SOLID WASTE MANAGEMENT IN THE PHILIPPINES: A SMALL ISLAND EXPERIENCE

D. Alan Mair, P.E.
ENVIRON Consulting Services (M) Sdn Bhd
Kuala Lumpur, Malaysia

J. Glenn Gaac
Municipal Government of Odiongan
Odiongan, Romblon, Philippines

Matthew DiNisco
United States Peace Corps
Manila, Philippines

1.0 INTRODUCTION

The Philippines is a country of 85 million people and encompasses 7,107 islands, though only about 2,000 islands are currently inhabited. The Philippines has a total area of 30 million hectares (ha), which is roughly 90% the total area of Malaysia. The archipelago stretches more than 1,800 kilometers (km) north to south and 1,100 km east to west, and is located between the South China Sea and the Philippine Sea. Taiwan lies to the north of the island chain while Malaysia and Indonesia lie to the south. [1]

With a rapidly growing population and lack of adequate disposal sites, solid waste has become a major problem for most medium to large-size cities. When Philippine President Gloria Macapagal-Arroyo took office in January 2001, the first act she signed into law dealt with solid waste management.[2] In recent years, inadequate solid waste management systems have posed serious health risks particularly in densely populated areas. In Manila, for example, the closure of the largest disposal site in 2000 combined with the inadequate capacity at other sites resulted in the disposal of tons of waste along city streets, empty lots, and in the waterways and bays in and around the city. Scavenging for recyclable material at open dumps is very common throughout many parts of the Philippines. Tragically, excessive open dumping of solid waste combined with the seasonal monsoon rains at the Payatas site in July 2000 caused a large-scale slope failure that resulted in the deaths of hundreds of scavengers.

Currently, there is a lack of active sanitary landfills throughout the entire country. Solid waste in small island communities is managed primarily through open dumping and open burning. However, several permitted "controlled dumps" have been constructed and they employ a minimum of environmental controls. Controlled dumps differ significantly from open dumps in that cover material is used to bury waste. In some progressive communities, composting, recycling, and resource recovery operations have been implemented. In the more remote areas of the country, solid waste is managed at the household level since there are no community-wide collection and disposal services.

The municipal government of Odiongan (Municipality) in the Province of Romblon is implementing an ecological solid waste management program (or ESWMP). The objectives of the ESWMP include the following:

- Manage solid waste in a manner that protects the public health and minimizes impacts to the environment by using systems that are simple, sustainable, and economically affordable,
- Create and promote alternative livelihoods for community residents,
- Provide beneficial resources (i.e. compost) to the community to reduce the dependence on outside resources.

2.0 COMMUNITY DESCRIPTION

The Province of Romblon, one of the 10 poorest provinces in the Philippines, consists of 20 islands located in the central portion of the country known geographically as the Visayan Region. The province receives an average of 195 centimeters (cm) precipitation annually. The national average is 188 cm.[3] The Municipality of Odiongan is located 275 km southeast of Manila on the west coast of Tablas Island. Tablas Island is the largest island in the province and has a total area of 66,046 ha (slightly smaller than Singapore).

Odiongan is comprised of 25 villages with an estimated residential population of 40,000 and encompasses a total area of 13,603 ha.[4] Odiongan is the largest in population and third largest in land area for the entire province.[5] Fishing and agriculture are two of the main industries. However, a significant portion of the community makes a living as subsistence farmers and fisherfolk. Average annual income per capita is approximately $500.[6] The latitude and longitude coordinates are 12° 51' north and 121° 58' east, respectively.

3.0 FORMER SOLID WASTE MANAGEMENT PROGRAM

The solid waste collection area is comprised of portions of the four (4) villages that make up the downtown area of Odiongan. These villages have a combined estimated residential population of 4,000 or roughly 10% of the total population. There are four (4) post-secondary schools (college, trade, or vocational) in the downtown area of Odiongan with a combined enrollment of approximately 4,000. The students represent a transient group of residents not reflected in the estimated population of the downtown area. Solid waste is also collected from two schools located outside the downtown area with a combined enrollment of approximately 500. Therefore, the population served by the existing waste collection service may rise to more than 8,500 when all schools and businesses are open and operating. In addition, there are numerous government institutions and commercial establishments including a wet and dry market that generate a significant amount of waste.

From 1995 to 2001, unsegregated solid waste was collected from the downtown area using an open flatbed truck and transported six (6) km away to an open dump in the village of Anahao. Unfortunately, the Municipality originally purchased the open dump property for use and development as a public cemetery. Development of the cemetery ceased in 1995 after the open dumping of solid waste commenced. The Municipality assessed an annual solid waste fee of $3 for select businesses but assessed no fee at the household level.

During the annual monsoon season (June to October), frequent disruptions in collection occurred because the unpaved access road to the cemetery became impassible. Families of scavengers combed through the unsegregated waste searching for recyclable material. Hospital waste, including used needles, had also been deposited at the cemetery site. Surface runoff and leachate from the property flowed to cultivated rice paddies immediately adjacent to the property. Ironically, the village of Anahao produces the largest amount of rice in all of Odiongan.

