 8" polyethylene bags	1:1:1 ratio sand, garden soil, and compost		

PLANT NAME	PRICKING		POTTING		INOCULATION	
Scientific Name / Common Name	Method	Time	Container size	Medium/Ratio	Micro-organism	Dosage
Cocus nucifera/ Coconut			41cmx41cm polybag for small seed nuts 46cm x46cm polybag if seed nut is tilted	clay loam to silty clay loam		
Livistona rotundifolia (Lam.) Mart. var *luzonensis* Becc./ Anahaw			4" x 6" polyethylene bags	1:1:1 top soil saw-dust and sand		
Michelia champaca/ Champaca			4"x6" polyethylene bag			
Mussaenda sps.						
Helliconia pssittacorum/ False bird of paradise				equal parts of loam and thoroughly decayed manure and a bit of sand		
Psidium guajava, L/ Guava				clay loam soil mixed with compost		
Brassica rapa/ Peachay Baguio	Thin seedlings 12-20 inches between plants with in the row.					
Muntingia calabura Linn./Datiles	Start pricking the germinants when the first true leaf appears		4 x 6" plastic bag	Ordinary soil + dried humus + coconut coir dust at 1:1:1 Ratio	Inoculate with my-corrhiza and capsulated Rhizobium	5g of mycorrhiza and capsulated Rhizobium can be applied in the center of half filled plastic bag with the potting medium before transplanting.

PLANT NAME	PRICKING		POTTING		INOCULATION	
Scientific Name / Common Name	Method	Time	Container size	Medium/Ratio	Micro-organism	Dosage
Roystonea regia/ Royal Palm						
Samanea saman/ Rain Tree or Acacia	In shaded area, using pointed stick	Anytime of the day in shaded area	4"x6" plastic bag	1:1:1 OGS, sand and dried OM	Mycovam	5g mycovam is inoculated in half filled polybag then fill the bag with potting Medium
Sphasneticola trilobata (L.C. Rich) pruski Wedelia						
Tabubea rosea/ Pink tecoma						
Vetivera zizanioides Vetiver grass	Propagation by root division or lips that are usually ripped off the main clumps and potted. Stem cutting with 2 nodes at 30-50 cm cutting to encourage tillery and 40 cm giving best results. Ratooning or cutting to the ground and left to sprout.		7"x15" and 10"x20" plastic bags 4"x6" plastic bags was found to be more economical		Mycovam	25g of chipped roots of maize with mycovam (*Glomus* spp.)
Zizyphus jujuba (L.) Lam and Mill. Mansanitas	Start pricking when a pair of leaves is already formed	Anytime of the day in shaded area	4"x6" plastic bag	1:1:1 OGS, dried OM or coir dust	Mycovam	5g mycovam in half filled medium, then add the remaining half of the medium before trans-planting

Appendix Table 4. Nursery Techniques continued .....

PLANT NAME	TRANSPLANTING & OTHER PRACTICES				FERTILIZATION/AMENDMENTS	
Scientific Name / Common Name	Grading	Re-potting	Root pruning	Spacing	Basis	Form
Acacia auriculiformis/ Auri	Vigorous seed-lings are first to be transplanted	Repotting should be done immediately for replacements to cope up the rest in terms of growth & survival		When leaves start to over-lap, provide space between seedlings by placing wood or any material which will not affect the growth of seedlings	If possible application of fertilizer is not recommended since it make the stem and leaves succulent and this predisposed the seedlings to the attack of pests and diseases. How- ever if the analysis of potting medium lack the essential nutrients for development, soil amendment like fertilizer applica-tion is necessary by spraying or by incorporation in the soil.	If NPK is lacking one time application of complete fertilizer is enough.
Acacia mangium Willd./ Mangium		Transplant the seedling carefully in 4"x6" bag with the medium and inocu-lants			Nutrient	NPK
Anona squamosa Linn./ Atis				4-6 cm apart		
Antigonon leptopus/ Cadena de amor				12-15 ft (3.6- 4.7 m] 15-20 ft (4.7-6m)	Fertilize weekly during the growing season.	NPK
Areca catechu L./Bunga	Transplant the healthy robust seedlings			2.7 x 2.7m		100 g N, 40 g P205 and 140 g K2O per palm annu-ally in two applications, e..g. from Sept. to Oct. and Mar to April
Bambusa blumeana/ Kauayan tinik					distance of 25-50 cm between rows	

