Solid Waste Management in Costa Rica and the United States

A Comparative Analysis of Five Municipalities

CICA
Adam Levesque
Brad Pelletier
Eryn Samuels

Adam Levesque
Brad Pelletier
Eryn Samuels

WPI
100 Institute Road
Worcester, MA 01609

June 30, 2003

Dr. Ronald Arrieta
Centro de Investigaciones en Contaminación Ambiental
Universidad de Costa Rica
San Pedro—San José
Costa Rica

Dear Dr. Arrieta:

Enclosed is our proposal entitled *Solid Waste Management in Costa Rica and the United States: A Comparative Analysis of Five Municipalities*. It was written at the University of Costa Rica during the period of March 11 through June 29. Preliminary work was completed in Worcester, Massachusetts, prior to our arrival Costa Rica. Copies of this report are simultaneously being submitted to Professors Vernon-Gerstenfeld and Manzari for evaluation. Upon faculty review, the original will be catalogued in the Gordon Library of Worcester Polytechnic Institute. We appreciate the time you devoted to us.

Sincerely,

Adam Levesque
Adam Levesque

Brad Pelletier
Brad Pelletier

Eryn Samuels
Eryn J. Samuels

Adam Levesque
Brad Pelletier
Eryn Samuels

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100 Institute Road
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June 30, 2003

Dr. Ronald Arrieta
Centro de Investigaciones en Contaminación Ambiental
Universidad de Costa Rica
San Pedro—San José
Costa Rica

Estimado Dr. Arrieta:

Adjunta es nuestro proyecto titulado *El manejo de desechos sólidos en Costa Rica y los Estados Unidos: Un análisis comparativo de cinco municipalidades*. El documento fue escrito en la Universidad de Costa Rica desde el 11 de marzo al 29 de junio. Investigaciones preliminares fueron acabadas en Worcester, Massachussets, antes de nuestra llegada en Costa Rica. Copias de este proyecto están siendo sometidas a los Profesores Vernon-Gerstenfeld y Manzari para evaluar. Al repaso por la facultad, el proyecto original será catalogado en el Gordon Library of Worcester Polytechnic Institute. Estamos agradecidos por el tiempo que ha dedicado a nosotros.

Atentamente,

Adam Levesque
Adam Levesque

Brad Pelletier
Brad Pelletier

Eryn Samuels
Eryn J. Samuels

TITLE PAGE

Report Submitted to:

Professor Susan Vernon-Gerstenfeld and Professor H. J. Manzari

Costa Rica, Project Center

By

Adam Levesque

Brad Pelletier

Eryn Samuels

In Cooperation With

Dr. Ronald Arrieta

CICA

SOLID WASTE MANAGEMENT IN COSTA RICA AND THE UNITED STATES:
A Comparative Analysis of Five Municipalities

June 29, 2003

This project report is submitted in partial fulfillment of the degree requirements of Worcester Polytechnic Institute. The views and opinions expressed herein are those of the authors and do not necessarily reflect the positions or opinions of CICA or Worcester Polytechnic Institute.

This report is the product of an education program, and is intended to serve as partial documentation for the evaluation of academic achievement. The report should not be construed as a working document by the reader.

ABSTRACT

Solid Waste Management in Costa Rica and the United States: a Comparative Analysis of Five Municipalities was prepared for El Centro de Investigaciones en Contaminación Ambiental (CICA). The main objective of this report was to recommend sustainable methods for the management of solid waste in three select Costa Rican municipalities. By means of research, interviews, and observations, we obtained data that aided in our understanding of solid waste management in both Costa Rica and the United States. A detailed analysis was devised for each Costa Rican municipality, and recommendations were specifically formulated according to each individual municipality's budget and sustainable waste management needs.

AUTHORSHIP PAGE

Each member of the group contributed equally to the creation of this report. Adam Levesque applied his organization skills to the formatting of the report, while Brad Pelletier utilized his math skills to both organize and analyze the data collected. Eryn Samuels used her language skills, as she was the editor-in-chief and the Spanish translator.

ACKNOWLEDGEMENTS

We would like to acknowledge the following people whose assistance was invaluable to the completion of our project:

Dr. Ronald Arrieta, Project Liaison

Professor Susan Vernon-Gerstenfeld, Project Advisor

Professor H. J. Manzari, Project Advisor

Maribel Manzari, Spanish Project Editor

Bill Sprat, Clinton Superintendent Department of Public Works

Tom Murray, Fitchburg landfill Operational Manager

Douglas Alpízar Villalobos, WPP Engineer

Jorge Cardoza, Río Azul landfill Operational Engineer

Roberto Fallas, Uruca landfill Operational Engineer

Siany Villalobos Argüello, San Isidro Department of Public Works

Alba Ramírez Villalobos, San Isidro Department of Public Works

Ana Flor Villalobos, Manager of Casa Hogar para Ancianos

Luis Rodriguez, Escazú Department of Public Works

Alberto Durano, Santa Ana Department of Public Works

THANK YOU,

Adam Levesque

Brad Pelletier

Eryn Samuels

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EXECUTIVE SUMMARY

Costa Rica's current systems for solid waste management are not in accordance with the principle of sustainable development: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs (http://www.doc.mmu.ac.uk/aric/esd/menu.html)." Therefore, the goal of this project was to improve the current waste management systems in the Costa Rican municipalities of San Isidro de Heredia, Escazú, and Santa Ana based on the principle of sustainable development. Our main objective was to prepare a comparative analysis of the current systems of waste management in three Costa Rican municipalities to those of two towns in the United States and to make recommendations that would improve Costa Rica's current systems.

Many waste collection systems in Costa Rican municipalities operate inefficiently due to an excess of workers and inefficient collection trucks. Recycling programs in Costa Rica, the few that exist, are not sufficiently developed to be utilized by entire municipalities, and the types of items that can be recycled are limited. In addition, fifty-eight percent of Costa Rica's waste is biodegradable, yet not a single municipality practices the disposal method of composting (Ronald Arrieta, personal communication, May 27, 2003).

There exist two private waste management companies in Costa Rica, Empresas Berthier (EBI) and Waste Placement Profession (WPP). EBI manages the landfill named El Parque de Tecnología Ambiental, which is located in Uruca. The Uruca landfill is well-maintained and is it not hazardous to the environment. WPP manages the landfills of Río Azul, which is used by Escazú, and Los Mangos, which is used by Santa Ana.

WPP's landfills are not as well-maintained as the landfill in either Uruca or any of the landfills in the United States due to a lack of enforcement on the part of the regulating body of El Ministerio de Salud (Ronald Arrieta, Professor of Chemistry at University of Costa Rica, personal communication, May 27, 2003).

To complete our comparative analysis, we evaluated the current methods of solid waste management in the two United States' towns of Clinton and Shrewsbury, Massachusetts and in the three Costa Rican municipalities. As the first step of the evaluation, we conducted interviews with the administration in the solid waste management department of each municipality. We then visited landfills and recycling centers utilized by the municipalities and conducted interviews with the managers of these sites. In addition, we obtained copies of Costa Rica's legislation for the disposal of solid waste, and we asked a Costa Rican environmental group for its views on the enforcement of these regulations and the environmental effects of landfills. We also researched the buying power of a U.S. dollar in Costa Rica so as to analyze costs at comparable values.

By means of interviews with the administrative personnel from each municipality's solid waste department, we obtained data on the number of families that receive the waste and recycling services and the monthly fee that each household pays for these services. We also received information about the annual number of metric tons of waste produced by each municipality and the fee to dispose of each ton of waste in a landfill. We obtained details concerning the number of workers employed by each municipality for the services of waste collection and recycling, in addition to the frequency of collections. The group then collected information from each municipality

about the number of trucks it owns and the capacities of each truck for both the collection of waste and recyclable items. We also received photocopies of the three Costa Rican municipalities' financial documents. From these documents, we found that each municipality's budget is divided into eight major categories: wages, tipping fees, non-personnel services, maintenance and repairs, materials and supplies, depreciation, administration, and benefits for future development. The deficit of each municipality, as incurred by their waste management service, was calculated by subtracting the amount of money received from residents from the total cost to the municipality.

We toured three landfills located in Costa Rica and one landfill located in the United States. We interviewed the managers of these landfills to learn about the environmental effects and maintenance methods of each landfill. We observed, and inquired about the following structures: an impermeable layer, methane emission flares, leachate collection systems, and leachate treatment plants. Each of the above structures helps to protect the environment from the hazardous pollutants generated by landfills.

Escazú's waste management system is extremely efficient and has been used as a model for the other two Costa Rican municipalities. Escazú employs 3.2 workers per waste collection vehicle, which is only 1.1 times the sufficient amount. Escazú generates the lowest amount of waste per 1,000 inhabitants. Escazú's recycling program currently collects from sixty percent of its residents.

We recommend that Escazú expand its recycling program until it services the entire municipality. In addition, a composting system should be developed to divert waste from landfills.

Santa Ana's management of solid waste is the least efficient of the three Costa Rican municipalities. The municipality incurred a deficit last year for its waste collection services of thirty-one percent its waste management budget. The municipality generates approximately fifty more metric tons of waste per 1,000 inhabitants than Escazú. Santa Ana not only generates a high amount of waste per 1,000 inhabitants, but it also pays 4,600 colones per metric ton for the disposal fee. This results in a final disposition fee that is 6,000,000 colones more than that of Escazú, despite having 19,000 fewer people. Santa Ana averages 4.7 workers per truck, which is 1.6 times the sufficient amount, resulting in a loss of money on wages for unnecessary workers. The recycling program only collects from ten percent of the municipality and it does not collect aluminum or cardboard.

To improve the efficiency of Santa Ana's waste disposal system, we recommend the installation of a composting system to decrease the high amount of waste produced. In addition, the recycling program should be expanded to service the entire municipality. Two of the waste collection employees should be relocated to other waste management departments. One of the workers should transfer to the composting system and the other worker to the recycling service. Santa Ana should lay-off two additional workers from the collection department to decrease its deficit by fifteen percent.

San Isidro's waste management service only incurred a deficit of about four percent of the waste management budget last year. Despite the low deficit, San Isidro's system still has inefficiencies that need to be addressed. San Isidro produces the most trash per 1,000 inhabitants-- five metric tons more than Santa Ana. The municipality employs eight workers for the management of one waste collection vehicle, which is over

2.67 times the sufficient number of workers. The truck operated for the collection of waste is among the oldest in the country and it incurs high maintenance costs. Also, San Isidro's recycling program is small and only collects from ten percent of its residents by means of a small, one-ton-capacity pick-up truck.

As with Escazú and Santa Ana, San Isidro should create a system of composting to dispose of organic waste, and the recycling program should expand to reduce waste generation as a whole. In order for the above two recommendations to occur, two workers from the waste collection department should be relocated, one transferred to the composting system and the other to the recycling program. San Isidro should also fire an additional three workers from the waste collection department to increase funds for the investment in a new collection truck.

The landfill in Uruca, El Parque de Tecnología Ambiental, should be a model to other Costa Rican landfills. This landfill uses modern technology to monitor all environmental hazards created by the waste disposal method of landfilling. The landfill's daily cover and numerous methane flares eliminate most foul odors and harmful gas emissions. Its impermeable layer prevents ground contamination, and pumps transport leachates to a treatment plant where the water is treated before it is released into the nearby river.

In conclusion, all three Costa Rican municipalities must institute a composting system, as is mandated by law, in addition to expanding their recycling programs. By doing so, the amount of waste to be landfilled will be significantly reduced and the lives of those landfills utilized will be elongated. Most importantly, future Costa Rican

landfills should follow El Parque de Tecnología Ambiental's lead to decrease environmental pollution and to minimize the health hazards of nearby residents.

RESÚMEN EJECUTIVO

Los sistemas costarricenses actuales para el manejo de desechos sólidos no acatan el principio de desarrollo sostenible: "el desarrollo que obedece las necesidades del presente sin comprometer la capacidad de las futuras generaciones para cumplir con sus necesidades propias (http://www.doc.mmu.ac.uk/aric/esd/menu.html)." Por lo tanto, la meta de este proyecto fue mejorar el manejo actual de los sistemas de desechos en las municipalidades costarricenses de San Isidro de Heredia, Escazú, y Santa Ana basado en el principio de desarrollo sostenible. Nuestro objetivo principal fue preparar un análisis comparativo de los sistemas actuales para el manejo de desechos entre tres municipalidades costarricenses y dos pueblos estadounidenses, y hacer recomendaciones, las cuales mejorarían los sistemas actuales en Costa Rica.

Una gran cantidad de los sistemas para recolección de desechos en las municipalidades costarricenses opera ineficientemente por un exceso de trabajadores y por los camiones de recolección que son ineficientes. Los programas de reciclaje en Costa Rica, los pocos que existen, no están desarrollados suficientemente para ser utilizados por las municipalidades enteras, y los artículos que pueden ser reciclados están limitados. Además, cincuenta y ocho por ciento de los desechos costarricenses es biodegradable, pero no hay ninguna municipalidad que practique el método de disposición con un sistema de abono (Ronald Arrieta, Profesor de Química en la Universidad de Costa Rica, comunicación personal, el 27 de mayo en 2003).

Existen dos compañías privadas del manejo de desechos sólidos en Costa Rica—Empresas Berthier (EBI) y Waste Placement Profesión (WPP). El EBI maneja el relleno sanitario nombrado El Parque de Tecnología Ambiental, que está situado en Uruca. El

relleno sanitario de La Uruca está bien manejado y no es peligroso para el medio ambiente. El WPP maneja los rellenos sanitarios de Río Azul, que está utilizado por Escazú, y Los Mangos, que está utiliazado por Santa Ana. Los rellenos sanitarios del WPP no están manejados tan bien como los rellenos sanitarios en Uruca o en los de los Estados Unidos a causa de una falta de ejecución por parte del cuerpo reglamentario del Ministerio de Salud (Ronald Arrieta, comunicación personal, el 27 de mayo en 2003).

Para terminar nuestro análisis comparativo, hicimos una evaluación de los métodos actuales del manejo de desechos sólidos en los dos pueblos estadounidenses de Clinton y Shrewsbury, Massachussets, y en las tres municipalidades costarricenses. Como la primera parte de la evaluación entrevistamos al personal administrativo del departamento de desechos sólidos en cada municipalidad. Luego, visitamos los rellenos sanitarios y los centros de acopio utilizados por las municipalidades y entrevistamos a los directores de estos sitios. Además, obtuvimos una copia de la legislación costarricense para la disposición de desechos sólidos, y le pedimos a un grupo ambientalista en Costa Rica sus opiniones en cuanto a la ejecución de las regulaciones y los efectos ambientales de los rellenos sanitarios. También investigamos el poder del dólar para comprar algo en Costa Rica para analizar los costos a valores comparables.

A través de entrevistas con el personal administrativo del departamento de desechos sólidos de cada municipalidad, obtuvimos los datos en cuanto al número de familias que recibe los servicios de la recolección de desechos y de los artículos reciclables. También recibimos información sobre el número anual de toneladas métricas de desechos producidos por cada municipalidad y la tarifa para eliminar cada tonelada de los desechos en un relleno sanitario. Los detalles en cuanto al número de trabajadores

empleados por cada municipalidad para los servicios de recolección de desechos y los artículos reciclables, más la frecuencia de las recolecciones, fueron realizados. Después, nuestro grupo obtuvo información de cada municipalidad sobre el número de camiones que posee y las capacidades de cada camión para la colección de desechos y artículos reciclables. También recibimos fotocopias de los documentos financieros de las tres municipalidades costarricenses. Descubrimos de estos documentos que el presupuesto de cada municipalidad es dividido en ocho categorías mayores: salarios, disposición final, servicios no personales, mantenimiento y reparación, materiales y suministros, depreciación, administración, y beneficios para el futuro desarrollo. El déficit de cada municipalidad, como está incurrido por el servicio del manejo de desechos, fue calculado restando la cantidad de dinero recibida de los residentes del costo total a la municipalidad.

Visitamos cuatro rellenos sanitarios, tres de los cuales están situados en Costa Rica, y el restante está situado en los Estados Unidos, en el estado de Massachussets. Entrevistamos los directores de los rellenos sanitarios para aprender los efectos ambientales y los métodos de mantenimiento de cada relleno sanitario. Además de preguntar sobre las siguientes estructuras, también las buscamos; una capa impermeable, encenderos de la emisión de metano, sistemas para la junta de lixiviados, y plantas de tratamiento para los lixiviados. Cada una de estas estructuras ayuda en la protección del medio ambiente de los contaminantes generados por los rellenos sanitarios.

El sistema del manejo de desechos en Escazú es muy eficiente, y por eso, Escazú fue usado como modelo para las dos otras municipalidades costarricenses. Escazú emplea 3.2 trabajadores por camión de la recolección de desechos, que es solo 1.1 veces

más del número necesario. Escazú no genera una cantidad de desechos particularmente grande en comparación a su población. Actualmente, el programa de reciclaje para la municipalidad de Escazú colecta de sesenta por ciento de sus residentes, y el programa sigue creciendo.

Nosotros recomendamos que Escazú continúe a expandirse el programa de reciclaje hasta que colecte de la municipalidad entera. Además, un sistema de abono debe ser desarrollado para desviar los desechos de los rellenos sanitarios.

El manejo de los desechos sólidos en Santa Ana es el menos eficiente de las tres municipalidades costarricenses. La municipalidad incurrió un déficit el año pasado para su servicio de la recolección de desechos que alcanzó treinta y uno por ciento del presupuesto del manejo de desechos. La municipalidad genera aproximadamente cincuenta toneladas más de desechos por 1,000 residentes que Escazú. Santa Ana no sólo genera la mayor cantidad de desechos por 1,000 residentes, sino que también paga 4,600 colones por tonelada métrica como la tarifa de la disposición final. Eso resulta en una tarifa de la disposición final que es 6,000,000 colones más que la de Escazú, a pesar de tener una población de 19,000 residentes menos. Santa Ana tiene un promedio de 4,7 en cuanto al número de trabajadores por camión, lo cual es 1,6 veces más la cantidad suficiente, y resulta en una pérdida de dinero en salarios para trabajadores que no son necesarios. El programa de reciclaje sólo colecta de diez por ciento de la municipalidad, y no colecta ni aluminio ni cartón.

Para mejorarse la eficiencia del sistema de la disposición de desechos en Santa Ana, recomendamos la instalación de un sistema de abono para reducir la cantidad alta de los desechos producidos. Además, el programa de reciclaje debe ser expandido para

proveer un servicio para la municipalidad entera. Dos de los empleados de la recolección de desechos deben ser cambiados a otros departamentos de desechos sólidos. Uno de los trabajadores debe ser cambiado al sistema de abono e el otro al programa de reciclaje. Santa Ana debe despedir a dos trabajadores adicionales del departamento de la recolección de desechos para bajar el déficit por quince por ciento.

El servicio del manejo de desechos sólidos en San Isidro de Heredia sólo incurrió un déficit de aproximadamente cuatro por ciento del presupuesto el año pasado. San Isidro produce la mayor cantidad de desechos por 1,000 residentes, la cual es cinco toneladas métricos más de la de Santa Ana. La municipalidad emplea ocho trabajadores para el manejo de un camión para la recolección de desechos, lo cual es más de 2,7 veces del número suficiente de trabajadores. El camión operado por la recolección de desechos es el más viejo en el país e incurre costos altos para su mantenimiento. Además, el programa de reciclaje es pequeño y sólo colecta de diez por ciento de sus residentes por el uso de un camión pequeño con una capacidad de una tonelada.

Como Escazú y Santa Ana, San Isidro debe establecer un sistema de abono para eliminar los desechos orgánicos, y el programa de reciclaje debe expandirse también para reducir la generación de desechos. Para ocurrir estas dos recomendaciones, dos trabajadores del departamento de la colección de desechos deben ser cambiados; uno al sistema de abonos y el otro trabajador al programa de reciclaje. San Isidro debe despedirse de tres trabajadores adicionales del departamento de la recolección de desechos para aumentar los fondos para investirse en un camión nuevo.

El relleno sanitario en Uruca, Parque de Tecnología Ambiental, debe ser un modelo para los otros rellenos sanitarios costarricenses. Este relleno sanitario utiliza

tecnología moderna para vigilar los peligrosos ambientales creados por el método de disposición de rellenos sanitarios. La capa diaria del relleno sanitario y los numerosos encenderos de metano casi eliminan los olores apestosos y las emisiones de gases peligrosos. Su capa impermeable impide la contaminación de la tierra, y hay bombas que transportan los lixiviados a una planta de tratamiento donde el agua está tratada antes de que esté puesta en el río cercano.

En conclusión, cada de las municipalidades costarricenses debe instituir un sistema de abono, como está mandado por la ley, además de expandirse su programa de reciclaje. Al hacer eso, la cantidad de desechos para ser eliminada en un relleno sanitario será bajada y las vidas de los rellenos sanitarios utilizados serán alongadas. De mayor importancia, los futuros rellenos sanitarios en Costa Rica deben seguir el ejemplo del Parque de Tecnología Ambiental para disminuir la contaminación ambiental y para reducir al mínimo los riesgos de salud de los residentes cercanos.

I. INTRODUCTION

The management of solid waste is a matter of global importance due to growing populations and limited land resources. The longer that communities wait to address their waste management options, the more scarce their options become. Those communities will eventually be forced to practice improper waste management methods that will lead to hazardous living conditions. A well-planned sustainable waste management system, which utilizes appropriate technologies and suits the characteristics of the community, creates a positive impact on health, water quality, and aesthetics.

The current systems for the management of solid waste in Costa Rica are not in accordance with the principle of sustainable development: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs (http://www.doc.mmu.ac.uk/aric/esd/menu.html)." The goal of this project was to improve the current waste management systems in the Costa Rican municipalities of San Isidro de Heredia, Escazú, and Santa Ana based on the principle of sustainable development.

Landfills are the most widely-used systems for the management of solid waste in the United States (M.S. Fitzpatrick, Associate Professor of Civil and Environmental Engineering at WPI, personal communication, March 27, 2003); however, the landfills in Costa Rica are not as strictly monitored as they are in the U.S (Ronald Arrieta, Professor of Chemistry at University of Costa Rica, personal communication, May 27, 2003). Many Costa Ricans believe that landfills are the source of the country's waste management problem. This is because laws and regulations preventing water supplies from being contaminated, and the air from being polluted, are not strictly enforced by

their mandating body, El Ministerio de Salud (Ronald Arrieta, personal communication, May 27, 2003). Many collection systems in Costa Rican municipalities operate inefficiently because too many workers are employed for the number of people they serve. Recycling programs in Costa Rica are not sufficiently developed to be utilized by entire municipalities, and the types of items that are recyclable are limited. Eventhough a law was passed in 1949 that states that every municipality must have a composting system, there is not a single municipality that practices this method of disposal (Ronald Arrieta, personal communication, May 27, 2003).

According to our liaison Dr. Ronald Arrieta, ninety percent of the waste produced in Costa Rica is usable. He has developed a diagram (Figure 1) that

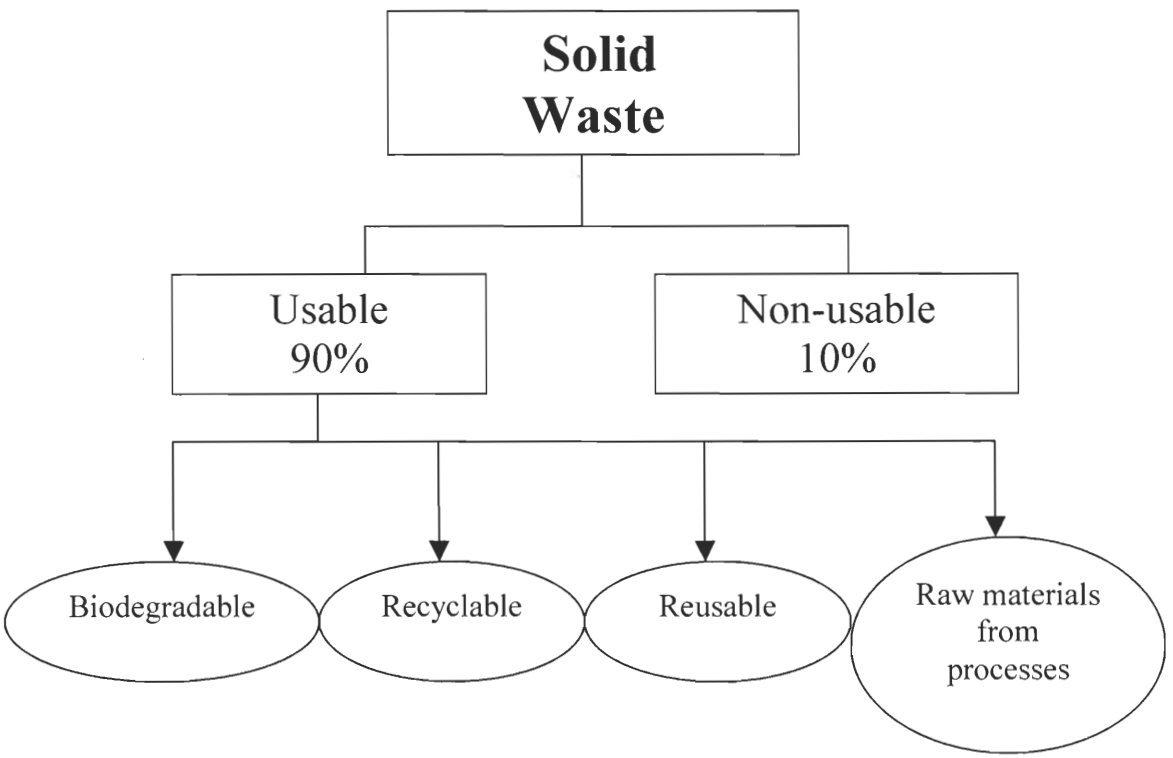


Figure 1: Arrieta's Model for the Catergories of Solid Waste in Costa Rica
Ronald Arrieta Calvo. (2003). Manejo de los Desechos Sólidos en Costa Rica.

separates solid waste into two different categories, usable and non-usable. Currently, only ten percent of waste in Costa Rica is used. Therefore, the amount of solid waste generated can ideally be reduced by eighty percent, which would have a positive affect on the environment and the health of the inhabitants of Costa Rica.

The Centro de Investigaciones en Contaminación Ambiental (CICA) is an organization that utilizes various techniques for researching and analyzing environmental pollution. The organization's mission is to investigate and contribute scientific information that will assist in the world-wide effort to protect the natural environment. Our research, analysis, and recommendations to improve Costa Rica's current methods of solid waste management will aid CICA in its effort to protect Costa Rica's natural environment. Also, our project will advance our liaison's studies in the area of solid waste management by providing him with new information on possible waste management options in Costa Rica.

To accomplish the project's goal, we did a comparative analysis between the management of solid waste in two United States and three Costa Rican municipalities. The objective of the analysis was to identify areas in need of improvement and to formulate recommendations to improve each municipality's system. To complete the analysis, we obtained information on the solid waste systems in the five municipalities. We researched the methods of waste management in the two U.S. towns of Shrewsbury and Clinton, MA prior to our arrival in Costa Rica. Also, while in Costa Rica we investigated the systems in the municipalities of San Isidro de Heredia, Escazú, and Santa Ana. The methods of interviews and observations were used to collect data and information on each municipality's budget for solid waste management, the types of

equipment and number of workers used for solid waste removal, and the conditions and maintenance of disposal sites and recycling centers.

We then analyzed the issues of cost, environmental effects, and socio-political issues pertaining to the Costa Rican solid waste management systems. Our group compared the quality and cost of the systems in the three Costa Rican municipalities to those in the two U.S. towns. From the data, we identified the areas in need of improvement and formulated recommendations for the most cost-efficient, socially-acceptable, and sustainable methods for the management of solid waste in the Costa Rican municipalities. The group sent recommendations to the administrative personnel in the solid waste department of each Costa Rican municipality. A report was also sent to El Ministerio de Salud, the governing body for all laws and regulations regarding the management of solid waste, so that it can become aware of Costa Rica's current hazardous and potentially-dangerous disposal methods.

> This report was prepared by members of Worcester Polytechnic Institute Costa Rica Project Center. The relationship of the Center to CICA and the relevance of the topic to CICA are presented in Appendix A.

II. BACKGROUND INFORMATION

The methods and processes used for the management of solid waste in the United States are discussed, taking into consideration both social and economic contexts. The elements of the municipal solid waste management systems in the U.S. towns of Clinton and Shrewsbury, MA are described, along with those in the Costa Rican municipalities of San Isidro de Heredia, Santa Ana, and Escazú. Health and safety issues regarding landfilling are discussed, as well as a comparison of United States landfills to three landfills currently being filled in Costa Rica. We also examined socio-political issues that pertain to waste disposal in Costa Rica, such as the locations of landfills and their future uses.

Waste Management

Solid waste includes, "any garbage, trash, rubbish, waste tire, refuse, sludge from a waste treatment plant, water supply treatment plant or pollution control facility and other discarded material, including solid, liquid, semisolid or contained gaseous material (http://www.azleg.state.az.us/ars/49/00701-01.htm)." (Refer to Appendix B) Generation, collection and transportation, and disposal are the three components that structure solid waste management systems (Powell, 1996). Figure 2 shows how these three elements function in relation to each other in a waste management system.

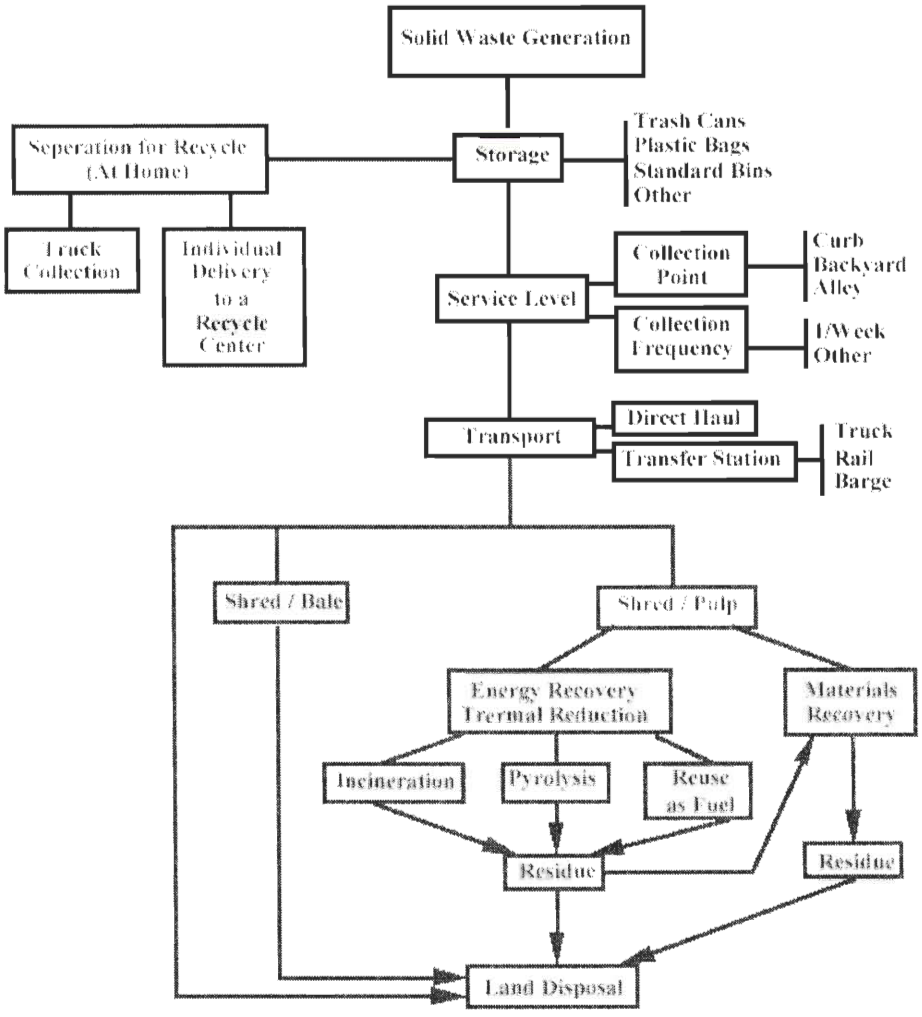


Figure 2: The Functional Elements of a Solid Waste Management
J.C. O'Shaunessy, CE3059 lecture notes (2002).

Financial restrictions and environmental regulations govern how these three components are implemented in an effective system. A sustainable solid waste management system, which is appropriately designed for a community, should prove to operate efficiently, as well as to improve living conditions.

Generation

Controlling and reducing the amount of waste generated is the first step of solid waste management (Curi & Or, 1993). The high cost of sanitary landfilling, diminishing landfill space, and the difficulty in finding acceptable landfill sites has made it necessary to form policies and practices that decrease the amount of waste that requires disposal. Many cities and towns are using the methods of waste reduction, reuse, and recycling to divert waste from landfills (Byer & Noehammer, 1997).

The most effective way to manage solid waste is by reducing the amount generated at the household level (M. S. Fitzpatrick, personal communication, March 27, 2003). Various means can be used to reduce solid waste produced, such as increased regulation and economic devices. Studies have shown that an increase in the price of waste disposal often causes the amount of waste discarded to decrease and the recycling volume to increase (Adamowicz, Luckert & Salkie, 2001).

Reuse is another effective method used to reduce waste generation. The construction industry could take advantage of this method. When an old building is knocked down, the construction materials are disposed of in a landfill. If buildings were constructed so that they could be taken apart and their materials could be reused, the result would be a decrease in waste (M. S. Fitzpatrick, personal communication, March 27, 2003).

Recycling is an excellent form of waste reduction because it decreases the amount of waste disposed of by making use of old waste. Recyclable items, such as plastics, are melted down to form new products using the original material. In order to be successful,

recycling programs need a substantial amount of investment and commitment (Byer & Noehammer, 1997).

Recycling programs experience two problems when being developed by a community: implementation costs and variable public participation. By designing a program that suits the characteristics of the community, and one that meets the objectives of the municipality, these issues can be controlled (Byer & Noehammer, 1997). An effective recycling program makes use of community structures that are favorable to recycling, increases recycling program awareness through education, and encourages participation by various devices, such as economic inducements, legislation, and convenience (Everett & Pierce, 1993).

Collection and Transportation

Collecting and transporting waste to disposal sites is the second step of solid waste management (Curi & Or, 1993). Frequency of collection, collection sites, and the type of transportation used are the three critical parts of this stage. Collection systems are designed to accommodate the particular conditions of a community, as they are not automatically transferable from one community to another (Korfmacher, 1997). A community's collection options are restricted by financial capabilities, population density, and distance to disposal or transfer sites.

House to house and site collection are the two most common collection systems. House to house collection systems involve a truck with a compactor, or in poorer communities, a pickup truck or cart that goes from house to house to pickup waste. In regards to site collection, people bring their waste to a designated area where it is transported to disposal facilities. Solid waste collection is important because of the

positive impacts on health, water quality, and aesthetics to which a successful system can lead (Korfmacher, 1997).

Disposal

Disposal sites are used to eliminate solid wastes, which operates as the final step in the waste management process (Curi & Or, 1993). The most common disposal methods are landfilling, incineration, refuse-derived-fuel, and composting.

Landfilling is the most common and well-known method of solid waste disposal. During this process, waste is brought to landfills where it is then dumped and stored. Full landfills are covered with a thick layer of clay to contain odors and to prevent water penetration. Shrewsbury, MA has plans to build a park on top of their landfill after it is capped (Nancy Allen, Director of Public Health in Shrewsbury, MA, personal communications, March 31, 2003), and Los Mangos already has built a soccer field on an old portion of its capped landfill. Only minor structures, such as playgrounds and parks, can be built on capped landfills because the layer of clay must remain intact to contain the landfill's harmful gas emissions (M. S. Fitzpatrick, personal communication, March 27, 2003).

Siting for new landfills is a difficult task faced by many communities when implementing a solid waste management program (Charnpratheep, Zhou, & Garner, 1997). Growing populations and limited land resources have made landfill siting a difficult and even more critical undertaking than in the past. Landfills are generally prohibited from being located within environmentally sensitive areas, such as flood plains and wet lands. Furthermore, landfills should be located near roads to reduce the cost of their construction and operation. Landfill siting analysis evaluates environmental, social,

and economic factors to locate communal sites appropriate for landfills (Kao, Lin, & Chen, 1997).

The scarcity of available land that is suitable for landfilling is becoming a significant problem in the disposal of municipal solid wastes. Incineration is a feasible management option, reducing waste mass and volume up to eighty and ninety percent, respectively (Lu, 1996). Some incinerator residues can be used for construction-related applications; however, most of these residues end up in landfills (Lu, 1996). Incineration creates heat energy that produces electricity. This process allows landfills to have a longer lifetime than if the waste were just dumped without being incinerated because of the reduction in waste volume (J. C. O'Shaughnessy, Professor of Civil and Environmental Engineering at WPI, personal communication, April 2, 2003).

Refuse-derived-fuel (RDF) is another method of waste disposal. A plant for RDF production selects materials with high heating values, such as paper and plastic, and processes these materials to produce a combustible. The combustible is then sold to industries that then burn it as fuel (Fiorucci, Minciardi, Robba & Sacile, 2003). Therefore, this technique makes use of waste as a source of power (Alter, 1996).

Composting is the least expensive of all the disposal methods, but it can only be used for organic wastes. A community with composting decreases the amount of waste it produces each week because organic waste is collected separately from solid waste. The organic waste is brought to a facility where it is composted. The compost acts as a fertilizer and can be used for covering capped landfills and scrap pieces of land or it can be used for farming (M. S. Fitzpatrick, personal communication, March 27, 2003).

Waste Management Strategy

The main objective of a waste management strategy is the disposal of waste at the lowest possible cost to the community and a regard for the protection of the environment by use of waste as a resource. This can be done by undertaking an economic evaluation of waste management options that incorporate the social costs and benefits incurred by a society as a whole (Powell, 1996).