4.0 SURVEYS OF SOLID WASTE COMPOSITION AND GENERATION

In August and September 2000, the Municipality conducted a qualitative solid waste survey of residents, commercial businesses, government institutions, and schools in order to assess waste composition and individual generation rates. The Municipality conducted additional surveys of waste collection rates from September to December 2002. Results of the survey performed in 2000 reported a solid waste generation rate of 0.4 kilograms per person per day (kg/p/day). A rate of 0.5 kg/p/day is generally considered an accurate estimate for solid waste generation for many rural communities of the Philippines. In addition, results of both surveys indicate that approximately 70 to 75% (by volume) of household waste is biodegradable and composed of kitchen and yard waste. For comparison, composition of solid waste in Manila is summarized in Table 1 (no similar composition data available for Odiongan).

Table 1. Composition of Solid Waste in Manila[7]

Waste Type	Composition (% wet weight)
Metals	5.8
Glass	3.5
Plastics	1.6
Other Inerts Paper Putrescibles	20.7 12.9 53.7
Textiles	1.8
Total	100

Based on the above population estimates and a generation rate of 0.4 kg/p/day, the downtown residential areas are generating somewhere between 1,560 and 3,360 kg/day depending on the resident population. Based on an estimated waste density of 209 kilograms per cubic meter (kg/m^3) from other studies in the Philippines, the populations noted above should generate solid waste at a rate between 7.5 and 16 cubic meters of solid waste per day (m^3/day). However, results of the survey performed in 2002 reported an average daily waste collection rate of approximately 7.1 m^3/day. Discrepancies between volume estimates and the amount collected from the collection area are likely due to the lack of total coverage throughout all four villages.

5.0 SURVEY OF WASTE MANAGEMENT PROGRAMS IN OTHER COMMUNITIES

From 1999 to 2001, the Municipality surveyed other waste management programs and operations in Manila and other communities in order to aid development and implementation of a solid waste management program in Odiongan. A summary of the facilities surveyed during this period is presented in Table 2.

Table 2. Summary of Waste Management Facilities

Facility Name and Location	Type of Operation	Key Features
AWARE, Inc. Santa Maria, Bulacan	Composting	Use of dry market waste for compost material
Barangay Alangilan Recycling Center Batangas City, Batangas	Recycling/Resource Recovery	Buyback center for recyclable material. Direct connection to Odiongan via ferry service.
Barangay Blue Ridge Quezon City, Manila	Composting, Recycling/Resource Recovery	Zero waste management – 100% reduction of residual waste
IDEAS Silang, Cavite	Collection, Composting, Recycling/Resource Recovery	Waste segregation at household level with 70% compliance
International Rice Research Institute Los Banos, Laguna	Composting, Recycling/Resource Recovery	70% reduction of residual waste
Valenzuela Controlled Dumping Site Valenzuela City, Manila	Landfilling, Recycling	Use of rice hull ash as daily cover material and odor control
Zero Kalat sa Kaunlaran Navotas, Manila	Recycling/Resource Recovery	Alternative livelihood for 25 volunteers

All of the above operations include a component aimed at reducing the amount of residual waste *and* generating an alternative livelihood. The Valenzuela facility, a controlled dump facility, did conduct some limited waste segregation and resource recovery operations prior to burial of residual waste. The Valenzuela facility was the only facility operated by a local government unit, while non-government organizations (NGOs) or private individuals operated the other facilities.

6.0 ECOLOGICAL SOLID WASTE MANAGEMENT PROGRAM

In 1997, the Municipality formally adopted an ecological solid waste management program (or ESWMP) through adoption of a resolution by the municipal council. The Municipality hopes to achieve the objectives of the ESWMP described in Section 1.0 by implementing the following four ESWMP components:

- Public awareness campaign
- Waste segregation into biodegradable, recyclable, and residual components
- Recycling and composting of recyclable and biodegradable components
- Landfilling of residual solid waste.

In order to implement the ESWMP components, the Municipality developed a waste processing center as described in Sections 6.1 and 6.2. Implementation of the ESWMP components is discussed in Section 6.3.

6.1 Development Plan Preparation

In 2001, the Municipality prepared development plans to construct infrastructure for a solid waste processing center (SWPC) that includes a small landfill, as well as composting and recycling operations.[8,9] The development plans for the SWPC were submitted to the Philippine Department of Environment and Natural Resources (DENR) for review and approval.

The landfill development plan includes the following elements: landfill design, fill sequence plans, final cover design, leachate collection and treatment systems, and an open dump closure plan. Landfill design and construction, leachate collection and treatment, and open dump closure are described in Sections 6.2.2 and 6.2.5.

The composting and recycling operation development plan includes the following elements: design plans for composting five-chamber structure, process description for composting biodegradable waste, and plan for managing recyclable waste. The composting operation transforms biodegradable waste (kitchen waste, yard clippings, etc) into an organic soil conditioner/fertilizer through a controlled decomposition process. The organic soil conditioner/fertilizer may then be resold at a nominal price to local farmers. The goal of the recycling program is to recover materials of value and resell them to local buyback centers. A secondary goal of both programs is to reduce the amount of residual waste in order to lengthen the lifespan of the landfill. Design and construction of the composting structure is described in Section 6.2.3.

Preparations for conducting a public awareness campaign were informally arranged through a series of meetings and agreements between Municipality personnel and community leaders.

6.2 Solid Waste Processing Center Development

In 1996, the Municipality purchased a 4.4-ha property with the intent of developing it into a solid waste processing center (SWPC) and later transferring all waste disposal operations from the open dump (public cemetery) to the new SWPC upon completion. The landfill component of the SWPC was developed first in order to accommodate an unsegregated waste stream. The Municipality later added a composting structure in order to reduce the amount of residual waste and create alternative livelihoods. Once the landfill component was under construction, plans for developing the composting and recycling operations at the SWPC were then prepared and implemented.