PLANT NAME	TRANSPLANTING & OTHER PRACTICES				FERTILIZATION/AMENDMENTS	
Scientific Name / Common Name	Grading	Re-potting	Root pruning	Spacing	Basis	Form
Canarium ovatum Engl./ Pili			Some leaves of the seed-lings may be cut-off prior to planting			
Cocus nucifera/ Coconut	the earliest germinators occupy the first row.	When sowing, the seed nut should be laid upright or slightly tilted with its stem- end above the ground.		40 cm apart or 25-40 seed-lings/row		corn cob as soil filler/ ameliorant
Livistona rotundifolia (Lam.) Mart. var *luzonensis* Becc./ Anahaw						
Michelia champaca/ Champaca		Seedlings are trans-planted when they have 2 pairs of leaves.				
Mussaenda sps.					Enrich the soil	organic matter such as well rotted compost, sphagnum peat or choir.
Helliconia pssittacorum/ False bird of paradise		Repotting should be done in February			36"-60"	
Psidium guajava L/ Guava					2-3 cm apart	

PLANT NAME	TRANSPLANTING & OTHER PRACTICES				FERTILIZATION/AMENDMENTS	
Scientific Name / Common Name	Grading	Re-potting	Root pruning	Spacing	Basis	Form
Brassica rapa/ Peachay Baguio		Transplant may be protected with plastic row cones. The transplant should be set in the soil to a depth of the first pair of leaves.		6"-12" apart		Composted manure and cover crops residue .
Muntingia calabura Linn./Datiles	As much as possible, select germinants of the same size. Avoid Pricking unhealthy germinants					
Roystonea regia/ Royal Palm		Repot in an 8 cm pot when the first leaves developed a little. Place the pot at the edge of the window exposed to sun.				
Samanea saman/ Rain Tree or Acacia	Select germinants of vigorous growth and avoid transplanting unhealthy seed-lings.			Provide enough space between seedlings to avoid Overlapping of leaves and to provide aeration.		

PLANT NAME	TRANSPLANTING & OTHER PRACTICES				FERTILIZATION/AMENDMENTS	
Scientific Name / Common Name	Grading	Re-potting	Root pruning	Spacing	Basis	Form
Sphasneticola trilobata (L.C. Rich) pruski Wedelia			Cuttings root readily in five to seven days under moist conditions. It can be easily established by sprigging by hand or with a hydraulic seeder; planting rooted or unrooted cuttings, or from nursery-grown plants.		Growth can be controlled by carefully managing nitrogen fertilizer and irrigation. Water and fertilize only enough to provide adequate growth and color.	
Tabubea rosea/ Pink tecoma			Trees withstand a little amount of pruning but not pollarding.			
Vetivera zizanioides Vetiver grass		Slips with 2-3 tillers are planted in a furrow 15-20 cm deep. Two row system planting in soil bed at 6" between rows			Apply when needed	NPK 6gms nugget Kokei (NPKMg)
Zizyphus jujuba (L.) Lam and Mill. Mansanitas				Place the bag after another in rows so as not to topple down the bag to prevent injury to the newly transplanted seedlings.		

Appendix Table 5. Pest and Disease Control Strategies in the Nursery and Plantation for Species Suitable for Urban Rehabilitation

PLANT NAME	SEED			NURSERY		
Scientific Name /Common Name	Pests and Diseases	Causal Pathogen	Control Measure(s)	Pests and Diseases	Causal Pathogen	Control Measure(s)
Acacia auriculiformis Auri	*Seed diseases	**Lasiodiplodia theobromae* **Colletotrichum loeosporoides* **Macrophoma phaseolina* **Aspergillus flores/ niger*	After pre-treatment, soak the seeds in 0.02% fungicide solution overnight	Powdery mildew	*Oidium* spp.	Observe sanitation; Spray Dithane M-45 or Captan emulsion every 2 weeks; proper disposal of infected leaves to prevent spreading of disease.
Acacia mangium Willd. Mangium	*Seed diseases	* *Pestalotia* sp * Fusarium moniliforme * Aspergillus flavus/ niger	Soak pretreated seeds in fungicide solution at 2.5 g/li of water	Powdery mildew	*Oidium* sp.	Avoid overcrowding in the nursery, spray any contact fungicide once infection is observed.
Anona squamosa Linn. Atis						
Antigonon leptopus/ Cadena de amor	No serious insect or disease problem.					
Areca catechu L. Bunga						
Averrhoa bilimbi L. Kamias						
Brassica rapa/ Pechay Baguio				*Pests 1. Hymenoptera a. Harvester ant	*Pogomyrmx rugasus*	Pour boiling water that contains citrus extract around the ant hill to kill population inside.