The evaluation of waste management options can be done in a number of different ways, but the most common method is based solely on financial costs and revenues. The BATNEEC principle (Best Available Technology Not Entailing Excessive Cost) implies that objectives, such as environmental effectiveness and economic feasibility, have to be set in a way that accepts a community's financial limitations. By evaluating the net financial cost of disposal options per ton of waste and the financial profitability of recycling programs, communities are able to choose the waste management options that are most suitable for their lifestyle (Powell, 1996). The various options for waste management system design include combinations of landfilling, incineration, RDF, and recycling. The effectiveness of an implemented system depends mainly on the attitude shown by citizens towards the measures in the plan itself (Brio, Junquera & Muniz, 2001).

Solid Waste Systems in U.S. Municipalities

Shrewsbury

We used Shrewsbury's composting program as a model when making recommendations because it exemplifies good U.S. practices. Shrewsbury, MA has 31,460 residents who produced 12,000 tons of trash in 2002. The town has an extremely

efficient waste management system. Shrewsbury charges its residents $9.16 per month (3,585 colones per month) for each household for the waste removal services it provides them. Shrewsbury has a contract with the private company of Wheelobraiter Inc., which collects and disposes of Shrewsbury's waste (Nancy Allen, Director of Public Health in Shrewsbury, MA, personal communications, March 31, 2003).

Wheelobraiter utilizes two trucks per day and collects the waste by means of curbside pick-up from each home once a week. The company owns a large incineration plant that burns the waste collected from the residents of Shrewsbury. The incineration of trash produces steam that is then utilized for the production of energy. Wheelobraitor collects and disposes of waste not only for Shrewsbury but also for thirty-five other communities. The incinerated waste from all thirty-six communities is then disposed of in a landfill that Shrewsbury owns and maintains. This relatively small landfill is able to service such a large quantity of waste due to the proceeding incineration process. Incineration reduces the volume of waste from between eighty-five to ninety-five percent. Shrewsbury charges Wheelobraitor a large fee to dispose of the ash in the landfill, and the town also charges a $1,000,000 stipend to dump the coal ash that was used to burn all the trash as well. By owning this landfill, Shrewsbury is able to make money from the management of solid waste—money that is then used to improve several other aspects of the town (Nancy Allen, personal communication, March 31, 2003).

Wheelobraitor also collects recyclable items for residents of Shrewsbury every other week. The items collected include cardboard, plastic, paper, aluminum, and glass. Shrewsbury recycles 2,347 tons of those items per year. Nancy Allen stated that the

percentage of waste that is recycled is slowly growing each year as people become increasingly more aware of the service the town provides them.

Shrewsbury also uses composting as a means to reduce the amount of waste produced. Of the 12,000 tons collected by Wheelobraitor, fifteen to seventeen percent of this waste is composted. Therefore, roughly 2,040 tons of the towns' waste is composted. Shrewsbury then uses the composted material as a daily cover for its landfill (Nancy Allen, personal communication, March 31, 2003).

The cost of trash removal in Shrewsbury was $439,000 (171,649,000 colones) in 2002 for the curbside pickup service. In addition, the town paid Wheelobraitor $385,000 (150,535,000 colones) in 2002 to burn that trash. Recycling in 2002 cost the town $273,000 (106,743,000 colones) and the cost of composting totaled $24,000 (9,384,000 colones). Shrewsbury paid a grand total of $1,121,000 (438,311,000 colones) for the removal and disposal of its 12,000 tons of waste and 2,800 tons of recyclables produced in 2002, which yields a per capita cost of $35.43 (13,853 colones) for the service. Shrewsbury is able to afford these high costs by owning its own landfill, which allows them to produce a profit for the town based on their waste management strategy (Nancy Allen, personal communication, March 31, 2003).

Clinton

We used Clinton's waste collection service as a model when making recommendations because it exemplifies good U.S. practices. Clinton, MA has a population of 13,435 residents who produced 3,000 tons of trash in 2002. The town's waste management strategy utilizes a PAYT system (Refer to Appendix F). Residents must buy $1.00 (391 colones) stickers at the local super market or convenient stores, and

they attach this sticker to a thirty-five gallon bag of trash to signify to the sanitary workers that they have paid for the disposal service. The bags are then put in a rubbish truck for disposal in a landfill, as Clinton does not compost any waste (Bill Sprat, Superintendent of Public Works in Clinton, MA, personal communications, April 14, 2003).

The town of Clinton employs three workers and owns two trucks that are utilized for the collection of waste from each residence once a week. One of the trucks was recently purchased, and there is another truck is slightly older and used solely as a back-up truck incase the newer truck encounters problems that require maintenance. Once the waste is collected from each house on the daily collection route, the driver then transports the waste to the Fitchburg landfill, which is located approximately twenty-five minutes outside of Clinton. The town of Clinton was charged $78.00 (30,498 colones) per ton for the disposal of its waste in 2002 (Bill Sprat, personal communications, April 14, 2003).

Clinton does not utilize a curbside service for recyclable items, so residents must bring these items to a drop-off station located in the center of town. The station is only open on Saturday from 8:00 AM to 1:00 PM. It costs $1.00 for residents to dispose of recyclable items if these items are not accompanied with a bag of garbage. Recyclable items in Clinton include plastic, paper, glass, cardboard, and aluminum. For a detailed listing of the cost of disposing of items at Clinton's Solid Waste & Rubbish Convenience Station refer to Appendix G (http://www.townofclinton.com).

Clinton paid $418,657.00 (163,694,887 colones) for the collection and disposal of its 3,000 tons of waste produced in 2002. Annually, the per capita cost yields $31.16 (12,184 colones). Clinton currently has a deficit that it is in the process of being

eliminated by raising sticker prices. The PAYT program was implemented last year as an experiment. The town has evaluated the program and has decided to increase the charge of stickers from $1.00 to $1.40 to make its waste management system completely self-sufficient (Bill Sprat, personal communications, April 14, 2003).

Solid Waste Systems in Costa Rican Municipalities

San Isidro de Heredia

San Isidro, a town of 17,000 residents, produced 4,945 tons of solid waste in 2002. San Isidro has a waste management strategy that is inexpensive when compared to the other towns of Santa Ana and Escazú. San Isidro charges its residents 807 colones ($2.06) per month for waste removal services. San Isidro utilizes curbside pick-up, which visits each household two times per week. Currently, San Isidro does not compost any of its waste (Siany Villalobos Argüello, San Isidro de Heredia Department of Public Works, personal communication, May 18, 2003).

Ten people are employed in the waste management sector of the Department of Public Works--two drivers and eight laborers. San Isidro owns two trucks—one for the collection of waste and one for the collection of recyclable items. The waste disposal truck is the oldest disposal truck in the country and it is in bad operating condition. After the daily collection route is complete, the waste is then transported for forty-five minutes by the drivers to a landfill in San Pablo for a cost of 2,400 colones ($6.14) per metric ton dumped (Siany Villalobos Argüello, personal communication, May 18, 2003).

San Isidro paid 42,302,821 colones ($108,191) for the collection and disposal of its 4,945 tons of trash in 2002, yielding a per capita cost of 2,488 colones ($6.36) per

year. San Isidro's waste management service suffered a deficit of 1,619,325 colones ($4,169) last year (Siany Villalobos Argüello, personal communication, May 18, 2003).

La Casa Hogar para Ancianos, the recycling center in San Isidro de Heredia, services both municipal and local families, totaling approximately six-hundred. The center is a supervised home in which the elderly assist in its management by tearing-up phone books and other non-reusable paper. In addition to this center, San Isidro also has a warehouse that is owned by the Red Cross, which is used as an overflow storage room by the La Casa Hogar para Ancianos. Because the recycling program is only a pilot, only three municipal communities receive the collection service—San Josito, Aprochaves, and Urbanización San Isidro. Although the entire municipality does not receive the service, all residents are welcome to bring their recyclable items to the center on their own. A municipal pick-up truck that has a capacity of one ton collects recyclable items every fifteen days. Recyclable items are separated into the following categories: paper, plastic, periodicals, glass, and cardboard. The goal of the municipality is to expand the recycling program and increase awareness of the importance of recycling (Ana Flor Villalobos, Manager of Casa Hogar para Ancianos, personal communication, June 2, 2003).

Not only does La Casa Hogar para Ancianos obtain paper in return for managing the center, but it also receives all money made from the selling of the recyclable items to local residents or directly to companies or institutions. The center received approximately 1,368,500 colones ($3,500) in the year 2002-2003 from the selling of recyclable items (Ana Flor Villalobos, personal communication, June 2, 2003).

The center owns a minibus that can deliver items to various companies and institutions; however, the vehicle is not large enough for some companies to bother

utilizing the center's drop-off service. Therefore, the center is forced to sell to independent buyers for a lesser fee. These intermediate parties own larger trucks and are able to sell the same items to companies at a higher cost than the cost at which they bought the items (Ana Flor Villalobos, personal communication, June 2, 2003).

Escazú

Escazú, a town with 54,000 residents, produced 12,700 tons of waste in 2002. The municipality paid 213,610,046 colones ($546,317) for the collection and disposal of its 12,700 tons of waste last year, yielding a per capita cost of 3,127 colones ($8.00). Escazú's waste management system incurs a high price when compared to other Costa Rican municipality budgets. The municipality obtained 151,940,825 colones ($388,596) from residents in 2002. Escazú utilizes curbside pickup and collects two times per week from each household (Luis Rodriguez, Escazú public works, personal communication, March 20, 2003).

Escazú employs nineteen workers for the disposal of trash and it owns six trucks, five of which are used for the collection of waste. The remaining truck is used for the collection of recyclable items. Workers follow specific routes for the collection of waste. The routes are based on studies to assure that they are the most efficient routes. Trucks then transport all of the trash to a landfill in Río Azul for a cost of 3,400 colones ($8.70) per ton (Luis Rodriguez, personal communication, March 20, 2003).

Sixty percent of Escazú's residents are provided with a collection service for recyclable items. Such items include paper, plastic, glass, aluminum, and cardboard, and they are collected from residents once a week. These items are brought to a recycling

center where they are then sold to companies that make use of the items (Luis Rodriguez, personal communication, March 20, 2003).

Santa Ana

Santa Ana, a municipality of 34,000 residents, produced 10,000 tons of solid waste in 2002. Curbside collection of waste is utilized by the community. The municipality charges its 7,470 households 1,200 colones per month ($3.10) for the waste removal service. The per capita cost last year for this service was 4,739 colones ($12.12) (Alberto Durano, Santa Ana public works, personal communication, March 21, 2003).

Santa Ana brought in 117,000,000 colones ($299,233) from residents in 2002, but the service cost the municipality 168,545,698 colones ($431063), resulting in a deficit of thirty-one percent of its disposal costs. The municipality is currently conducting a study to learn if, and how, it can raise the cost that residents must pay for waste disposal so that Santa Ana will no longer need to cover a large portion of the cost (Alberto Durano, personal communication, March 21, 2003).

Santa Ana owns one truck for recycling and three trucks for waste collection. Each truck follows a specific route that is conducted twice a week to control the odors caused by organic waste in this tropical climate (Dr. Ronald Arrieta, personal communication, May 27, 2003). There are fourteen employees for the collection and disposal of waste. Santa Ana transports waste daily to a landfill located in Alajuela for a tipping fee of 4,600 colones ($11.76) per metric ton (Alberto Durano, personal communication, March 21, 2003).

Santa Ana has its own recycling center that collects paper, glass, aluminum, cardboard, and plastic. The municipality employs two workers that collect the recyclable

items. A study is currently being conducted to see what steps the municipality should take to increase the percentage of waste that is recycled. Santa Ana does not have composting; however, the municipality used to have a composting system (Alberto Durano, personal communication, March 21, 2003).

Landfills

Health and Safety Issues

Both the United States and Costa Rica utilize landfills as their primary method for the final disposal of waste (M. S. Fitzpatrick, personal communication, March 27, 2003) and (Dr. Ronald Arrieta, personal communication, May 27, 2003). Although landfills can be properly managed to minimize potential health and environmental hazards, landfills do have the ability to cause major negative effects. These effects include a reduction in ones' health, air pollution, ground contamination, and water contamination. We have been informed by Jorge Cardoza, the head engineer of the Río Azul landfill, that residents of the nearby community suffer from cancer, skin conditions, and headaches that are caused by the landfill (Refer to Appendix Q for an environmental report on Costa Rica's landfills).

Landfills release approximately five percent of the currently estimated global annual emission of methane. Although this percentage does not appear to be significant, methane is produced in large amounts in landfills due to the decomposition of organic matter under anaerobic conditions (Borjesson & Svensson, 1997). To give some meaning to this fact, methane is combustible and mixtures of approximately five to fifteen percent in the air are explosive. Although methane is not toxic when inhaled, it can produce

suffocation by reducing the concentration of oxygen inhaled (http://scifun.chem.wisc.edu/chemweek/methane/methane.html).

Another effect of landfills is the contamination of water supplies. Approximately twenty-two percent of the locations on the U.S. National Priority List for hazardous waste site cleanup are closed municipal landfills, as 200,000 tons of volatile organic compounds (excluding methane) are produced and released from municipal solid waste (MSW) landfills per year. These volatile compounds include both odor-causing agents and hazardous pollutants. Once solid waste begins to break-down within a landfill, biological, chemical, and physical events occur that result in the emission of hazardous gases and liquids. Municipal water supplies can then be affected by landfill leachates, which are produced as a result of rainwater mixing with the solid waste within the landfill (Reinhart, 1993).

Landfills in the United States

Waste Management (WM) has the largest network of landfills in the industry. Each of its landfills utilize state-of-the-art liners, leachate collection systems, ground water monitoring, and gas control systems, along with operational procedures that protect the environment and meet or exceed federal, state, and local regulations. The company also owns a subsidiary, Recycle America, which is the largest collector of recyclable materials from households in North America. The Environmental Protection Agency (EPA) recognized four of WM's facilities in 2000 for implementing environmental programs that benefit people, communities, and the environment (www.wm.com). Tom Murray is in charge of several operations for Waste Management, including overseeing operations at the Fitchburg landfill.

Landfills in the United States have extremely specific regulations that must be obeyed (Refer to Appendix R for Pictures of the Fitchburg, MA Landfill). The majority of the regulations are based on scientific studies that demonstrate the most efficient ways by which to run an environmentally-safe landfill (Waste Management, 2003). The regulations that are most important to the environment include those pertaining to impermeable bottom layers, leachate collection systems, and methane collection systems. Other regulations include those dealing with the grade on which the landfill must be built, the use of daily covers, sectioning, layering, and on-site composting. Once the landfill has reached its capacity it then has to be capped, which is a highly-regulated process in itself (Tom Murray, Manager of Fitchburg Landfill owned by Waste Management, personal communication, May 1, 2003).

The impermeable bottom layer consists of multiple layers that are made of plastic, clay, and dirt. U.S. regulations not only state that an impermeable layer must exist, but they also state the minimum thickness of every layer and the necessary level of impermeability of these layers. The purpose of the layers of clay, plastic, and dirt is to prevent the toxic chemicals, known as leachates, from leaking out from the bottom and/or the sides of the landfill and contaminating water supplies (Tom Murray, personal communication, May 1, 2003).

A system specifically-designed to collect these hazardous leachates is therefore essential. Known as a leachate collection system, the purpose of the design is to collect the contaminated rainwater and to treat it with chemicals that eliminate any contaminants before the water enters into the final body of water, such as a river (Tom Murray, personal communication, May 1, 2003).

Designed by engineers, most leachate collection systems in the U.S. consist of rain waterways that resemble small streams. The waterways are extremely rocky and are constructed on a low grade. The water that flows through these waterways is constantly tested for its degree of contamination so as to assure that the rainwater does not become dangerously contaminated (Tom Murray, personal communication, May 1, 2003).

The waterways are controlled by the leachate collection and treatment pumps. The treatment pumps collect the rainwater and keep it flowing at a constant, slow pace. The pumps also push the water into and out of the leachate collection ponds. Engineers calculate the time necessary for one molecule of water to flow from the entrance of the pond in order to then calculate the amount of time it will take for the water to reach the next pump. This particular pump moves the water out of the pond and into a stream, where the described process is repeated. In the landfill in Fitchburg, which is owned by Waste Management Ind. (WM), exists a series of five collection ponds that are connected by four pumps and four streams (Tom Murray, personal communication, May 1, 2003).

The estimated time for one molecule of water to flow from the origin to its final destination in a nearby river is twenty-three days, which allows the rainwater more than enough time to dispose of the leachates as it is treated at each pump. This extended pond-stream system slows down the rainwater so that WM can be sure that it is not polluting the nearby river in which the rainwater is deposited in the final stages of the leachate collection system (Tom Murray, personal communication, May 1, 2003).

A methane collection system is also an important installation for current landfills. A methane collection system consists of a series of pumps throughout the landfill that are connected to a larger methane pump. The large methane pump is located five-hundred

yards away from the landfill as a safety precaution because it is connected to a large flare where the methane can be collected and burned. In the landfill in Fitchburg, the methane is collected and sold to a power plant located a short distance away from the landfill. The power plant uses this methane to create electricity for the towns of Fitchburg and Lancaster, MA (Tom Murray, personal communication, May 1, 2003).

The first step involved in making a methane collection system is drilling holes with a width of about one foot into the bottom of the landfill. These holes are then filled with rocks to prevent waste from getting pulled into the pump. There is sufficient space between the rocks for the methane to flow to the pump system. The tops of the drilled holes are tightly capped in order to prevent the leakage of methane. The methane pump continually pulls all of the methane to the main collection system at which all of the methane is collected and then sent to the Fitchburg power plant (Tom Murray, personal communication, May 1, 2003).

It is also necessary for the section of the landfill that is still being filled to have a methane collection system. Small methane flares are setup to force the methane out from below the surface of the landfill. The methane flares continuously spark until the adequate amount of methane collects in the flare chamber to cause ignition. When the flare chamber ignites, the system burns off the collected methane. The described process aids in the elimination of the harmful chemicals and the foul odors that are released from landfills (Tom Murray, personal communication, May 1, 2003).

Landfills must be built at a thirty-three percent grade to prevent the landfill from buckling or collapsing from its own weight. An example of the importance of this regulation is that of the landfill located in Boylston, MA that was built on a forty-five

percent grade. After several years of use, the landfill began to collapse. The town did not have sufficient funds to repair the problem, so the town used funds from the state of Massachusetts that totaled over $40 million (Tom Murray, personal communication, May 1, 2003).

Daily covers are also necessary for the safe management of a landfill. The daily cover serves a multitude of purposes, ranging from the reduction of odors to the prevention of animals from rummaging through the waste. The cover also forces a portion of the rainwater to run off the landfill in order to prevent it from seeping into the waste and producing an increased amount of leachates. The cover consists of either composted material or chipped construction material. The landfill in Fitchburg, MA, for example, uses ground construction material that is disposed of as waste as its daily cover. Due to the importance of a cover, it is a regulation in Massachusetts that a daily cover is used (Tom Murray, personal communication, May 1, 2003).

On-site composting exists at most U.S. landfills. Compost can be used as daily cover; however, compost is most commonly used as cover for capped landfills. The items that tend to be composted on-site are yard wastes, such as grass and leaves. The thirty-three percent grade is upheld by the growth of grass on this composted yard waste, which prevents the sides from washing away with heavy rainfalls. By composting yard waste, the landfill owners are reducing the amount of daily waste to be landfilled, as 17.9 percent of waste in the U.S. consists of yard trimmings (Tom Murray, personal communication, May 1, 2003).

Currently, landfills in the U.S. must be sectioned. Sectioning is when an area with an impermeable layer is created and then filled with waste. Once the capacity of

this section is reached, a bordering section is then constructed in the same manner. The new section must obey any new ordinances and regulations. The two sections are then connected, and a new section can then be constructed on top of these connected sections. It is also equally likely that yet another bordering section be created. Landfills are constructed at a flat, even height, and once the entire area of the landfill reaches this height, it is then that a new layer is built. This layering process continues until the section has reached its maximum capacity (Tom Murray, personal communication, May 1, 2003).

The process of sectioning therefore allows the landfill to continuously follow all regulations without having to dig-up decomposed waste or fix any systems that have been proven to be unsafe or environmentally-hazardous. To ensure the most environmentally-safe management of a landfill in the United States, each section must have both leachate and methane collection systems, and an impermeable bottom layer. Each section must also use a daily cover.

El Parque de Tecnología Ambiental

San José, along with private companies, utilize the landfill El Parque de Tecnología Ambiental (P.T.A.) (Refer to Appendix S), which is located in Uruca. The landfill has been operating for three years and 800 metric tons of waste are dumped in it each day. 500 of those tons dumped per day come from San José, while the other 300 come from the private companies. P.T.A. charges 3,900 colones per metric ton of waste dumped in its landfill (Roberto Fallas ,EBI, personal communication, June 12, 2003).

El Parque de Tecnología Ambiental is owned and operated by Empresas Berthier, EBI, which is a Canadian company. It is the first landfill of its kind in Costa Rica. EBI

manages the landfill beyond the regulations set by El Ministerio de Salud. Waste collection trucks are washed with a microorganism, EMOR, before exiting the landfill. The microorganism kills harmful bacteria that could form on the trucks. In addition, EMOR is sprayed onto new waste twice a day to control odors and increase the decomposition rate of the waste, which results in an increase in methane emission. The peanut plant is planted around the edge of the landfill to introduce nitrogen into the soil (Roberto Fallas, personal communication, June 12, 2003).

Eighteen of the landfill's twenty-three hectares can be used for landfilling, while the remaining five hectares are used for the maintenance of the landfill. The landfill has a total of six phases that are each two-and-a-half hectares in size. Currently, the second phase is being used for waste disposal. After a phases' capacity is filled, it is covered with one meter of soil, and then several rows of the vetiver plant are planted so that its long, screw-like roots can act as a stabilizer of the filled section. There are twelve years remaining until the landfill's capacity is reached. Once the landfill is capped, it will be transformed into a park for the community. However, the landfill must first sit and be monitored for fifteen years before the construction of the park can begin (Roberto Fallas, personal communication, June 12, 2003).

Each phase is protected by an impermeable layer of plastic. Below the plastic is seventy meters of volcanic rock. A one meter layer of tires is placed on top of the impermeable layer and under the solid waste. The solid waste is then piled up at a thirty-three percent grade (Roberto Fallas, personal communication, June 12, 2003).

The leachate collection system of El Parque de Tecnología Ambiental pumps leachates into two lagoons. One of the lagoons has a volume of 2,500 cubic meters,

while the other has a volume of only 500 cubic meters. The leachates are then transported to a treatment plant, which is checked monthly for its level of contamination. Once the water has been sufficiently treated, it is deposited in the nearby river (Roberto Fallas, personal communication, June 12, 2003).

The underground water is checked monthly at three points for contamination. In addition, the air and sand around the landfill is checked tri-monthly. To control odors and infestation, a daily cover is placed over the dumped waste. Numerous methane flares that burn methane gas are also used to aid in the reduction of odors and pollution. When the landfill has reached its capacity and is capped, the methane pipes that lead to the flares will be connected and the methane will be sold to power plants for the production of electricity (Roberto Fallas, personal communication, June 12, 2003).

Río Azul

Located in Río Azul, San José, the landfill Río Azul (Refer to Appendix T) is utilized by eleven municipalities, including that of Escazú. The landfill was constructed thirty years ago when the hazardous effects of landfilling were entirely unknown to Costa Ricans. Therefore, the landfill does not have an impermeable layer that protects the ground from leachates. The only layer between the earth and the waste is a layer of clay. Leachates are collected by rainwater that runs down the side of the landfill's pyramid-like structure and into pipes that drain into a lagoon. The leachates are then transported to the company Kimberely-Clark where the contaminated water is chemically-treated before the water is dumped into a nearby river (Jorge Cardoza, Civil Engineer, personal communication, June 17, 2003).

There are three points for monitoring water contamination below the surface of the landfill. Two of these points are located at the top of the landfill and the other is located at the bottom of the landfill. These monitoring points are checked on a monthly basis (Jorge Cardoza, personal communication, June 17, 2003).

There exist four small methane flares that burn the methane that is produced and released from the landfill. There is a project currently underway that is managed by CNFL (Electrificación de toda la Finca La Caja) to filter the biogas and sell it to an electric company. The goal of WPP is to complete this project by the end of this year; however, there is currently a lack of funding for the completion of the program (Jorge Cardoza, personal communication, June 17, 2003).

A daily cover of dirt is used to control odors; however, heavy rainfall can cause the workers to neglect this job out of the dislike of getting wet. When a phase of the landfill is filled, it is covered with three layers. The first layer consists of fifteen centimeters of clay, the intermediate layer consists of sixty centimeters of clay, and the final layer consists of eighty centimeters of vegetal matter (Jorge Cardoza, personal communication, June 17, 2003).

The design of the landfill is of a pyramidal formation, and it is filled at a slope of thirty-three percent. The method of sectioning is used, in addition to the compacting of waste. These two methods are utilized to stabilize the landfill (Jorge Cardoza, personal communication, June 17, 2003).

The landfill receives 750 tons of waste per day, and it charges 3,400 colones per metric ton of waste. Scavengers search through the daily waste for items that they can sell in return for money. The landfill has two to three years remaining before its capacity

of forty hectares is reached. The landfill will then be capped and transformed into a park. Before the close of the landfill, a treatment plant for the leachates will be completed on-site. There already exist a pre-treatment facility and three lagoons that have been constructed for this treatment plant. Once completed, the first lagoon will collect sedimentary particles. The contaminated water will then be pumped into the second lagoon where it will be treated with oxygen. Finally, the third lagoon treat will treat the water with chlorine before it is released into a river. In the summer months, the treatment plant will receive approximately fifty cubic meters of water daily that contain leachates. As much as two-hundred fifty cubic meters of water is collected and treated in the winter months. The construction of the treatment plant is being managed by FEDEMUR, which is the administrative company that has supervised the workers of the Río Azul landfill for the past two years (Jorge Cardoza, personal communication, June 17, 2003).

WPP is in charge of the operation of the landfill. This company is aware of the problems caused by the landfill, which affect the water, the air, the animals, and the health of nearby residents. Nearby water supplies are contaminated by leachates, the air is contaminated by biogases, and the ground used for the landfill causes a fauna barrier. According to Jorge Cardoza, there have been several reports of headaches, skin conditions, and cancer cases of residents that live in close proximity to the landfill (Jorge Cardoza, personal communication, June 17, 2003).

Los Mangos

Santa Ana utilizes the landfill Los Mangos, which is located in Alajuela (Refer to Appendix U). The landfill has a fifty kilometer service diameter and takes in approximately 550 metric tons of waste per day, charging 4,600 colones per ton of waste.

Los Mangos complies with all the rules administered by El Ministerio de Salud, which is why the dumping fee is 1,000 colones more per ton than that of Río Azul (Douglas Alpízar Villalobos, WPP Engineer, personal communication, June 21, 2003).

Thirty years ago this landfill was a dump. WPP took over the site ten years ago, but before WPP could begin construction of the landfill it had to take 10,000 metric tons of waste out of the nearby river, Río Itiquis (Douglas Alpízar Villalobos, personal communication, June 21, 2003).

Twenty-seven hectares of the landfill can be used for landfilling and the remaining seven hectares constitute the area around the landfill's edge, thus serving as a buffer zone between the landfill and the nearby community. The landfill has between four and five years remaining before its capacity is reached. When the landfill is capped, it will be turned into a park for the community (Douglas Alpízar Villalobos, personal communication, June 21, 2003).

The landfill is currently in its fifth phase. Each phase is protected with a geomembrane, a layer of plastic, which is placed over the bottom layer of clay. The leachate collection system is placed over the impermeable layer and sand is placed on top of the leachate collection system to improve drainage. Waste is placed in three meter layers and then covered with dirt until ground-level is reached. When the ground-level is reached, waste is piled up on a thirty-three percent grade (Douglas Alpízar Villalobos, personal communication, June 21, 2003).

Each phases' leachate collection system pumps the water that is collected on the impermeable layer into a collection pipe. The contaminated water is then pumped into a truck that transports it to the treatment facility of Kimberely-Clark, which is located in

San Antonio de Belen. Every month, a chemical analysis is performed on the leachate pipes to check for their contamination levels. Los Mangos plans to construct a treatment plant on-site within two to three years (Douglas Alpízar Villalobos, personal communication, June 21, 2003).

The landfill checks underground water contamination on a monthly basis from five different points in the landfill. Three of these points are located near the river that spans approximately one-third of the landfill's perimeter, one at the beginning of the river, one in the middle, and one at the end. This placement ensures that the water is not becoming contaminated at any point (Douglas Alpízar Villalobos, personal communication, June 21, 2003) .

Everyday, the waste is leveled with a small bulldozer and then compacted. A daily cover of dirt is placed over the waste to contain odors and infestation. In addition, the landfill has eight methane flares to burn the methane gas before it enters the atmosphere, hence reducing odors. Within a few years, WPP intends to construct a production plant for electricity that will utilize the landfill's methane emissions (Douglas Alpízar Villalobos, personal communication, June 21, 2003).

Social Benefits

The proper management of solid waste in its entirety creates positive impacts on health, water quality, and environmental aesthetics. Landfills aid in solving issues of public health problems in Costa Rica, as the management of solid waste is an integral issue. While in operation, landfills create job opportunities for the surrounding communities. In addition, the construction of a landfill requires the repaving of nearby roads for the transportation of waste, which benefits all travelers (EBI, 2003). Landfills

also present future benefits, such as the production of electricity and the transformation of land into an ecological park. When landfills are capped, methane is collected and sold to power plants that use it as a source of electricity (Roberto Fallas, personal communication, June 12, 2003).

III. METHODOLOGY

The goal of this CICA project was to improve the current waste management systems in the Costa Rican municipalities of San Isidro de Heredia, Escazú, and Santa Ana based on the principle of sustainable development. To accomplish the project's goal we did a comparative analysis between the management of solid waste in two United States towns and three Costa Rican municipalities. Our primary objective in completing the analysis was to recommend sustainable changes in the three Costa Rican municipalities' waste management systems.

We researched the methods of waste management in the two U.S. towns of Shrewsbury and Clinton, MA prior to our arrival in Costa Rica. While in Costa Rica, we investigated the waste management systems in the municipalities of San Isidro de Heredia, Escazú, and Santa Ana. The methods of interviews and observations were used to collect data and information on each municipality's budget for solid waste management, the types of equipment and number of workers used for solid waste removal, and the conditions and management of disposal sites and recycling centers.

To achieve our primary objective, we completed an evaluation of the current methods of solid waste management in the three Costa Rican municipalities. As the first step in the evaluation, we conducted interviews with the administrative personnel in the solid waste management department of each municipality. The administrators interviewed provided us with copies of financial documents related to waste management, along with the opportunity to ask specific questions regarding the municipality's methods of collection and disposal. We visited landfills and recycling centers utilized by the municipalities and conducted interviews with their managers.

These interviews and visits provided us with operational information about the sites, as well as an applied perspective of the current situation. The group explored Costa Rica's legislation for waste disposal that is mandated by the regulating body El Ministerio de Salud (Refer to Appendices BB-EE). We contacted a Costa Rican environmental group to obtain its views on the enforcement of waste disposal laws and the environmental dangers caused by landfills. In addition, we researched the buying power of a dollar in Costa Rica to normalize cost data.

We developed a questionnaire in both Spanish (See Appendix K) and English (See Appendix L) that consisted of the questions needed for a complete and concise evaluation of each municipality's waste management system. The questions focused on the municipalities' demographics and the financial and operational details of their solid waste management system.

Answers to the questions regarding demographics provided us with information on the number of families who receive the waste and recycling services in each municipality. We compared the number of trucks and workers to the number of people receiving the service to make an evaluation of each system's efficiency. Demographical data was also utilized when we compared the waste production of each municipality, as it was compared in terms of one thousand residents.

Financial records on the municipalities' waste management budget supplied us with information pertaining to their financial capabilities and expenses. We examined the financial breakdown of each municipality's budget. Each budget consists of eight major categories: wages, tipping fees, non-personal services, maintenance and repair, materials and supplies, depreciation, administration, and assets for future development.

The group also obtained information on the deficit incurred by each municipality due to its waste management services. Our analysis used the above information to formulate comparisons concerning how the municipalities are budgeting their money for waste management, and to make recommendations on how to more efficiently allocate their financial resources.

Other important costs were also acquired during the interviews. We obtained the monthly fee that each household must pay for solid waste services to find out how much money the municipalities should be receiving in return for their services. In addition, the group obtained information regarding the number of metric tons of waste that are produced by the municipalities each year and the fee to dispose of each ton of that waste in a landfill. The group used the information to calculate the municipalities' efficiency for waste generation and disposal costs.

Operational information acquired from the municipalities made it possible for us to gain an understanding of how efficiently each municipality is using its capital resources. The interviews provided us with information on the number of workers each municipality employs for waste disposal and recyclable pickup and how often they collect both waste and recyclable items. We then obtained information from each municipality on the number and types of trucks they own and each truck's capacity for waste and recyclable collection. The group used the above information to calculate ratios to be utilized in the analysis of each municipality's waste management efficiency. The ratios included the number of workers per truck, the number of trucks per 10,000 inhabitants, and the number of workers per 10,000 inhabitants. By examining these

ratios, we determined how each municipality should modify its collection system to operate more efficiently.

We visited two landfills maintained by Waste Placement Profession (WPP) and one recycling center used by the municipalities, in addition to the private sanitary landfill in Uruca that is managed by Empresas Berthier (EBI). We interviewed the engineers who maintain the landfills and the operational manager of the recycling center. The interviews and visits served to obtain the facilities' financial and operational information, as well as to gain a visual perspective of the methods of disposal that are currently implemented in Costa Rica.

By interviewing the engineers of the three landfills, we obtained operational information that made it possible for us to understand how each of the disposal sites functions. A questionnaire was created in Spanish (Appendix M) and in English (Appendix L) and was given to the managers of the landfill to fill out to provide us with information on the maintenance methods used by the sites. We learned whether the landfills had an impermeable layer, methane emission flares, leachate collection systems, and leachate treatment plants. By touring the landfills, we saw whether these systems are actually utilized. The group then used the above information to compare the measures of environmental protection employed by each landfill. The three landfills were then compared to a landfill in the United States, and recommendations were made for the improvement of the Costa Rican landfills make their practices less environmentally-hazardous.

The operational capability of the recycling center was important for gaining a better understanding of Costa Rica's waste management systems. The interview with the

manager of the center provided us with the knowledge of the types of items that can be recycled and the storage capacity of the center. This information aided us in understanding the amount and types of waste that can be diverted from landfills.

We then examined Costa Rica's national legislation pertaining to the management of solid waste that is mandated by El Ministerio de Salud. We read the laws to educate ourselves on Costa Rica's restrictions and regulations for the management of solid waste. We then used this knowledge, in conjunction with our comparative analysis of the municipalities and disposal sites, to make recommendations for the improvement of the municipal solid waste systems of Santa Ana, Escazú, and San Isidro de Heredia.

For the final part of our procedure, we normalized our financial data by researching the buying power of a dollar in Costa Rica. Buying power is "the potential dollar amount available (after-tax income) to spend on goods and services (http://www.laopinion.com/corporate/market_research/buying _power/index.phtml?lang=en)." The group contacted the U.S. Embassy in San Jose, Costa Rica, and was told that the dollar has approximately forty percent times more buying power in Costa Rica than in the United States. We then normalized the United States cost data by multiplying all the values by 0.71 in our results section.

IV. RESULTS

The following data presents demographics, waste collection, recycling abilities, disposal methods, and costs for the overall management of solid waste in each of the five municipalities. The significance of our data is explained within this chapter. It is important to note that all the United States towns' monetary values have been multiplied by a factor of 0 .71 to normalize them with the buying power of a dollar in Costa Rica. Also, the U.S. towns' values were presented in colones to allow a more meaningful comparison. The towns of Clinton and Shrewsbury, MA were utilized as models for comparison to the Costa Rican municipalities. These two U.S. towns abide by all U.S. and Massachusetts laws and regulations regarding the collection and the disposal of waste. Therefore, the towns serve as examples of good practices of waste management principles in the U.S. These good practices were compared with each Costa Rican municipality and recommendations were made accordingly.

Table 1. General Data of Municipalities *

	Population	Cost (Col/Month)	Tons of Waste/1000 Residents (2002)
San Isidro	17,000	807	291
Santa Ana	35,000	1,200	286
Escazú	54,000	933	235
Clinton	13,435	2,221 ($5.68)	203
Shrewsbury	31,640	2,545 ($6.51)	345

* This table lists all five municipalities and shows the population, the cost for collection of waste per month (in colones), and the tons of waste produced per 1,000 residents in the year 2002.

Table 1 contains information needed to analyze each system. The purpose of the analysis was to determine the efficiency of each municipality's system of the

management of solid waste. The municipality's population was used throughout the analysis as a common factor to ensure that data was being compared on equal grounds with respect to population sizes. The number of tons of waste produced per 1,000 residents relates to efficiency, as an efficient system reduces the amount of waste produced per person. However, it would not be sufficient to define an efficient system solely in terms of the amount of waste produced per person. Shrewsbury, MA, for example, has the most sanitary and environmentally-conscious system for management of waste; however, Shrewsbury's residents produce the greatest amount of waste when compared to the other four municipalities. The cost per month is the fee that is supposed to be paid by each household for the removal of solid waste. Santa Ana, for example, charges its households two hundred sixty-seven colones more per month than Escazú does for the removal of solid waste.