6.2.1 Property Description

The SWPC property is located approximately five (5) km southwest of Odiongan in the village of Anahao and in an area zoned for agriculture. The topography is comprised of mostly mildly undulating grass-covered hillsides with some rice fields located in the west central and east central portions of the property. The property has been historically used for rice cultivation and livestock grazing. Active rice fields front the western, northeastern, and southeastern property boundary.

There are no tenants residing at the SWPC property. The closest residents are located northeast, east, and west of the property. The households northeast and east of the property are located approximately 20 meters from the property boundary. The household west of the property is located approximately 40 meters west of the property boundary. These residents have used portions of the property for rice and vegetable cultivation.

Surface soils are comprised of silty sandy clay known locally as Tuguiz clay. The Anahao Formation, which is comprised of tuffaceous sandstone, mudstone, calcareous shale and bioclastic limestone lenses, underlies these clay deposits.[10] The exact depth and thickness of the clay deposits and the underlying Anahao formation is not known. However, the thickness of surface clay deposits is at least 1.5 meters based on observations made during on-site excavation activities. Permeability of the surface clay deposits is not known; however, typical values of permeability for clay soil range from 10^{-8} to 10^{-6} centimeters per second (cm/s). An active gravity fault is located approximately 1.5 to 2 km west of the property. However, the fault is believed to be too far from the property to have any adverse effect on a landfill operation.

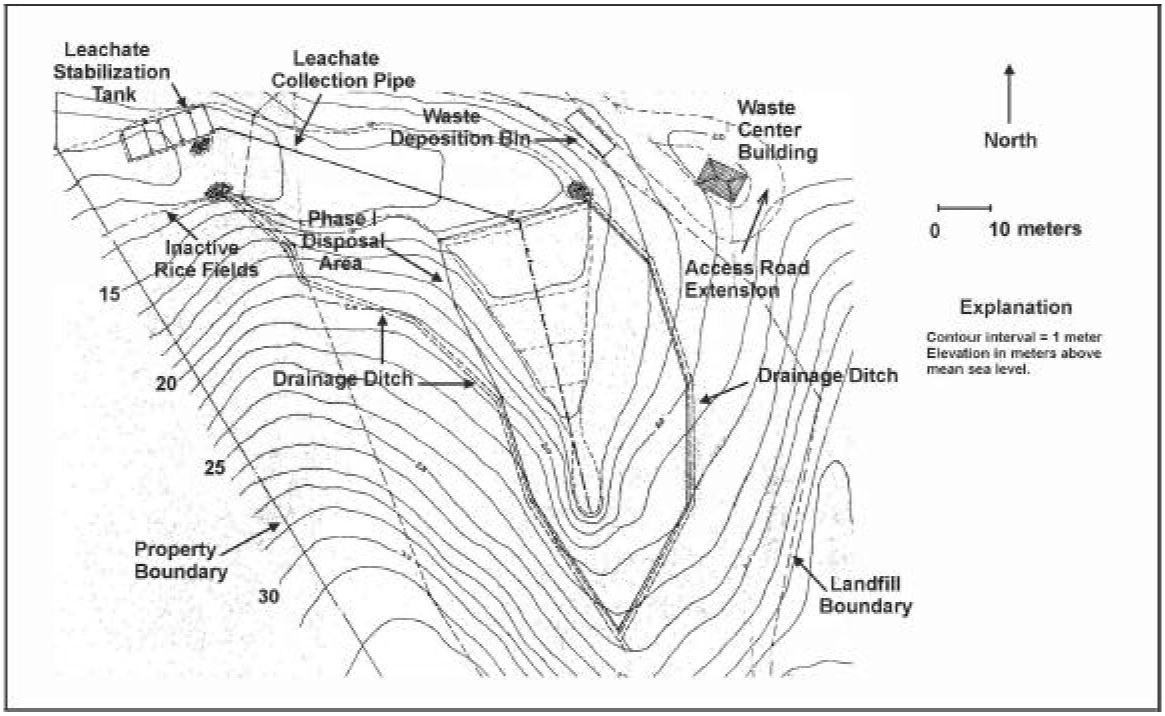
Depth to ground water is estimated to be less than six (6) meters in most areas of the SWPC property and may be within a meter or two of the ground surface near or within rice cultivation areas. A shallow on-site well equipped with a vacuum hand pump is located near the eastern property boundary. The household located east of the property is currently using the on-site well for household purposes including drinking and cooking. There are no other wells located on the property. A shallow off-site well also equipped with a vacuum hand pump is located approximately 50 meters west of the property and is used by the household west of the property for household purposes including drinking and cooking.

A small ephemeral spring is located in the west central portion of the property. Water from the spring flows to the rice fields on-site and west of the property.

6.2.2 Landfill Design and Construction

The landfill disposal area encompasses approximately 1.1 ha and includes a former rice paddy. Design of the landfill disposal area incorporated surface topography in order to limit soil excavation activities to the grading and trenching work required for the leachate collection and removal system (LCRS). Design features of the landfill include a field office, paved access road, waste deposition bin (or tipping area), LCRS, leachate treatment system, surface water drainage, and a waste disposal area. Development of the disposal areas was partitioned into three phases in order to reduce the amount of initial preparation activities, maintain environmental controls over a limited area, and allow flexibility for future modification. Figure 1 presents the planned development of Phase I.