PLANT NAME	SEED			NURSERY		
Scientific Name /Common Name	Pests and Diseases	Causal Pathogen	Control Measure(s)	Pests and Diseases	Causal Pathogen	Control Measure(s)
Brassica rapa/ Pechay Baguio				2. Diptera a. Cabbage maggot	*Delia radicum*	Insecticide treatment is more effective when applied before seeding because cabbage maggots and a stand establishment pest.
				*Diseases Damping -off	*Pythium sp* *Rhizoctonia solani*	All residues from the previous crops should be plowed before planting.
*Canarium ovatum/*Pili						
Cocos nucifera/ Coconut	*Pest 1. Rat		Use either trunk banding or baiting.	* Diseases 1. Leaf spot	*Pestalozzia palmarum*	Adequate application of muriate of potash or sodium chloride ,makes the palms resistant to leaf spot. To prevent the spread of the disease, isolate or dispose seedlings which exhibit advanced symptoms.
				2. Bacterial leaf stripe	*Helmintho sporium spp.*	Spray physan at the rate of 0.5 tbsp/liter of water weekly to biweekly until infection subsides.
Helliconia pssittacorum/ False bird of paradise						

PLANT NAME	**SEED**			NURSERY		
Scientific Name /Common Name	Pests and Diseases	Causal Pathogen	Control Measure(s)	Pests and Diseases	Causal Pathogen	Control Measure(s)
Livistonia rotundifolia (Lam.) Mart. Var *luzonensis* Becc. Anahaw						
Lagerstroemia indica Melendres						
Muntingia calabura Linn. Datiles						
Pongamia pinnata (Linn.) Merr/ Bani						
*Psidium guajava/*Guava						
Roystonea regia/ Royal palm						
*Samanea saman/*Rain tree	Seed diseases	*Fusarium solani, Lasiodiplodia theobromae*	Soak seeds in fungicidal solution for 2 hours prior to sowing.			
Sphagneticola trilobata (L.C. Rich.) Pruski/Wedelia						
Tamarindus indica L. Sampalok						
Vigna radiata L./Mungo	Seed decay	Avoid thick seeding; maintain proper soil moisture: protect seeds with seed-protectant chemicals such as Orthocide 50, Arasan SF, Vitavax, Demo-san at the rate of 185g/ cavan of seeds.				

Appendix Table 5. Pest and Disease Control continued ……

PLANT NAME	PLANTATION		
Scientific Name /Common Name	Pests and Diseases	Causal Pathogen	Control Measure(s)
Acacia auriculiformis/Auri	Powdery mildew	*Oidium spp.*	Observe sanitation; Spray Dithane M-45 or Captan emulsion every 2 weeks; proper disposal of infected leaves to prevent spreading of diseases.
Acacia mangium Willd./Mangium	Dieback Root rot Pests: pinhole borer; carpenter ants; scale insects; mealy bug; leaf *Cerambycid*	**Colletotrichum* * *Fusarium* sp * *Pestalotia* sp *Phellinus noxiores*	Avoid tree injury; if injured, apply fungicide in affected areas Select good plantation site; plant resistant trees; establish mixed plantation; avoid wounding the roots. Apply contact insecticide to prevent spread of infestation.
Anona squamosa Linn./Atis	Moth borer, inflorescence rot, pink disease, rhizoctonia thread blight		Remove infected parts and spraying the trees with appropriate fungicides
Antigonon leptopus/Cadena de amor			Regular spraying with Bordeaux mixture is recommended during breaks in the rainy season
Areca catechu L./Bunga	Fruit rot	*Phytopthora palmivora*	The damaged portion should be pruned and burned
Averrhoa bilimbi L./Kamias		*Cerambyoid* borer (*Pterolophia bigiberra* Newman) Aphids, scale insects	