Table 2. Waste Collection *

	Collection of Waste Per Week	# of Veh./10,000 Residents	# of Workers/ 10,000 Residents	Relation of Workers With Clinton	# of Workers/ Veh.	Relation of Workers to Vehicle with Clinton
San Isidro	2	0.59	4.7	2.11	8	2.67
Santa Ana	2	0.88	4	1.79	4.67	1.56
Excazú	2	0.93	2.78	1.25	3.2	1.07
Clinton	1	1.49	2.23	1	3	1
Shrewsbury	1	N/A	N/A	N/A	N/A	N/A

* This table lists all five municipalities and shows the number of collections of solid waste per week, the number of vehicles used for the collection of solid waste per 10,000 residents, the number of workers per 10,000 residents, number of workers in relation to Clinton, the number of workers per truck, and the number of workers per truck in relation to Clinton.

We used the information in Table 2 when making a comparison of the systems of the collection of waste. In the three Costa Rican municipalities of interest, the collection

of waste occurs twice per week, whereas collections occur once per week in the two U.S. towns of interest. Collection occurs twice per week in Costa Rica due to the tropical climate, coupled with the fact that more than half of Costa Rica's waste is biodegradable. Therefore, Costa Ricans need their waste removed as often as possible to reduce odors caused by high humidity and temperatures (Ronald Arieta, personal communications, June 10, 2003).

To understand each municipality's vehicle-operating efficiency, the number of vehicles was divided by a factor of 10,000 residents. The more trucks that a municipality uses per 10,000 residents, the more likely it is that the municipality will be able to adjust to residential growth. The ability to adjust to residential growth is highly dependent on the town in question. Therefore, the ability to adjust to residential growth will be explored in each town's individual analysis. The reason Clinton has more trucks is because it owns one extra truck that is only used when the regular truck breaks down.

To understand each municipality's personnel efficiency, the number of workers per 10,000 residents was calculated. This data was used to identify an excess of employees, which is the case in two municipalities. The number of workers per 10,000 residents should be under three in order to be considered efficient for the population served. The number of workers per truck may however change if the town is densely populated. The trucks that run in the city of San Jose, for example, may need more than three workers per truck due to the much larger production of waste in this densely-populated area. Clinton, MA, for example, is able to effectively manage its waste with 2.23 workers per 10,000 residents, while San Isidro uses 4.70 workers per 10,000 residents. When this comparison is made, coupled with the fact that San Isidro only has

0.59 trucks, it is evident that San Isidro has too many workers in its current system for the management of solid waste. The money used to pay the excess number of workers could therefore be used more effectively and could thus improve the current system. Having analyzed the waste management systems of the two U.S. towns, it is our belief that the Costa Rican municipalities should aim toward employing no more than three workers per truck.

The relation of workers per 10,000 residents was made for each municipality with respect to Clinton to show the excess number of workers used for solid waste management in some Costa Rican municipalities. This data strengthens the previous argument and shows that San Isidro has 2.11 times more workers per 10,000 residents than does Clinton. The number of workers per truck was also calculated to show the severity of the excess number of workers that are employed in specific municipalities for the amount of equipment each municipality operates.

Table 3. Municipality's Ability to Recycle *

	# of Veh./ 20,000 Res.	# of Work./ 20,000 Res.	% With Access to Recycling Program	Recyclable Items
San Isidro	1.17	2.35	10	Plastic, Paper, Glass, and Cardboard
Santa Ana	0.57	1.14	95	Plastic, Paper, Glass, Cardboard, and Aluminum
Excazú	0.37	1.48	60	Plastic, Paper, Glass, Cardboard, and Aluminum
Clinton	0	0	100	Plastic, Paper, Glass, Cardboard, and Aluminum
Shrewsbury	N/A	N/A	100	Plastic, Paper, Glass, Cardboard, and Aluminum

* This table lists all five municipalities and shows the number of vehicles used for the collection of recyclable items per 10,000 residents, the number of workers for recycling per 10,000 residents, the percentage of the municipality with the current ability to recycle, and the types of items that are currently being recycled.

We used the data in Table 3 to analyze the recycling ability of each municipality. The number of vehicles and workers per 20,000 residents served to examine the Costa Rican municipalities' future abilities to expand their recycling programs. The percentage of the population with the current ability to recycle is noted to provide an understanding of the expansion of service needed in each municipality. Only ten percent of the population from San Isidro, for example, is provided with the service of recycling. Therefore, the need to expand the recycling program in this municipality is great;

however, the municipality's ability to expand the program is still questionable. We also list the items that are currently being recycled within each municipality to make comparisons and provide recommendations regarding additional items that should be recycled.

Recycling is not mandatory in any of the five municipalities, although by forcing residents to recycle, the programs will become more effective. It would be very hard to enforce recycling in Costa Rica, which is exemplified in San Isidro's situation. San Isidro is unable to collect monthly payments from a small percentage of the town, which therefore makes the expansion of the program very difficult. Clinton does not have a curbside pickup service for recyclable items. Therefore, there are neither workers nor trucks in this part of Clinton's system.

Table 4. Disposal Site Information*

	Cost Per Ton (¢)	**Form of Disposal**
San Isidro	2,400	Landfill
Santa Ana	4,600	Landfill
Excazú	3,400	Landfill
Clinton	19,700 ($50.40)	Landfill
Shrewsbury	17,300 ($44.37)	Incineration, then Landfill

* This table lists all five municipalities and shows the cost for the disposal of solid waste per ton, and the form of disposal that each municipality uses.

Table 4 lists disposal costs and the method of disposal that is currently used by each municipality. The total amount Shrewsbury pays for incineration and landfilling, as compared to the cost Clinton pays, is much lower. This differnece exists because

incineration reduces the mass of the waste by ninety percent, so tipping fees are greatly reduced (Nancy Allen, personal communication, March 31, 2003).

Table 5. Budget Efficiency *

	Per Capita Cost (¢)	% of Defecit	% of Budget Consisting of Wages	% of Budget Consisting of Tipping Fees
San Isidro	2,488	3.8	33	28
Santa Ana	4,739	31	35	28
Escazú	3,127	+	30	26
Clinton	8,700 ($22.12)	27	25	60
Shrewsbury	9,800 ($25.16)	+	N/A	54

* This table lists all five municipalities and shows the total cost per capita, the percentage of the waste management budget represented by the deficit (incurred in the year 2002), the percentage of the total cost to the municipality that is paid to the workers as wages, and percentage of the total cost to the municipality that is paid to the landfill in the form of tipping fees.

Table 5 shows the overall costs related to each municipality's waste management system, and it provides a general example of the system's efficiency. The table also provides the annual per capita cost. A high per capita cost can be a sign of inefficiency, as it can mean that residents are paying too much for waste removal services. Because all financial aspects must be considered when making recommendations, the percentage of each municipality's waste management budget that is the deficit is also important to note. Personnel costs are noted because we observed that the Costa Rican municipalities of Santa Ana and San Isidro both have an excess of workers and incur a deficit due to waste management services. A municipality that employs an excess number of workers is increasing its deficit—an observation that will be a topic of recommendation. The percentage of the budget that consists of tipping fees was also provided.

Table 6. Costs per 10,000 Residents (¢) *

	Wages	Non Personnel Services	Materials and Supplies	Lease Mantenance and Repair	Depreciation	Tipping Fees	Admin.	Future Assets
San Isidro	8,307,285	432,170	3,359,903	514,706	964,158	6,981,782	2,056,000	2,261,600
Santa Ana	16,331,193	2,945,714	5,289,714	314,286	631,654	14,285,714	3,979,828	4,377,810
Escazú	8,929,585	2,470,090	3,832,044	1,073,502	1,259,086	8,282,626	2,584,693	2,843,163
Clinton	21,672,177	0	0	8,265,278	0	52,377,889	4,192,355	0

* This table displays all aspects of the budgets for the four municipalities of San Isidro, Santa Ana, Escazú, and Clinton. The actual costs were broken down to the money spent per 10,000 residents.

The benefits of the data in this table are immediately noticeable after breaking down the costs per 10,000 residents, as it is easy to identify in which areas each municipality is spending too much money. We used the above data to strengthen our recommendations for each municipality and to adjust its costs in specific areas by reallocating financial resources. An easier and more meaningful comparison can be made when the data of each municipality is compared according to a common factor, as demonstrated above. Santa Ana, for example, pays double the wages per 10,000 residents, as compared to the two other Costa Rican municipalities. In addition, Santa Ana's tipping fee (cost for disposal of waste in a landfill) is significantly higher, as compared to the other municipalities.

V. ANALYSIS OF RESULTS AND RECOMMENDATIONS

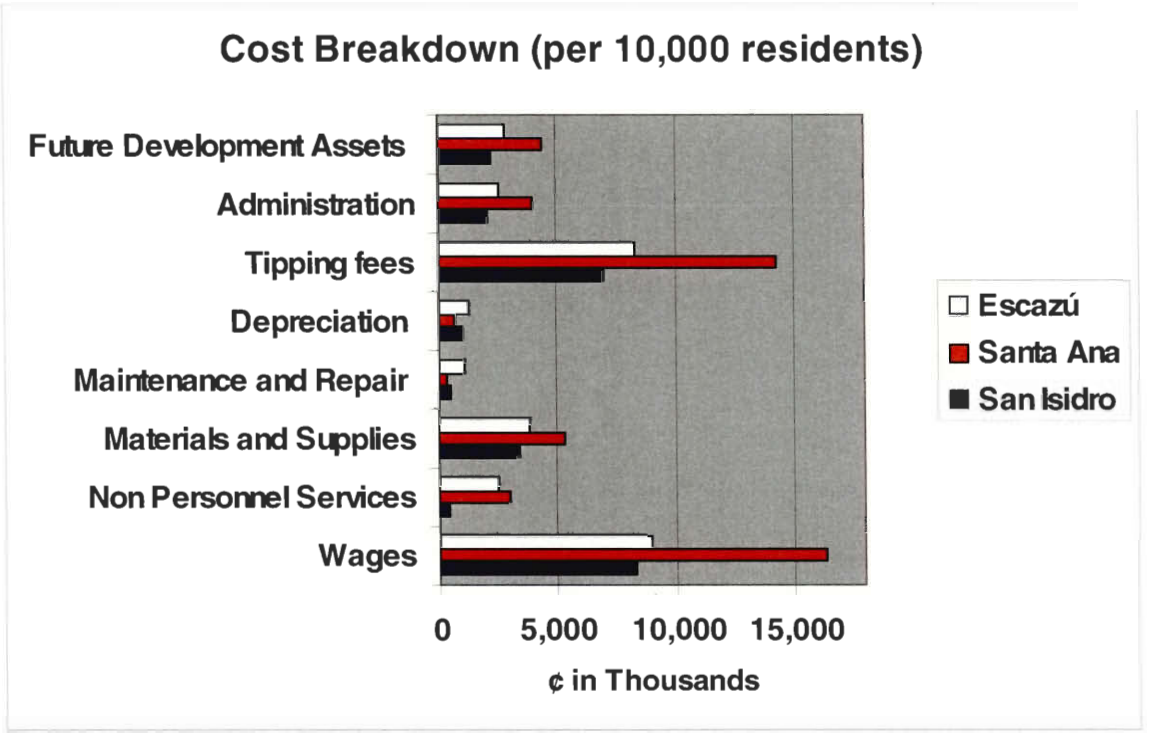


Figure 3: This chart presents the cost breakdown for the three Costa Rican municipalities per 10,000 residents.

Analysis of Santa Ana

Of the three Costa Rican municipalities, Santa Ana has the highest deficit at thirty-one percent of its total budget for the management of solid waste. The above graph identifies the cause of this deficit, as it is evident in the categories of tipping fees and wages that Santa Ana pays a significantly higher amount of money per 10,000 residents than the other Costa Rican municipalities. According to the data presented in the previous chapter, Santa Ana has a poor system for the collection of waste, a highly inefficient program for recycling, poor disposal methods, and excessive costs in 2002.

Collection

Santa Ana charges the households that receive the service of waste collection 1,200 colones per month. Compared to the other Costa Rican municipalities, this number is the greatest; however, this sum of money is not sufficient to cover the cost of its waste management system. Therefore, Santa Ana does not utilize its funds efficiently, as will be explained further. Santa Ana produces two hundred eighty-six tons of waste per 1,000 residents, which is high. This high generation of waste could be the result of an inefficient recycling program. The large amount of waste produced, coupled with the high price the municipality pays per ton of waste dumped, explain why Santa Ana's tipping fees per 10,000 residents are 6,000,000 colones more than those of Escazú.

Santa Ana has a vehicle-operating efficiency of 0.88 trucks per 10,000 residents, while the desirable ratio is one truck per 10,000 residents. Implications of vehicle-operating efficiency are the municipality's ability to handle future residential growth and expansion. The town of Clinton has 1.49 trucks per 10,000 residents; however, Clinton owns a truck that is not used on a regular basis. This truck is used only when the daily truck encounters maintenance problems. Therefore, Santa Ana's vehicle-operating efficiency is reasonable. Alberto Durano, the municipal director of the management of solid waste in Santa Ana, told us that Santa Ana will be purchasing a new truck next year, which will raise its vehicle-operating efficiency to 1.14 trucks per 10,000 residents. If Santa Ana maintains a ratio close to one truck per 10,000 residents, then an increase in the number of residents that receive the service of waste collection due to residential growth and expansion will be manageable until the ratio drops below 0.70 trucks per 10,000 residents.

The municipality of Santa Ana has a worker efficiency of four workers per 10,000 residents; however, there exists no need to employ any more than three workers per 10,000 residents for the collection of waste. The municipality would be able to manage the current load of waste produced with three workers per 10,000 residents, in addition to be able to handle residential growth. It is important, however, that the ratio does not go below two workers per 10,000 residents.

The town of Clinton efficiently provides the service of waste collection to its residents with a ratio of 2.23 workers per 10,000 residents. Therefore, a comparison of all Costa Rican municipalities to Clinton, which serves as a baseline of an efficient system, was made. Santa Ana has 1.79 times the number of workers per 10,000 residents than does Clinton, which further supports the conclusion that Santa Ana employs an excess of workers.

Another aspect of collection that was calculated is the number of workers per truck in each municipality's solid waste collection system. Santa Ana has 4.67 workers per truck, where as in the United States the norm is to have three workers per truck, especially in residential areas. Clinton has the desirable three workers per truck, so a relation to Clinton and the Costa Rican municipalities was calculated. We noticed that Santa Ana has 1.56 times the number of workers per truck than does Clinton, which is very high, especially since Santa Ana is not a densely populated municipality. Santa Ana is primarily residential, so there are few areas that will be generating larger quantities of waste, which would require more than three workers per truck. By employing more workers than is necessary, the municipality is adding to its large deficit.

Recycling

Recycling is currently an option in Santa Ana; however the program is not well-developed. Recyclable items could be picked up from ninety five percent of its residents, since only five percent live in the mountainous region; however, only ten percent of Santa Ana's residents utilize this service. The recycling center is small, and the municipality lacks sufficient funds to expand its current program.

A sufficient vehicle-operating efficiency for recycling is 0.75 trucks per 20,000 residents, as recycling pick-up need only be done once per week and the volume of recyclable material is low compared to that of solid waste. Therefore, one truck could easily collect the recyclable material from more than 20,000 residents (Tom Murray, personal communication, May 1, 2003). The vehicle-operating efficiency for the service of recycling was calculated for the municipality of Santa Ana per 20,000 residents. Currently, Santa Ana owns 0.57 trucks per 20,000 residents, which is low and needs to be remedied.

The number of workers employed for the recycling service per 20,000 residents was also calculated for Santa Ana. Currently, Santa Ana employs 1.14 workers per 20,000 residents. For a town to service its residents properly, it should employ a minimum of two workers per 20,000 residents (Tom Murray, personal communication, May 1, 2003). Since only ten percent of the residents actually recycle, it seems obvious that the problem lies within the fact that the residents lack knowledge on the benefits of recycling.

Costs

The municipality of Santa Ana collects and transports all of its waste to a landfill located in Alajuela. The fee to dispose of its waste in the landfill is 4,600 colones per

metric ton. This cost is quite high, as a significantly more advanced landfill located in Uruca charges only 3,900 colones per ton. Unfortunately, that landfill currently services solely central San José. Yet another point of reference is the landfill located in Río Azul, which charges 3,400 colones per metric ton of waste disposed. Therefore, Santa Ana is paying a great deal more per ton than is necessary.

The costs that Santa Ana incurs are very high, and with a deficit of thirty-one percent, costs need to be lowered. If all residents split evenly the cost for the entire system for the management of solid waste in 2002, the per capita cost would be 4,729 colones. This fee is much higher than that of Escazú, and it is almost double the per capita cost in San Isidro.

A significant part of Santa Ana's budget consists of wages (thirty-five percent). Wages include both the salaries paid to workers and the workers' benefits. According to Table 6 on page 44, the wages spent by Santa Ana per 10,000 residents totaled over 16,000,000 colones, while the municipalities of Escazú and San Isidro each spent about 8,000,000 colones. Therefore, Santa Ana spent double the amount on wages per 10,000 residents than in both Escazú and San Isidro in 2002. Twenty-five percent of Clinton's budget is spent on wages, while Santa Ana spends thirty-five percent on wages. Our liaison, Dr. Ronald Arietta, conducted a study in 2002 that showed that the average percentage of the budget spent on wages is 25.7 in eleven local Costa Rican municipalities (Martin, 2003). The results of this study further support the conclusion that Santa Ana employs too many workers for its waste management system.

Non-personnel services in Santa Ana were seven percent of the budget in 2002. Non-personnel services include any costs for temporary workers and consulting fees.

When compared to Escazú and San Isidro, the fee incurred per 10,000 residents in Santa Ana is highest. (Clinton includes non-personnel services in the wages category of its budget.). In Dr. Arietta's study, eleven local municipalities averaged 7.50 percent of the budget for non-personal services (Martin, 2003). Although Santa Ana is below this average, the municipality still needs to consider ways to lower the costs in this area.

Materials and supplies for the municipality of Santa Ana consist of eleven percent of its budget. The category of materials and supplies consists of gloves, masks, uniforms, and any other supplies that are needed for the collection of waste. This category does not include, however, any supplies needed for the trucks. When percentages are compared, San Isidro uses fourteen percent and Escazú uses twelve percent of its budget on materials and supplies. Dr. Arietta's study shows that the average percentage of the budget consisting of materials and supplies is 12.3 percent (Martin, 2003). In 2002, Santa Ana spent 5,000,000 colones, San Isidro spent 3,000,000 colones, and Escazú spent 4,000,000 colones per 10,000 residents. Therefore, Santa Ana is once again paying far more for a service than the other two Costa Rican municipalities.

Lease, maintenance, and repairs are all equipment-related costs regarding the trucks (Figure 4, and Figure 5). This category includes the cost for any parts, the monthly payment on the trucks, and the fees owed to mechanics. In 2002, Santa Ana spent one percent of its budget in this category, while San Isidro spent four percent and Escazú spent three percent. Not only did Santa Ana spend the lowest percent of its budget on this category, but it also had the lowest maintenance fees per 10,000 residents, which suggests that Santa Ana is efficiently maintaining its trucks.

Figure 4: One of Santa Ana's Waste Collection Trucks

Figure 5: Another One of Santa Ana's Waste Collection Trucks

Tipping fees compose the annual amount that must be paid to dump a municipality's waste in a landfill. Santa Ana and San Isidro each spent twenty-eight percent of its budget on tipping fees, while Escazú spent twenty-six percent. These numbers are misleading because once the cost for tipping fees is broken down to 10,000 residents, there actually exists a large difference between the amount spent by Santa Ana and the amounts spent by Escazú and San Isidro. In 2002, Santa Ana spent 16,000,000 colones per 10,000 residents, while Escazú and San Isidro spent 8,000,000 and 7,000,000 colones, respectively. Therefore, Santa Ana spent more than double on tipping fees than did both Escazú and San Isidro. The high cost is due to the large production of waste (three hundred ninety-one more tons per 10,000 residents than Escazú), and the high fee per ton dumped (1,200 colones more per ton than Escazú). The amount spent for tipping fees in 2002 by the municipality of Santa Ana per 10,000 residents was far too high.

Recommendations for Santa Ana

Santa Ana has a system of solid waste management that is neither cost-efficient nor environmentally-beneficial. The municipality spends the majority of its budget on

wages and tipping fees, which are expenses that must be lowered. To lower Santa Ana's current deficit, the municipality also needs to increase awareness of the recycling program that is available to its residents. Santa Ana will need to reduce additional costs that increase the deficit incurred by Santa Ana. Lastly, the municipality will need to implement a system for composting, which will effectively reduce the amount of waste produced. This system will be explained later , as all three Costa Rican municipalities will need to implement a similar system.

Recycling

The increase in the use of the recycling program should also be a top priority to Santa Ana. Santa Ana currently produces an excessive amount of waste per 1,000 residents. However, with an increase in the use of the recycling program, the municipality would decrease its production of waste. For this expansion to be effective, there are several steps that must be accomplished by the central government. The municipality first needs to increase the awareness of its residents of the environmental benefits of recycling. The government should then increase the size of its recycling facility to effectively manage the increased amount of recyclable items.

To increase environmental awareness of the benefits of recycling, Santa Ana should create an informational pamphlet that focuses on the effects that the lack of an efficient recycling program has on the environment. The details of this pamphlet will be discussed later, as San Isidro should create a similar pamphlet.

Currently, Santa Ana has a small recycling center that accepts paper, plastic, cardboard, and glass. However, the municipality needs to expand its program to include aluminum. To double the space of the existing storage facility, Santa Ana need only pay

approximately 2,000,000 colones, which was the fee paid by La Casa Hogar Para Ancianos in San Isidro for the construction of its storage room. The additional space would allow for the efficient management of an increased volume of recyclable items, and the newly-extended storage room would be able to store the items gathered by all of Santa Ana's residents. If the center is unable to separate or sell items within a sufficient time period, then the municipality should consider increasing the number of employees. If the center is able to sell items reasonably quickly, however, storage space is an issue, then the construction of another new storage facility should be considered by the municipality.

Reduce Cost

Another important issue is Santa Ana's need to reduce its expenses. The total cost for the management of solid waste in Santa Ana is only 3,000,000 colones less than that of Escazú, a municipality that is home to an additional 19,000 people. The above recommendations are focused on reducing the amount of money spent on tipping fees by effectively reducing the amount of waste produced by the residents. There are, however, several other factors that also contribute to the deficit.

Wages, for example, need to be reduced, which can be done by relocating some workers and releasing others. One worker should be moved from the collection of waste to the collection of recyclable items. This will provide the recycling service with three workers per truck so that the program will be better equipped to handle the increase in the amount of items recycled. One other worker from the collection of waste should be relocated to manage the new composting facility, which can easily be managed by one person. This relocation of two workers will reduce Santa Ana's worker efficiency to 3.40

workers per 10,000 residents. The reduction of workers in the waste collection department does not, however, reduce the fee that must be paid in wages, and the number of workers per 10,000 residents is still 1.53 times higher than that of Clinton. If two workers are released, then the deficit will be decreased by 8,000,000 colones, which is fifteen percent of the deficit. The release of workers will reduce the worker efficiency to 2.87, and it will create a worker per truck ratio of 3.3. These figures are much more reasonable, as they will prove to help in the reduction of the deficit without compromising the quality of the waste collection service.

Non-personnel services consist of the wages that are paid to temporary workers. Temporary workers are those that are hired solely to cover for a full-time employee who is unable to work for a brief period of time. The only way to minimize this cost is to utilize ten workers, which consist of one driver and two collection men per truck. One worker either fills in for any missing worker or works as a forth man on one of the trucks on any given day. If the above model is followed, then the amount of money spent on non-personnel services will decrease and the deficit will therefore be reduced.

Materials and supplies is another section of the budget in which Santa Ana spends significantly more per 10,000 residents than do Escazú and San Isidro. With the reduction in workers and the relocation of workers, the amount spent on materials and supplies will decrease, which will also reduce the deficit.

Tipping fees is the cost incurred by the municipality to dispose of the waste produced by its residents. The expense will be reduced upon the expansion of the recycling system and the implementation of a composting system, as these systems will reduce the amount of waste produced per resident. Santa Ana pays 4,600 colones per

metric ton to dump its solid waste in the landfill of Los Mangos, which is located in Alajuela. Los Mangos will only be available for use for another six years. There is a landfill located in Uruca that is owned by EBI of Canada, which charges only 3,900 colones per ton to dispose of waste. EBI is planning to build a larger landfill near San José that will be able to service all municipalities in the Central Valley. EBI plans to begin the construction of this landfill within the next two years, so the municipality of Santa Ana should open a line of communication with EBI and discuss arrangements for the use of the new landfill. The current landfill managed by EBI charges less per ton than does Los Mangos, and it is considered environmentally-safe by U.S., Canadian, and Costa Rican standards.

Analysis of San Isidro

San Isidro incurred a deficit of 3.8 percent of its budget in 2002. Unlike Santa Ana, the cause of San Isidro's deficit is not easily identifiable from Figure 3 (presented earlier). In fact, we noticed that San Isidro appears to be more conscious of its spending per 10,000 residents, as the municipality actually spends less than the other two municipalities in every category, with the exception of one. Therefore, we concluded that the cause of this deficit is not due to excessive spending, but rather to a combination of an inefficient recycling program and system for the collection and disposal of waste.

Collection

San Isidro charges those households that receive the service of the collection of waste 800 colones per month. When compared to the other Costa Rican municipalities, San Isidro charges the lowest monthly fee. This fee, however, is not sufficient to cover the total cost for the collection and disposal of solid waste, and it therefore contributes to

San Isidro's deficit. Unfortunately, it would be extremely difficult to raise this fee (Siany Villalobos Argüello, Executive of solid waste system in San Isidro, May 19, 2003).

San Isidro has a vehicle-operating efficiency of 0.59 trucks per 10,000 residents, while the desirable ratio is one truck per 10,000 residents. Implications of vehicle-operating efficiency are the municipality's ability to handle future residential growth and expansion. The town of Clinton has 1.49 trucks per 10,000 residents. However, Clinton owns a truck that is not used on a regular basis. This extra truck is used only when the daily truck encounters problems that require maintenance. When compared to the other Costa Rican municipalities of Santa Ana and Escazú, which have vehicle-operating efficiencies of 0.88 and 0.93, respectively, it is evident that San Isidro is in need of another truck. The one truck that is owned by San Isidro is not sufficient to manage the collection of the population, as on some days the truck is forced to collect and dump twice. In addition, the truck is among the oldest waste collection trucks in the central valley, says Ms. Villalobos, and large sums of money are spent on its maintenance.

The worker efficiency for San Isidro was calculated to be 4.70 workers per 10,000 residents. However, there exists no need to employ any more than three workers per 10,000 residents for the collection of waste. When compared to the municipalities of Santa Ana and Escazú, which have worker efficiency ratios of 2.78 and 4.00, respectively, San Isidro's ratio is significantly high.

The town of Clinton is able to effectively provide the service of waste collection to its residents with a ratio of 2.23 workers per 10,000 residents. Therefore, a comparison of all Costa Rican municipalities to Clinton was made. San Isidro has 2.11 times the number of workers per 10,000 residents than does Clinton, which further

supports the conclusion that San Isidro employs an excess of workers. In comparison with Santa Ana and Escazú, which have relations of 1.79 and 1.25, respectively, San Isidro is again the least efficient.

Another aspect of collection that was calculated is the number of workers per truck in each municipality's solid waste collection system. San Isidro has eight workers per truck, where as in the United States it is uncommon to have more than three workers per truck, especially in a residential area. Clinton has the desirable three workers per truck, so a relation to Clinton and the Costa Rican municipalities was calculated. We noticed that San Isidro has 2.67 times the number of workers per truck as does Clinton, which a large difference. Employing eight workers for one truck is absolutely unnecessary. By employing more workers than needed, the municipality is adding to its deficit. San Isidro has only one truck for the municipality, and it employs eight workers that work on this one truck on a daily basis. This overstaffing is financially hurting San Isidro, and it needs to be remedied.

Recycling

Recycling is currently an option in San Isidro, but the program is not well-developed. Recyclable items are picked up from only ten percent of its residents, so if the remaining ninety percent want to recycle they must bring the items themselves to the small center. The truck that is currently used will not suffice for an increase in the collection of recycling; however, the municipality lacks sufficient funds to expand its current program due to its deficit.

The vehicle-operating efficiency for the service of recycling was calculated for the municipality of San Isidro per 20,000 residents. Currently, San Isidro owns 1.17

trucks per 20,000 residents. One truck could easily manage the collection of recyclable items from more than 20,000 residents (Tom Murray, personal communication, May 1, 2003). According to the number calculated for San Isidro, it appears that the municipality does not need to purchase a new truck at this moment. The truck that is currently used is a small pick-up truck with a capacity of only one ton (Figure 6). This truck can easily handle the current load of recyclable items, and it could even manage an increase of 3,400 residents before it reaches its capacity.

Figure 6: San Isidro's Recycling Truck

The number of workers employed for the recycling service per 20,000 residents was also calculated for San Isidro. San Isidro currently employs 2.35 workers per 20,000 residents. For a town to properly service its residents' production of recyclable items, it should employ a minimum of two workers per 20,000 residents (Tom Murray, personal communication, May 1, 2003). Since San Isidro employs more than two workers per

20,000 residents, and because the workers currently service only 1,700 residents, there exists no need to increase the number of workers for recycling.

Costs

The municipality of San Isidro collects and transports all of its waste to a landfill located in San Pablo. The fee to dispose of its waste in the landfill is 2,400 colones per metric ton. This cost is quite low as a result of the landfill's poor maintenance and inability to adhere to Costa Rican regulations.

The costs that the municipality of San Isidro incurs are not significantly high when compared to those of Santa Ana and Escazú. However, there are particular sections of San Isidro's budget that need to be evaluated and remedied to reduce the deficit. These sections include wages and maintenance and repair.

Thirty-three percent of San Isidro's budget goes toward wages, which is a high value. Escazú spends thirty percent on wages, and Clinton spends twenty-five percent on wages. San Isidro spent 8,000,000 colones per 10,000 residents in 2002. Although this number is lower than those of the other two Costa Rican municipalities, it still needs to be reduced.

San Isidro spends more per 10,000 residents on maintenance and repairs than do the other Costa Rican municipalities. This is due to the fact that the truck is old and breaks down often (Figures 7 and 8). Each time a problem arises, an outside mechanic is called in. It is evident that San Isidro is spending large quantities of money on a truck that should be replaced.

Figure 7: San Isidro's Waste Collection Truck (side)

Figure 8: San Isidro's Waste Collection Truck (front)

Recommendations for San Isidro

San Isidro has a system of solid waste management that is neither efficient nor environmentally-beneficial. The municipality spends the majority of its budget on wages, and it also spends a great deal on maintenance and repairs. To lower San Isidro's current deficit, the municipality needs to expand the recycling system, decrease spending on wages, and implement a system for composting, which should be done by all three Costa Rican municipalities.

Recycling

The expansion of the recycling program should be a top priority. San Isidro currently produces the largest amount of waste per 1,000 residents; however, with the expansion of the recycling program, the municipality can decrease its production of waste. For this expansion to be effective, there are several steps that must be accomplished by the central government. The municipality first needs to increase awareness of its residents for the environmental benefits of recycling. The government should then increase the size of its recycling facility to effectively manage the increased amount of recyclable items. San Isidro should also increase the lengths of its route on a

bi-monthly basis to allow for the adjustment of the recycling facility to the increase in items. Once San Isidro collects from approximately 20,000 residents, an evaluation of the efficiency of the system should be conducted according to specific criteria; vehicle-operating efficiency, worker efficiency, and facility efficiency.

To increase environmental awareness of the benefits of recycling, San Isidro should create an informational pamphlet that focuses on the effects that the lack of an efficient recycling program has on the environment. A similar pamphlet is needed by Santa Ana as well, therefore the details of the pamphlet will be described later in a general format.

Currently, San Isidro has a small recycling center that accepts paper, plastic, glass, and cardboard; however, the municipality needs to expand its program to include aluminum. To double the space of the existing storage facility, San Isidro needs only pay approximately 2,000,000 colones to construct another storage facility like the one already located at the senior home. The additional space will allow for the efficient management of an increased amount of recyclable items, and the newly-extended storage room will be able to store the items gathered by all of San Isidro's residents.

The expansion of the recycling program to include the entire municipality involves three major modifications: an increase in the number of routes, an increase in the number of residents included on each route, and a new truck for collection. The increase in the number of routes should be done on a bi-monthly basis, at which points an additional ten percent of the municipality's population will receive the service of collection. For the service of collection to be successful, the routes should be planned in advance and the residents should be notified of the day that their recycling service is to

begin. If the above model is followed, then all residents of San Isidro will have the option of utilizing the collection service within eighteen months of the start of the plan.

Once San Isidro's recycling program services 5,100 residents, an evaluation of the program should be made, which would be after about four months. An evaluation of the number of workers must also be made, which will ideally demonstrate the employment of two or three workers. More importantly, however, is an evaluation of the truck. The municipality will have to consider the truck's capacity, the workers' ability to manage the amount of recyclable items collected, and the recycling center's ability to store the items.

If the truck is beyond its capacity at this point, then the purchase of a new truck should be considered. However, if the truck is not beyond its capacity, then the purchase of a new truck can wait. If the latter is the case, then an analysis of the truck's capacity must be done every other month until the truck reaches its capacity. At this point, San Isidro will then need to decide if sufficient funds are available and if the purchase of a new truck is a feasible option.

If San Isidro employs three workers to manage the one truck, then an increase in the number of workers is unnecessary. The number of employees, however, is dependent on the budget and the available funds. The recycling program can be managed by two workers, so if three are employed for the collection of recyclable items then one worker should be released.

Lastly, San Isidro needs to evaluate the recycling facility itself. It is important that the center be able to separate, store, and sell the recyclable items that are collected. If the center is unable to do so, then the municipality should consider increasing the

number of employees. If storage space is an issue, then the construction of a new storage facility should be considered.

Reduce Costs

The above recommendations are focused on reducing the amount of money spent on tipping fees by effectively reducing the amount of waste produced by the residents. There are, however, several other factors that also contribute to the deficit. Wages, for example, need to be reduced, which can be accomplished by relocating some workers and releasing others.

One worker should be relocated from the collection of waste to the collection of recyclable items. This relocating will provide the recycling program with three workers per truck so that the program will be better able to handle the increase in the amount of items recycled. One other worker from the collection of waste should be relocated to manage the new composting facility, which can easily be managed by one person. This relocation of two workers will reduce San Isidro's worker efficiency from 4.70 to 3.50 workers per 10,000 residents. This reduction of workers in the collection of waste, however, does not reduce the total that must be paid in wages, and the worker efficiency is still 1.60 times higher than that of Clinton. If three workers are released, then the deficit will be decreased by 4,870,000 colones. The release would therefore bring San Isidro's account to a positive 3,251,000 colones and the deficit would no longer exist. The release of workers would also reduce the worker efficiency to 2.10, and it will create a worker per truck ratio of 3.00. These figures are much more reasonable, as they will prove to help in the elimination of the deficit without compromising the quality of the waste collection service.

As previously mentioned, maintenance and repairs is another problematic section of San Isidro's budget. The municipality spent 875,000 colones on maintenance and repair on its sole truck that is used for the removal of waste. With the reduction of workers, 3,251,000 colones will be saved to purchase a new truck. In addition, if a ten percent reduction of waste from the expansion of the recycling program and the institution of a composting system results, San Isidro will save an extra 1,330,000 colones. The total savings sum 4,581,000 colones. With the purchase of a new truck, the fee for maintenance and repairs will be significantly reduced, which will leave an excess of funds that will sum over 5,000,000 colones. This money could be used to help pay for the new truck's first year payments.

Analysis of Escazú

The municipality of Escazú has a very well-managed and efficient system for the collection and disposal of waste. Not only is this statement true when Escazú is compared to the other Costa Rican municipalities, but it is still valid when compared to the U.S. towns of Clinton and Shrewsbury, Massachusetts. Escazú does not currently have a deficit, and the municipality actually has an excess of money that can be used to improve its system. Refer to Figure 3 (previously presented) for the budget expenses of Escazú.

Collection

Escazú charges its residents 933 colones per month for the collection and disposal of its waste and recyclable items. This fee is between those of Santa Ana and San Isidro, and it is a fair rate. Not only does this fee provide the municipality with enough money to cover the cost of the collection and disposal of all waste, but there is a sum of money

that remains that could be used toward the expansion of the recycling program. Escazú produced 235 metric tons of waste per 1,000 residents in 2002. This is the lowest generation by far when compared to the other two Costa Rican municipalities. This low generation is due to its more effective recycling program and the efforts of the public health department in educating the residents on the benefits of recycling and trash reduction.

The vehicle-operating efficiency and worker efficiency in Escazú comply with those efficiencies of the model. Escazú has a vehicle-operating efficiency nearing one truck per 10,000 residents, with less than three workers per 10,000 residents. The combination of these two factors shows that Escazú is efficiently managing its collection of waste. This statement is supported by the data of workers per vehicle, which is 3.20, while the desirable value is three workers per truck.

Recycling

Recycling in Escazú, when compared to the two other Costa Rican municipalities, is extremely effective in the reduction of waste. The collection service is provided to sixty percent of the residents in the municipality. Expansion of the collection service can only further help to reduce the amount of waste produced.

Escazú's recycling program currently has a vehicle-operating efficiency of 0.40 trucks per 20,000 residents, which is low. The worker efficiency rating for Escazú's recycling program is 1.50 workers per 20,000 residents. This number is also low for a municipality of its size, as there should be no less than two, and no more than three, workers per 20,000 residents for a recycling program to be effective. The municipality of

Escazú collects all five of the commonly accepted items for recycling in the U.S. These items are plastic, paper, aluminum, glass, and cardboard.

Cost

Waste is transported by the municipality to a landfill in Río Azul, which is owned by Waste Placement Profession (WPP). The final disposal fee is 3,400 colones per metric ton. When compared to Santa Ana, Escazú is reasonably charged.