Figure 1. Phase I Development Plan



Fill sequence plans were prepared for each phase of devebpment in order to guide the sequence of waste deposition. To aid in monitoring the performance of the landfill operation, a series of surveyed monuments were installed in and around the disposal area. The available disposal capacity and estimated life span of each phase is summarized in Table 3.

Table 3. Estimated Disposal Capacity and Life Span

Phase	Disposal Capacity (m^3)	Life Span[a] (years)
Phase I	6,300	2.4
Phase II	11,400	4.4
Phase III	24,800	9.6
Total	**42,500**	**16.4**

[a] Estimated life spans are based on a disposal rate of 7.1 m^3/day and does not take into account expanded collection routes, population growth, or the impact of a recycling or composting operation.

6.2.2.1 Leachate Collection and Removal System Design

An LCRS was designed for the landfill operation. A water balance was performed on the entire landfill area (Phases I, II, and III) in order to estimate the leachate generation rate.[11] Using the results of the water balance and accounting for technical as well as economic feasibility, a simple LCRS was designed with the following key features.[12]

- Base of the landfill (former rice field area) graded as a V-shaped trough with a diagonal slope of at least 3%.
- Perforated collection pipe consisting of 150 millimeter (mm) diameter PVC pipe installed at a slope of at least 2% used to convey leachate under gravity flow
- A 30 cm thick drainage layer consisting of 50 mm diameter cobbles covering the perforated collection pipe and graded base of the disposal area

A liner comprised of compacted low-permeability clay, HDPE, or geotextiles was not incorporated into the LCRS design because of the high cost and technical infeasibility with installing liners in a remote island location. However, surface soils at the SWPC property are comprised of clay with a thickness of at least 1.5 meters and should impede the infiltration of leachate to the subsurface and aid in the collection of leachate via the LCRS.

6.2.2.2 Effluent Standards for Leachate

Leachate characteristics change over time depending on the type of waste decomposition occurring in the buried waste. The primary form of waste decomposition after the wastes are buried is aerobic. This phase is usually brief lasting less than six (6) months before anaerobic decomposition takes over. The "acid phase" corresponds to the first phase of anaerobic decomposition of solid waste and typically lasts about 12 months after aerobic processes have ended. The "methanogenic phase" corresponds to the second phase of anaerobic decomposition where methane and carbon dioxide gases are produced and can last for many years. Typical leachate characteristics for select parameters are presented in Table 4.

Table 4. Typical Leachate Characteristics (USEPA 1998)

Parameter	Units	Acid Phase		Methanogenic Phase	
		Average	Range	Average	Range
pH	-	6.1	4.5 to 7.5	8	7.5 to 9
5-Day Biological Oxygen Demand (BOD_5)	mg/l	13,000	4,000 to 40,000	180	20 to 550
Chemical Oxygen Demand (COD)	mg/l	22,000	6,000 to 60,000	3,000	500 to 4,500
BOD_5/COD	-	0.58	-	0.06	-
Sulfate	mg/l	500	70 to 1,750	80	20 to 600

mg/l = milligrams per liter

Surface runoff from the disposal area drains to active rice fields located immediately west of the SWPC property. These rice fields depend in part on surface runoff from the SWPC property for their irrigation needs. Waste water effluent standards for unrestricted irrigation promulgated by the DENR were used to determine the off-site discharge limits for leachate.[13] The effluent standards are summarized in Table 5.

Table 5. Effluent Standards (DENR 1990)

Parameter	Unit	Standard
Temperature (maximum rise in degree Celsius above receiving waters)	ºC rise	3
pH	-	6.0 – 9.0
BOD_5	mg/l	120[(a)], 130[(b)]
COD	mg/l	200
Total Suspended Solids	mg/l	1,500

(a) For influent BOD_5 concentrations less than 3,000 mg/l
(b) For influent BOD_5 concentrations greater than 3,000 mg/l, standard is taken as 200 mg/l or 99% removal of influent BOD_5, whichever is lower. The average BOD_5 concentration for acid phase leachate is 13,000 mg/l and is used for determining standard.

6.2.2.3 Leachate Treatment System Design

A typical design for leachate treatment in many developed portions of the world involves three stages of treatment: 1) pretreatment, 2) biological treatment, and 3) physical and chemical treatment. Generally, pre-treatment involves screening, sedimentation, and pH adjustment. Biological treatment is designed to remove primarily the BOD_5, COD, and some of the nutrients. The more common methods of biological treatment include oxidation (stabilization) ponds, aerated lagoons, and activated sludge. The last and final stage includes settling, ozone oxidation, sand filtration, flocculation, and others (USEPA 1998).