PLANT NAME	PLANTATION		
Scientific Name /Common Name	Pests and Diseases	Causal Pathogen	Control Measure(s)
Brassica rapa/Pechay Baguio	1. Coleoptera a. Striped flea beetle *Phyllotreta striolata* b. Potato flea beetle *Epitrix cucumeris* c. Western black flea bettle *Phyllotreta pusilla* d. Western striped flea beetle *Phyllotreta ramosa* e. Darling beetle *Blapstinus sp.* f. Rove Beetle *Staphylinids sp.* 2. Orthotera a. cricket *Schistocera* sp. b. Spur-headed grasshopper c. Desert (migratory) grasshopper 3. Diptera a. leaf miner * Diseases Fungal Diseases a. *Downy* mildew b. *Schlerostinia* Rot	 *Melanoplus sanguinnepes* *Liriomyza sp.* *Peronospora parasitica* *Schlerotinia mina* *Schlerotinia*	Methomyl, diazinon and pyrethroids are frequently use treat-ment for the control of flea beetles. Control weeds, which would act as host for flea beetles. Placing baits around the perimeter of the field will provide some control when beetles migrate into the field. Baits such as permethron and Carbaryl can be used to control crickets. Avoid planting near cotton, alfalfa and other host feeds, because leaf miners will migrate from these fields. Control weeds Fields should be irrigated with care, to avoid conditions
Canarium ovatum/Pili	*Pests 1. twig borer (Niphonoclea capito Pasc.I 2. gray mealy bugs (*Ferrisia virgata* ck II)		Insect pests seem not to be a serious problem. The attack can be controlled by spraying with insecticide.

PLANT NAME	**PLANTATION**		
Scientific Name /Common Name	Pests and Diseases	Causal Pathogen	Control Measure(s)
Cocos nucifera/ Coconut	* Pests 1. Rhinoceros beetle (*Oryctes rhinoceros*). 2. Coconut spike moth (*Tirathaba rufivena*) 3. Asiatic palm weevil (*Rhynchophorous* schach) 4. slug catterpillars 5. Bud rot 6. Socorro Wilt 7. Stem Bleeding	*Phytopthora palmivora* *Ceratostomella (Thielaviopsis) Paradoxa*	Cut and burn crown- less palms. Pour 1% chlordane on newly-cut coconut stumps to discourage breeding of other pests . In case of severe outbreaks, spray with triazophos, diazinon, azinphos- ethyl and dimethoate at 0.05%. Collect and kill larvae and cocoons. If early symptoms of the disease are spotted and there is some hope of recovery, remove the infected tissue plus some healthy tissues bordering the infected lession. Cut the infected tree and thoroughly burn the crown to eliminate sources of infection. Cut and burn diseased palms immediately to reduce sources of infection. Search for disease -resistant or tolerant coconut cultivars/hybrids. Chisel out the infected tissues including about 5cm of the healthy portion.
Helliconia pssittacorum/ False bird of paradise	**Diseases 1. leaf spots 2. root rot & stem rot	*Cercospora Helminthospo-rium*	plant in well-drained soil Spray with fungicide. Keep the soil well-drained.
Livistonia rotundifolia (Lam.) Mart. var *luzonensis* Becc./Anahaw	shoot borer		
Lagerstroemia indica/Melendres	*Disease 1. Powdery mildew 2. Sooty Mold	*Cercospora* It is the result of a fungus growing on honeydew excretives made by insects such as aphids	Apply fungicide when the diseases are first noticed. Plant disease-resistant variety. Use aphids-resistant cultivars.
Muntingia calabura Linn./Datiles	Twig die back, foliage leaf spot and leaf defoliator	Unknown	
Pongamia pinnata (Linn.) Merr/Bani		Large bloth mines appear on the surface of the leaflets. Acrocerops anthracuris Meyrick	Constant inspection of the plantation, especially during rainy seasons, may help remove the eggs on the surface of the leaves. The eggs should be removed and destroyed.