The total cost to Escazú in 2002 was only three million colones more than that to Santa Ana, which is a municipality with a population of 19,000 fewer residents than Escazú. The per capita cost in 2002 was significantly less than that of Santa Ana, however more than that of San Isidro. Although Escazú had a higher per capita fee than did San Isidro, it is justified by its well-managed collection service and recycling program. It is also important to note that Escazú did not incur a deficit in 2002 and that it spends about thirty percent of its budget on wages.

Recommendations for Escazú

Escazú does not need to make any changes to its system for the collection of municipal waste. The municipality has the lowest production of waste per 1,000 residents, but this number can still be reduced by means of instituting a system for composting and expanding the service of recycling to collect from all residents.

Recycling

There are several steps that must be taken to expand the service of recycling in Escazú. Firstly, Escazú needs to continue to inform its residents of the benefits of recycling. Secondly, each section of the municipality needs to be adjusted to service all residents.

Escazú currently has a pamphlet that has been given to its residents (See Appendix W). The pamphlet stresses the importance of recycling to the community as a whole and how to make the collection of recycling more effective by explaining how to properly prepare the recyclable items for collection. These pamphlets should also be passed out to residents that are soon to be included in the recycling service, and they should include the date that the recycling service is to begin.

To expand the recycling program in Escazú, the municipality must first purchase a new truck. Only one truck is used currently to service 32,000 residents, and this truck is filled to near capacity on its daily routes. With an additional truck, Escazú will have a vehicle-operating efficiency of 0.74 trucks per 20,000 residents, while the recommended value is 0.75 trucks per 20,000 residents.

After the purchase of a new truck, workers for this truck will be needed. Escazú currently employs three workers for the collection of recyclable items. Three employees give the town a worker efficiency of 1.50 workers per 20,000 residents, which is low according to the recommended minimum value of two workers per 20,000 residents. If the municipality hires one driver and two other workers to collect the recyclable items, Escazú will increase its worker efficiency to 2.20 workers per 20,000 residents. This is an ideal number as it is over the minimum level, and it will allow the municipality to manage the collection of all recyclable items efficiently. Since Escazú has a profitable collection program, to increase the number of workers would not put a burden on the budget.

Once the new truck and workers have been added to the program, the expansion of the recycling program can begin. The expansion should be done on a gradual, monthly

basis, adding 5,400 residents to the collection route each month. This method would allow the collection from all of its residents after four months of its start. If the model stated above is followed, then the municipality will already be at ideal levels for worker and truck efficiencies. Therefore, an evaluation of these sections would not be necessary. The evaluation of the recycling facility should be made to identify potential problems. Any problematic issues could easily be remedied by adding workers to the program or by building a new storage facility for an overflow of items. The municipality already has a well-established recycling program. Therefore, the sale of items should not be a problem, as a large market exists for recyclable items--cardboard and plastic in particular (Ana Flor Villalobos, personal communication, June 2, 2003)

Analysis of Río Azul

Río Azul was built into the side of a hill near a poor and highly populated community (For figures see Appendix T). The area surrounding the landfill is being contaminated because no impermeable layer exists to protect the ground from leachates. In addition, the system for the collection and treatment of leachates is technology out-dated, as it is ineffective and unacceptable when analyzed with U.S. standards. Lastly, Río Azul's system for releasing methane does little to prevent the landfill from polluting the air.

Río Azul has been in use for over thirty years and has between two and three years remaining before it reaches its capacity. The landfill's structure consists of sections that are strategically built on top of one another to prevent collapsing. The sections fill the side of a hill that was dug out during the construction of the landfill. Since the landfill was built thirty years ago, an impermeable layer was not constructed to prevent

leachates from contaminating the ground and water supplies because such technology was unknown in Costa Rica.

Numerous health hazards are already affecting the community surrounding the landfill. These health hazards include cancer, skin conditions, and headaches (Jorge Cardoza, personal communication, June ,2003). The ground below the landfill is highly contaminated with leachates and other chemicals, which can cause harm to living organisms. A nearby river has been contaminated by the landfill, spreading the hazardous chemicals over an even greater distance (Douglas Alpizar Villalobos, personal communication, June 21,2003).

This contamination could affect farm land that could then affect humans, plants, and animals. Communities' water supplies could be contaminated and therefore hazardous to drink. Due to their extreme state of poverty, many of the nearby residents have no other place where they can live.

Río Azul's current leachate collection system is extremely ineffective. The leachates are neither collected nor properly treated (See Appendix T). Also, there are no means of preventing untreated leachates from by-passing the collection system, which adds to soil contamination.

Leachates are carried down the mound of waste by rainwater to the bottom of the landfill where a portion of this contaminated water is then collected. The remaining leachates seep into the ground where they can reach underground water sources. The water that flows down the hill is not guided in any particular direction or pumped to a lagoon. There is a small lagoon that sits at the bottom of the landfill. This lagoon is simply a hole in the ground that has no means of preventing the leachates from

seeping into the ground below. Some of the rainwater that flows down the hill ends up in the lagoon (See Figure 9 below). Rainwater is collected through a system of drains, which flows into this lagoon, but this type of water generally does not carry leachates since it has not mixed with the dumped waste. Therefore, only a small percentage of leachates end up in the lagoon and are sent to a treatment plant.

Figure 9: Model of Río Azul after being closed and capped. Notice the small black rectangle (A). That is the lagoon that is meant to hold the leachates produced by the entire landfill above (B).

Methane is a hazardous gas produced by landfills as a result of the decomposition of waste. Río Azul is a large, old landfill that produces a great deal of methane gas. The system controlling methane emission has two main flaws: methane is not burned and methane is not collected. The system for methane control leaves large pockets of methane to sit under capped sections, which has led environmentalists to claim that the landfill Río Azul is "an artificial mountain which is a threat that seems ready to explode (Pacheco, 2003)."

The benefits of burning methane as it escapes into the atmosphere include a reduction in methane odors and air pollution. Río Azul has four methane flares; however, these four flares only collect and burn methane from about twenty percent of the landfill. The rest of the methane is released into the atmosphere by chimneys located throughout the landfill, which run deep into the ground. By just releasing the gas and not burning it, the surrounding air becomes extremely polluted. Methane collection is another beneficial option. This system functions by collecting all the methane through a common set of pumps, which is advantageous because methane is a valuable gas that could be sold to power plants to produce electricity.

Recommendations for Río Azul

Río Azul creates a great deal of negative environmental effects, which result in air and water contamination. Some of these effects may be remedied; however, doing so will be expensive. Leachate collection and treatment needs to be more effective, and the improvement of methane collection is absolutely necessary in order to become more environmentally safe.

WPP has already begun construction of an on-site leachate treatment system. This system will remove and treat any leachates collected in the lagoons. Since only a small amount of the leachates are actually collected, the benefits of a treatment facility are minimal.

For the leachate treatment system to be effective, it needs an effective system for the actual leachate collection. Río Azul could improve this system by building an impermeable layer in the buffer zone of the landfill. This impermeable layer would collect any water that flows on top of the clay layer that currently separates the landfill

from the ground. The impermeable layer should cover the entire length of the bottom of the landfill and be constantly drained into the treatment lagoons. After all the leachates are treated by the treatment plant, the water could safely be dumped into the nearby river. This system would collect a great deal of the untreated leachates that otherwise would have by-passed the system and contaminated the soil and water.

The current system used for controlling the landfill's methane emissions is not effective enough. Methane should be collected and either burned to reduce air pollution or sold to a power plant that can use it to produce electricity. WPP claims that it plans to collect the methane after the landfill is closed, but in our opinion there is no reason that WPP should wait. If a system were built to collect all the methane, the methane could be burned in a large flare until an agreement could be made with a power plant for the sale of the methane. Building the system as soon as possible will allow the landfill to monitor more precisely how much methane is produced by the landfill.

A system for the collection of methane includes two major parts: small collection chambers and a main collection pump. The chimneys that are currently in place need to be removed. Methane collection chambers and pumps should be installed in the chimneys' place, according to the standard used in the landfill in Fitchburg, MA (See Appendix R). Once this system is set up, the methane could be sold for a profit to a power plant.

When the landfill has reached its capacity and has been capped, WPP plans on building a park on this ground for the nearby residents. This is a dangerous idea since the landfill is already causing health problems for these residents. To build this park will only encourage the locals to use the facility and become more closely in contact with the

hazards of the landfill. Therefore, the landfill should be capped and closed to the public to reduce the risk of the population getting cancer and other harmful diseases.

Analysis of Los Mangos

Los Mangos is a landfill located in Alajuela , and it is owned by WPP (For figures see Appendix U). This landfill has an impermeable layer, but it contains less than half the waste in the landfill. The system for the collection of leachates from the impermeable layer is sufficient, but leachates are not collected from the entire landfill. Lastly, the system for controlling methane is sufficient, but there are more effective and profitable options.

WPP installed the impermeable layer ten years ago when the company bought the landfill. The landfill was previously a dump that was so poorly managed that sections of it would spontaneously ignite due to the huge amounts of methane that was being produced (See Figure 10 below). The dump had been in existence for twenty years before WPP took control, and it had accumulated a great deal of waste over these years. WPP capped this area and started a new section with an impermeable layer. Sections with impermeable layers consist of less than half of the area with waste in the landfill, so the previously dumped waste could still be contaminating ground water supplies.

Figure 10: Los Mangos when purchased by WPP. The sections of smoke are the result of unsupervised fires that would spontaneously ignite.

The leachate collection system is efficient in the sections where it exists. The system leaves the leachates on top of the impermeable layer in a drainage area. This water is then pumped into a truck where it is then brought to a treatment facility. If the entire landfill had an impermeable layer, then this would be an effective system. However, some of the sections do not have the impermeable layer and are still contaminating the underground water supplies (see Figure 11). Another issue with this system is that it would be much more cost-efficient to have an on-site collection and treatment system, which could also be used to collect the rain wash-off from the old, unprotected section.

Figure 11: Area of landfill without an impermeable layer or leachate collection system. Note the green substance in the water. This is water that is highly contaminated and sits stagnant on the outside of a collection stream. The water will stay here until heavy rains wash it into the stream below.

Methane is not collected in Los Mangos, but it is well-controlled. There are multiple methane flares set up throughout the landfill, which draw out the methane from under them and burn it. This system reduces the odors produced by the landfill. It also reduces air pollution caused by the release of large quantities of methane. Overall, the system is efficient, but other options exist that are more effective and profitable.

Recommendations for Los Mangos

Los Mangos is a landfill that claims to follow all of Costa Rica's regulations, yet the landfill is still contaminating underground water supplies. The landfill has a system for leachate collection that is effective, but it has room for improvement. Lastly, the

landfill needs to collect the methane it produces because this method is more effective at reducing air pollution and it has the potential to be very profitable.

In order to improve the system for leachate collection and treatment, Los Mangos will first need to build an on-site treatment facility. This facility can utilize lagoons, which can treat the leachates with oxygen and chlorine, or it can use new substances like the microorganisms used at El Parque de Technología Ambiental (See Appendix S). The leachates should be collected from all sections of the landfill that have impermeable layers and treated in these lagoons. The leachates should also be collected by means of leachate streams, which should be systematically located around the base of the landfill. All these streams should be connected to the leachate collection system so that contaminants, as seen in Figure 11, will wash into the streams and be treated. Although this will not treat all the leachates, it will reduce the amount of untreated leachates that could contaminate ground water supplies or the nearby river.

The landfill's system for methane collection could be improved. This system should be improved by using the landfill located in Fitchburg, MA and owned by Waste Management Industries as a model. First, methane pumps and collection chambers should be set up throughout the landfill. These collection chambers should all be connected to a main pump at which all the methane can be collected. The collected methane could be sold to a power plant that would use the methane to produce electricity. The sooner this system is completed, the more profit the landfill can yield. Los Mangos will continue to produce great deals of methane for over fifteen years after being capped. Therefore, WPP could continue to make money off of the landfill after it reaches its

capacity. This system for methane collection is environmentally-safe because it collects almost all of the methane.

VI. GENERAL CONCLUSIONS

The municipalities of Santa Ana, San Isidro de Heredia, and Escazú each need to reduce the amount of waste produced per 1,000 residents. The reduction of waste can be accomplished by means of expanding the recycling program and instituting a composting system in each municipality.

A facility for the composting of yard waste should first be constructed, as composting is an effective way to significantly reduce the amount of waste produced by residents. As a result of a decreased production of waste, the total cost to the residents for the collection of the waste is lowered and the fee to the municipality to dump the waste in the landfill is also lowered. Shrewsbury, MA, for example, composts about seventeen percent of its solid waste per year, and it only costs the town $24,000 for this service (Nancy Allen, personal communication, March 27, 2003). This means that the town saves approximately $145,000 and diverts about 2,040 tons of waste from being disposed of in the landfill.

Each of the three Costa Rican municipalities would benefit from the development of a composting system. Since fifty-eight percent of Costa Rica's solid waste composition is biodegradable, it only stands to reason that it should be composted. Each municipality would save a lot of money by composting its organic waste because as the system expands and the composting rate increases, the municipality would be diverting several tons of waste from the landfill, thus saving money on tipping fees.

The composting program should be placed at a communal dumping site at which residents can dispose of their yard trimmings. Since the purchase of a truck for this program would not be in the budget in the beginning, a collection service would not be

available until the composting program became more established. To begin its composting program, each municipality should relocate one of its workers from solid waste collection to composting. That one worker's job would be to maintain the composting facility by taking drop-offs and turning over compost. Upon development, the facility should only accept yard-trimmings for disposal, as food waste requires a significantly higher level of maintenance due to the odors and insect infestation caused by its decomposition. In the United States, food composting is accomplished with a 4:1 ratio of dry materials to food waste in order to reduce the odors and insect infestation (http://www.cfe.Cornell.edu/compost/composting_homepage.html). In a tropical climate, the ratio of dry materials to food waste would have to be even higher due to a combination of heavy rains, humidity, and high temperatures. Compost should be rotated after a predetermined period of time to increase decomposition rates by the method of putting old, rich compost on top of new, fresh compost.

To increase environmental awareness of the benefits of recycling, Santa Ana and San Isidro should create an informational pamphlet that focuses on the effects that the lack of an efficient recycling program has on the environment. This pamphlet should explain the process of separation and the collection of recyclable items, in addition to stressing the advancement into a new era of waste collection by means of an efficient recycling program. The booklet should specify that recyclable items not only need to be separated from the rubbish, but that they also need to be separated from each other. Paper and cardboard, for example, can be bagged together; however, these items should be bagged separately from aluminum, glass, and plastic. Specific items that cannot be recycled should also be specified. Plastic bags and aerosol cans, for example, are items

that cannot be recycled. In addition, the preparation for the disposal of each item need to be explained, such as the rinsing of plastic bottles and aluminum cans and the placement of these items in transparent bags. Lastly, the pamphlet should stress the fact that the municipality has a center for recycling that is available to any and all residents who currently do not have the collection service. The final product should then be mailed to all residents, in addition to be available at El Palacio Municipalidad (Town Hall).

The municipality of Santa Ana has the least efficient system for the collection of waste when compared to the Costa Rican and American municipalities of interest. Santa Ana spends far too much money on wages and tipping fees, which are costs that can be reduced according to our recommendations. Santa Ana needs to increase the percentage of residents who use their system for recycling. The implementation of a composting facility will also help to reduce the amount of waste produced by the residents. The combination of the fulfillment of these two recommendations will help to reduce Santa Ana's deficit, in addition to making its system for waste collection and disposal more efficient.

San Isidro has a waste management system that appears to be well-managed, based on financial data, but when all collected data is scrutinized, many flaws appear. The municipality has a poor system for the collection of recyclable items. Therefore, the recycling program needs not only to expand, but it first needs to become better-equipped to do so. The system for the collection of waste employs far too many workers, so it is recommended that three be released as a cost-cutting measure. These changes, combined with the implementation of a composting facility, will rid San Isidro of its deficit and allow the municipality to purchase a badly-needed new truck for the collection of waste.

Escazú has a very efficient system for waste management. This municipality has been able to reduce its waste generation by means of providing its residents with a well-managed recycling program. Once the recycling program is expanded and a composting system is implemented, Escazú will be able to further reduce the amount of waste produced. The reduction in waste will not only make the municipality's system for waste management more cost-efficient, but it will also aid in the protection of the environment by diverting waste from landfills.

The landfill located in Río Azul, which is owned by WPP, is an example of the inconsistencies that exist in Costa Rica's current waste disposal systems. Río Azul does not have an impermeable layer and its manager claims that leachates are collected for treatment. In reality, the majority of the leachates produced by Río Azul completely by-pass the leachate treatment system and contaminate the surrounding area. WPP claims to have methane flares, but the fact is that only four small flares exist. A large quantity of methane is released into the atmosphere through chimneys, which results in the pollution of the atmosphere. The Río Azul landfill needs a proper method for the collection of leachates for treatment, and it also needs to finish the construction of the on- site leachate treatment facility. Additionally, Río Azul should improve its system for methane control either by burning the methane or collecting it and selling it to a power plant to produce electricity.

Los Mangos is the landfill located in Alajuela that is owned by WPP. This landfill does have an impermeable layer in some sections; however, these sections contain less than half of the total volume of waste in the landfill. Leachates are collected only from these areas with impermeable layers, while the older sections of the landfill are

left to contaminate ground water supplies and the nearby river. The system for the control of methane is effective, as methane is burned by flares throughout the landfill that help to reduce air pollution. Los Mangos needs to improve its system for leachate collection by adding an on-site treatment facility and by building an effective and safe leachate collection system in the old area of the landfill. Methane should be collected and sold, which would be profitable and more effective than the current methane control system.

If the above recommendations are followed, then each municipality will reduce its amount of waste produced, in addition to implementing a more environmentally-conscious system for waste management. If the landfills are improved, then they will reduce the contamination of the surrounding areas and the pollution of the atmosphere as a whole. The methodology utilized in this report for both data collection and analysis should be used to analyze other municipalities and landfills in Costa Rica. The result would be the reduction of solid waste generation in Costa Rica by means of instituting environmentally-safe systems of waste management that are practiced in the U.S.

VII. APPENDICES

Appendix A: Mission and Organization of CICA

The Centro de Investigaciones en Contaminación Ambiental (CICA) is an organization that utilizes various techniques for researching and analyzing environmental pollution. CICA was founded in 1982, and it works in conjunction with the University of Costa Rica, which is located in San Pedro (Pouliot, Trovato, &Yim, 2001). For the past twenty-one years, CICA has been utilizing a variety of techniques for investigating and analyzing environmental pollution. Their technical instruments are currently among the most advanced in the country. The organizations mission is to investigate and contribute scientific information that will assist in the world-wide effort to protect the natural environment. The research team includes scientists from a variety of fields: physics, chemistry, biology, toxicology, pharmacology, chemical engineering and microbiology. The organizations main focus is on the quality of water, the atmospheric emissions, and the chemistry of pesticides in Costa Rica (Pouliot, Trovato, &Yim, 2001).

CICA receives its financial support from three different sources. The University of Costa Rica's administration provides a small amount of funding for some of CICA's projects. A second source of funding comes from consulting services within the country, such as chemical analysis and sampling. Financial support also comes from the national and international institutional organizations to which CICA directs much of their research and project efforts. Some of these organizations include the Inter-American Development Bank, the National Organization of Atomic Energy, the Pan American Health Organization, the United Nations Development Program, the Institute of

Municipal Promotion and Advisory, and the National Service of Underground and Irrigation Waters (Pouliot, Trovato, &Yim, 2001).

Each research center receives a set of by-laws from the government. CICA has a committee called Consejos Scientificos that set the policies for their research center. The director of the center enforces the policies of CICA (Pouliot, Trovato, &Yim, 2001).

Our liaison Sr. Arrieta works at the University of Costa Rica's School of Chemistry. His work for CICA is in the area of solid waste management. Ronald is currently the only person at CICA working on this issue.

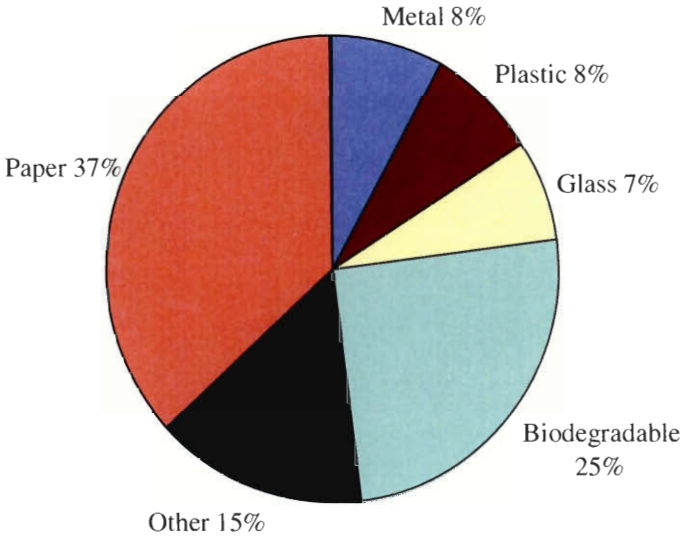
The goal of our IQP is to propose a sustainable system for the management of solid waste in three Costa Rican municipalities. Our research, analysis, and recommendations to improve Costa Rica's current methods of solid waste management will aid CICA in its effort to protect Costa Rica's natural environment. In addition, our project will advance our liaison's studies in the area of solid waste management by providing him with new information on possible waste management options in Costa Rica.

Appendix B: Refuse Material by Kind, Composition, and Sources

Kind	Composition	Sources
Garbage	Wastes from preparation, cooking, and serving of food. market wastes; wastes from handling, storage, and sale of produce	Households, restaurants, institutions, stores,etc.
Rubbish	Combustible: paper, cartons, boxes, barrels, wood, tree branches, yard trimmings, wood,furniture, bedding Noncombustible: metals, tin cans, metal furniture, dirt, glass, crockery, minerals	
Ashes	Residue from fires used for cooking and heating and from on-site incineration	
Street refuse	Sweepings, dirt, leaves, catch basin dirt, contents of litter receptacles	Streets, sidewalks, alleys, vacant lots
Dead animals	Cats, dogs, horses, cows	
Abandoned vehicles	Unwanted cars and trucks left on public property	
Industrial	Food-processing wastes, boiler house cinders, lumber wastes scraps, metal scraps, shavings	Factories, power plants
Demolition wastes	Lumber, pipes, brick, masonry, and other construction materials from razed buildings and other structures	Demolition sites to be used for new construction
Construction wastes	Scrap lumber, pipe, other construction materials	New construction, remodeling
Special wastes	Hazardous solids and liquids; explosives, pathological wastes, radioactive materials	Households, hotels, hospitals, institutions, stores, industry
Wastewater treatment residue	Solids from coarse screening and from grit chambers; septic tank sludge	Wastewater treatment plants, septic tanks

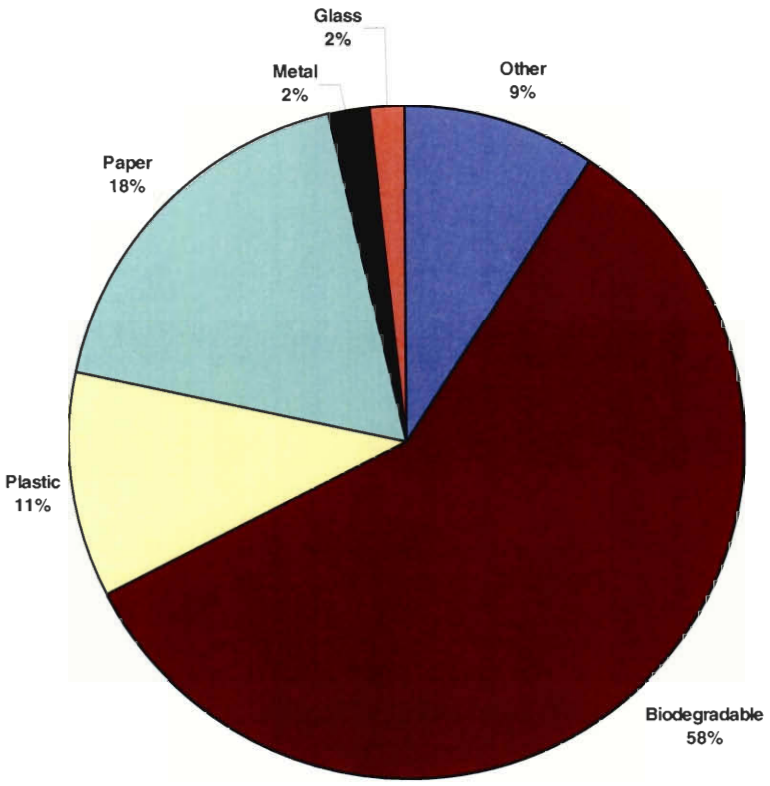
O'Shaughnessy. (2002). Municipal Solid Waste.

Appendix C: Solid Waste Composition in the United States



O'Shaughnessy. (2002). Municipal Solid Waste.

Appendix D: Solid Waste Composition in Costa Rica



Chacón, Garcia, & Guier. (2000). Ambiente Problemática y Opciones de Solución.

Appendix E: Town of Shrewsbury Curbside Pickup Regulations

Acceptable Trash For Pickup

Rags
Cartons
Automobile tires (without rims)
Rugs
Furniture
Household items
Kitchen waste

Unacceptable Trash For Pickup

Bricks
Plaster
Demolition debris
Automobile parts including batteries and truck tires
Fences
Appliances

Recyclable Items

Newspapers
Magazines
Paper book`s
Light weight cardboard
Glass bottles and jars
Water jugs
Aluminum cans

(http://www.shrewsburyma.gov/health/reg_rubbish.asp)

Appendix F: Pay as You Throw (PAYT)

The Pay as You Throw (PAYT) system forces users to pay a set fee per bag of waste produced instead of incorporating the cost of waste disposal within the property tax. Stickers are purchased from the town and are then attached to approved waste disposal bags and carts and/or containers (Document given to us by Bill Sprat during a meeting, April 14, 2003). The most important aspect of the PAYT system is that it charges the participants in the town as close to the real cost as is possible for their generation of waste. If established recycling programs exist within a community, then PAYT has been found to increase the residents' motivation to recycle. After the implementation of a PAYT program communities recycling rates change between -3 to +30 percent. Residents in general are more likely to recycle with a PAYT system because there are not any fees imposed on recyclable items. Therefore, recycling reduces the number of bags that need to be purchased, and as a result lessens the cost that residents must pay (Document given to us by Bill Sprat during a meeting, April 14, 2003).

Variable and fixed costs are the two major cost subsets for the PAYT program. These costs need to be identified so that user fees can be appropriately structured, based on a community's program. Fixed costs consist of both indirect and direct expenses. Direct expenses include salaries for collection workers and contracted amounts. Indirect costs consist of a town's overhead expenses and benefits (Document given to us by Bill Sprat during a meeting, April 14, 2003).

The user cost is determined by fixed costs, and it varies based on an increase in disposal fees or the cost of bags or stickers themselves. An ideal PAYT system results in

a neutral impact on the town's budget by having revenues and expenses equal to each other. Communities can reduce fees charged to their residents by paying for additional expenses by means of taxes or other available revenue. A community's current political and financial situations determine the type of a PAYT system that should be implemented (Document given to us by Bill Sprat during a meeting, April 14, 2003).

The first step in implementing a PAYT system is to identify the user obstacles--financial, operational, and attitudinal. Residents with low incomes and fixed incomes, such as senior citizens, can be burdened by the costs of waste disposal. Operational obstacles include the change in using approved bags or stickers, and the distribution network where these items can be purchased. People will also have some doubts and questions when their disposal program changes. They will be angered that they are now paying for something that was "free" before. Many users will overfill bags and practice illegal dumping to get around the fee for disposal (Document given to us by Bill Sprat during a meeting, April 14, 2003).

Approaches then need be identified to resolve such obstacles. Regulations need to be enforced in regards to the volume of disposal bags, so that users do not abuse the system and pay less for the disposal of their waste than other users pay by using larger bags. Therefore, pre-program communication should be used, such as surveys, to acquire resident opinions before implementing a PAYT system. The costs incurred by citizens in a PAYT system must be explained so they realize that distributing costs over the use of the services is fairer than having a flat rate to be paid by all users. Graphics could also be applied to show users *how* full is *too* full. Fines for illegal dumping, and a convincing

threat of investigation and apprehension need to be established also (Document given to us by Bill Sprat during a meeting, April 14, 2003).

Budget elements involving expenses and revenues must be thoroughly analyzed, and pricing models need to be produced to determine the cost that the town should charge for each bag or sticker. It is also necessary that the new budget take into account the need for new staffing or capital items (Document given to us by Bill Sprat during a meeting, April 14, 2003).

Outreach and communication are necessary components in helping people to understand and to accept the new waste disposal program. Local television or radio advertisements, along with town mail, can be used to inform residents on the PAYT system and budget. After the implementation of the system, a survey could be given to the residents in order to get their thoughts about the new program (Document given to us by Bill Sprat during a meeting, April 14, 2003).

Measurement and revision is the last step that is needed before a PAYT system is implemented. Data is needed on the rates of all the materials being managed. All expenses for recycling and disposal rates need to be tracked, along with the expenses and revenues for all materials, operations, and capital items. To maintain the system, results must be analyzed and changes need to be made to the program when deemed appropriate (Document given to us by Bill Sprat during a meeting, April 14, 2003).

Appendix G: Town of Clinton

Solid Waste & Rubbish Convenience Station
Hours: Saturday 8:00am to 1:00pm – Residential use only
Fees as of 5/12/02

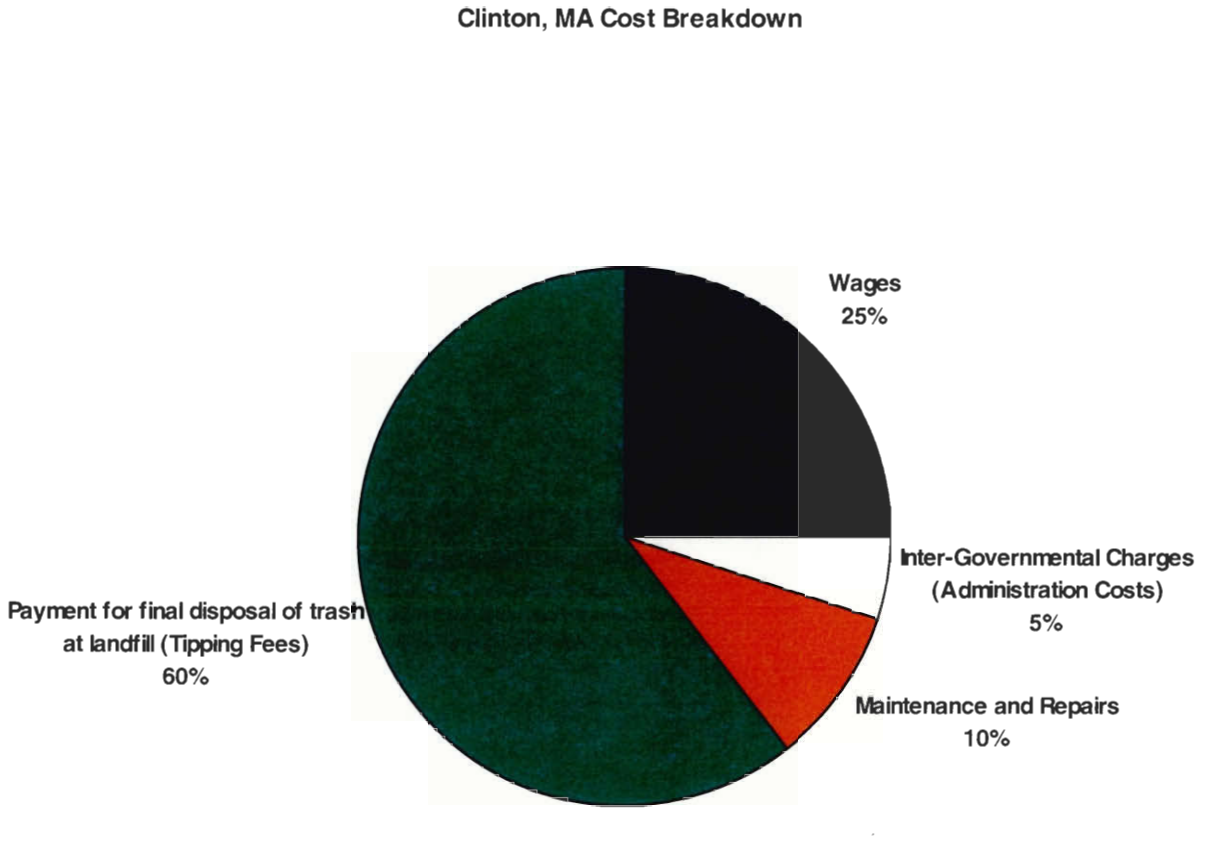
Trash, garbage (larger than 33 gal bag)	$5.00
Trash, garbage (30-33 gal bag)	$3.50
Trash, garbage (10 gal bag)	$1.75
Recyclables (plastic, aluminum, tin, and glass)	Free*
Newspapers and inserts	Free*
Leaves, brush cuttings, yard debris (30 gal bag)	$5.75
Wooden chair	$5.00
Upholstered chair	$15.00
Recliner	$20.00
Sofa	$20.00
Sleeper Sofa	$30.00
Twin mattress or boxspring	$10.00
Full or larger mattress or boxspring	$10.00
Portable TV	$15.00
Console TV	$20.00
Rug (average size 10x10, 12x12)	$20.00
Hot water tank (30-40 gal)	$15.00
Refrigerator, freezer (appliance with freon)	$25.00
Window air conditioner	$20.00
Passenger car tire (without rim)	$3.50
Passenger car tire (with rim)	$5.00
All prices include sales tax	
* Free only if accompanied with a bag of garbage, otherwise $1.00 fee	

(http://www.townofclinton.com/)

Municipality of Clinton, MA
Waste Management Budget for 2002 (Amount in $)

Wages	104,883.00	
Inter-Governmental Charges (Administration Costs)	20,289.00	
Maintenance and Repairs	40,000.00	
Payment for final disposal of trash at landfill (Tipping Fees)	253,484.00	
Total Rubbish Cost Per Year		418,656.00
Money collected from families ($1 sticker * 305000 stickers sold)	305,000.00	
Cost for town (money from family - total rubbish cost => a deficit is currently created)		(113,656.00)

Document given to us during a meeting with Bill Sprat, April 14, 2003

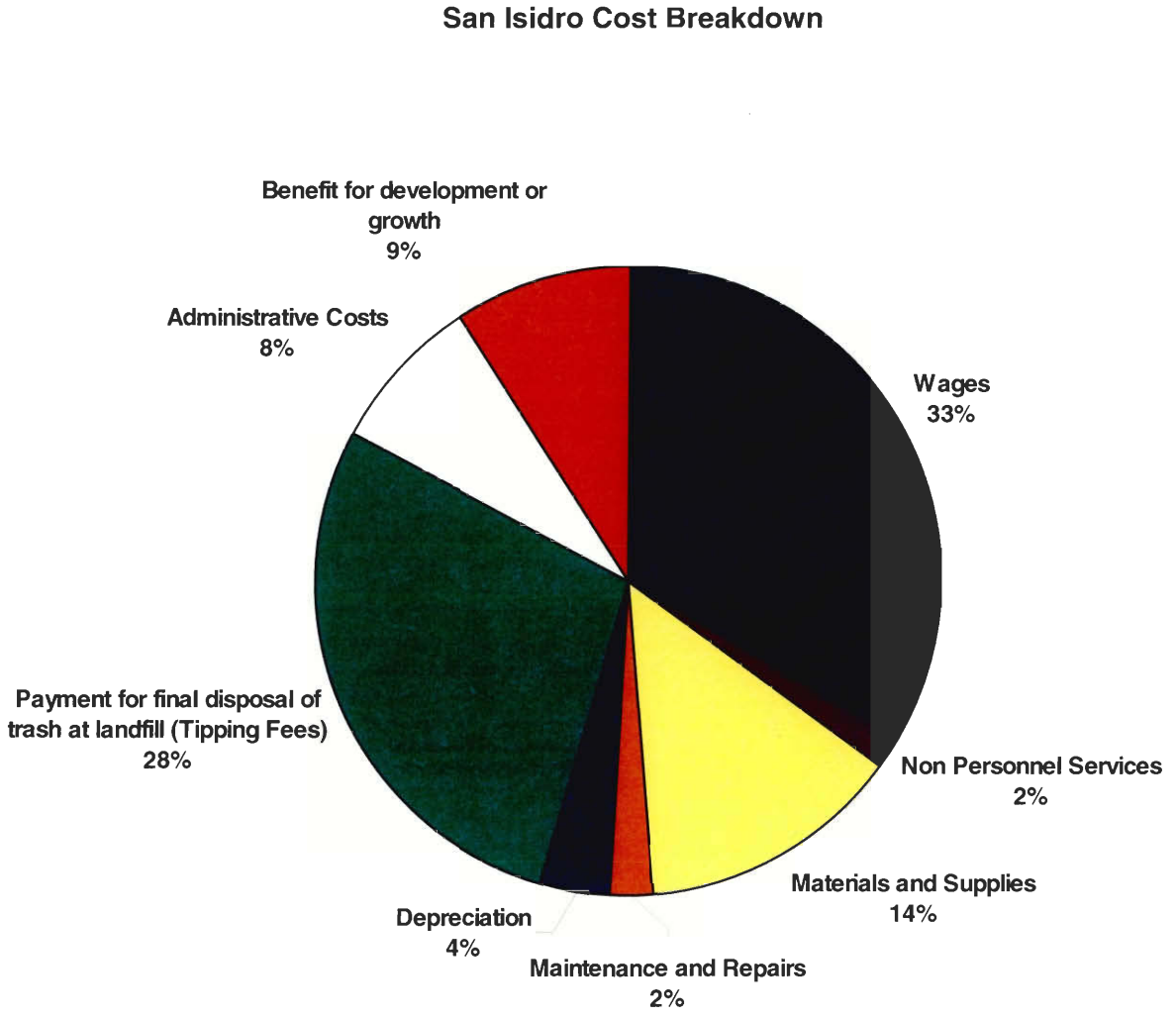


Document given to us during a meeting with Bill Sprat, April 14, 2003

Appendix H: Municipality of San Isidro (Amount in Colones)

Wages	14,122,384.00	
Non Personnel Services	734,689.00	
Materials and Supplies	5,711,835.00	
Maintenance and Repairs	875,000.00	
Depreciation	1,639,069.00	
Payment for final disposal of trash at landfill (Tipping Fees)	11,869,029.00	
Total Incurred Costs		34,952,006.00
Administrative Costs (10% of total incurred cost)	3,495,200.60	
		38,447,206.60
Benefit for development or growth (10% of Incurred + Administrative)	3,844,720.66	
Total Rubbish Cost Per Year		42,291,927.26
Money collected from families (807 col/mon * 4200 families)	40,672,602.00	
Cost for town (money from family - total rubbish cost => a deficit is currently created)		(1,619,325.26)

Zamora, (2000). Clarification of the costs of the budget for the collection, transportation, and disposal of solid wastes in the canto of San Isidro Heredia.