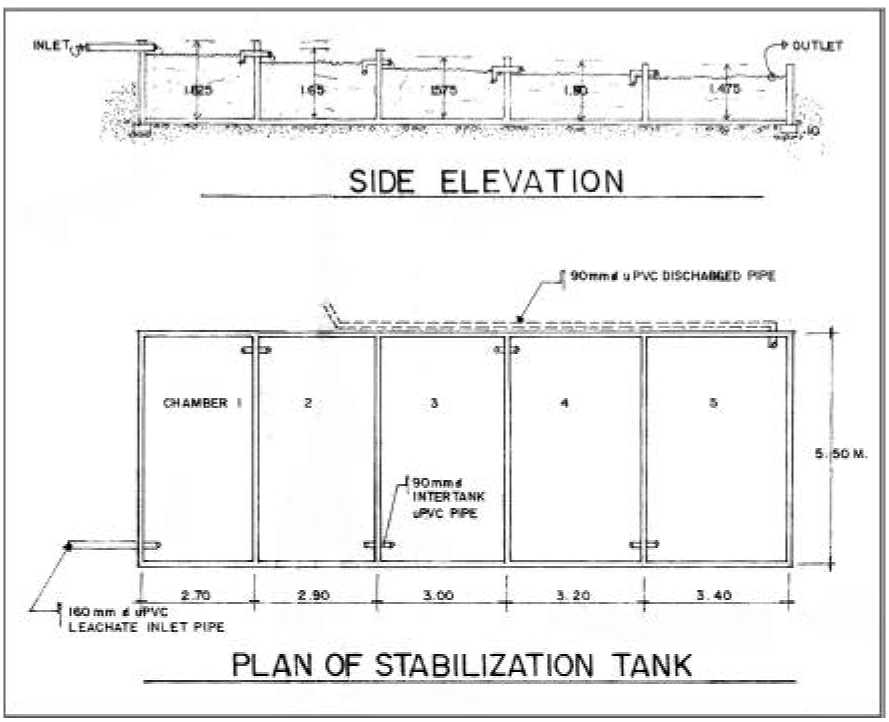
A typical three-stage treatment system is too costly and technically infeasible for a small developing community like Odiongan. Simple and affordable biological leachate treatment systems are considered a reasonable choice for leachate treatment, particularly if the solid waste is predominantly of domestic origin and putrescible, like Odiongan’s waste. Because of its’ relative simplicity, low cost, and proven ability to treat wastewater, the Municipality designed a stabilization pond for treating leachate and discharging the effluent to adjacent rice paddies.

The design of the stabilization pond is based on the following assumptions:[14]

- 30-day hydraulic residence time
- Maximum influent BOD_5 concentration of 1,000 mg/l
- Year round temperatures above 15°C
- Effluent standards of 25 mg/l for BOD_5
- Landfill is at full capacity and final cover is in place

The design utilizes a combination of anaerobic, facultative, and aerobic conditions to remove leachate BOD. In order to achieve a 30-day hydraulic residence time, a 5-chamber tank design was selected with a 6-day residence time per chamber. A tank volume of 118 m^3 was calculated based on the results of a water balance performed over the 1.1-ha disposal area. Figure 2 presents the design specifications of the leachate stabilization tank.

Figure 2. Leachate Stabilization Tank Design



Using a stabilization tank for leachate treatment, the effluent BOD_5 concentration should comply with the standards presented in Table 5 when influent BOD_5 concentration are less than 1,000 mg/l. However, under acid phase conditions, average influent BOD_5

concentrations on the order of 13,000 mg/l may overload the treatment system and reduce the treatment efficiency as well as create odor problems. The stabilization tank should minimize odor problems, provided that the BOD loading rate is less than 400 grams per cubic meter per day (g/m^3d) for any one of the five chambers and the sulfate concentration in the leachate is less than 500 mg/l (Feacham et al 1977).

In order to check for overloading, the BOD loading rate for the first chamber (anaerobic system) of the stabilization tank was calculated based on average concentrations of BOD_5 and sulfate for acid phase and methanogenic phase leachate. The calculation was performed assuming the landfill was at full capacity. The estimated BOD loading rate for acid phase and methanogenic phase leachate is summarized in Table 6.

Table 6. BOD Loading Rates

Parameter	Units	Acid Phase	Methanogenic Phase
BOD Loading Rate	g/m^3d	2,157	30
Sulfate	mg/l	500	80

These results clearly indicate that a potential odor problem exists under acid phase conditions. However, since the Phase I disposal area comprises around 0.2 ha or 20% of the total landfill area, the corresponding estimated leachate flow rate may be reduced by as much as 80%. Assuming an 80% reduction in the estimated leachate flow rate, the BOD loading rate for the first chamber reduces to 431 g/m^3d. Although this may still represent a potential odor problem, the tank design is based on typical leachate characteristics. Actual performance of the stabilization treatment tank will depend on site-specific leachate characteristics. The need for modifications and/or additional treatment capacity should be assessed after monitoring the performance of the treatment system during Phase I operations.

6.2.2.4 Phase I Construction

Construction of Phase I was completed in June 2001 and included the following::

- A 50 m^2 building for use as field office and storage area
- A 50 m^3 waste deposition bin for use as tipping area
- Paved access road to tipping area and field office
- Phase I disposal area
- LCRS for Phase I disposal area
- Leachate stabilization tank
- Drainage ditch network for surface water control

6.2.3 Composting Structure Design and Construction

In November 2001, a simple uncovered and unlined composting bin was constructed to compost biodegradable waste as an interim system until a more permanent composting facility was established. In October 2002, a five-chamber permanent composting structure was completed and replaced the interim system. The permanent composting structure is located adjacent to and east of the office building shown in Figure 1 (composting structure not shown in Figure 1). The compost chamber design consists of an elevated A-frame shape centerline constructed of bamboo in order to aid in aerating decomposing waste. The structure dimensions measure 2.5 meters by 15 meters, which is then further divided into five 2.5 meter by 3 meter composting chambers. A small tipping area was also incorporated into the composting structure design. In December 2002, the Municipality established a supply of electricity and a water system at the SWPC, further enhancing the capability of the composting operation.