PLANT NAME	PLANTATION		
Scientific Name /Common Name	Pests and Diseases	Causal Pathogen	Control Measure(s)
Psidium guajava/Guava	* Pests 1. Oriental fruit fly	*Daucus dorsalis (Hendel)*	Bagging the fruit. Harvest at the earliest possible. Collect the infested fruits into a kerosene can with a thin layer of sand at the bottom and destroy the larvae/pupa.
	2. Aphids	*Aphys gosypili (Glover)*	Spray with appropriate insecticide (like malathion) when necessary.
	3. Green Scale Insects	*Cocus viridis (Green)*	Use of entomogenous fungi, effective especially during rainy season.
	4. Common white mealy bug	*Planocous lilacinus Ckll*	Seldom needs remedial action
	5. Moth	*Zuezera coffea Nien*	If destroyed early enough, the infested stem may be saved by inserting a coconut leaf midrib into the funnel and pushing it as far as it would go to splash and kill the caterpillar inside. If infected twigs that have not broken off should be broken and the pupa speared.
	6. Spotting	*Gloeosporium psidi G. Del.*	No control measure has ever been recommended although spray of fungicides can be recommended.
Roystonea regia/Royal palm	* Diseases 1.Ganoderma butt rot * Pests 1. Palm leaf skeletonizer 2. Royal Palm bug 3. giant palm weevil 4. scales		

PLANT NAME	PLANTATION		
Scientific Name /Common Name	Pests and Diseases	Causal Pathogen	Control Measure(s)
Samanea saman/ Rain tree			
Sphagneticola trilobata (L.C. Rich.) Pruski/ Wedelia	Chewing insects, mites and leaf-hoppers. Leaf spots and root rot.		Chemical pest controls are only recommended for severe infestation.
Tamarindus indica L./Sampalok	Sooty mold, aphids, scale insects, mites shoothole borers, toy beatles, leaf-feeding caterpillars, bagworms, mealy bugs	*Aonidiella orientalis* newstand *Drosicha atebbingi* green *Hemiberlesia lataniae* signoret *Lacifer lacca kerr.* *Amblyrhinus poricollis* schoenherr *Caryedon gonagra* *Myllocerus discolor* Boheman	Insect-pest of tamarind may be controlled by spraying the infested trees with common insecticides such as Sevin or Malathion at the recommended dosage. If damage is serious, insects related to sooty mold fungi should be controlled first. Spraying organic phosphorous. Chemical is effective in eradicating these insects. Emulsion of MEP Sumithion (1000 times) Thiometon (1000 to 2000 times) is used to control these sucker insects./
*Vigna radiata L./*Mungo	*Pests 1. Bean fly (*Ophiomyia phaseoli*) Tyron 2. Bean leaf roller (Lamprosema *indicata*) 3. Coffee leaf folder (*Homona coffearia*) 4. Corn earworm (*Helicoverpa amigera*)		Apply 0.5 kg/ha of Cabofuran in the rows immediately after planting. Do not repeat granular application. The spray recommendation for the bean fly may be followed through the vegetative and reproductive stages. The spray recommendation for the bean fly may be followed. Spray the leaves with 4-5 tbsp. of Diazinon or 2-3 tbsp. Endosulfan or Monocrotophus or 5-10 tbsp. Eradex per 20 liters of water as soon as the damage is observed .

PLANT NAME	PLANTATION		
Scientific Name /Common Name	Pests and Diseases	Causal Pathogen	Control Measure(s)
*Vigna radiata L./*Mungo	* Diseases 1. Powdery mildew 2. Cercospora Leaf spot 3. Mossaic 4. Bean lycaenid *Catochrysops cnejus* 5. Leaf hopper *Empoasca* sp. 6. Common cut worm *Spodoptera* litura 7. Corn semi-looper *Chrysodeixis-chalcites* 8. White grubs *Leucopholis irrotata*	 Fungi Virus	The disease can controlled by spraying benomyl fungicide such as Benlate, two times in the growing season 14 days apart at 1/2 tbsp. per liter of water or Thiophanate methyl fungicide like Fungitox at 1 tbsp. per liter of water Apply Benlate fungicides. Use 1/2 tbsp. Benlate per liiter of water. Never use infected seeds for planting; have a good insect and weed control program. Spray recommendations on the bean fly may be followed. Spray recommendation on the bean fly may be followed. Spray recommendation for earworm may be followed. Spray recommendations on earworm may be followed. Thorough preparation of the field before planting.
Zizyphus jujuba (L.) Lam and Mill./ Mansanitas	The fruit is susceptible to insect pests such as fruit flies, fruit worms and some leaf defoliators	Fruit flies *Lepidopteron* Insects	Apply any insecticide that can prevent flies and leaf defoliators

Appendix Table 6. Field Plantation Cultural Management Techniques of Species Suitable for Urban Rehabilitation.