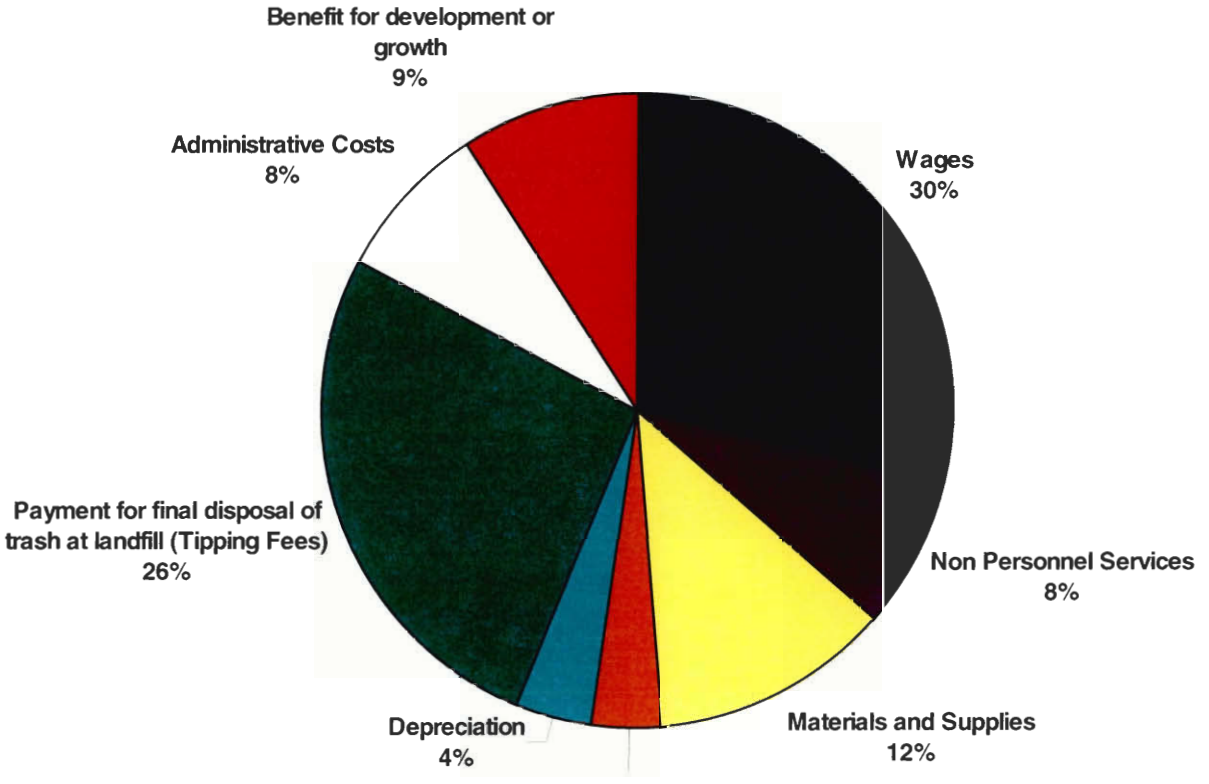


Zamora, (2000). Clarification of the costs of the budget for the collection, transportation, and disposal of solid wastes in the canto of San Isidro Heredia.

Appendix I: Municipality of Escazú (Amount in Colones)

	Amount in Colones	
Wages	48,219,761.55	
Servicios no personales	13,338,484.00	
Materials and Supplies	20,693,038.45	
Maintenance and Repairs	5,796,910.83	
Depreciation	6,799,063.92	
Payment for final disposal of trash at landfill (Tipping Fees)	44,726,182.00	
Total Incurred Costs		139,573,440.75
Administrative Costs (10% of total incurred cost)	13,957,344.08	
		153,530,784.83
Benefit for development or growth (10% of Incurred + Administrative)	15,353,078.48	
Total Rubbish Cost Per Year		168,883,863.31
Money collected from families (933 col/mon * 13571 families) + Money collected from companies	213,610,046.00	
Cost for town (money collected - total rubbish cost => Money for improvement)		44,726,182.69

Financial documents given to us during a meeting with Mario Porras, Escazú, Costa Rica, 2003

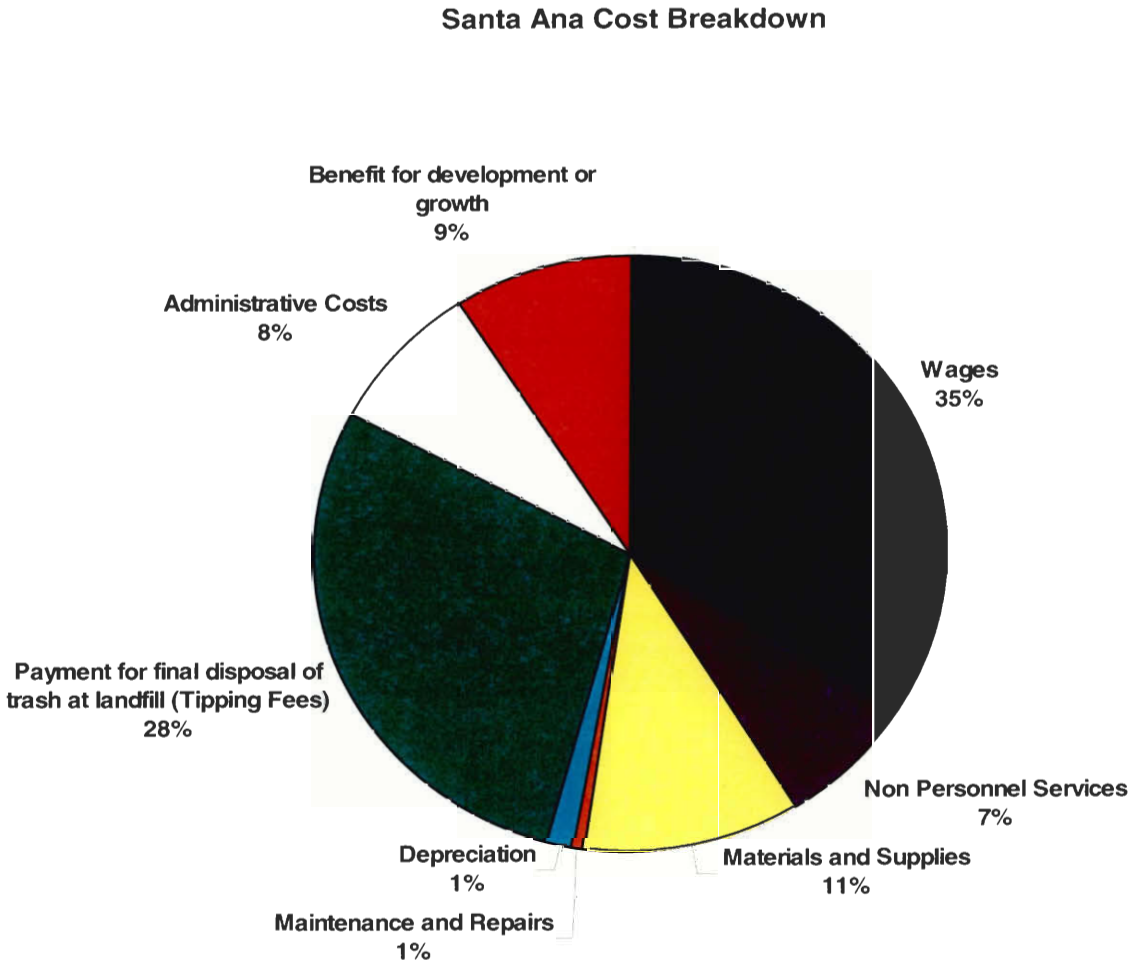


Financial documents given to us during a meeting with Mario Porras, Escazú, Costa Rica, 2003

Appendix J: Municipality of Santa Ana (Amount in Colones)

	Amount in Colones	
Wages	57,159,177	
Servicios no personales	10,310,000	
Materials and Supplies	18,514,000	
Maintenance and Repairs	1,100,000	
Depreciation	2,210,788	
Payment for final disposal of trash at landfill (Tipping Fees)	50,000,000	
Total Incurred Costs		139,293,965.00
Administrative Costs (10% of total incurred cost)	13,929,397	
		153,223,361.50
Benefit for development or growth (10% of Incurred + Administrative)	15,322,336	
Total Rubbish Cost Per Year		168,545,697.65
Money collected from families (1200 col/mon * 8125 families)	117,000,000	
Cost for town (money collected - total rubbish cost => A large deficit)		(51,545,697.65)

Municipality's budget for 2003 given to us during a meeting with Alberto Durano, Santa Ana, Costa Rica, 2003



Municipality's budget for 2003 given to us during a meeting with Alberto Durano, Santa Ana, Costa Rica, 2003

Appendix K: Preguntas directazas a los administradores del manejo de los desechos sólidos en las municipalidades costarricenses

1. ¿Cuál es la población de la municipalidad?
2. ¿Cómo paga los habitantes por el servicio de eliminación de desechos sólidos?
3. ¿Cuántas familias reciben el servicio de eliminación de desechos sólidos?
4. ¿Cuántas familias reciben el servicio de reciclaje?
5. ¿Dónde está situada el relleno sanitario, si existe?
6. ¿Cuántas toneladas de desechos sólidos están producidas por año (en promedio)?
7. ¿Cuánto dinero tiene que pagar la municipalidad por cada tonelada de desechos sólidos que está producida e eliminada?
8. ¿Cuáles artículos están reciclados?
9. ¿Cuántos camiones tiene la municipalidad? ¿Están usados todos?
10. ¿Qué es la capacidad de los camiones?
11. ¿Cuántos trabajadores hay para el sistema de reciclaje y para el manejo de desechos sólidos?
12. ¿Cuántas veces cada semana vienen los dos servicios a las casas?
13. ¿Qué es el déficit hoy en día?
14. ¿Cuáles son las ideas que tiene la municipalidad en cuanto lo que quiere hacer en el futuro?

Appendix L: Questions Directed to Administrators of the Management of Solid Waste in Costa Rican Municipalities

1. What is the population of the municipality?
2. How do the residents pay for the service of waste removal?
3. How many families receive the service of waste removal?
4. How many families receive the recycling service?
5. Where is the municipality's landfill located, if one in fact exists?
6. How many tons of solid waste is produced per year (on average)?
7. How much money must the municipality pay for the disposal per ton of solid waste produced?
8. What items are recycled?
9. How many disposal trucks does the municipality own, and are all of the trucks used?
10. What is the capacity of the trucks?
11. How many workers are there for the recycling system and for the solid waste system?
12. How many times per week do the services go to the houses?
13. What is the municipality's current deficit?
14. What ideas does the municipality have in regards to the future management of waste?

Appendix M: Preguntas a los administradores de los rellenos

1) ¿Existe una capa impermeable de plástico que impida la contaminación de áreas cercanas con los lixiviados?

2) ¿Si lo tiene, de cuáles materiales fue creada esta capa?

3) ¿Existe un sistema para juntar los lixiviados? Para clarificar, un sistema de ese tipo consiste en cualquier manera de retardarse el agua contaminada antes de que llegue a una fuente de agua.

4) ¿Cuántas veces al mes se analizan las aguas subterráneas?

5) ¿Dónde están los puntos de monitoreo?

6) ¿Sabe Usted de alguna fuente de agua que ha sido contaminada, o que está en peligro de estar contaminada, del relleno?

7) ¿Sabe Usted de algún problema ambiental que ha causado este relleno?

8) ¿Existen sistemas para recolectar el metano? Si lo tiene, ¿está quemado el metano?

9) ¿Cómo están controlados los olores del relleno?

10) ¿Cómo fue construido el relleno, y tiene alguna inclinación?

11) ¿Cuándo está cubierto el relleno con materiales para tapar los desechos?

12) ¿Tiene un sistema de abonos? Si lo tiene, ¿cuáles materiales están compostadas?

13) ¿Está seccionado el relleno en la manera en cual cada sección tiene una capacidad que tiene que estar conseguido antes de que otra sección pueda ser usada?

14) ¿Están majados los desechos y puestos en el relleno a un nivel igual cuándo está llenado el relleno?

15) ¿Tiene alguna idea en respeto al período de tiempo que tiene el relleno antes de que llegue a su capacidad?

16) ¿Cómo estará tapado el relleno cuando llega a su capacidad?

Appendix N: Questions for Landfill Managers

1) Does this landfill have an Impermeable Layer of clay or plastic that will stop leachates or toxic chemicals from reaching underground water sources?

2) If so, how was it constructed and with what materials?

3) Does this landfill have a leachate collection system? This system could consist of ponds, pumps, streams, or any other means of slowing down the contaminated water before it reaches any water supplies.

4) How many times per week is underground water analyzed?

5) Where are the monitoring points?

6) Do you know of any water supplies that are in danger of being contaminated by, or have been contaminated by, this landfill?

7) Do you know of any environmental problems this landfill may have caused?

8) Does this landfill have a system for collection and/or reduction of methane production, and if so, is the methane burned to be rid of it?

9) If no system for collection of methane exists, how are the odors produced by the landfill controlled, if at all?

10) How was this landfill constructed, and will it be built up on a certain grade or slope?

11) When is the landfill covered to cap the waste?

12) Does this landfill have on-site composting? If so, what types of materials are collected to make this compost?

13) Will the area that this landfill will eventually occupy be sectioned off, and will each section be filled individually until the landfill reaches its capacity?

14) Is the waste crushed and kept at an even height as it is filled?

15) Do you have an estimate of how many years will pass before the capacity of the landfill is reached?

16) How will this landfill be capped when it reaches its capacity?

Appendix O: Preguntas para los administradores de los centros de acopio

1) ¿Cuánto de cada tipo de artículo reciclable puede manejar el centro? En otras palabras, ¿cuánto de un aumento de los artículos puede manejar el centro?

2) ¿Cuánto gana el centro en la venta de cada artículo reciclable, y en cuál forma están vendidos los artículos? ¿Por kilogramos o por número de artículos?

3) ¿Tiene problemas en encontrarle a un comprador de los artículos reciclables o reutilizables?

4) ¿Existe a un comprador consistente para algunos artículos específicos?

Appendix P: Questions for Recycling Center Managers

1) How much of each type of recyclable items is this center able to manage? In other words, how much of an increase of items could be handled?

2) How much does this center get paid to sell each type of recyclable item, and in what form are the items sold? For example, by kilogram or by number of items?

3) Does this recycling center ever have a problem finding a buyer of the recyclable and/or reusable items?

4) Is a there a consistent buyer of certain items?

Appendix Q: Basura y Falsedad

Todavía se escucha el eco de las palabras del exministro de Salud Rogelio Pardo anunciándole a la nación la solución definitiva al "problema de la basura". Acompañado de su compinche, el alcalde Johnny Araya y de su más entusiasta seguidor, el director del Departamento de Protección del Ambiente Humano del Ministerio de Salud, Oscar Guzmán, don Rogelio hablaba del vertedero de La Carpio y de los otros rellenos regionales que vendrían a acabar, "de una vez por todas", con el viejo problema.

Pero el tiempo vino a demostrar la falsedad de lo pregonado. Con la sanción que recibieran de parte del Tribunal Centroamericano del Agua, se creyó que atenderían responsablemente la llamada de atención y se preocuparían (¡de verdad!) por promover la erradicación de ese símbolo del subdesarrollo que ensucia la cara ambiental de Costa Rica. Sin embargo, la demagogia siguió sustituyendo a la verdad.

Hoy la situación demuestra que estábamos muy lejos de alcanzar una solución y que la supuesta preocupación gubernamental no era más que un cuento. Y es que más bien el problema se profundizó al poner a las instituciones del Estado, ministerios y municipalidades, en situación de rehenes de las empresas privadas que dicen prestar el servicio de tratamiento de la basura, mientras se cierran los ojos ante las opciones que germinarían a partir de una adecuada planificación.

Hay que cerrar el botadero de Río Azul, pero no se sabe a dónde se podría llevar la basura que se amontona en esa amenazante montaña artificial que parece lista a explotar. Por su parte, el vertedero situado en un tajo de La Uruca, pomposamente llamado "Parque de tecnología ambiental", por un lado lanza sus gases malolientes hacia los vecinos de La Carpio y Cariari, mientras que los inmundos fluidos lixiviados que no

logran filtrarse hacia los acuíferos allí presentes, siguen su camino hacia el río Virilla. Además, de sobra es conocido el incumplimiento de los compromisos ambientales y administrativos, que determinan que al depósito de basura sólo puede ser llevada basura proveniente de la Municipalidad del Cantón Central de San José, por lo que sigue siendo irregular el depósito de basura proveniente de otros cantones del país, sea ésta municipal o privada. Así, mientras se espera la acción de las autoridades ambientales, de la Contraloría General de la República y de la Defensoría, por el momento nos limitamos a invitar a los responsables a cumplir su deber.

Finalmente, tenemos el llamado "relleno sanitario" de Los Mangos, que hoy desvela a los vecinos de Alajuela sinceramente preocupados por el ambiente que los cobija. Como parte de la lista de irregularidades que lo caracteriza, se tienen los gases sin tratar, los lixiviados que, según la Setena, "desfogan a la quebrada ubicada en este sector", la excesiva cantidad de basura que se recibe diariamente, el limitado espacio que presagia su pronto colapso, el hecho de gastar un tercio del presupuesto municipal solo por la recolección y vertido de la basura en ese lugar... La denuncia penal presentada por el Grupo Ecológico de Occidente (GEO) y la responsable actitud de las nuevas autoridades municipales encabezadas por su alcalde don Fabio Molina, despiertan la esperanza y hacen prever una toma de posición razonable donde los favorecidos serán, indiscutiblemente, los habitantes de Alajuela que sueñan con heredar a sus hijos y nietos, una calidad de vida digna.

Pero así como en La Uruca y en Río Azul han sido los vecinos los que han tenido que sustituir de facto a los complacientes funcionarios de los ministerios de Ambiente y Salud, en Alajuela también ha sido necesaria la acción de los grupos sociales ajenos al

gobierno, para avanzar hacia el ejercicio del derecho a un ambiente sano y ecológicamente equilibrado, según se consagra en la Constitución Política. Ahora, con la toma de posición de la Municipalidad de Alajuela, en conjunto se le está señalando un camino a los demás municipios del país, para que no se conviertan en rehenes de la basura ni de los que lucran con ella. ¡Ojalá! tomen nota de esta lección, los habitantes de otros lugares que hoy se sienten "amenazados" por la ofertas de desarrollo tecnológico que adornan las propuestas de los entes privados que merodean por sus cantones.

(Dr. Freddy Pacheco, 2003)

Appendix R: Fitchburg, MA Landfill

Owned by Waste Management

Leachate Collection System

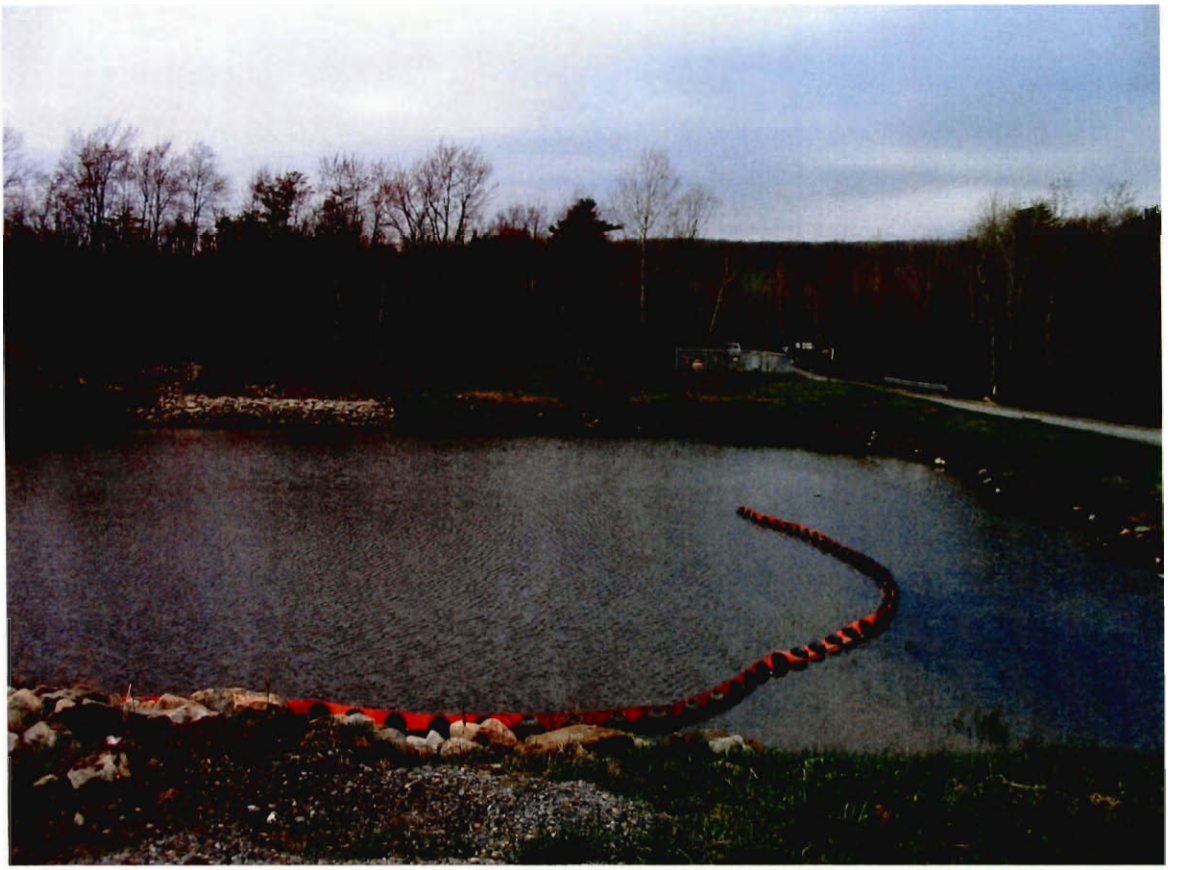


Figure 1. Leachate Collection Pond

The leachate collection pond serves as a method of slowing down the flow of rainwater. The main function of the pond is to force the water to slow down and release the silt, which could carry leachates. Collection ponds are tested on a weekly basis so as to assure that no unsafe chemicals or leachates are passing through the system. Therefore, the collection pond aids in assuring that the landfill is environmentally conscious (Operational Manager of Waste Management Inc., Tom Murray, personal communication, May 1, 2003).

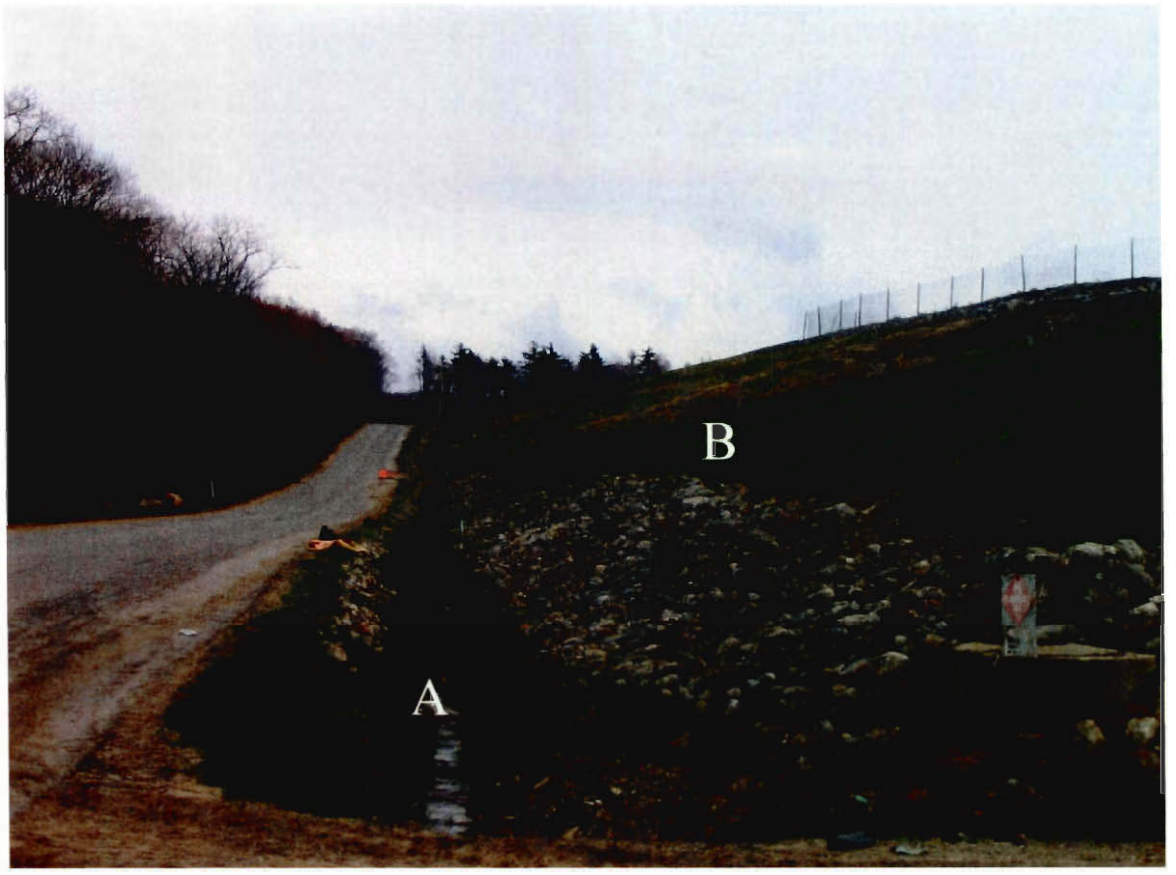


Figure 2. Leachate Collection Stream

The leachate collection stream (A) runs the entire length of the landfill. This stream is rocky and is created at a slight slope to slowdown the flow of the rainwater to the next leachate collection pond or leachate collection pump, where it is then treated. Just behind (B), where dead grass is present, is a rainwater wash-off. This grove in the landfill serves to collect and pull rainwater off of the landfill so that the water will not seep into the ground and collect the leachates. Note also the gradual thirty-three percent slope that makes a stable landfill (Operational Manager of Waste Management Inc., Tom Murray, personal communication, May 1, 2003).

Figure 3. Leachate Pump Station #1

The fenced in area (A) is where the leachate pump is stored. The pump draws in water from the pond in Figure 1. It then treats the water for the final time before it enters the nearby stream (B). Once the water leaves this pump, it is checked once per week and after any heavy rainfalls to assure that the water does not contain any silt, which could carry leachates into the stream. The leachate pump is one of four that treat and pull the water throughout the system (Operational Manager of Waste Management Inc., Tom Murray, personal communication, May 1, 2003).

Figure 4. Large Methane Flare

The large methane flare is the site in which all the methane is pumped and burned. The flare functions by constantly sparking until there is enough methane within to ignite, at which point all the methane inside the flare is burned. In the Fitchburg landfill, however, this flare is not used, but rather the methane is collected and sent to a nearby power plant (Operational Manager of Waste Management Inc., Tom Murray, personal communication, May 1, 2003).

Figure 5. Methane Collection System--Main Pump

This figure shows the main pump (A) for the methane collection system. The pump pulls all of the methane throughout the landfill as a method of collection, and it also pumps the methane to the Fitchburg power plant. If the large flare were used, the methane would be pumped through the pipe (B) where it would then be burned. In the background (C) is the landfill, which is about 500 yards away from the pump. This distance serves as a safety precaution, as large amounts of methane are collected here (Operational Manager of Waste Management Inc., Tom Murray, personal communication, May 1, 2003).

Figure 6. Small Methane Flare

The above picture shows a small methane flare. Although this type of flare is not connected to the methane collection system, it is still a major part. This small flare is situated in areas where the landfill is currently being filled and layered. The flare has its own pump, which is in green in the above photograph. A hole is dug all the way down to the bottom of the landfill, and is then filled with rocks. The pump draws out the methane through this hole, and the methane then collects in the conical flare area. It is in this area that sparks are constantly produced, and the flare ignites (Operational Manager of Waste Management Inc., Tom Murray, personal communication, May 1, 2003).

Figure 7. Methane Collection Pump

The above methane collection pump is one of over twenty throughout the landfill. These methane collection pumps are connected to the main pump shown in Figure 5. The taller part of the pump system is connected to the deep hole, which reaches the bottom of the landfill, and pulls the methane out of this area. The methane then flows into the shorter tube, where it is connected to the main methane pump that collects all of the methane (Operational Manager of Waste Management Inc., Tom Murray, personal communication, May 1, 2003).

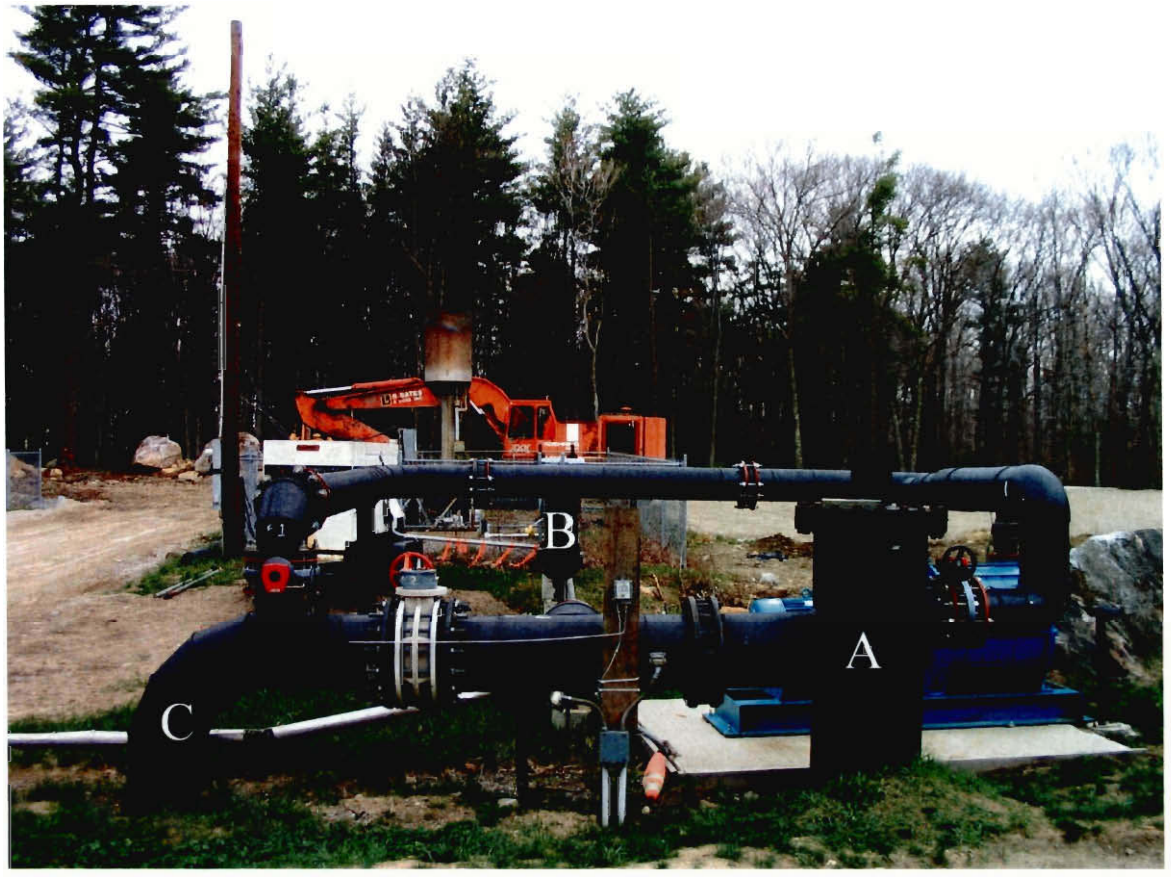


Figure 8. Collection and Transport Pipes

The large pipe (A) is connected to the landfill. This is where all the methane is collected by the pump. The methane can then either be sent to the large flare in the background (B) or to the Fitchburg power plant (C) (Operational Manager of Waste Management Inc., Tom Murray, personal communication, May 1, 2003).

Daily Cover

Figure 9. Daily Cover

The above figure shows the previous day's load of waste (A) that has all ready been covered with ground construction material. The current days' waste (B) is still being pushed, crushed and layered. This section will also be covered with the ground construction materials at the end of the day. Note also that the sections are of equal height, that they have been layered, and that behind them is a flat surface that continues to the end of the section (Operational Manager of Waste Management Inc., Tom Murray, personal communication, May 1, 2003).

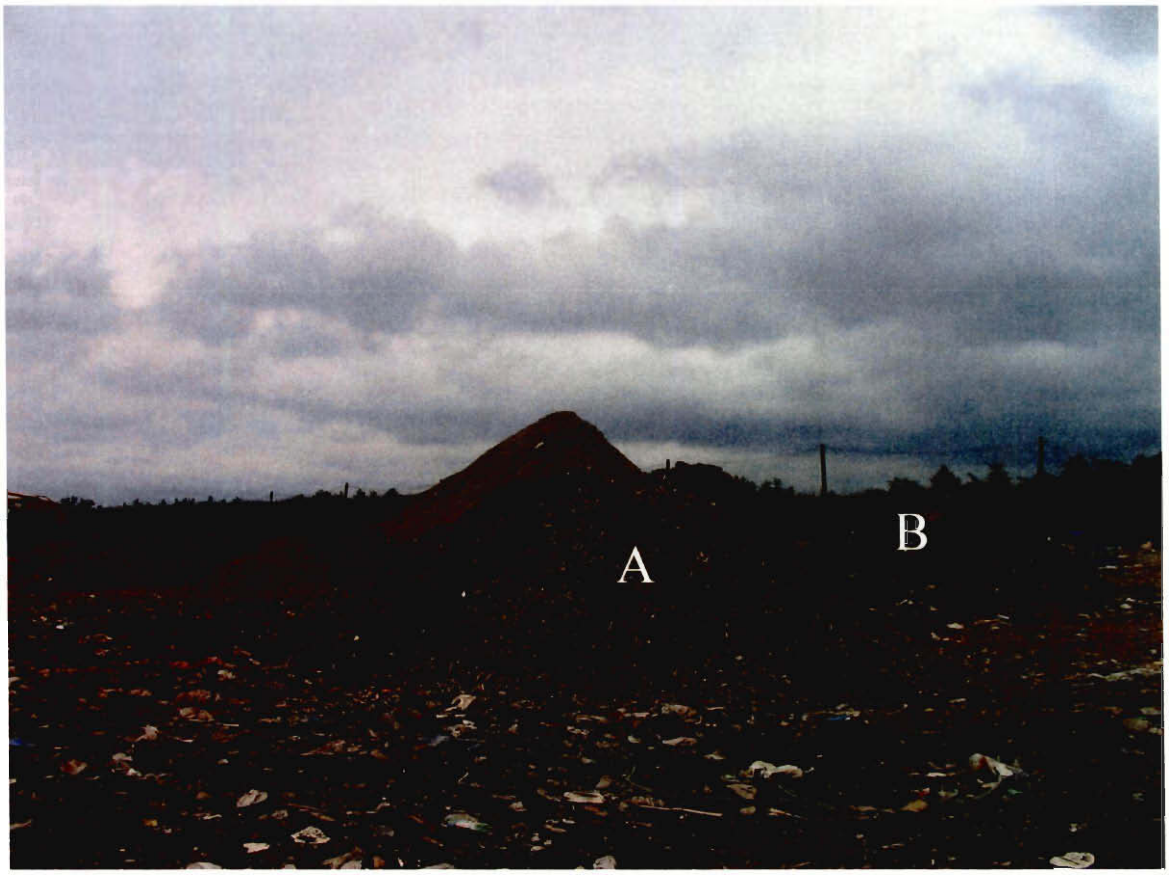


Figure 10. Daily Cover Piles

This figure shows the piles that are used for the daily cover. Pile (A) is ground construction material, and pile (B) is composted yard waste. The composted yard waste is used on the sides of the landfill as layers are built. The composted waste creates a tight grade, and it allows grass to quickly grow, thus preventing the landfill from washing away with heavy rainfalls (Operational Manager of Waste Management Inc., Tom Murray, personal communication, May 1, 2003).

Figure 11. On-Site Composting

This figure shows how on-site composting is managed. The first pile is pre-composted yard waste (A), which is moved to the other yard waste pile shown in Figure 10, as needed. The other pile (B) is yard waste that is being composted, and it can also be added to pile A. The last pile (C) is clean pallets and other forms of construction waste that will be ground-up and used as a daily cover (Operational Manager of Waste Management Inc., Tom Murray, personal communication, May 1, 2003).