6.2.4 Pre- Disposal Groundwater Monitoring

The on-site well is located approximately 80 meters northeast of the proposed landfill area. The off-site well is approximately 75 meters west of the proposed landfill area. Although the direction of ground water flow is not known in the area, surface topography suggests these two shallow wells are potentially downgradient of the waste disposal and composting areas.

In 2000 and 2001, three rounds of quarterly pre-disposal ground water sampling was performed at the on-site and off-site wells. The samples were tested for fecal coliform bacteria and total dissolved solids (TDS). The results of the water testing are presented in Table 7.

Table 7. Ground Water Quality Data

Well	Parameter	Units	4th Qtr 2000	1st Qtr 2001	2nd Qtr 2001
Off-site	Total Dissolved Solids Fecal Coliform	mg/l #/5 tubes[a]	240 0/5	283 5/5	DRY DRY
On-site	Total Dissolved Solids Fecal Coliform	mg/l #/5 tubes	210 2/5	193 1/5	194 5/5

a) #/5 tubes = number of test tubes that tested positive for fecal coliform out of 5 in multiple tube fermentation test

The Municipality proposes to close the on-site well to public use and convert it into a monitoring well for assessing potential ground water contamination. To compensate the household residents east of the SWPC, the Municipality donated a vacuum hand pump and drop pipe for use in constructing a new off-site water well.

6.2.5 Open Dump Closure

The Municipality has closed the existing open dump and plans to return the site to its original land use as a public cemetery. However, uncontrolled landfill gas generation and migration represents a potential explosion hazard as well as a potential health risk via an inhalation exposure pathway. Landfill gas is composed of roughly 50% carbon dioxide and 50% methane, and methane gas is highly flammable. For example, future cemetery development will include the excavation and construction of pantheons and sepulchers, and landfill gas generated by decomposing waste may migrate via the subsurface and accumulate in these confined spaces. The observance of some religious holidays, such as All Saints Day, involves the use of open fires at the cemetery, thus creating the risk of an explosion in excavations, pantheons, and sepulchers. Uncontrolled surface fires of burning waste were often observed during the dry months and represent an additional ignition source.

Therefore, in order to mitigate these risks, the Municipality prepared a closure plan that includes the installation of a passive landfill gas vent and placement of a final soil and vegetative cover. The gas vent design utilizes locally available materials such as bamboo and steel drums. The final cover incorporates a simple three-layer design consisting of a hydraulic barrier, a drainage layer, and a surface layer for supporting hardy, perennial grasses that promote evapotranspiration. An LCRS consisting of a perimeter drain around the existing waste pile was also included. Development activities in and around the open dump would be prohibited or restricted for a minimum period of time.

6.2.6 Community Approval

In 2000 and 2001, representatives from the Municipality met with the village council of Anahao, municipal council of Odiongan, and members of three neighboring churches in Anahao to present and discuss the proposed development plan for the new SWPC. These entities later endorsed the development of the SWPC through formal letters to the Municipality.

6.2.7 Regulatory Approval

In November 1998, staff geologists from the DENR conducted a geological assessment of the SWPC. In their report, the DENR stated that the physical properties of the clay make it suitable for use as a soil cover in a landfill operation and concluded that the SWPC "… *is deemed suitable for a landfill site*" (DENR 1998).

In December 2000, the Municipality applied to the DENR for a permit to operate the landfill component of the SWPC. At that time, permitting of waste disposal facilities was promulgated by DENR's guidance document titled *Administrative Order No. 98-49, Technical Guidelines for Municipal Solid Waste Disposal, 1998* (DAO No. 98-49). Under DAO No. 98-49, the landfill operation was classified as a "controlled dump" because the proposed design lacked selected features of a true sanitary landfill such as a composite liner and landfill gas controls. In support of their permit application, the Municipality later submitted the development plan for the SWPC and the closure plan for the open dump to DENR.

In January 2001, the Philippine government enacted a new law, Republic Act No. 9003, for reviewing and approving waste disposal facilities. The new law, known as the *Ecological Solid Waste Management Act of 2000*, repealed DAO No. 98-49 and changed the permitting procedures for waste disposal facilities. The new law defines ecological solid waste management as "*the systematic administration of activities which provide for segregation at source, segregated transportation, storage, transfer, processing, treatment, and disposal of solid waste and all other waste management activities which do not harm the environment*."

Under the new law, a controlled dump site may not be permitted without a more detailed environmental review and approval process. DENR indicated that a formal permit approving the landfill operation could not be issued under the new law. Instead, DENR issued an "acknowledgement receipt", thereby approving the landfill operation in May 2001. DENR formally approved the composting operation in June 2002.

6.3 Program Implementation

Initial implementation of the various components of the ESWMP was conducted over a period of three years beginning in 1999 and continuing through 2002. Operations at the new SWPC formally commenced in November 2001 with the opening of the landfill component, interim composting, and recycling operations. Waste disposal at the open dump officially ceased in November 2001. The ESWMP operations were implemented by the Municipality and other government organizations.

6.3.1 Public Awareness Campaigns

In 1999, the Municipality formed a solid waste task force to help educate and promote the objectives of the ESWMP, and to help enforce local ordinances on littering and illegal disposal of liquid and solid waste. The task force included volunteers from different government organizations and non-government organizations, as well as concerned citizens of Odiongan. Members of the task force conducted periodic patrols of the community and issued citations and fines for violations such as littering or urinating in public.