PLANT NAME	SITE PREPARATION		PLANTATION		
Scientific Name /Common Name	Clearing	Staking	Hole size	Spacing	Planting Procedures
Acacia auriculiformis/ Auri					Spaces in between for leguminous shrubs like pigeon pea, creepers like mani-mani and pasture crops like stylosanthes.
Acacia mangium Willd. Mangium			Large enough to accommodate the seedlings in 4x6 plastic bags and soil amendments to be added		
Anona squamosa Linn. Atis	In medium to large scale operation, the land is prepared by plowing it deeply and harrowing it a few times to attain the desired soil tilth.			4-6 m apart	The plants are usually spaced 4-6 m apart following either the triangular or square planting. The leaves of the planting material are pruned in halves, to reduce transplanting shock. The ball of soil that goes with the root system should be leveled with the ground or a few centimeters below the ground level The plants are watered right after providing with mulch.
Antigonon Leptopus Cadena de amor					Plant 3/4" depth in a well drained soil mix and barely covered.
Areca catechu L./Bunga	Prepare the land well by plowing repeatedly. Provide water channels and drainages.			2.7 x 2.7 m (about) 1300 plants/ha	Remove the bags completely before planting the seedlings in the hole. Place green leaves or apply cattle manure, etc. around the base of the palm or in trenches near the base.

PLANT NAME	SITE PREPARATION		PLANTATION		
Scientific Name / Common Name	Clearing	Staking	Hole size	Spacing	Planting Procedures
Averrhoa bilimbi L. Kamias	For backyard planting cultivate the area thoroughly to remove the existing weeds that may compete with the plants. Dig holes deep and wide enough to accommodate the ball of soil that goes with the planting materials. For orchard plantation plow the soil deep enough to eliminate weeds. Harrow the soil two to three times to attain the desired soil tilth.	Layouting and staking of the site		5 - 7 m apart	After careful removal from the containers, plants are set in the dug holes. The extra space in the holes are filled up with topsoil, pressed firmly around the roots. The plants are watered immediately after planting.
Barringtonia asiatica (Linn.) Kurtz. Botong			Depth of hole must accommodate new plant roots	2 x 4 m	
Brassica rapa/ Pechay baguio	Prior to planting field may be deeply tilled.				
Canarium ovatum Engl./ Pili	Areas to be planted are cleared by plowing or brushing.		just wide and deep enough to accommodate the Seedlings	10 m apart	For each hill, two seedlings are planted 30-40 cm apart since there is a 50% chance that half of the seedlings may turn out to be male.
Cocus nucifera/ Coconut	If the land has been cleared, no special advanced preparation is necessary.		45 cm deep and 45 cm wide	9m	Seedlings should be planted at the center of the planting hole in such a way that the top of the seed nut's husk is vey lightly covered with soil. The soil around the base should be pressed firmly. It should neither cover the seedling collar nor get into the leaf axils.

PLANT NAME	SITE PREPARATION		PLANTATION		
Scientific Name / Common Name	Clearing	Staking	Hole size	Spacing	Planting Procedures
Ficus benjamina Balete			2 x 2 m		
Helliconia pssittacorum/ False bird of paradise					The rhizome should be placed with the top (lef/stem/new shoot/buds pointing upwards no more than 3-4 cm under the soil. New shoots or large buds should be above the soil.
Lagerstoemia indica/ Melendres			at least two times wider than the root ball.		Set the plant no deeper than it originally grew in the container on field. Then backfill with the soil removed from the hole after breaking apart clods.
Livistona rotundifolia (Lam.) Mart. var *luzonensis* Becc./ Anahaw	Underbrush about 1 m strip of vegetation of the selected site where the seed- lings are to be planted	Put stakes for ease in the holing prepa- ration	The size of the hole depends on the size of bags used in the nursery	2 x 2 m	Outplanting should be done at the onset of the rainy season. The plastic bags of the potted seedlings must be removed carefully. Mulching materials should be placed at the base of the plants while pulverized topsoil should be placed around the root system to allow good anchorage of the seedlings.
Michelia champaca/ champaca				15-20 ft (4.7-6.0m)	
Muntingia calabura Linn Datiles		Trenches are dug at 1m x 0.5 m x 0.3 m. Top soil plus farm manure are filled up in trenches before planting.			Outplanting is usually done on the onset of rainy season. Remove the bag completely before planting the seedlings
Mussaenda sps.					Set the plant at the same level as it grow in the container, carefully backfill the planting hole and water thoroughly. Apply a 3/4" covering of organic mulch, keeping a 3-4" away from the stem.