Figure 12. Collection of Easily Composted Materials

This figure shows an area of the landfill where residents can dump their easily composted yard waste. Having a section like the one above encourages residents to separate their yard waste so that it may be composted. It also helps to reduce the amount of waste that needs to be landfilled (Operational Manager of Waste Management Inc., Tom Murray, personal communication, May 1, 2003).

Sectioning

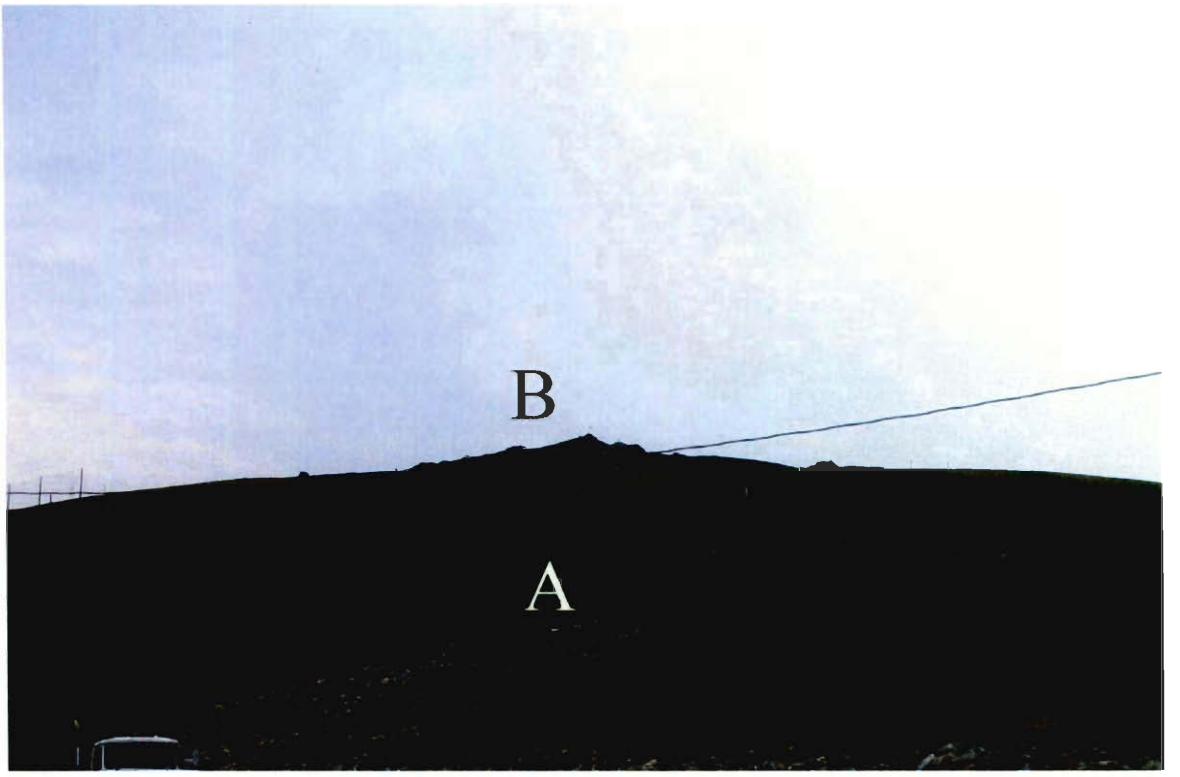


Figure 13. Sectioning

This figure shows an old section of the landfill (A), which is the area covered in grass. This section was capped in 1976 and it was not used again until 1992 when the new section (B) was built by Waste Management Inc. The new section can be noticed by the pile of freshly-composted material that is kept there for use of daily cover (Operational Manager of Waste Management Inc., Tom Murray, personal communication, May 1, 2003).

Appendix S: El Parque de Tecnología Ambiental

Owned by Empresas Berthier (EBI)

Leachate Collection System

Figure 1. Water Treatment Lagoon

This photograph shows the larger of the two water treatment lagoons in the landfill in Uruca, with a capacity of 2,500 cubic meters. There are two motors that pump the water either to the top of the landfill to recycle the water through the system again or to the pumps that then release the water in the nearby river. This lagoon treats the water with microorganisms that reduce smell and clean the water of leachates (Engineer of Uruca Landfill owned by EBI of Canada, Roberto Fallas, personal communication, June 12, 2003).

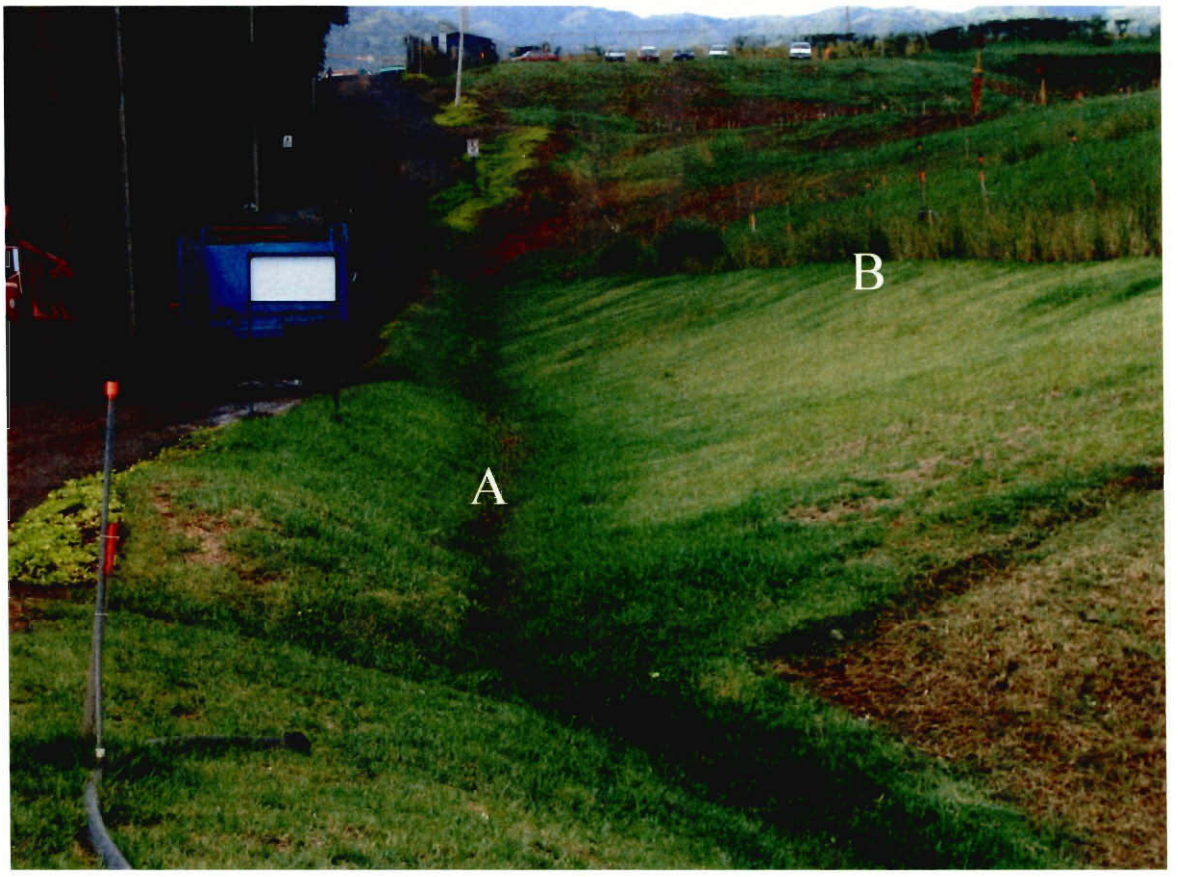


Figure 2. Leachate Collection Stream

The leachate collection stream (A) runs the entire length of the landfill. This stream was created with a slight slope to slowdown the flow of the rainwater on its path to the water treatment plant. Just behind (B), note the gradual thirty- three percent slope that sustains a stable landfill (Engineer of Uruca Landfill owned by EBI of Canada, Roberto Fallas, personal communication, June 12, 2003).

Figure 3. Microorganism Sprayer

Figure 4. Microorganism Fermentation Station

Figure 3 is a microorganism sprayer that is used to wash down every truck after its contents are dumped in the landfill. Employees of the landfill spray the trucks to kill all bacteria before they leave the landfill. Figure 4 shows the barrels in which the microorganisms are fermented, and then stored in the large tank labeled 1-B. The production of the microorganisms costs the landfill $1,000 per month. The microorganisms are very effective in the reduction of odor, and they kill any potentially harmful bacteria. The microorganisms also have other uses that will be shown in later pictures (Engineer of Uruca Landfill owned by EBI of Canada, Roberto Fallas, personal communication, June 12, 2003)

Methane Collection System

Figure 5. Large Methane Flares

The methane flares are set-up throughout the landfill. These tall yellow flares are used to collect and then burn all the methane produced by the landfill. These flares are constructed by the digging of large holes that reach the bottom of the landfill, and then the filling of these holes with rocks. The methane produced within the landfill seeps through the rocks and exits the top of the flare where the methane is then burned. These flares are only temporary, however, as the methane flares will be connected when the landfill reaches its capacity (twelve to fifteen years from now), and the methane will be sold to a power plant that will burn it to produce electricity (Engineer of Uruca Landfill owned by EBI of Canada, Roberto Fallas, personal communication, June 12, 2003).

Daily Cover

Figure 6. Dumped Waste

Figure 6 shows two days' worth of waste. This landfill does not utilize a daily cover, but rather covers the waste with dirt every other day or so. Microorganisms are, however, sprayed over the waste throughout the day with the microorganism sprayer shown in Figure 3. The spraying of the microorganisms on the waste serves two main purposes. Firstly, it reduces the odors that are released by the landfill. Secondly, the spraying increases the rate of decomposition of the waste. The result of increased decomposition of waste is an increase in the production of methane. This is why there are multiple methane flares set-up around the section in which the waste is currently being dumped (Engineer of Uruca Landfill owned by EBI of Canada, Roberto Fallas, personal communication, June 12, 2003).

Sectioning

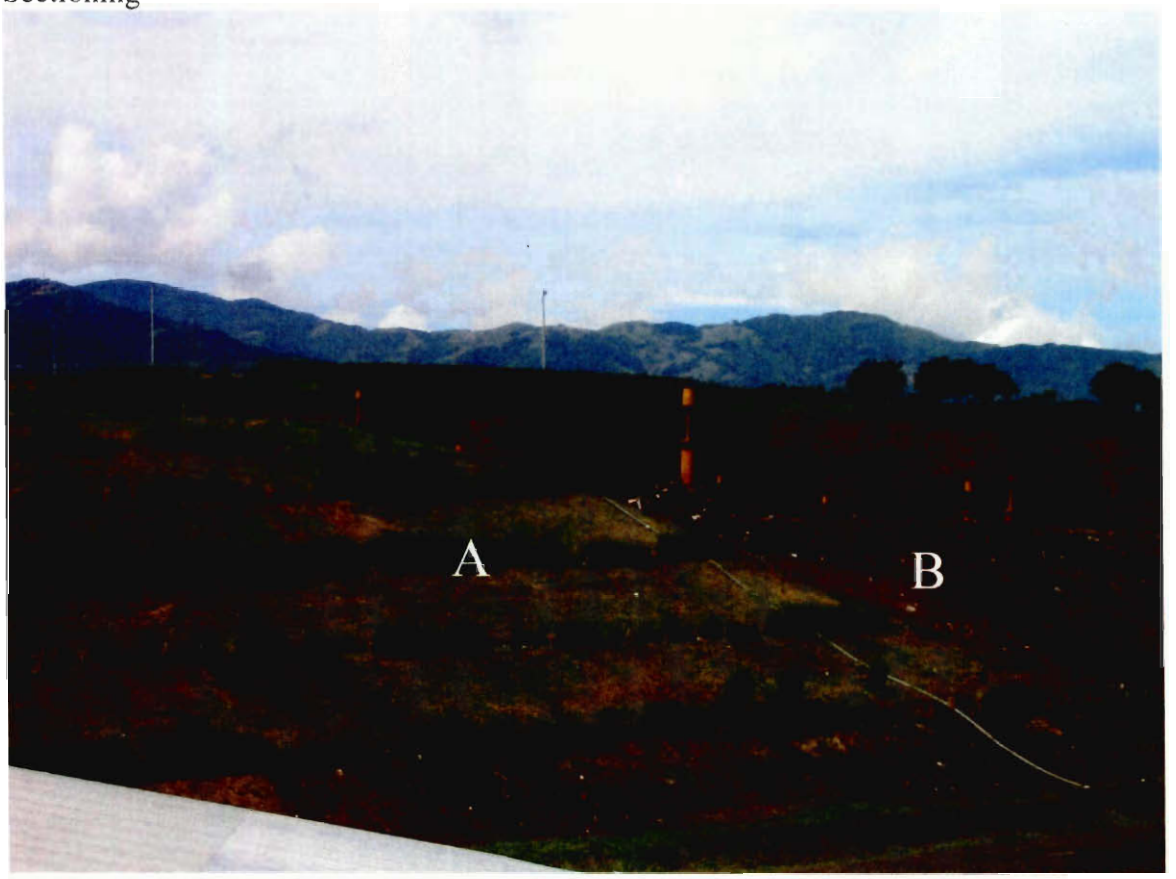


Figure 7. Sectioning

Figure 7 shows an old section of the landfill that is called Phase 1 (A). The new section (B) is the area that is currently being used for the dumping of waste. The landfill will have six phases of sections before it has reaches its capacity (Engineer of Uruca Landfill owned by EBI of Canada, Roberto Fallas, personal communication, June 12, 2003).

Impermeable Layer

Figure 8. Impermeable Layer

Figure 8 shows a major part of the landfill's impermeable layer. The thick rubber material is laid down on the bottom of the landfill, and the next layer is a net-like plastic material that is used to create space between the remainder of the impermeable layer so that water can pass through. The next layer is a filter that allows only water to pass through in order for the water to be easily separated. The filter is covered by a thick layer of ground tires that the water must first pass through. These materials, in addition to other classified materials, create a layer that is impermeable to all water so that it cannot contaminate ground water (Engineer of Uruca Landfill owned by EBI of Canada, Roberto Fallas, personal communication, June 12, 2003).

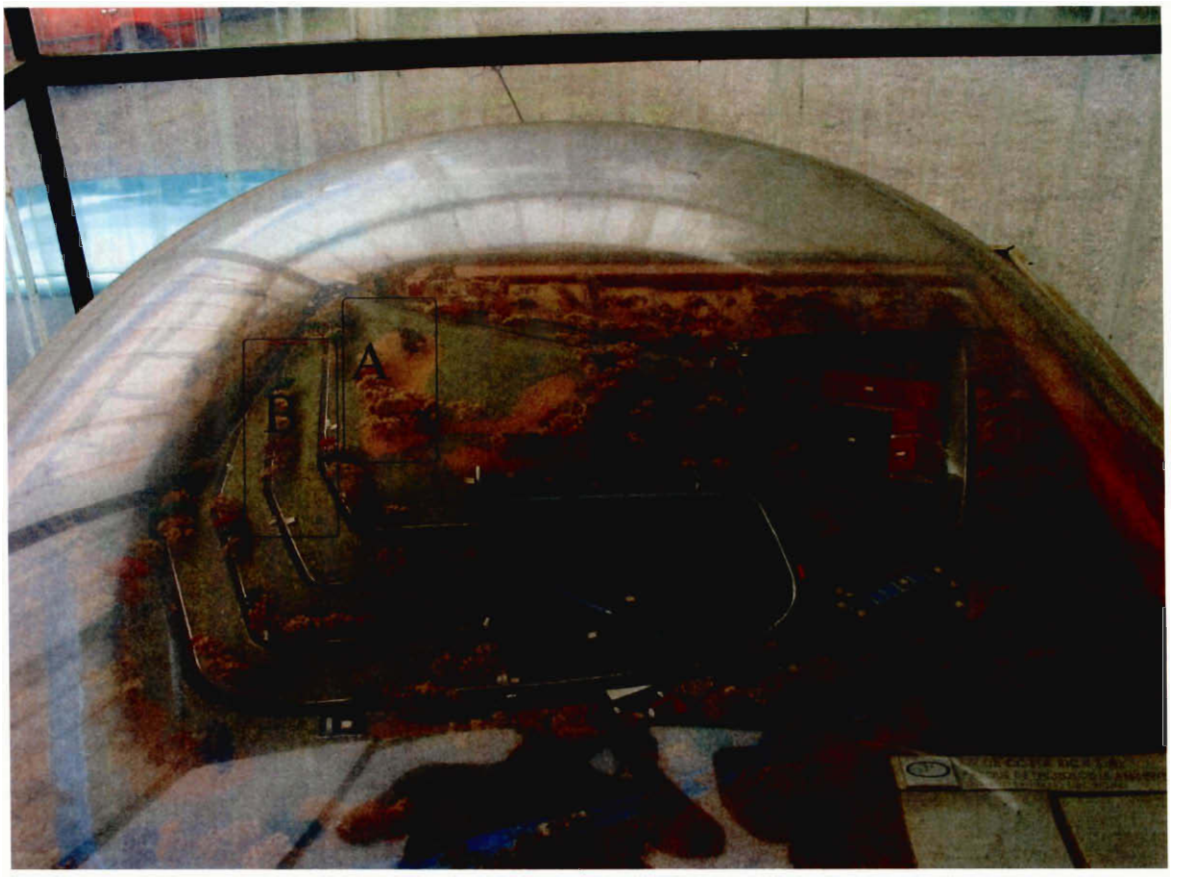


Figure 9. Future Plans

Figure 9 shows how the landfill will look once it reaches its capacity and is capped. The boxed in areas (A and B) represent the areas that were shorn earlier as the section that has all ready reached its capacity, and section A is the section that is currently being filled. This landfill, once capped, will be transformed into a park with soccer fields and basketball courts for the residents of San José (Engineer of Uruca Landfill owned by EBI of Canada, Roberto Fallas, personal communication, June 12, 2003).

Appendix T: Río Azul

Owned by Waste Placement Profession (WPP)

Leachate Collection and Treatment System

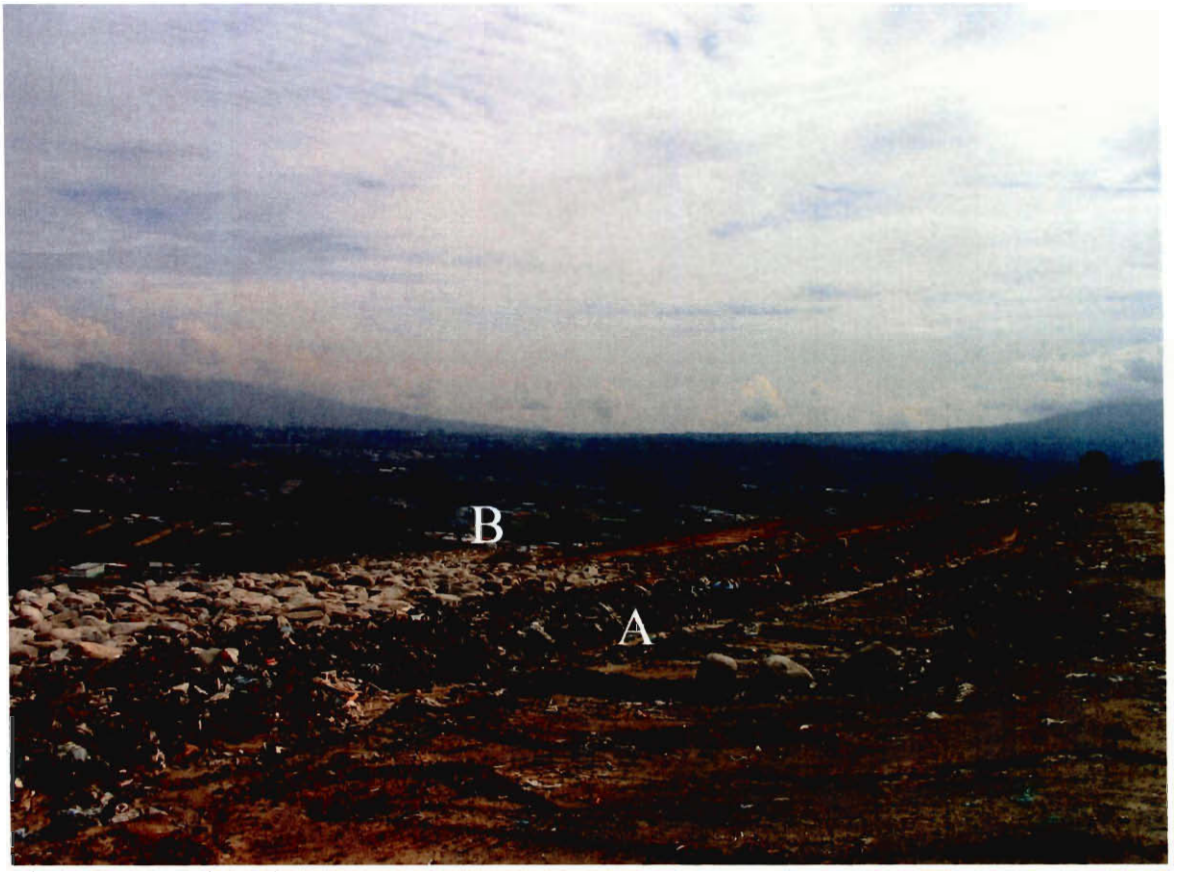


Figure 1: Leachate Stream

This picture was taken from the top of the pyramid-like structure of the Río Azul landfill. Note the rainwater run-off (A), which is supposed to divert water from entering into the landfilled waste. Notice that on the sides of the stream there are large amounts of waste and that the stream is only a trough-like hole that was dug along the surface of the landfill. The run-off is diverted to the side of the landfill where it then flows down into other streams similar to this one shown above, until it either reaches the leachate collection lagoon or seeps into the ground. The seeping of the leachates into the ground contaminates the underground water supplies and affects the extremely poor and densely populated nearby community (B) (Jorge Cardoza, personal communications, June 17, 2003).

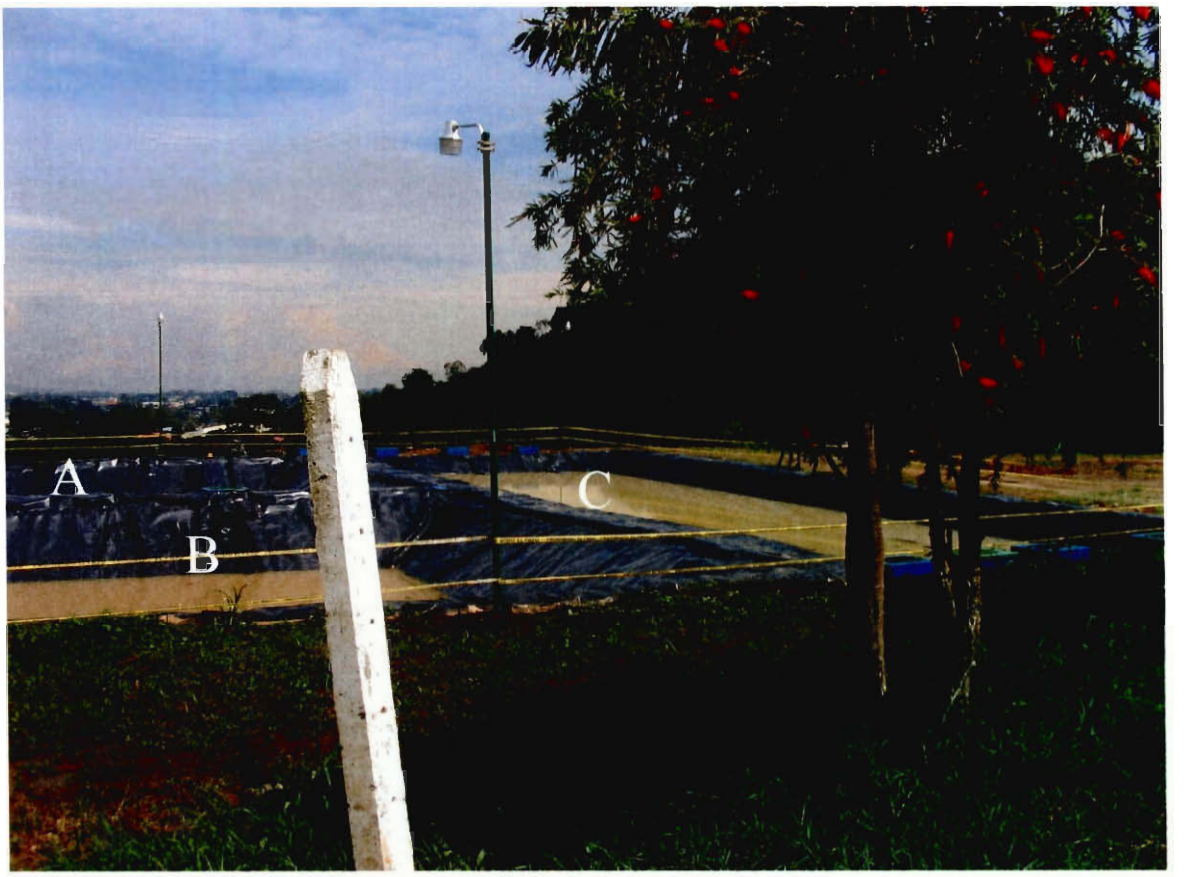


Figure 2: Future Leachate Treatment Lagoons

WPP plans on building an on-site leachate treatment facility that consists of three lagoons that will treat the collected water and remove all the leachates from the water. The facility is a series in which the first lagoon (A) will collect the silt that is carried in the water by keeping the water sedimentary. The second lagoon (B) will treat the leachates with oxygen until the water is pumped into the final lagoon (C), which will treat the leachates with chlorine. This process should eliminate all leachates, and at that point the water should be safe to dump into the nearby river. However, this system will not be finished for another two years (Jorge Cardoza, personal communications, June 17, 2003).

Figure 3: Methane Flare

The small methane flare shown above is used to collect and burn methane from the area of the landfill that is below it. Río Azul has four of these flares set-up throughout the landfill. These flares serve only to remove methane from a small area around it. Therefore four flares are not sufficient for a landfill of this size (Jorge Cardoza, personal communications, June 17, 2003).

Figure 4: Methane Chimney

The two barrels stacked on top of each other serve as methane chimneys. These are set-up throughout the landfill, and their purpose is to release the methane that is produced below them. These chimneys are ineffective, as they have no form of suction to help remove the methane, which leaves great deals of methane sitting under the landfill's cap and creating a potentially hazardous situation. The chimneys also release the methane into the air without burning it, resulting in the pollution of the air (Jorge Cardoza, personal communications, June 17, 2003).

Landfill Condition

Figure 5: Poor Management of Waste

The tractor shown below is running-over and crushing all the waste that was collected and that has remained uncovered for an uncertain number of days. The rainwater is therefore able to enter the landfilled waste where it can then produce and carry leachates out of the landfill (Jorge Cardoza, personal communications, June 17, 2003).

Figure 6: Scavengers

Figure 7: Scavengers

Figures 6 and 7 show some of the many scavengers that are allowed into the landfill to pick-out any glass or plastic items. The presence of the scavengers shows just how poor the neighboring town is, as the selling of these items produces their only source of income (Jorge Cardoza, personal communications, June 17, 2003).

Figure 8: Neighboring Community

This aerial picture shows the size of the landfill as compared to the neighboring community. This community is very poor, and some of the residents' homes are built on the very edge of the landfill's boundary (Jorge Cardoza, personal communications, June 17, 2003).

Appendix U: Los Mangos

Owned by Waste Placement Profession (WPP)

Leachate Collection and Treatment System

Figure 1: Leachate Stream

Figure 2: Leachate Stream

Los Mangos landfill has leachate streams that collect rainwater and span throughout the landfill, carrying all of the water to a collection point. The leachates are collected by a truck and transported to a waste-water treatment plant (Douglas Alpizar Villalobos , personal communications, June 21 ,2003).

Figure 3: Stream Collection Reservoir

Figure 4: Contaminated Water

The leachate streams in Figures 1 and 2 above collect at Figure 3 where the water sits until it is removed by a truck. Figure 4 shows contaminated water oozing out of the side of the landfill, where it will remain until rainwater washes it into the leachate stream (Douglas Alpizar Villalobos , personal communications, June 21 ,2003).

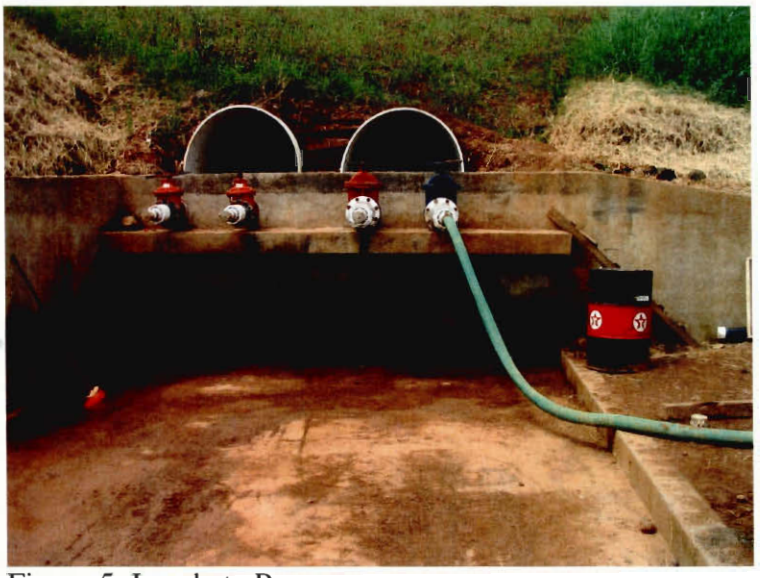


Figure 5: Leachate Pumps

Figure 6: Collection Truck

Figures 5 and 6 show the system that removes leachates from the five sections of the landfill. The leachates sit on the impermeable layer at the bottom of the landfill until they are pumped out of the landfill and into a truck. The truck then brings all of the leachates to a treatment plant owned by a private company (Douglas Alpizar Villalobos , personal communications, June 21, 2003).

Figure 8: Methane Flare

Los Mangos has eight methane flares like the one shown above that are located throughout the landfill. These flares reduce the amount of methane released into the air by the method of burning, which reduces air pollution (Douglas Alpizar Villalobos, personal communications, June 21, 2003).

Figure 9: Daily Cover

Figure 9 shows the area where the day's waste is dumped. This waste is compacted and moved by a large tractor with spiked, metal wheels. At the day's end, the waste is covered with dirt, unless heavy rainfall ensues (Douglas Alpizar Villalobos, personal communications, June 21, 2003).

Figure 10: Landfill before WPP purchased

Before purchasing the landfill, Los Mangos was a dump. The trash was left in huge piles with no form of cover or maintenance. It was just dumped. The methane production was so great that fires would spontaneously ignite and burned unsupervised. WPP had to fix-up the site, and it removed over 10,000 tons of trash from the nearby river. The section was then capped and new sections were built according to Costa Rican regulations (Douglas Alpizar Villalobos, personal communications, June 21, 2003).

Figure 11: Soccer Field on Landfill

WPP plans on turning Los Mangos into a park once it reaches its capacity and is capped. As shown above, there is already one soccer field on the site, but WPP's future plan is to make the landfill into a larger park that local families will be able to enjoy (Douglas Alpizar Villalobos, personal communications, June 21, 2003).

NO INCLUIR:

- Excremento de: Personas, perros, gatos, cerdos
- Carnes
- Productos lácteos
- Productos grasosos
- Huesos

VENTAJAS DEL COMPOSTAJE

(Abono Orgánico)

- Utiliza materiales baratos y fáciles de conseguir.
- Fabricación en poco tiempo
- Recicla la materia orgánica y no contamina el medio ambiente.
- Respeta la fauna y la flora
- Son abonos más completos y enriquecen los suelos.

Para mayor información sobre compostaje, vermicompostaje o el programa de reciclaje de Escazú comuníquese al departamento de Contraloría Ambiental de la Municipalidad de Escazú a los teléfonos:

228-5757 / ext. 259 ó 289
228-7762

E-mail:
fundatamu@yahoo.com

o visite nuestra hoja web:
www.fundatamu.or.cr

Guía para elaborar fácilmente compostaje en su casa

PROYECTO

Escazú recicla

Promovido por:

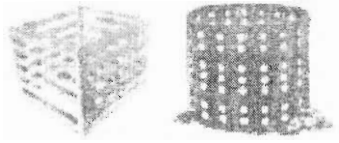
Convenio Bilateral de Desarrollo Sostenible entre Costa Rica y el Reino de los Países Bajos
(Fundecooperación para el Desarrollo Sostenible)
Municipalidad de Escazú
ASOFAMISAE
Fundación TAMU - COSTA RICA
(Texas A&M University)

Para hacer la compostera:

1. Seleccione un lugar en el jardín, nivelado, y que reciba igual cantidad de sol y de sombra durante el día.

2. Remueva una capa de zacate de manera que quede expuesta la tierra. Se recomienda preparar un área mínima de 1 m^2.

3. Puede utilizar malla de alambre, madera o bloques para conformar la estructura donde se va a hacer la composta, el diseño debe permitir una buena circulación de aire. La altura recomendable es de 1 m.



Elaboración:

1. Se coloca una capa inicial de 10 cm de material grueso como ramas picadas, hojas y paja.

2. Luego se agrega una capa de materiales compostables caseros.

3. Se debe agregar una pequeña capa de cal apagada, ceniza y/o cáscaras de huevo trituradas para neutralizar malos olores.

4. Repita la secuencia utilizando en lugar de ramas solo residuos de jardín tales como zacate, paja, hojas y plantas.

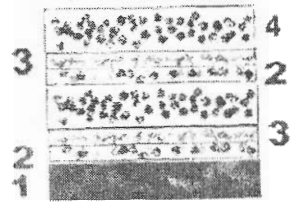
5. Se le pueda agregar una capa delgada de tierra negra y suelta o de compost preparado, para que acelere el proceso.

6. Revolver 1ó 2 veces por semana, y mantener húmedo (no empapado) rociándole un poco de agua, (entre más se revuelva, más rápido se descompone).

7. Mantenga la compostera cubierta con una capa de hojas ó zacate para prevenir la proliferación de insectos. En el invierno se recomienda cubrirla con un plástico para que no se empape.

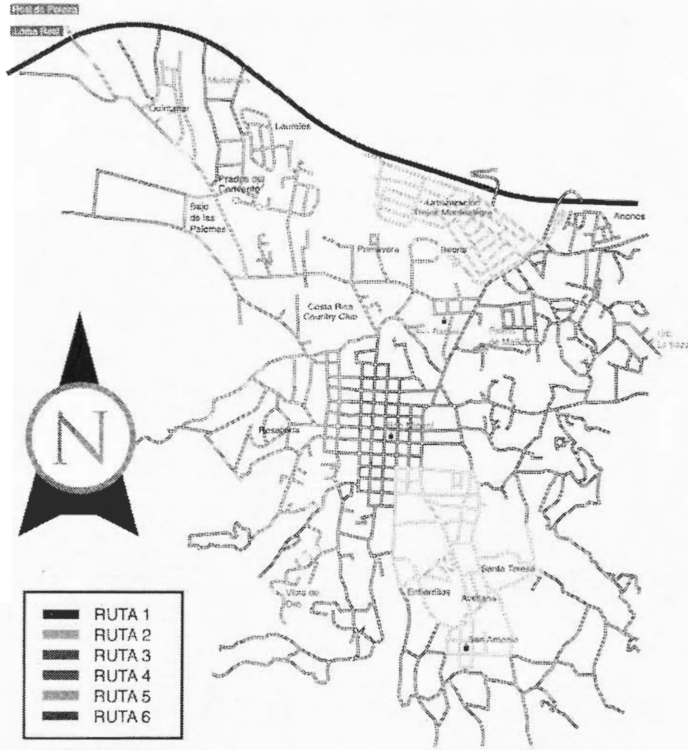
8. El abono está listo cuando toma una coloración negra y una textura homogénea. (3 meses aprox).

9. Si tiene a su alcance excremento de gallina, vaca, caballo, cabra, conejo u oveja alternarlas entre las capas de desechos de jardín y los materiales compostables caseros.



Materiales compostables caseros:

- Cáscaras y recortes de frutas y verduras
- Residuo de café después de chorreado.



RUTA ESPECIAL
Se hará una ruta adicional con las escuelas y colegios que quieran participar y están fuera de las rutas de recolección y los comercios interesados en que se le recoja más a menudo. Si está interesado favor contactarse con nosotros.

Números de teléfono importantes

Para mayor información comuníquese al departamento de Contraloría Ambiental de la Municipalidad de Escazú a los teléfonos:

228-5757 / Ext. 289 ó 259
228-7762
e-mail: fundatamu@yahoo.com
O visite nuestra hoja web: www.fundatamu.or.cr

Reciclaje de desechos sólidos en el cantón de Escazú

Guía para la separación y recolección de desechos sólidos reciclables

Promovido por:
Municipalidad de Escazú
Asociación de Ayuda a la Mujer y Familia de San Antonio de Escazú (ASOFAMISAE)
Fundación TAMU-Costa Rica (Texas A & M University)

Guía Práctica para Reciclaje

MATERIAL	CÓMO PREPARARLO	NO INCLUIR
 **Aluminio** Latas de aluminio. (Latas de refresco, de cerveza y algunos jugos). Latas suaves.	Enjuagar y drenar. Aplastarla. Colocar en bolsa transparente.	No se deben de incluir latas de atún, verduras, frutas ni de pinturas. Tampoco se aceptan latas de aerosol.
 **Vidrio** Botellas y frascos, de todos colores y formas. Vidrio de ventana transparente. Vajillas de vidrio.	Enjuagar y drenar. No hay que quitar las etiquetas. Colocar en bolsa transparente. El vidrio quebrado debe venir por seguridad en una caja de cartón.	No se deben de incluir bombillos, vidrio de automóvil, espejos, pyrex, ni vajillas de cerámica.
 **Plásticos** Botellas plásticas con el símbolo (PET), como las de refrescos gaseosas y agua (busque el símbolo en la base del envase). Envases plásticos de detergentes, aceite, shampoo hechos con el símbolo (HPDE).	Enjuague y drene. Le puede quitar la tapa. No le quite la etiqueta. Aplastar y colocar en la bolsa transparente.	No se aceptan bolsas plásticas, o envoltorios. No se aceptan plásticos que tengan símbolos de reciclaje con números diferentes al ó . No incluir platos ni vasos desechable ni muebles plásticos.
 **Papel, Cartón y Cartulina** Papel periódico, revistas, directorios, papel blanco y de colores. Cartón café grueso. Cartón delgado tipo cartulina (e.g. cajas de cereal o de medicinas).	Las cajas de cartón y de cartulina deben de desarmarse y colocarse en una bolsa plástica transparente. No se debe arrugar el papel (hacer bodoques) porque ocupan mucho espacio. El papel se debe de colocar en bolsas plásticas transparentes para que no se moje.	No incluir cartón o papel con residuos de comida o grasa, o sucios. No se debe incluir envases tetrabrik (cajas de leche o jugos). Tampoco incluir platos o tazas de cartón, servilletas, toallas sanitari o mantillas desechables.