In 2001, a house-to-house information campaign was conducted by the Municipality with the assistance of the respective village councils. The purpose of the information campaign was to educate and instruct residents within the waste collection area on how to segregate their waste into biodegradable, recyclable, and residual waste fractions. The Municipality with the assistance of other government agencies prepared and distributed fliers with written instructions on how to segregate waste to each household.

6.3.2 Waste Segregation and Collection

The Municipality established a collection schedule for the collection of the three waste fractions. Solid waste is collected five days a week (Monday through Friday) by means of two open flatbed trucks. Biodegradable waste is collected three times a week while recyclable and residual wastes are collected twice a week on alternating days. Since implementation began in 2001, sanitation workers assigned to each truck often assist with the final segregation during collection and before placement onto the truck. After collection, the waste is then covered and transported to the SWPC.

Although the intention of the Municipality was to minimize segregation activities at the SWPC, there are now families of scavengers present at the SWPC who remove recyclable material from the newly deposited waste before the completion of the residual waste disposal process.

6.3.3 Composting Operations

In November 2001, composting operations began on an interim basis with the opening of the new SWPC. A simple uncovered and unlined compost bin was used to contain shredded biodegradable waste where it was allowed to decompose for a period of approximately one month. However, the amount of biodegradable waste delivered to the center greatly exceeded the capacity of the interim composting operations and much of the biodegradable waste collected during this period was deposited into the landfill.

In October 2002, composting capabilities were greatly enhanced with the completion of a covered five-chamber structure. Upon arrival at the SWPC, biodegradable waste is mechanically shredded and placed into one of the five composting chambers. Each composting chamber is roughly 2.5 meters by 3 meters in area and about 1.5 meters in height. In order to enhance the decomposition process, one of two types of organic composting additives is added and mixed with the newly shredded waste. The composting additives consist of 1) a mixture of pure culture trichoderma and water and 2) a compost fungus activator (CFA) comprised of sawdust, leaves, vinegar, water, and pure culture trichoderma. Both of these additives are produced locally. Shredded waste within each chamber is allowed to decompose for an average of one month before being removed from the bin and sun-dried. Once the compost has sufficiently dried, the compost material is then placed in sacks and stored within the field office building.

With the completion of the composting structure, compost produced at the SWPC was then tested for carbon, potassium, phosphate, and nitrogen content in order to determine it's viability as an organic fertilizer. The carbon, potassium, and phosphate were reported at acceptable levels. However, the nitrogen content was reported at around 2%, which is well below the required 7% for the compost product to be called "fertilizer" per requirements of the Philippine Fertilizer and Pesticides Authority. Therefore, the compost has been termed a "soil conditioner" due to the low nitrogen content.

As of December 2002, approximately 6,100 kilograms of biodegradable waste per week was being processed at the SWPC. However, frequent disruptions due to equipment failures have prevented the compost operation from maintaining a consistent production level. Proposals have been submitted to the Municipality requesting that the composting operation be handed over to a NGO.

As of July 2003, the soil conditioner was being sold at P50 per 50 kilogram sack and used for primarily for small farming projects. Unfortunately, local commercial farmers, a key sector of intended beneficiaries, are hesitant to rely on the soil conditioner due to the low nitrogen content and unreliable production rate.

6.3.4 Recycling Operations

In November 2001, recycling operations were initiated with the opening of the SWPC. Segregated recyclable materials collected by the sanitation workers are delivered to the center where they are stored in the field office building. The recyclable materials are then periodically transported from the center to buyback centers located in a neighboring village. Families of scavengers also comb through newly deposited residual waste in the landfill to recover additional recyclable material.

Recyclable material resold to the buyback center includes the following:

- Car and Truck Batteries
- Cardboard
- Metal (tin, aluminum, copper wire)
- Glass
- Plastic containers
- Rubber
- Paper (mixed and white)

As of December 2002, approximately 0.4 m^3/week of recyclable material was recovered by the Municipality and resold to the buyback centers.

6.3.5 Landfill Operations

In November 2001, landfill operations commenced in the Phase I disposal area of the landfill. Under the planned operation of the landfill, incoming residual waste is placed into a waste deposition bin (i.e., tipping area) where it is then transferred to the working face within the Phase I disposal area. At the end of each day, daily cover is placed on the newly deposited residual waste. Surplus rice hull available from local farmers is used as daily cover material. Once the waste is covered, it is then compacted with a front loader or equivalent.

Due to frequent equipment breakdown during startup operations (e.g., front loader), a gravel road was constructed from the paved access road directly to the Phase I disposal area in order to bypass the tipping area and allow the trucks to deposit residual waste near the working face. Frequent breakdown of the mechanical shredder resulted in large amounts of biodegradable waste being deposited into the landfill.

Due to the frequent dramatic fluctuations in the amount of waste disposed in the landfill, it is difficult to estimate the actual deposition rate. However, the daily deposition rate is estimated at between 3 and 7 m^3/day. Despite the disruptions, the composting and recycling operations have reduced the overall amount of residual waste deposited into the landfill. Consequently, the lifespan of the Phase I disposal area has been lengthened beyond the 2.4 years estimated in Table 3.