PLANT NAME	SITE PREPARATION	PLANTATION			
Scientific Name / Common Name	Clearing	Staking	Hole size	Spacing	Planting Procedures
Psidiumguajava L./ Guava	Plow the area once or twice followed by several harrowing to completely pulverize the soil.	Stake the field during dry season		5-7 m	Seedlings about 25cm height are used for outplanting.
Pongamia pinnata (Linn.) Merr. Bani				5 x 5 m	
Roystonea regia/ Royal palm	Installation site should be well drained, standing water should not appear at the bottom of the planting hole.	Stake the Royal Palm for support until it is established.	Hole should be wide enough to easily accept the rootball and provide at least several inches of new growth from the ball.	15-20 ft (4.7-6 m)	Lower the tree and allow the root ball to remain two or three inches above the ground. When backfilled with soil. Water thoroughly and generously mulch around the tree.
Samanea saman (Jacq.) Willd./ Rain Tree or Acacia		Stakes will be installed in between distance for ease in site preparation or in holing.	Holes should be large enough to accommodate the seedlings planted in 4x6 plastic bag.	2x2	Totally remove the plastic bag and carefully plant the seedlings Provide mulching materials to cover the newly outplanted seedlings to prevent drying up and maximize soil moisture needed by the seedlings.
Tamarindus indica L. Sampalok	Plowing once and harrowing several times until the desired soil tilth is attained.	Setting the stakes following the desired distance of Planting	Digging holes at the positions occupied by the stakes	5 x 5 m	Plant during the rainy season to reduce the need for frequent watering. If water is available for irrigation, planting may be done anytime of the year, even during dry season. Partial shade should be provided to newly transplanted tamarind, particularly, if planting is done during the dry season.

PLANT NAME	SITE PREPARATION		PLANTATION		
Scientific Name / Common Name	Clearing	Staking	Hole size	Spacing	Planting Procedures
Vigna radiata/ Mungo	When using tractor, one plowing and one harrowing of four passings may be enough. With the use of animal power, two plowings may be required and at least two harrowings with one harrowing of four passing's after plowing.			Wider row spacing is recommended for the wet season. Shallow furrows are made 50 cm apart depending on the implements used and the season.	Mungo is planted either by the row drill method, hill or broadcast method.

Appendix Table 6. Field Plantation continued…….

PLANT NAME	PLANTATION		CARE AND MAINTENANCE
Scientific Name / Common Name	Timing	Soil Amendments	Hole size Spacing Planting Procedures
Acacia auriculiformis/ Auri		Apply 30g complete (NPK). Cover the seedlings fully with top soil. Put 6 cm. mulching material to conserve soil moisture.	
Acacia mangium Willd. Mangium	Plant during the start of rainy season	Apply 30g complete (NPK). Cover the seedlings fully with top soil. Put 6 cm mulching material to conserve soil Moisture	Make periodic obser- vation on pest or disease occurrence, weeds/vines that may creep on the stem of the seedling.
Anona squamosa Linn. Atis	anytime of the year but the best time is at the onset of the rainy season	It prefers slightly acidic and soil conditions with pH of 5.5 - 6.5	Close monitoring of the occurrence of pests and diseases. Water the seedlings regularly.
Antigonon Leptopus Cadena de amor			Water regularly, 1 per week in hot season.
Areca catechu L. Bunga			Perform hoeing and weeding twice a year. Drain surplus water during heavy rainfall and irrigate during dry season.
Averrhoa bilimbi L. Kamias	At the onset of the rainy season	Apply compost or manure to promote vegeta- tive growth. Organic fertilizers such as ammo- nium sulfate, may also be applied at 100—200 g/tree/year.	
Barringtonia asiatica (Linn.) Kurtz./Botong	Start of the rainy season		By brushing around the plants for a year. Plants must be protected from wild fires