Nunca la recolección de basura va a ser igual

Desde el 7 de enero del 2002, la Municipalidad de Escazú comenzó con la primera etapa de la recolección de desechos sólidos reciclables. Estos desechos se recolectan una vez cada quince días. No se afectará la recolección normal de la basura tradicional.

Estos desechos son procesados por una empresa comunal, con un importante componente de género, al contar con la participación de ASOFAMISAE, generando así empleo y recursos para invertir en proyectos ambientales del cantón.

El financiamiento del proyecto fue posible gracias al apoyo y cooperación del gobierno holandés a través de Fundecooperación para el Desarrollo Sostenible y la asistencia técnica de la Fundación TAMU-Costa Rica.

Acerca del reciclaje

El reciclaje puede reducir los desechos sólidos que usted produce hasta en un 40%. Entre más reciclemos podremos disminuir el número de toneladas que diariamente se envían al relleno sanitario. Actualmente el cantón de Escazú produce alrededor de 50 toneladas diarias con un crecimiento anual de un 12% a un 14%.

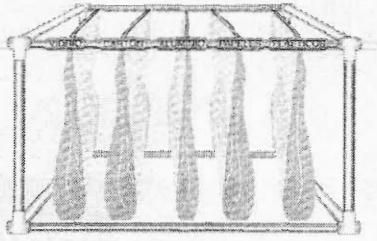
Para disminuir este efecto, la Municipalidad de Escazú aprobó el "Reglamento para el manejo discriminado de desechos sólidos en el Cantón de Escazú", el cual fue publicado en La Gaceta del 15 de abril del 2002. En este reglamento se indica la obligación de separar los desechos sólidos reciclables de la basura normal con multas de cien colones (¢100) por metro cuadrado de propiedad (Artículo 83), a quienes no cumplan.

¿Cómo separar?

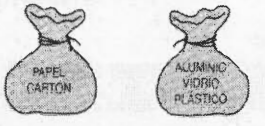
Se recomienda la separación de los desechos sólidos reciclables en 5 grupos: aluminio, vidrio, papel, cartón y plástico.

Los desechos sólidos reciclables deben de colocarse en bolsas plásticas transparentes. Esto nos permite verificar que el contenido de la bolsa no se encuentre contaminado.

Para facilitar la separación, se recomienda el uso de canastas hechas de tubos plásticos. Estas canastas podrán ser adquiridas en la Oficina de Centro de Acopio o en el camión de reciclaje.



Si tiene problemas de espacio se permite separar el plástico, el vidrio y el aluminio en una bolsa transparente y el papel y el cartón en otra. Nunca debe de mezclarse el papel con los envases para que no se moje.



¿Dónde conseguir las bolsas plásticas transparentes?

Las bolsas plásticas transparentes son vendidas en los principales supermercados del cantón: Saretto, Mas x Menos, Automercado, Palí, Super Calderón, Super Aldino y cualquier abastecimiento que desee participar.

Calendario de recolección 2003

Se ha adoptado un sistema de recolección de desechos sólidos reciclables quincenal. El siguiente calendario indica las semanas en que se recolectará en su ruta dependiendo del color. Para las rutas 1,2 y 3 se brindará el servicio de recolección los días lunes,martes y miércoles respectivamente durante las semanas marcadas en azul, mientras que las rutas 4, 5 y 6, lunes, martes y miércoles durante las semanas en verde. Se informará conforme nuevas rutas sean creadas, hasta cubrir todo el cantón.

enero

D	L	M	M	J	V	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

febrero

D	L	M	M	J	V	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	

marzo

D	L	M	M	J	V	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

abril

D	L	M	M	J	V	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

mayo

D	L	M	M	J	V	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

junio

D	L	M	M	J	V	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

julio

D	L	M	M	J	V	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

agosto

D	L	M	M	J	V	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24/31	25	26	27	28	29	30

setiembre

D	L	M	M	J	V	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

octubre

D	L	M	M	J	V	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

noviembre

D	L	M	M	J	V	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23/30	24	25	26	27	28	29

diciembre

D	L	M	M	J	V	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

Nota: Los días marcados en rojo, no se dará el servicio de recolección.

RUTAS DE RECOLECCIÓN

RUTA 1 (Lunes) * Ver mapa

ZONA DE BELLO HORIZONTE

Incluye las casas y locales circunscritos por la calle de la entrada principal de Bello Ho hasta la calle Los Llanos, en el lindero sur hacia Toycos y por la calle principal de hasta la entrada de Bello Horizonte.

Incluye: Urbanización Los Ángeles, Calle Villalobos y Urbanización Palma de Mallorca Alemán, Vista Alegre, Urbanización La Suiza, Palermo y Urbanización Anonos.

RUTA 2 (Martes)

ZONA DE SAN ANTONIO

Abarca de la esquina noroeste del Colegio Nuestra Señora del Pilar a la Calle Ent hasta la Calle San Miguel. Además incluye: Las urbanizaciones La Macadamia, Guevara, La Nuez, Barrio Santa Teresa, La Avellana, Entierrillos y el cuadrante cen San Antonio, de la guardia rural a la intersección con la ruta 105 y alrededores de la Juan XXIII.

RUTA 3 (Miércoles)

ZONA ESTE DE SAN MIGUEL

Incluyen las casas y negocios que van desde Jaboncillos hasta el inicio de la colindando con el Country Club, por el este la calle 6 hasta el Country Day contir hasta el Barrio Corazón de Jesús.

Incluye: Urbanización Rosalinda, Calle Fendel, Urbanización Vista de Oro, Jabon Calle La Cuesta.

RUTA 4 (Lunes)

ZONA SAN RAFAEL NOROESTE

Incluye las urbanizaciones al norte de la ruta viejo a Santa Ana desde el cruce con 105 hasta la Urbanización Ayala. Incluye: Cabañas (embajadas), Laureles, Urban Americana, La Socola, La Carchita, Lotes Facio, La Primavera, Quesada, Carflor y del Convento. Además incluye Lotes Carazo, Maynard y alrededores de la iglesia Rafael.

RUTA 5 (Martes)

ZONA TREJOS MONTEALEGRE

Urbanización Trejos Montealegre, Zona Comercial- Boulevard Rosa (acera oeste) y Comercial Trejos Montealegre y Urbanización Betina.

RUTA 6 (Miércoles)

ZONA GUACHIPELÍN, BAJO DE LAS PALOMAS, QUINTANA

Abarca la calle principal a Guachipelín: Del Banco de San José hasta la Urb. Real de

Incluye: Urbanización Loma Real , Real de Pereira, Quintanar y Bajo de Las Paloma

Appendix X: El Parque de Tecnología Ambiental Pamphlet

La vida útil del Parque se estima en 11 años, sin embargo puede ampliarse una vez que se fortalezcan los procesos de recuperación, reutilización y reciclaje de un alto porcentaje de los desechos sólidos, a través de programas permanentes de educación y sensibilización hacia la ciudadanía para que conozcan los procesos de clasificación y separación de desechos, desde la fuente de origen, para facilitar así su manejo integral. Finalmente el Cierre Técnico permite habilitar todo el terreno que se utilizó como Relleno Sanitario, en una zona ecológica para el disfrute de la comunidad.

Beneficios del Parque de Tecnología Ambiental

1. Sociales

- Electrificación de toda la Finca La Caja. (CNFL)
- Ampliación y mejoras de las condiciones físicas de la escuela de la localidad. (EBI, MSJ, MOPT)
- Asfaltado de las carreteras. (MOPT)
- Fideicomiso para promoción y desarrollo socio - comunal. (EBI)
- Construcción de cordón, aceras y caños. (MSJ)
- Apertura de 5 Equipos Básicos de Atención Integral en Salud (EBAIS). (CCSS)
- Escritura de las propiedades de los habitantes de la finca. (IMAS)
- Oportunidades laborales para la comunidad.

2. Educativos

La empresa E.B.I. mantiene un programa de educación ambiental con énfasis en gestión integral de desechos, dirigido principalmente a estudiantes de primaria y secundaria del cantón central de San José.

Foto: Alex Uli

3. Ambientales

- Garantiza el funcionamiento eficiente y eficaz de las instalaciones del Parque de Tecnología Ambiental.
- Vela por la calidad del agua, aire y suelo.
- Contribuye en la solución de un problema de salud pública para el país, como es el manejo integral de los desechos sólidos del cantón central de San José.

¿Cómo llegar al Parque de Tecnología Ambiental de La Caja?

ebi

Oficinas Centrales
(506) 232-7618 ó 232-4271

Fax: (506) 232-4142

Correo Electrónico
ebicosta@racsa.co.cr

Apartado Postal:
295-1150 La Uruca, San José

Oficinas del Parque de Tecnología Ambiental:
(506) 290-7464

Fax: (506) 290-6014

ebi

Grupo EBI de Costa Rica

Parque de Tecnología Ambiental

bienvenidos

Una Experiencia Tecnológica para proteger el Ambiente y la Salud Pública

Parque de Tecnología Ambiental (P.T.A.)

l P.T.A. se cuenta con un área destinada al tratamiento in-
al de los desechos sólidos, sus componentes principales
onstituyen: el relleno sanitario mecanizado, centro de se-
ación y reciclaje, planta de producción de compostaje (abo-
rgánico), planta de tratamiento de lixiviados y generación
nergía.

T.A. aplica un proceso tecnológico de punta, en armonía
el ambiente: el uso de geomembranas, drenajes sintéticos,
extiles, tratamiento de los lixiviados y la cobertura diaria
los desechos compactados, constituyen componentes
nciales para su buen funcionamiento y operación.

este P.T.A. se implementará el principio de las 3R-V
ucir, reutilizar, reciclar y valoración de los desechos). De
manera iniciamos nuestros primeros pasos hacia el
rrollo de una cultura consciente y respetuosa con el
miento y disposición de los desechos.

Preparación del Terreno

el Parque de Tecnología Ambiental contribuimos con la
ección y mejoramiento de las condiciones ambientales del
, prueba de esto es la protección que hemos hecho, espe-
amente en el área destinada al funcionamiento del Relleno
itario. Este terreno está compuesto de material rocoso que
ide el paso de líquidos a las áreas subterráneas, sin embar-
para asegurar una protección adicional, se cubrió toda la
con arcilla compactada.

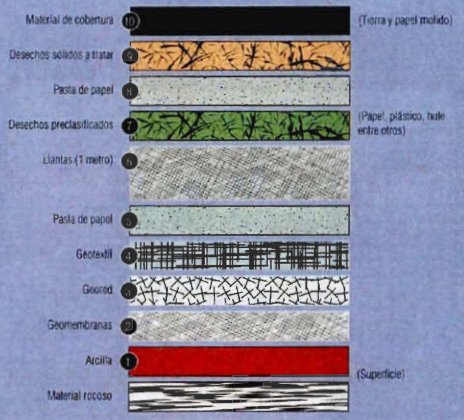
uidamente se colocaron tres tipos de sellos plásticos: geo-
nbrana, geored y geotextil. Los materiales de plástico están
puestos de polietileno de alta densidad (HDPE) y garanti-
la impermeabilización.

eotextil es una tela que permite filtrar líquidos para que a
eomembrana lleguen únicamente los lixiviados que pasan
s tuberías y desde ahí son bombeados para que lleguen a
guna de tratamiento o sean recirculados al Relleno.

Sobre las membranas se colocó una pasta de papel y además un metro de llantas usadas que fueron cubiertas con desechos preclasificados (papel, plástico, tela, hule, entre otros).

Los desechos preclasificados fueron cubiertos con papel molido, quedando así el terreno preparado para recibir los desechos sólidos a tratar.

La totalidad de estas capas constituyen varios metros de espesor que conforman una barrera de protección tanto para las membranas como para el terreno mismo.



Principales Áreas del Parque de Tecnología Ambiental

Primera Etapa

1. Cuenta con 18 hectáreas.
   (10 Has. son utilizadas en el Relleno Sanitario).
2. Laguna de tratamiento de lixiviados.
3. Romana, capacidad: toneladas.
4. Plataforma de lavado para camiones.
5. Taller.
6. Área de deporte y recreación para la comunidad.

Segunda Etapa

1. Nave industrial para la clasificación de desechos sólidos inorgánicos para reciclaje.
2. Zona para producción de abono o compostaje mediante el aprovechamiento de los desechos orgánicos.

"Etapas de tratamiento de los desechos"

- **Desechos sólidos:** Una vez que los desechos sólidos son depositados en el patio del relleno sanitario, se procede a distribuirlos y compactarlos para posteriormente cubrirlos con tierra y pasta de papel.
- **Los lixiviados:** se generan en el proceso de descomposición de los desechos sólidos, pasan a la laguna y ahí son tratados aeróbicamente (con oxígeno) mediante el sistema de aireación.
  La mayor parte se recircula hacia el Relleno, otro se evapora y una parte menor ya transformada en agua limpia, se deposita en el cause del río Virilla.
- En el mismo proceso de descomposición se genera principalmente gas metano -biogás- además de otros tipos con los cuales se produce energía eléctrica.

Vida útil del Parque de Tecnología Ambiental Finca La Caja

Foto: Alex Ulate

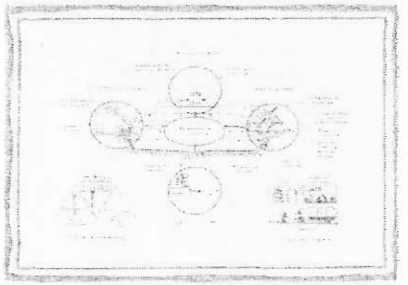
El cantón Central de San José produce diariamente alrededor de 400 toneladas de desechos sólidos, según Dirección de Sanidad, Municipalidad de San José, 1994- el 60% son materia orgánica (de origen vegetal o animal) y el 40% restante es material inorgánico (papel, cartón y plástico entre otros).

Cierre Técnico

El diseño y construcción de un relleno sanitario es una actividad continúa que finaliza cuando se agota la capacidad disponible o permitida. Para asegurar el funcionamiento de los controles ambientales durante la clausura y 20 años después de ella, debe desarrollarse previamente un plan o proyecto de cierre técnico. Se debe tomar en cuenta aspectos tales como:

- Diseño de cobertura final
- Sistema de control de aguas superficiales y drenajes
- Control de gases
- Control y tratamiento de lixiviados
- Sistemas de supervisión ambiental
- Utilización post cierre del terreno

Diagrama de Cierre Técnico de un Relleno Sanitario



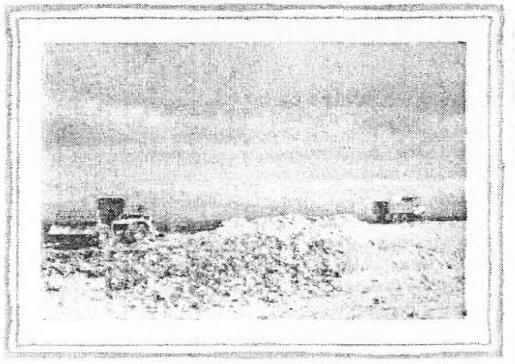
Para minimizar el impacto ambiental y lograr un amortiguamiento biológico, los terrenos del Relleno se destinarán para la creación de un parque ecologico, ya que el terreno debe ser una zona de bajo tránsito; además se pretende instalar un vivero.

Datos Generales

En el Relleno Sanitario de Rio Azul, depositan los desechos sólidos las siguientes Municipalidades: Alajuelita, Aserri, Coronado, Curridabat, Desamparados, Escazú, Goicoechea, La Unión, Moravia, Montes de Oca y Tibás, además de particulares, industrias, hospitales y clínicas del Gran Área Metropolitana.

El promedio de ingreso de desechos sólidos por día es de 800 Toneladas

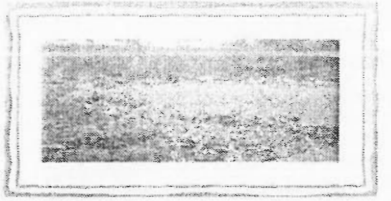
RELLENO SANITARIO DE RÍO AZUL



Teléfono: 276-9800 / 276-6583
Fax: 276-8142
Correo: fedemur@racsa.co.cr

En el año 1973 empieza la disposición de basura en lo que hoy es el Relleno Sanitario de Río Azul. La administración del Relleno pasaba de mano en mano y el Relleno se convirtió durante mucho tiempo en vertedero a cielo abierto.

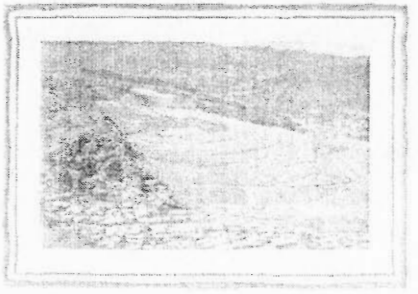
En varias administraciones anteriores, debido a que el problema de los desechos cayó en el campo político, nunca se pudo resolver el problema adecuadamente desde los puntos de vista ambiental, social, técnico y operativo.



Relleno Sanitario de Rio Azul en el pasado

En un plazo muy corto, la Federación Municipal Regional del Este, FEDEMUR, constituida por las municipalidades de Curridabat y La Unión y creada para la administración del Relleno puso manos a la obra, y logró dar una solución al grave problema producto del mal manejo de los desechos sólidos en el Relleno de Rio Azul.

Con FEDEMUR se ha logrado mantener una buena relación de respeto y ayuda a las comunidades, ordenar y capacitar a los buzos, dar mantenimiento a las áreas clausuradas, inspeccionar diariamente la operación del Relleno, monitorear y llevar a cabo un programa de control ambiental.



Relleno Sanitario de Río Azul en la actualidad

Residuos Sólidos

Son todos lo residuos que surgen de las actividades humanas y animales, que normalmente son sólidos y se desechan como inútiles. Muchos de los materiales que se desechan son reutilizables.

Frente de trabajo

Gestión Integral de Desechos

Es un término aplicado a todas las actividades asociadas con la gestión o manejo de los residuos dentro de la sociedad. La meta es lograr que esa tarea sea compatible con las preocupaciones ambientales y la salud pública.
La Gestión Integral de los desechos sólidos se puede dividir en:

- ✓ Generación
- ✓ Segregación
- ✓ Reciclaje
- ✓ Almacenamiento
- ✓ Recolección y Transporte
- ✓ Disposición Final
- ✓ Tratamiento

Los desechos sólidos se pueden agrupar en dos grandes categorías: Ordinarios y Especiales

Desechos Ordinarios

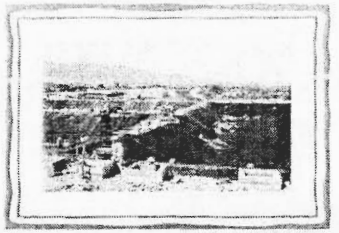
Desechos Especiales

El problema de la basura...

Cuando la basura es dispuesta en un relleno sanitario, genera dos grandes contaminantes: el lixiviado y el biogás

Planta de tratamiento de lixiviados

El lixiviado es el producto del líquido que percolado a través de los desechos sólidos, depositados en diferentes estratos del relleno sanitario, entra en contacto con los mismos y acarrea materiales disueltos o suspendidos.



Construcción de planta de tratamiento de lixiviados

Planta generadora de electricidad

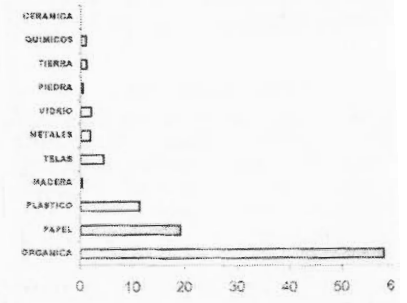
La Compañía Nacional de Fuerza y Luz firmó un convenio para la extracción y explotación del biogás que se genera en el Relleno. De esta manera se avanza en el proceso de cierre técnico.
La propuesta técnica de desarrollo propone una obra de mitigación utilizando el gas metano como combustible para mitigar el impacto ambiental sobre las comunidades. Este proyecto podrá generar 5000 kilovatios de energía eléctrica por periodo sostenido.

Única mirando al mar...

Los llamados "buzos" o recuperadores son perso
que ven el relleno sanitario su fuente de ingreso e
nómico. Ellos trabajan recuperando de la basura y v
diendo materiales que pueden ser reciclados, tales
mo botellas de vidrio, latas de aluminio, papel, car
botellas PET, metales como bronce, cobre, etc.

Composición Física de los Desechos Sólidos Municipales

TIPO DE DESECHO	%
Orgánico	57.91
Papel	19.15
Plástico	11.31
Madera	0.35
Telas	4.49
Metales	1.91
Vidrio	2.11
Piedra	0.49
Tierra	1.21
Químicos	1.01
Cerámica	0.07



Appendix BB: Regulations for Costa Rican Landfills

DECRETO
N° 27378- S
EL PRESIDENTE DE LA REPUBLICA
Y EL MINISTRO DE SALUD

AL-3750-98

En uso de las facultades que confiere el artículo 140 incisos 3) y 18) de la Constitución Política; 28), 2.b) de la Ley General de la Administración Pública y 278 al 284, 302, 303 y 304 de la Ley No. 5395 del 30 de octubre de 1973, "Ley General de Salud".

CONSIDERANDO:

1. Que la adecuada disposición final de los desechos sólidos en el país, así como su recolección y acarreo es un serio problema que atenta severamente contra la salud pública, la vida y un ambiente sano y ecológicamente equilibrado.

2. Que la disposición final de desechos mediante rellenos sanitarios, es técnicamente la alternativa más conveniente de disposición.

3. Que es potestad del Poder Ejecutivo establecer las disposiciones reglamentarias necesarias, para prevenir los problemas sanitarios debidos a la mala disposición de los desechos, fijar las directrices técnicas para la ubicación, diseño, construcción, operación y mantenimiento de rellenos sanitarios, en beneficio y protección de la salud pública.

4. Que mediante Decreto Ejecutivo N°22595-S del 14 de octubre de 1993, publicado en la Gaceta N°202 del 22 de octubre de 1993, el Poder Ejecutivo promulgó el "Reglamento sobre Rellenos Sanitarios".

5. Que los reglamentos requieren de una revisión y actualización periódica para el cumplimiento de las funciones que contempla la Ley General de Salud.

6. Que es fin primordial del Estado velar por la salud de la población y brindar un servicio eficiente, mediante la eliminación de requisitos innecesarios que repercuten en distorsiones en el manejo de los desechos sólidos provenientes de las actividades personales, familiares, de la comunidad, productivas y otras.

7. Que la nueva estructura organizativa adoptada por el Ministerio de Salud, hace necesaria la modificación de algunos artículos del citado Reglamento.

REGLAMENTO SOBRE RELLENOS SANITARIOS

CAPITULO I
Disposiciones Generales

Artículo 1. Para los efectos del presente reglamento se entiende por:

a) **Celda:** Conformación geométrica que se da a los desechos sólidos y a su material de cobertura, debidamente compactados, como parte de la técnica de relleno sanitario.

b) **Desechos:** Sustancias u objetos muebles, sin uso directo, cuyo propietario requiere deshacerse de ellos o es obligado según las leyes nacionales.

c) **Desechos especiales:** son sólidos, gases, líquidos fluidos y pastosos contenidos en recipientes, que por su reactividad química, característica tóxica, explosiva, corrosiva, radiactiva u otro, o por su cantidad, causan daños a la salud o al ambiente.
Estos desechos necesitan de un manejo y vigilancia especial, desde su generación hasta su dispocisión final. Según su tipo y procedencia, se agrupan de la siguiente forma:

- **agroindustriales:** son los restos de plaguicidas, fertilizantes y materiales de empaque contaminados por ellos, así como los desechos de la agroindustria.

- **cuerpos de animales:** restos o cuerpos enteros de animales que deben recibir una adecuada disposición sanitaria.

- **de establecimientos de salud:** son los que requieren de un manejo especial dentro y fuera de la institución de salud donde se generan. Estos provienen de áreas de aislamiento de enfermos infectocontagiosos, laboratorios microbiológicos, cirugía, parto, servicios de hemodiálisis y otros. Incluye también los restos orgánicos humanos provenientes de las áreas de cirugía, parto, morgue y anatomía patológica, así como restos de animales de prueba de diagnóstico o experimentales.

- **domésticos peligrosos:** son desechos domiciliares, comerciales y administrativos de alta toxicidad, tales como bacterias con metales pesados, termómetros, cosméticos, medicamentos, recipiente con restos de propelentes halogenados, plaguicidas, restos de pinturas, etc.

- **emanaciones gaseosas:** son gases que contienen sustancias tóxicas o que al reaccionar en la atmósfera, las forman. Incluye humos, óxidos de azufre y nitrógeno, compuestos halogenados y compuestos de metales pesados.

- **radiactivos:** son desechos de las secciones de laboratorio, radioterapia y medicina nuclear, usualmente son generados en instituciones de salud.

- **industriales ordinarios:** son aquellos generados en cualquier actividad industrial, que por sus características y cantidad, no pueden recogerse o depositarse junto con los de origen doméstico.

- **residuos industriales peligrosos:** son desechos de las actividades industriales básicamente, de la industria química, metalúrgica, papelera, textiles, curtiembres, etc. Incluyen también los lodos provenientes del tratamiento de las aguas residuales industriales, si por su composición y efectos, son considerados peligrosos.

d) **desechos ordinarios:** son sólidos, gases, líquidos fluidos y pastosos que no requieren de tratamiento especial antes de ser dispuestos. Según su tipo y procedencia, se agrupan de la siguiente forma:

- **desechos domésticos y similares:** domiciliarios, administrativos, comerciales e industriales similares a los domésticos, barrido de calles, desechos de jardín, etc., que por naturaleza, composición, tamaño y volumen, son incorporados en las recolección que efectúa la entidad de aseo urbano.

- **escombros:** son desechos provenientes de la demolición de construcciones y tierras de excavaciones.

- lodos provenientes del tratamiento de aguas residuales domésticas o similares.

e) **Disposición final:** es la operación controlada y ambientalmente adecuada de depositar los desechos en un relleno sanitario, según su naturaleza.

f) **Relleno sanitario:** es la técnica mediante la cual diariamente los desechos sólidos se depositan, esparcen, acomodan, compactan y cubren empleando maquinaria. Su fin es prevenir y evitar daños a la salud y al ambiente, especialmente por la contaminación de los cuerpos de agua, de los suelos, de la atmósfera y a la población al impedir la propagación de artrópodos y roedores.

g) **Relleno sanitario manual:** es aquel en el que sólo se requiere equipo pesado para la adecuación del sitio y la construcción de vías internas, así como para la excavación de zanjas, la extracción, el acarreo y distribución del material de cobertura.
Todos los demás trabajos, tales como construcción de drenajes para lixiviados y chimeneas para gases, así como el proceso de acomodo, cobertura, compactación y otras obras conexas, se llevan a cabo manualmente.

h) **Relleno sanitario mecanizado:** es aquel en que se requiere de equipo pesado permanentemente en el sitio, así como de estrictos mecanismos de control y vigilancia de su funcionamiento.

i) **Vertedero de desechos:** es el sitio o paraje, sin preparación previa, donde se depositan los desechos, sin técnica o mediante técnicas muy rudimentarias y en el que no se ejerce un control adecuado.

j) **Vida útil del relleno sanitario:** es el período de tiempo comprendido entre el inicio de operaciones del relleno sanitario y su clausura.

Artículo 2: La aprobación, vigilancia y fiscalización de los rellenos sanitarios del país, estará a cargo del Ministerio de Salud a través de la Dirección de Protección al Ambiente Humano.

CAPITULO II
De la Clasificación de los Rellenos Sanitarios

Artículo 3: Para los efectos de este reglamento, los rellenos sanitarios se clasifican según su forma de operación, en dos tipos:

a) Relleno sanitario manual
b) Relleno sanitario mecanizado

Artículo 4: El relleno sanitario manual se utilizará como método de disposición final de los desechos ordinarios de poblaciones urbanas y rurales que generen menos de 20 toneladas diarias de estos desechos.

Artículo 5: El relleno sanitario mecanizado se utilizará como método de disposición final de los desechos ordinarios de poblaciones urbanas que generen mas de 40 toneladas diarias de estos desechos.

Artículo 6: En aquellas poblaciones urbanas y rurales que generen de 20 a 40 toneladas diarias de desechos ordinarios, podrá usarse cualquiera de los tipos de relleno sanitario a que alude el artículo 3 de las presentes disposiciones, o una combinación de ambos, según lo requieran las condiciones financieras y ambientales de cada caso.

Artículo 7: Toda propiedad que se destine para la disposición de desechos ordinarios, mediante la técnica de relleno sanitario deberá presentar las siguientes características:

a) Estar ubicado a una distancia que garantice que las zonas de recarga de acuíferos o de fuentes de abastecimiento de agua potable, estén libres de contaminación. Esta distancia será fijada por la autoridad competente según el artículo 68 de la Ley Forestal.

b) El suelo debe reunir características de impermeabilidad, remoción de contaminantes y profundidad del nivel de aguas subterráneas, que garanticen la conservación de los acuíferos de la zona, en caso de que estos existan.

c) Contar con suficiente material para la cobertura diaria de los desechos depositados durante su vida útil. En caso de no contar con material suficiente, se deberán presentar los

planos de ubicación de los bancos de préstamo a los que se recurrirá, así como las formas de transporte y almacenamiento de dicho material, para aprobación de la Dirección de Protección al Ambiente Humano.

d) Estar ubicado a una distancia de zonas de inundación, pantanos, marismas, cuerpos de agua y zonas de drenaje natural, que en cada caso definirá la Dirección de Protección al Ambiente Humano.

e) Estar ubicado a una distancia de los centro urbanos, fijada en cada caso por la Dirección de Protección al Ambiente Humano, en un sitio con fácil y rápido acceso por carretera o camino transitable en cualquier época del año.

f) Estar ubicado fuera de las áreas naturales protegidas, servidumbres de paso de acueductos, canales de riego, alcantarillados, oleoductos, y líneas de conducción de energía eléctrica.

g) Estar ubicado a una distancia mínima de 60 metros de fallas geológicas que hayan tenido desplazamientos recientes.

h) Otras que considere convenientes, según las condiciones particulares de cada zona y a juicio de la Dirección de Protección al Ambiente Humano.

CAPITULO III
De los Permisos

Artículo 8: Todo proyecto de relleno sanitario requiere de los siguientes permisos:

a) De Ubicación
b) De Construcción
c) De Funcionamiento

Para el trámite de cada uno de estos permisos, el interesado deberá presentar ante la Dirección de Protección al Ambiente Humano, que será la dependencia encargada de otorgar los mismos la documentación y requisitos indicados en el presente Reglamento.

Artículo 9: Toda entidad de aseo o empresa comercial o industrial, pública o privada, interesada en llevar a cabo un proyecto de relleno sanitario, deberá contar con un permiso de ubicación, emitido por la Dirección de Protección al Medio Ambiente Humano.

Artículo 10: Del Permiso de Ubicación: La solicitud de permiso de ubicación deberá presentarse acompañada de la siguiente información:

a) Planos catastrados visados, de al menos tres posibles sitios.
b) La siguiente información básica de los posibles sitios:
- Nombre del propietario actual

- Ubicación exacta
- Area
- Distancia del centro de población beneficiario
- Distancia del centro de población más cercano
- Nombre de los cuerpos de agua que atraviesan, limitan o circundan el terreno e indicación de las separaciones existentes.
- Dirección predominante del viento
- Estado de las vías de acceso
- Valor estimado del terreno
- Uso actual del terreno
- Clasificación de la zona según el plan regulador (si existe)

c) Población a servir (población de diseño)
d) Tipo de relleno sanitario propuesto
e) En el caso de entidades privadas de aseo, deberán presentar carta de la Municipalidad respectiva, haciendo constar la posibilidad de delegar en esta empresa la responsabilidad de la disposición final de los desechos ordinarios de su cantón, según condiciones exigidas por el artículo 280 de la Ley general de Salud.
f) Aprobación del Consejo Municipal de la Municipalidad respectiva, salvo en caso de emergencia nacional o calamidad pública debidamente decretada por el Poder Ejecutivo.

Artículo 11: En caso de que la Dirección de Protección al Ambiente Humano, considere alguno de los sitios propuestos como apto para relleno sanitario, el interesado deberá presentar además un estudio hidrogeológico y geotécnico del terreno en cuestión, que incluya como mínimo la siguiente información:

a) Caracterización y espesor de los diferentes estratos geológicos.
b) Evaluación del riesgo de contaminación de mantos acuíferos y recomendaciones al respecto.
c) Determinación de la profundidad del nivel freático según el diseño.
d) Localización de nacientes y otros cuerpos de agua.
e) Determinación de la permeabilidad del suelo, en cada uno de los estratos geológicos encontrados.
f) Censo de aprovechamiento hidráulico de la zona.
g) Unidades hidrogeológicas.
h) Modelo de funcionamiento hidrogeológico.

Artículo 12: La Dirección de Protección al Ambiente Humano, emitirá el criterio definitivo respecto al permiso de ubicación, dentro de los 30 días naturales siguientes al recibo de la solicitud con la información completa. En casos muy calificados a criterio de la Dirección el plazo podrá ser ampliado previa comunicación al interesado, pero dicha prórroga no podrá exceder los 15 días naturales.

Artículo 13: Del Permiso de Construcción: La Dirección de Protección al Ambiente Humano, aprobará el permiso de construcción de relleno sanitario, dentro de los 15 días naturales siguientes al recibo de la solicitud con la información completa.

Para lo cual el interesado deberá presentar ante dicha Dirección los siguientes requisitos:

a) Memoria de cálculo.
b) Planos y Manual de Operación y Mantenimiento del proyecto, así como una carta de compromiso de la Municipalidad de presentar periódicamente la información contenida en el artículo 19 del presente reglamento.
c) En caso de existir manantiales, ríos, lagos, embalses naturales y artificiales y áreas de recarga acuífera, el plano catastrado deberá aportar el alineamiento otorgado por la autoridad competente según el artículo 68 de la Ley Forestal.

Los requisitos señalados deberán incluir la información indicada en los artículos 14, 15, 16 y 17 del presente reglamento así como la contenida en los artículos 41 y 42 del " Reglamento de Manejo de Basuras".

d) Permiso de Ubicación según artículo 12 del presente reglamento.

Artículo 14: Del Permiso Sanitario de Funcionamiento: La Dirección de Protección al Ambiente Humano, aprobará el permiso de funcionamiento de relleno sanitario dentro de los 15 días naturales siguientes al recibo de la solicitud con la información completa.

Para el otorgamiento del permiso de funcionamiento mencionado en el artículo 8 de las presentes disposiciones, se requerirá que todo proyecto de relleno sanitario, independientemente de su tipo y tamaño, cumpla como mínimo con los siguientes requisitos técnicos:

a) Garantía de estabilidad del terreno y del relleno contra deslizamientos.
b) Vías internas de acceso, lastreadas o pavimentadas, transitables en cualquier época del año, con rótulos de información.
c) Cercado periférico que limite el terreno e impida el ingreso de animales y personas ajenas al relleno, con portón y entrada restringida.
d) Preparación del terreno con una base impermeable, con pendientes hacia las líneas de drenaje.
e) Canales periféricos para las aguas pluviales.
f) Drenajes para los líquidos lixiviados y chimeneas para gases y humos.
g) Instalaciones para captar y tratar o recircular sobre el relleno, los líquidos lixiviados.
h) Caseta, bodega, servicios sanitarios y otra infraestructura básica.
i) Personal suficiente y con capacitación adecuada. Supervisión calificada.
j) Cobertura diaria de los desechos con material inerte con un espesor mínimo de 15 cm.
k) Cobertura final del relleno con una capa de material de cobertura de 60 cm de espesor, con una capa adicional de 20 cm de espesor capaz de sostener vegetación y con la suficiente inclinación para impedir el ingreso de aguas pluviales a los desechos.
l) Diseño de diferentes fases de explotación del sitio de relleno.
m) Diseño de la configuración final del sitio, con su tratamiento paisajístico.
n) Ningún aprovechamiento posterior que implique construcciones, en un plazo mínimo de 20 años.

ñ) Franja de protección de un mínimo de 20 metros entre el área de disposición de desechos y el lindero de las propiedades vecinas.
o) Estar ubicado a una distancia que garantice que las zonas de recarga de acuíferos o de fuentes de abastecimiento de agua potable estén libres de contaminación.
p) Aprobación del permiso de construcción según artículo 13 del presente Reglamento .

Artículo 15: Los desechos infectocontagiosos podrán ser dispuestos en el relleno sanitario, después de su tratamiento mediante incineración o esterilización. En situaciones extraordinarias se podrá aceptar este tipo de desechos sin tratamiento en celdas especialmente acondicionadas, en cuyo caso la autorización para la ubicación del depósito y para los procedimientos para llevarlo a cabo, será otorgada por la Dirección de Protección al Ambiente Humano del Ministerio de Salud.