Samples of effluent from the leachate treatment tank were analyzed for compliance with DENR discharge requirements. All of the parameters were below discharge limits presented in Table 5 with the exception of BOD_5. No information is available on influent concentrations of BOD_5 or other parameters.

6.3.6 Farming Activities

As part of the ESWMP, the Municipality, other government agencies, and local community groups have conducted a variety of farming activities at the SWPC in an effort to enhance the SWPC's capability and raise community awareness. These activities include the following:

- Organic Mango Research Project – A mango orchard has been planted at the SWPC as part of a research project sponsored by the provincial government of Romblon using the soil conditioner produced by the composting operation. The orchard will serve a dual purpose of producing a reusable resource as well as serving as a visual barrier.
- Organic Farming Projects – Using the soil conditioner produced by the compost operation, local farmers in cooperation with the Municipality have planted a variety of fruits and vegetables at the SWPC.
- Tree Planting Activities – Over the last three years, mahogany, coconut, and other seedlings have been planted in boundary areas throughout the SWPC property in efforts to create visual and physical barriers.

6.4 Cost

A summary of capital and operational costs for the ESWMP including the SWPC is presented in Table 8.

Table 8. Capital and Operational Costs for ESWMP

Description of Expense	Cost (Pesos) [a]	Cost (Dollars) [b]
Capital Expenses		
Purchase of 4.4-Hectare Property	P486,000	$8,836
Waste Collection Trucks	P1,067,000	$19,400
Composting and Recycling	P496,000	$9,018
Landfill - Phase I	P3,226,000	$58,655
Landfill - Phase II (projected to 2004)	P773,000	$14,055
Landfill - Phase III (projected to 2008)	P429,000	$7,800
Total Capital Expense:	**P6,477,000**	**$117,764**
Operational Expenses for 2003		
Collection	P1,032,000	$18,764
Composting and Recycling	P400,000	$7,273
Landfill	P113,000	$2,055
Monitoring and Reporting	P12,000	$218
Total Operational Expenses:	**P1,557,000**	**$28,310**

[a] Capital expenses adjusted to 2003 using 7-year average real interest rate of 8% (1996 to 2002) [15]
[b] Based on exchange rate of $1 = P55 (September 2003) [16]

In 2000, the Municipality operated on a total budget of roughly US$711,000 (adjusted for interest and inflation to 2003 currency value). The operational costs in 2003 amount to roughly 4% of the total adjusted budget from 2000 (total budget amounts for later years were unavailable).

All of the operational expenses and most of the capital expenses (98%) were funded by Philippine government institutions.

7.0 CONCLUSIONS

The need for adequate solid waste management facilities in the Philippines is great. In many rural areas, the lack of environmentally friendly, sustainable and affordable waste management has led to the widespread open dumping and open burning of solid waste. The Municipality of Odiongan is a small island community of roughly 40,000 located in the central portion of the Philippine archipelago. The Municipality is implementing an ecological solid waste management program aimed at adequately managing solid waste using simple, sustainable systems that minimize the impact to the environment. Components of the program include public awareness campaigns, composting of biodegradable waste, recovery and resale of recyclable waste, and disposal of residual waste through landfilling. The program also aims to provide alternative livelihoods, reduce the dependence on outside resources like imported fertilizer, and dramatically diminish the amount of waste disposed through landfilling.

The Municipality has developed a 4.4-hectare parcel into a new solid waste processing center (SWPC) for composting segregated biodegradable waste, recovering recyclable material, and disposing of residual waste through landfilling. In May 2001, the Municipality received community and regulatory approval of the landfill development plan. Construction of the first phase of the landfill and other infrastructure at the SWPC, including a paved access road and field office building, was completed in June 2001. Waste disposal operations formally began at the new SWPC in November 2001 with an interim composting operation, recovery of recyclable material, and landfill disposal of residual waste. In June 2002, the development plan for a composting operation received regulatory approval. Construction of the composting infrastructure was completed in October 2002 and operations commenced in November 2002.

A house-to-house public awareness campaign was conducted in order to educate and instruct residents within the collection area on how to segregate their waste into biodegradable, recyclable, and residual waste components. After collection and transport to the SWPC, recyclable waste is stored temporarily at the waste center before it is periodically sold to a local buyback center. Biodegradable waste is mechanically shredded and composted into a soil conditioner. Residual waste is landfilled in a “controlled dump” equipped with a leachate collection and treatment system.

Due to frequent disruptions in production caused by equipment failures, compost production has been frequently interrupted and a significant amount of biodegradable waste has been deposited in the landfill. In addition, local farmers are reluctant to rely on the soil conditioner produced by the composting operation because of the low nitrogen content and inconsistent production rates. Much of the soil conditioner produced at the center has been used for small farming projects. Despite frequent disruptions in the compost operation, the amount of solid waste deposited in the landfill has been reduced and thus, the lifetime of the landfill has been lengthened. The Municipality is considering transferring the management of the compost and recycling operations to a local NGO.

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Peace Corps currently provides requesting communities in the Philippines with volunteers working in two main areas: education and the environment. Programs in the environment assist and support coastal resource and protected area management efforts, as well as water resource and sanitation needs for NGOs and local governments. From 1998 to 2003, two of the authors, Mr. Mair (1998 to 2001) and Mr. DiNisco (2001 to 2003), served as Peace Corps volunteers in the Province of Romblon and assisted the Municipality of Odiongan with the development and implementation of a solid waste management program.

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