PLANT NAME	PLANTATION		CARE AND MAINTENANCE
Scientific Name / Common Name	Timing	Soil Amendments	Hole size Spacing Planting Procedures
Brassica rapa/ Pechay baguio		Apply 50 pounds of N at planting and sidedress additional N at diminishing rate as the plant nears harvest.	Once the plant is established, furrow or drip irrigation is recommended.
Canarium ovatum Engl./ Pili	anytime of the year as long as sufficient water is available	Initial application of complete fertilizer (14-14-14) is recommended during out- planting at a dosage of 20 g per plant. Subsequent application 30-60g per plant per application. There shall be two application in a year, done at the start and toward the end of rainy season.	A newly established pili plantation should be maintained weed- free by brushing. Ring weeding at least twice a year may be done.
Cocus nucifera/ Coconut	at the start of the rainy season	Judicious application of fertilizers increases nut and copra yield. The three most needed fertilizers for coconut production at all growth stages are N-Cl-S.	Check weed growth within a circle of about 1-2 m radius by mulching the area with dried weeds or any organic mulches.
Ficus benjamina Balete	Plant during rainy season		
Helliconia pssittacorum/ False bird of paradise		Requires minimal fertilizer, may be quarterly or once a month.	They are very susceptible to excessive fertilization with the big problem of browning edges on the Leaves
Lagerstoemia indica/ Melendres		Soil amendments is not necessary when planting in individual hole .	flowering of plants will be enhanced if plants are watered during dry periods that occur during the flowering season.
Livistona rotundifolia (Lam.) Mart. var *luzonensis* Becc. Anahaw	Onset of the rainy season		Ring weeding should be done as often as necessary to allow normal growth and development of plants. Replace dead seed- lings as soon as possible.

PLANT NAME	PLANTATION		CARE AND MAINTENANCE
Scientific Name / Common Name	Timing	Soil Amendments	Hole size Spacing Planting Procedures
Michelia champaca/ champaca	during rainy season		
Muntingia calabura Linn Datiles		complete fertilizer (14-14-14) at 50g/ plant is applied during outplanting.	Use the available mulching material in the area such as dried leaves, grasses etc. If possible the material should be 6 cm thick to really conserve the soil moisture.
Mussaenda sps.		Foliar application 3-4 times/year using nutritional spray containing all the essential trace elements especially Manganese and Zinc.	it is best to prune Mussaenda after blooming to get a bushy plant.
Psidium guajava L./ Guava	at the onset of the rainy season	Incorporate organic matter into the soil.	Shallow cultivation around the base of the plant is recommended to prevent root injury.
Pongamia pinnata (Linn.) Merr./Bani			
Roystonea regia/ Royal palm	Transplant in the warmer month of the year.	Foliar spray of soluble macronutrients such as potassium and Manganese during the first four to six months after installation.	Royal Palms grow quite rapidly when given abundant water and fertilizer in full sun or dappled shade. They withstand strong winds and salt spray very well but some foliage injury will be evident on Royal Palm located next to the ocean.
Samanea saman (Jacq.) Willd./ Rain Tree or Acacia	Plant on the onset of the rainy season	Dried organic matter or farm manure is added to top soil.	Visit the outplanted seedlings periodically and monitor the pests and diseases occurrence. Apply any environment friendly pesticides once pests and diseases are observed to prevent outbreak in plantation.

PLANT NAME	PLANTATION		CARE AND MAINTENANCE
Scientific Name / Common Name	Timing	Soil Amendments	Hole size Spacing Planting Procedures
Tamarindus indica L. Sampalok	Plant during the rainy season		Weed the plants periodically. Provide stakes or temporary fence around the plantation or around individual plants. Conduct thinning and pruning particularly on trees with overlapping crown. Gather any occurrence of pests and diseases to prevent any outbreak of infestation.
Vigna radiata/ Mungo	Mungo can be grown during the wet and the dry seasons. Best results are expected during the dry season if supplementary irrigation is available.	The yield of mungo may be increased when mulched with rice straw.	A well prepared seedbed would give mungo seed- lings a good start against weeds. Mungo germinates fast but during the first three weeks the growth of the plant is slow that the weeds may catch up. Cultivation is done to suppress weed growth. Then hilling up is usually done when the crop closes in, which is about the fourth week.