Artículo 16: Los desechos industriales podrán ser dispuestos en el relleno sanitario, previo tratamiento o neutralización que los haga asimilables a desechos ordinarios o inocuos, en las celdas para desechos ordinarios. En caso de que los desechos industriales previo tratamiento o neutralización no resulten asimilables a desechos ordinarios o inocuos, deberán ser dispuestos en celdas especialmente diseñadas para este tipo de desecho.

Para lo anterior requieren autorización de la Dirección de Protección al Ambiente Humano, para la ubicación del depósito y de los procedimientos para llevarlo a cabo.

CAPITULO IV
De los Rellenos Sanitarios Manuales

Artículo 17: La aprobación de funcionamiento de un relleno sanitario manual, requiere además de los requisitos establecidos en los artículos 13 y 14 del presente Reglamento, los siguientes requisitos mínimos:

a) Vida útil superior a los cinco años.
b) Equipo mínimo para el movimiento y compactación manual de los desechos: palas, azadones, picos, pisones de mano, horquillas, rastrillos, carretillas, rodillos compactadores de operación manual, equipo de protección personal.
c) Disposición de desechos en capas de 20 cm a 30 cm de espesor para compactación.

CAPITULO V
De los Rellenos Sanitarios Mecanizados

Artículo 18: La aprobación de funcionamiento de un relleno sanitario mecanizado, requiere además de los requisitos establecidos en el artículo 13 y 14 del presente Reglamento, de los requisitos mínimos siguientes:

a) Vida útil superior a los diez años.
b) Taludes finales con una inclinación no mayor de 30%.
c) Area de ingreso con báscula, caseta de control y estacionamiento.
d) Area administrativa y de oficinas.
e) Servicio de electricidad, agua y teléfono en el área administrativa y de ingreso.
f) Acondicionar el terreno con una base de suelo impermeable, con un coeficiente de penetración no superior a los 10^8 m/s, de un espesor mínimo de 50 cm, excepto que se demuestre técnicamente que un espesor menor obtiene el mismo coeficiente de penetración y compactación al 95% del próctor estándar y con pendiente mínima del 3% hacia las líneas de los tubos de drenaje.
g) El sistema de drenaje para lixiviados contará con aditamentos para su inspección y mantenimiento y conducirá a estos líquidos hasta un sistema de tratamiento y disposición final con o sin recirculación en el relleno.
h) Control de la calidad del agua subterránea mediante la perforación de al menos tres pozos para detectar la posible presencia de contaminación por la operación del relleno.
i) Equipo y obras para impedir emisiones de polvo y de cualquier materia volátil.
j) Supervisión calificada permanente.
k) Disposición de los desechos en capas de 60 cm de espesor para compactación.
l) Compactación de cada capa mediante un mínimo de cuatro pasadas con maquinaria pesada, de manera que se obtenga una densidad mínima de 800 kilogramos por metro cúbico.
m) Sistema de emisión para gases con aprovechamiento o evacuación permanente previo tratamiento.
n) Vigilancia y control durante los 15 años posteriores al cierre.
o) Asignación de personal suficiente para el volumen de desechos a disponer.
p) Lavaderos de camiones y llantas con conducción de las aguas de lavado al sistema de tratamiento o recirculación hacia el frente de trabajo.

CAPITULO VI
De la Vigilancia Estatal

Artículo 19: El ente administrador del relleno sanitario, facilitará la entrada al relleno de las Autoridades de Salud, con el fin de practicar las inspecciones que se consideren necesarias.

Artículo 20: El ente administrador del relleno sanitario presentará trimestralmente a la Dirección de Protección al Ambiente Humano, reportes de operación del relleno sanitario, los cuales incluirán al menos la siguiente información:

a) Promedio diario, semanal y mensual de ingreso de desechos, expresado en términos de volumen y peso.

b) Registro de ingreso de vehículos de transporte de desechos, clasificándolos según su origen, peso y tipo de desechos.
c) Análisis de laboratorio, practicados mensualmente para rellenos mecanizados y

trimestralmente para los rellenos manuales y de los pozos de agua.

Este análisis incluirá como mínimo los siguientes parámetros:
- Demanda Bioquímica de Oxígeno ($DBO^{5,20}$)
- Demanda Química de Oxígeno (DQO)
- Potencial Hidrógeno (pH)
- Sólidos Totales (ST)
- Cromo total (Cr)
- Plomo (Pb)
- Mercurio (Hg)
- Níquel (Ni)

Artículo 21: El ente administrador deberá resguardar la salud ocupacional de sus empleados, para lo cual aplicará como mínimo las siguientes medidas:

a) Exigirá al personal que labore en el relleno sanitario, contar con su registro de vacunas al día.
b) Elaborará normas de seguridad del trabajo, con las respectivas indicaciones para el uso de equipo.
c) Proveerá al personal de un local para vestuario y duchas donde asearse y cambiarse de ropas después de la jornada de trabajo.
d) Establecerá un programa de exámenes médicos, que permita identificar y reducir los riesgos potenciales de contaminación relacionados con esta actividad.
e) Dotará a los trabajadores de guantes, botas y al menos de dos uniformes al año.
f) Cualquier otra que exija la Dirección de Protección al Ambiente Humano del Ministerio de Salud.

Artículo 22: Se derogan los siguientes Decretos Ejecutivos: N° 22595-S del 14 de octubre de 1993, publicado en la Gaceta N°202 del 22 de octubre de 1993; N° 23563-S del 05 de agosto de 1994, publicado en la Gaceta N°164 del 30 de agosto de 1994 y N° 24601-S del 28 de agosto de 1995, publicado en la Gaceta N°176 del 18 de setiembre de 1995.

Artículo 23: Rige a partir de su publicación.

TRANSITORIO UNICO.

Mientras no existan en el país, plantas de tratamiento de desechos especiales o uno o más rellenos de seguridad, estos desechos podrán disponerse en los rellenos sanitarios para desechos ordinarios, en áreas especialmente acondicionadas para tal fin, previa aprobación de ubicación y de la técnica de disposición, por parte de la Dirección de Protección al Ambiente Humano del Ministerio de Salud. En estos casos queda prohibida la disposición de desechos potencialmente incompatibles en una misma celda o frente de trabajo, según se indica en las listas de los siguientes grupos.

La mezcla de un desecho del grupo A) con otro del Grupo B) deberá ser evitada, por las consecuencias potenciales que en dichas listas se mencionan:

GRUPO 1

Consecuencias potenciales: generación de calor, reacción violenta

GRUPO 1-A	GRUPO 1-B
Lodos de acetileno Líquidos alcalinos cáusticos Limpiadores alcalinos Líquidos corrosivos alcalinos Líquido de batería alcalino corrosivo Agua de desecho cáustico Lodo de cal y otros álcalis corrosivos Agua de cal de desecho Cal y agua Sustancias cáusticas usadas	Lodo ácido Acido y agua Acido de batería Limpiadores químicos Líquido o solvente de ácido fuerte Compuestos líquidos limpiadores Lodo ácido Acidos usados Mezcla de ácidos usados Acido sulfúrico usado

GRUPO 2

Consecuencias potenciales: liberación de sustancias tóxicas en caso de fuego y explosión

GRUPO 2-A	GRUPO 2-B
Desechos de asbesto y otros Desechos tóxicos Desechos de berilio Recipientes de plaguicidas sin lavar Desechos de plaguicidas	Solventes limpiadores Líquidos de máquinas de procesamiento de datos y copiadoras Explosivos obsoletos Desechos de petróleo Explosivos vencidos Solventes Desechos de aceite Otros desechos inflamables y explosivos

GRUPO 3

Consecuencias potenciales: fuego o explosión, generación de hidrógeno gaseoso inflamable

GRUPO 3-A	GRUPO 3-B
Aluminio Berilio Calcio Litio Magnesio Potasio Zinc en polvo Otros metales reactivos e hidruros	Cualquier desecho de los Grupos 1-A ó 1-B

GRUPO 4

Consecuencias potenciales: fuego, explosión o generación de gases tóxicos o inflamables

GRUPO 4-A	GRUPO 4-B
Alcoholes Agua	Cualquier desecho concentrado de los Grupos 1-A ó 1-B Calcio Litio Potasio Sodio SO_2, Cl_2, $SOCl_2$, HCl_3, CH_3SOCl_3 y otros desechos que reaccionan con el agua

GRUPO 5

Consecuencias potenciales: fuego, explosión o reacción violenta

GRUPO 5-A	GRUPO 5-B
Alcoholes Aldehidos Hidrocarburos halogenados Hidrocarburos nitrogenados y otros	Desechos concentrados de los Grupos 1-A, 1-B ó 3-A

GRUPO 6

Consecuencias potenciales: fuego, explosión o reacción violenta

GRUPO 6-A	GRUPO 6-B
Soluciones usadas de cianuros y sulfuros	Residuos del Grupo 1-B

GRUPO 7

Consecuencias potenciales: fuego, explosión o reacción violenta

GRUPO 7-A	GRUPO 7-B
Cloratos y otros oxidantes fuertes. Cloro Cloritos Acido crómico Hipoclorito Nitratos Acido nítrico, fumante Percloratos Permanganatos Peróxidos	Acido acético y otros ácidos orgánicos Acidos minerales concentrados Desechos del Grupo 2-B Desechos del Grupo 3-A Desechos del Grupo 5-A Desechos inflamables y combustibles

Dado en la Presidencia de la República. San José, a los nueve días del mes de octubre de mil novecientos noventa y ocho.

MIGUEL ANGEL RODRIGUEZ ECHEVERRIA
DR. ROGELIO PARDO EVANS
MINISTRO DE SALUD

LA GACETA Nº 129 — Viernes 7 de julio de 1989

DECRETOS

Nº 19049-S

EL PRESIDENTE DE LA REPUBLICA
Y EL MINISTRO DE SALUD,

En uso de la facultades conferidas en los artículos 140 incisos 3) y 18) de la Constitución Política, 28 inciso b) de la Ley General de la Administración Pública y 2, 4, 278, 279 y 280 de la Ley General de Salud.

Considerando:

1º—Que en beneficio y protección ~~y superación~~ de la salud pública, se hace necesario establecer una serie de regulaciones relacionadas con los desechos sólidos provenientes de las actividades corrientes, personales, familiares, de la comunidad y otras a fin de evitar o disminuir en lo posible la contaminación del aire, del suelo o de las aguas.

Por tanto,

DECRETAN

El siguiente:

Reglamento sobre el manejo de basuras

CAPITULO I

De las definiciones

Artículo 1º—Para los efectos del presente reglamento entiéndase por:

a) Basura: Todo residuo sólido o semisólido putrescible o no putrescible, excluyendo las excretas de origen humano o animal. En esta definición se incluyen los desperdicios, desechos, cenizas, elementos del barrido de calles, residuos industriales y comerciales, de establecimientos hospitalarios y de mercados entre otros.

b) Residuo sólido: Todo objeto, sustancia o elemento en estado sólido o semisólido, que se abandona, bota, rechaza o desprende.

c) Desperdicio: Todo residuo sólido o semisólido de origen animal o vegetal, sujeto a putrefacción, proveniente de la manipulación, preparación y consumo de alimentos.

ch) Desecho: Cualquier producto deficiente, inservible o inutilizado que su poseedor destina al abandono o del que desea desprenderse.

d) Residuo sólido domiciliario: El que por su naturaleza, composición, cantidad y volumen es generado en actividades en las viviendas o en cualquier establecimiento asimilable a estas.

e) Residuo sólido comercial: Es aquel generado en establecimientos comerciales y mercantiles, tales como almacenes, depósitos, hoteles, restaurantes, cafeterías, sodas, carnicerías, mataderos, mercados de todo tipo, oficinas y otros tipos de negocios.

f) Residuo sólido institucional: Es el generado en establecimientos educativos, gubernamentales, carcelarios, religiosos, hospitalarios, terminales aéreas, terrestres, fluviales o marítimas, entre otros.

g) Residuo sólido industrial: Es el generado en actividades propias de ese sector del desarrollo, como resultado de los procesos de producción.

h) Residuo sólido patógeno: Es aquel que por sus características y composición puede ser reservorio o vehículo de infección.

i) Residuo sólido tóxico: Es el que por sus características físicas o químicas, dependiendo de su concentración y tiempo de exposición, pueden causar daños y aún la muerte a los seres vivientes, o provocar contaminación ambiental.

j) Residuo sólido combustible: Es el que arde en presencia de oxígeno u otro incidente, por acción de una chispa o de cualquier otra fuente de ignición.

k) Residuo sólido inflamable: Es el que puede arder espontáneamente en condiciones normales.

l) Residuo sólido explosivo: Es aquel que genera grandes presiones de gases en su descomposición instantánea.
ll) Residuo sólido volitalizable: Aquel que por su presión de vapor a temperatura ambiente, se evapora o volatiliza.
m) Residuo sólido radioactivo: Aquel que emite radiaciones electromagnéticas en niveles superiores a las radiaciones naturales de fondo.
n) Residuo sólido con características especiales: Incluye a los residuos sólidos patógenos, tóxico, combustible, inflamable, explosivo, volitalizable y radioactivo. Se incluye en esta definición los objetos o elementos que por su tamaño, volúmen o peso requieren un manejo especial.
ñ) Lodo: La suspención de sólidos en un líquido, provenientes de tratamiento de agua, de residuos líquidos o de otros procesos similares.
o) Tratamiento: El proceso de transformación física, química y geológica de los residuos sóljdos para modificar sus características o aprovechar su potencial, y en el cual se puede generar un nuevo residuo sólido de características diferentes.
p) Disposición sanitaria de basuras: Es el proceso mediante el cual las basuras son colocadas en forma definitiva, sea en el agua o en el suelo, siguiendo, entre otras, las técnicas de enterramiento, relleno sanitario y de disposición al mar.
q) Enterramiento de basuras: Es la técnica que consiste en colocar las basuras en una excavación, aislándolas posteriormente con tierra u otro material de cobertura.
r) Relleno sanitario de basuras: Es la técnica que consiste en esparcirlas, acomodarlas y compactarlas al volumen más práctico posible, cubrirlas diariamente con tierra u otro material de cobertura y ejercer los controles requeridos al efecto.
s) Disposición sanitaria al mar: Es la técnica utilizada para descargar las basuras al mar en condiciones tales que se evite al máximo su esparcimiento por efectos de corrientes y animales marinos.
t) Entidad de aseo: Es la persona natural o jurídica, sea esta pública o privada, encargada o responsable de almacenar, recoger, transportar y disponer las basuras.

CAPITULO II

De las disposiciones generales

Artículo 2°—El almacenamiento, recolección, transporte, disposición sanitaria y demás aspectos relacionados con las basuras, cualquiera sea la actividad o el lugar de generación, se regirán por lo dispuesto en el presente reglamento.

Artículo 3°—El manejo de basuras comprende las siguientes actividades:

a.—Almacenamiento
b.—Presentación
c.—Recolección
ch.—Transporte
d.—Tratamiento
e.—Disposición sanitaria
f.—Barrido y limpieza de vías y áreas públicas
g.—Transferencia
h.—Recuperación

Artículo 4°—Desde el punto de vista sanitario, el manejo de basuras se clasifica en dos modalidades:

a.—Servicio ordinario
b.—Servicio especial

Artículo 5°—La prestación del servicio ordinario tendrá como objetivo el manejo de las siguientes clases de basura:

a) Basuras domiciliarias.
b) Basuras que por su naturaleza, composición, tamaño y volumen pueden ser incorporadas, en su manejo, por la entidad de aseo y a su juicio, de acuerdo con su capacidad de operación.
c) Basuras no incluidas en el servicio especial.

Artículo 6°—La prestación del servicio especial tendrá como objetivo el manejo de las siguientes clases de basuras:

a) Basuras patógenas, tóxicas, combustibles, inflamables, explosivas, volatilizables y radioactivas.
b) Basuras que por su naturaleza, composición, tamaño y volumen, deban ser consideradas como especiales, a juicio de la entidad de aseo, de acuerdo con su capacidad.
c) Empaques o envases de productos químicos de cualquier naturaleza, en especial de plaguicidas y de preparaciones de uso agrícola o pecuario.
ch) Basuras que, por su localización, presentan dificultades en su manejo por inaccesibilidad de los vehículos recolectores.
d) Basuras no contempladas en los incisos anteriores que requieran para su manejo condiciones especiales de las de servicio ordinario.

CAPITULO III

De la responsabilidad en materia de basuras

Artículo 7º—El servicio de recolección, acarreo y disposición de basuras, estará a cargo de las municipalidades, la cuales podrán realizar por administración o mediante contratos con empresas o particulares, que se otorgarán de acuerdo con las formalidades legales y que requieren para su validez la aprobación del Ministerio.

Artículo 8º—La contratación de servicios para el manejo total o parcial de las basuras, no exime a la municipalidad de la responsabilidad mencionada y, por lo tanto, debe ejercer estricta vigilancia en el cumplimiento de las actividades propias del manejo de las basuras.

Artículo 9º—En el contrato que se realice entre la municipalidad y el contratista, deberá estipularse clara y específicamente, las condiciones de la prestación del servicio y la actividad o actividades que se efectuarán en el manejo de las basuras.

Artículo 10.—Independientemente de quien realice el servicio, el manejo de las basuras deberá obedecer a un programa que responda a las necesidades del servicio de aseo, el que debe incluir entre otros, los aspectos siguientes:

a) Establecimiento de rutas y horarios para la recolección de las basuras, los que serán dados a conocer a los usuarios.
b) Mantenimiento de los vehículos y equipos destinados a la recolección y disposición sanitaria de las basuras.
c) Entrenamiento del personal que realiza el manejo de las basuras para una mejor prestación del servicio y las medidas de seguridad que debe observar.
ch) Actividades a desarrollar en eventos de fallas ocurridas por cualquier circunstancia, que dificulten, restrinjan o impidan la prestación del servicio de aseo.
d) Mecanismos de información a los usuarios sobre, el almacenamiento y entrega de las basuras, en cuanto a localización, tamaño, capacidad y calidad de los recipientes y otros aspectos relacionados con la correcta prestación del servicio.

CAPITULO IV

Del almacenamiento de basuras

Artículo 11.—Los usuarios del servicio ordinario del manejo de basuras, tendrán las siguientes obligaciones en cuanto al almacenamiento:

a) Almacenar en forma sanitaria las basuras generadas, conforme lo especifica este reglamento.
b) No depositar sustancias líquidas, excretas, ni basuras de las contempladas para el servicio especial, en los recipientes destinados para la recolección en el servicio ordinario.
c) Colocar los recipientes en el lugar de recolección, de acuerdo con el horario establecido por la entidad de aseo.
ch) Otras disposiciones que establece el presente reglamento y que son de responsabilidad de los usuarios.

Artículo 12.—Los recipientes retornables para almacenamiento de basuras en el servicio ordinario tendrán, entre otras, las características siguientes:

a) Peso y construcción que faciliten el manejo durante la recolección.
b) Construidos de material impermeable, de fácil limpieza, con protección contra la corrosión, tales como plástico o metal.
c) Tendrán tapas con buen ajuste, que no dificulten el proceso de vaciado durante la recolección.
ch) Construidos de tal forma que, estando cerrados o tapados, no permitan la entrada de agua, insectos o roedores, ni el escape de líquidos por sus paredes o por el fondo.
d) Bordes y esquinas redondeados, de mayor área en la parte superior, para que se facilite el vaciado.
e) Capacidad de acuerdo con lo que establezca la entidad de aseo.

Artículo 13.—Los recipientes desechables utilizados para el almacenamiento de basuras en el servicio ordinario, serán bolsas de material plástico o de características similares y deberán reunir, por lo menos, las siguientes condiciones:

a) Su resistencia deberá soportar la tensión ejercida por las basuras contenidas y por la manipulación.
b) Su capacidad estará de acuerdo con lo que establezca la entidad que preste el servicio de aseo.
c) De color opaco.
ch) Debe poder cerrarse por medio de un dispositivo de amarre fijo o por medio de un nudo.

CAPITULO V

Del almacenamiento colectivo de basuras

Artículo 14.—Toda edificación para uso multifamiliar de cualquier tipo institucional o comercial y otras que la entidad de aseo determine, tendrán un sistema de almacenamiento colectivo de basuras, diseñado de acuerdo con las normas del presente reglamento y las que técnicamente, a juicio del Ministerio de Salud, sean aplicables.

Artículo 15.—Las áreas destinadas para el almacenamiento colectivo de basuras en las edificaciones a que hace referencia el artículo anterior, cumplirán, como mínimo, con los siguientes requisitos:

a) Los acabados de pisos, paredes y cielo raso serán lisos para permitir su fácil limpieza e impedir la formación de ambientes propicios para el desarrollo de insectos y microorganismos en general. Tendrán redondeadas las esquinas entre paredes y entre estas y el piso.
b) Tendrán sistemas de ventilación efectivos, de suministro de agua, de drenaje y de control de incendios.
c) Serán construidos de manera que impidan el acceso de insectos, roedores y otras clases de animales.

Artículo 16.—Las basuras que sean evacuadas por medio de ductos, serán empacadas en recipientes impermeables que cumplan las características exigidas en el artículo 13 de este reglamento.

Artículo 17.—Las edificaciones a que se refiere el artículo 14 de este reglamento, y cuya ubicación no facilite la prestación del servicio de recolección ordinario, podrán instalar cajas de almacenamiento de basuras dentro del perímetro de su propiedad, de conformidad con las normas que establezca la entidad de aseo, para lo cual se requiere el previo permiso de esta.

Artículo 18.—El aseo de los alrededores de cajas de almacenamiento de uso privado, será de responsabilidad exclusiva de los usuarios.

Artículo 19.—El tamaño, la capacidad, el número y el sistema de carga y descarga de las cajas de almacenamiento, serán determinados por la entidad de aseo, de acuerdo con las características del equipo de recolección y transporte que utilice.

CAPITULO VI

De la presentación de las basuras

Artículo 20.—La presentación de las basuras se debe realizar de conformidad con las disposiciones contenidas en el presente reglamento.

Artículo 21.—Los recipientes de basuras se colocarán en un sitio de fácil recolección por el servicio ordinario según sus rutas y horarios, pero evitando la obstrucción peatonal o vehicular.

Artículo 22.—No deberán permanecer los recipientes de basura en el servicio ordinario, en los sitios en que se recojan en días diferentes a los establecidos por el servicio de aseo.

CAPITULO VII

De la recolección de las basuras

Artículo 23.—Es responsabilidad de la entidad de aseo recoger todas las basuras que presenten o entregen los usuarios del servicio ordinario, de acuerdo con este tipo de servicio y siempre que la presentación de las basuras se haga de conformidad con los artículos 434 y siguientes del presente reglamento, para cada zona o sector de la población.

Artículo 24.—Las entidades de aseo, y los usuarios que utilicen el servicio especial, deberán sujetarse a las disposiciones contempladas en el presente reglamento.

Artículo 25.—La entidad de aseo establecerá la frecuencia óptima de recolección, lo que se hará por sectores y en los sitios de recolección, de tal forma que los residuos sólidos no se alteren o propicien condiciones adversas en la salud de las personas o contaminen el ambiente.

Artículo 26.—La recolección de basuras será efectuada por operarios designados por la entidad de aseo, de acuerdo con las rutas y las frecuencias establecidas para tal fin.

Artículo 27.—En el evento de que las basuras sean esparcidas durante el proceso de recolección, los encargados del mismo deberán proceder inmediatamente a recogerlas.

Artículo 28.—Cuando por ausencia o deficiencia en el cierre y mantenimiento de los lotes de terreno se acumulen basuras en los mismos, la recolección y transporte hasta el sitio de disposición estará a cargo del propietario del lote. En caso de que la entidad de aseo proceda a la recolección, este servicio podrá considerarse como especial y se hará con cargo al dueño o propietario del lote de terreno.

CAPITULO VIII

Del transporte de basuras

Artículo 29.—Los vehículos destinados al transporte de basuras reunirán las condiciones propias para esta actividad y las que se señalan en el presente reglamento. Su diseño cumplirá con las especificaciones que garanticen la correcta prestación del servicio de aseo.

Artículo 30.—Los vehículos y equipos destinados al transporte de basuras que no reúnen las condiciones exigidas, deberán ser adaptados o reemplazados dentro del plazo que fije el Ministerio de Salud, el que se determinará de acuerdo con el programa propuesto por cada entidad de aseo.

Artículo 31.—El mantenimiento y la operación de los vehículos y equipos destinados al transporte de basuras, estará a cargo de la entidad de aseo, de cuya responsabilidad no quedará eximida bajo ninguna circunstancia. Deberán estar permanentemente en correctas condiciones para prestar el servicio.

Artículo 32.—Al término de la jornada diaria se lavarán los vehículos y el equipo, a efecto de mantenerlos en condiciones que no atenten contra la salud de las personas.

Artículo 33.—Los vehículos destinados al transporte de tierra, escombros, papeles o cualquier otro material que pueda ser esparcido por el viento, deberá proveerse de los mecanismos o aditamentos necesarios para garantizar el correcto transporte y aislamiento de dichos materiales.

Artículo 34.—Los vehículos y equipo destinados al transporte de basuras deberán cumplir con las normas de circulación y tránsito vigentes en cada localidad, evitando ser obstáculo para la circulación de vehículos y personas.

CAPITULO IX

De la disposición sanitaria de basuras

Artículo 35.—La disposición sanitaria de las basuras correspondientes al servicio ordinario deberá someterse a las exigencias de la Ley General de Salud y a las normas que dicte el Ministerio de Salud, y realizarse de acuerdo con las técnicas siguientes:

a) Relleno Sanitario
b) Enterramiento

Artículo 36.—La técnica de disposición sanitaria al mar solo podrá emplearse, previa aceptación del Ministerio de Salud, cuando previos los estudios del caso, se demuestre que otras alternativas no son viables.

Artículo 37.—Es responsabilidad de la entidad encargada del manejo de las basuras en el servicio ordinario, seleccionar la técnica para su disposición sanitaria y la adecuación del sitio para llevarla a efecto, debiéndose recabar previamente la aprobación del Ministerio de Salud.

Artículo 38.—Los estudios dirigidos a la selección del sitio para disponer las basuras deberán someterse al análisis del Ministerio de Salud, previo a su utilización para tal fin.

Artículo 39.—Todo proyecto para disposición sanitaria de basuras en el servicio ordinario, deberá presentarse al Ministerio de Salud, adjuntando un estudio de impacto ambiental para su valoración.

Artículo 40.—En todo sitio destinado a la disposición sanitaria de basuras deberá darse cumplimiento a las normas de este reglamento y a las relacionadas con el control de la contaminación del aire y del agua.

Artículo 41.—Todo sitio para la disposición sanitaria de basuras provenientes del servicio ordinario, deberá cumplir, como mínimo, con los siguientes requisitos:

a) Estar aislado de sus alrededores, a fin de garantizar la no interferencia con actividades distintas de las allí realizadas así como para evitar efectos nocivos para la salud del las personas y en el ambiente.
b) Tener señales y avisos que lo identifiquen en cuanto a las actividades que ahí se desarrollan, definición de entrada y salida de vehículos; horarios de operación o funcionamiento; y clara indicación de que se prohibe expresamente el acceso a personas distintas a las que laboran en las actividades que ahí se realizan.
c) Contar con los servicios mínimos de suministro de agua, energía eléctrica, conexión telefónica, sistema de drenaje para evacuación de sus residuos líquidos, de acuerdo con la complejidad de las actividades realizadas.
ch) Contar con programas, adiestramiento de personal y sistema para la prevención y control de accidentes e incendios, como también para la atención de primeros auxilios, así como cumplir con las disposiciones legales que en materia de salud ocupacional, higiene y seguridad laboral dispongan el Ministerio de Salud y demás instituciones competentes.

d) Mantener condiciones sanitarias de operación y mantenimiento para evitar la proliferación de vectores y otros animales que podrían afectar la salud humana o la estética del contorno.
e) Ejercer control sobre el esparcimiento, y si fuere del caso, la compactación de las basuras, partículas, polvo y otros objetos y condiciones que por la acción del viento puedan ser transportados a los alrededores del sitio de disposición final.
f) Controlar, tipificar y tratar, los líquidos percolados que se originen por descomposición de las basuras y que puedan alcanzar cuerpos de agua superficiales o subterráneas.
g) Mantener un registro diario, a disposición de las autoridades del Ministerio de Salud, en el que se anote lo relacionado con cantidad, volúmenes, peso y composición promedios de las basuras destinadas a disposición sanitaria.

Artículo 42.—Cuando se utilice la técnica de disposición final por medio de relleno sanitario, la entidad encargada del manejo de las basuras, deberá presentar, como mínimo, al Ministerio de Salud, para su eventual aprobación los siguientes requisitos:

a) Planos y detalles de la infraestructura y zonas urbanas circunvecinas o periféricas.
b) Planos y detalles del terreno y del desarrollo del relleno sanitario, incluyendo vías permanentes y transitorias, división progresiva de las celdas y destino de zonas para basuras especiales o peligrosas.
c) Infraestructura del relleno, incluyendo edificaciones existentes o por construir.
ch) Niveles intermedios y finales del relleno sanitario.
d) Planes de control del tratamiento de afluentes líquidos y gaseosos.
e) Obras auxiliares y paisajismo necesario
f) Plan de operación del relleno sanitario.
g) Plan de inversiones y costos.
h) Plan de implementación del relleno sanitario.

CAPITULO X

De las disposiciones sobre el servicio especial de aseo

Artículo 43.—El manejo de los residuos sólidos con características especiales deberá cumplir, además de las disposiciones de carácter general del presente reglamento, con las que corresponden a las de este Capítulo.

CAPITULO XI

De los permisos de manipulación de los residuos con características especiales

Artículo 44.—Todo sistema de manejo de residuos sólidos con características especiales, deberá ser sometido a la aprobación por parte del Ministerio de Salud.

Artículo 45.—El interesado o responsable del transporte de residuos sólidos con características especiales, deberá solicitar y obtener permiso previo del Ministerio de Salud, el que establecerá las condiciones mínimas que deben reunir los vehículos destinados para este fin, así como establecerá las normas necesarias para la protección de los operarios y de los seres vivos.

Artículo 46.—Los operarios encargados del manejo de residuos sólidos con características especiales, deberán contar con el equipo de protección personal y los implementos necesarios, de acuerdo con las disposiciones que en materia de higiene y seguridad industrial dicte el Ministerio de Salud.

Artículo 47.—Los métodos de tratamiento y disposición sanitaria de los residuos sólidos con características especiales, deberán contar con el previo permiso del Ministerio de Salud.

CAPITULO XII

Del almacenamiento de los residuos especiales

Artículo 48.—El almacenamiento de residuos sólidos con características especiales, deberá efectuarse en recipientes distintos de los destinados para el servicio ordinario, deberán estar claramente identificados y se deberá observar con ellos medidas especiales de carácter sanitario y de seguridad, a efecto de proteger la salud humana y del ambiente.

Artículo 49.—Los materiales no biológicos desechables, considerados como residuos sólidos patógenos, tales como agujas hipodérmicas y otro tipo de instrumental, solo podrán ser mezclados con este tipo de desechos cuando cumplan las medidas tendientes a evitar riesgos en el manejo del conjunto, de lo contrario, deberán ser almacenados en forma separada.

Artículo 50.—Los recipientes para almacenamiento de residuos sólidos con características especiales, deberán ser de cierre hermético y estar debidamente marcados con las medidas a seguir en caso de emergencia.

Artículo 51.—El o los materiales que se utilicen en la fabricación de recipientes para el almacenamiento de residuos sólidos con características especiales, deberá estar de acuerdo con las características del residuo.

Artículo 52.—Las áreas de almacenamiento temporal de los residuos sólidos patógenos en las edificaciones donde se generan, deberán cumplir, por lo menos, con los siguientes requisitos:

a) Disponer de extractores de aire con filtro biológico.
b) Estar marcados en forma tal que puedan ser identificados fácilmente y bajo la prohibición expresa de no permitir la entrada de personas ajenas a las comprometidas en esta actividad.
c) Ser desinfectadas y desodorizadas con la frecuencia que garantice condiciones sanitarias.
ch) Contar con los dispositivos, disposiciones de seguridad necesarias para la prevención y control de accidentes e incendios.

Artículo 53.—Los residuos sólidos con características especiales, serán tenidos como tales aunque se presenten para su manejo empacados o envasados.

Artículo 54.—Toda mezcla de basura que incluya residuos sólidos patógenos, se considerará como residuo sólido con características especiales.

CAPITULO XIV

De los incineradores para residuos especiales

Artículo 55.—Todo proyecto para la construcción, modificación o ampliación de incineradores de residuos especiales, requiere el previo permiso del Ministerio de Salud, para lo cual el interesado deberá presentar, junto con la solicitud, la siguiente información:

a) Nombre, razón social y personería del solicitante.
b) Representación legal del solicitante.
c) Datos de localización, dirección y teléfono del peticionario.
ch) Relación detallada de los residuos sólidos a incinerar con indicación de la cantidad promedio a incinerar, peso y volumen.
d) Planos y memorias del proyecto.
e) Estudio del impacto ambiental.
f) Las demás que la autoridad sanitaria estime pertinente.

CAPITULO XV

De los propósitos de la recuperación de residuos

Artículo 56.—La recuperación de los residuos sólidos a partir de basuras, tiene dos propósitos principales:

a) Recuperación de valores económicos y energéticos que hayan sido utilizados en el proceso primario de elaboración de productos.
b) Reducción de la cantidad de basura producida y que se dispondrá sanitariamente.

CAPITULO XVI

De los lugares en que se puede separar y almacenar la basura

Capítulo 57.—Sólo se permitirá la separación de basuras en las fuentes de origen y en los sitios autorizados expresamente por el Ministerio de Salud.

Artículo 58.—No se permitirá el reciclaje o recuperación de residuos sólidos que por sus características sean susceptibles de causar daño a la salud humana, a juicio del Ministerio de Salud.

Artículo 59.—El acopio y almacenamiento temporal de elementos recuperables podrá efectuarse en bodegas, antes de su traslado al sitio de clasificación y empaque, siempre y cuando se observen condiciones sanitarias y de protección de los manipuladores y del ambiente.

CAPITULO XXI

De las prohibiciones a particulares y a las entidades en general

Artículo 74.—Se prohíbe depositar animales muertos, parte de estos y basuras de carácter especial, en los recipientes de almacenamiento, de uso público o privado, y que son recogidos por el servicio ordinario.

Artículo 75.—Se prohíbe la quema de basuras bajo ninguna circunstancia, pero se permite la incineración de residuos sólidos según las normas que establece el presente reglamento.

Artículo 76.—Se prohíbe la entrada y circulación de los operarios de recolección en inmuebles o predios de propiedad privada o pública, con el fin de retirar las basuras.

Artículo 77.—Se prohíbe entregar basuras a operarios encargados del barrido y limpieza de las vías y áreas públicas.

Artículo 78.—Se prohíbe a toda persona distinta de las del servicio de aseo, remover o extraer el contenido total o parcial de los recipientes para basuras, una vez colocados en el sitio de recolección.

Artículo 79.—Se prohíbe la disposición o abandono de basuras, cualquiera sea su procedencia, a cielo abierto, en vías o áreas públicas, en lotes de terreno y en los cuerpos de agua superficiales o subterráneas.

Artículo 80.—Se prohíbe arrojar basuras, de cualquier tipo, en vías públicas, parques y áreas de esparcimiento colectivo.

Artículo 81.—Se prohíbe el lavado y limpieza de cualquier objeto en vías y áreas públicas, cuando con tal actividad se originen problemas de acumulación o esparcimiento de basuras.

Artículo 82.—Se prohíbe al personal de las entidades de aseo, del servicio de barrido y limpieza de vías y áreas públicas, realizar actividades de separación de los componentes de las basuras.

Artículo 83.—Se prohíbe a los operarios encargados del servicio de barrido y limpieza de vías y áreas públicas, la recolección de basuras generadas en el interior de cualquier edificación.

Artículo 84.—Se prohíbe el almacenamiento de residuos sólidos en un mismo recipiente, cuando puedan interactuar ocasionando situaciones peligrosas.

CAPITULO XXII

De las sanciones

Artículo 85.—Los usuarios de los servicios que incumplieren con las disposiciones del presente reglamento, serán denunciados ante los tribunales correspondientes, conforme con las disposiciones contenidas en el artículo 378 de la Ley General de Salud.

Artículo 86.—En caso de incumplimiento a las disposiciones del presente reglamento, por parte de las corporaciones municipales o contratistas encargados del servicio de recolección, acarreo y disposición de basuras, el Ministerio de Salud podrá decretar por propia autoridad, medidas cuya finalidad tiendan a evitar la aparición de peligros en contra de la salud de las personas o del medio ambiente.

Artículo 87.—Rige a partir de su publicación.

Dado en la Presidencia de la República.—San José, a los veinte días del mes de junio de mil novecientos ochenta y nueve.

20-06-89

OSCAR ARIAS SANCHEZ

El Ministro de Salud a. i.,
VICTOR JULIO BRENES ROJAS

Nº 177 21-09-1944

LA JUNTA FUNDADORA DE LA SEGUNDA REPUBLICA

Considerando:

Que la agricultura desperdicia actualmente lo desechos animales y vegetales, los cuales deben volver al suelo, de donde vinieron, a enriquecerlo para que nos dé cosechas más saludables y abundantes.

Que es necesario para la Nación practicar estos sistemas de agricultura para que se puedan aprovechar estas fuentes de abonos orgánicos, base principal de toda agricultura racional.

Por tanto,

DECRETA:

Artículo 1º—La fabricación de abonos orgánicos o composte con los desechos y todos los materiales urbanos aprovechables, se regirá por la presente ley que se considera de interés público.

Artículo 2º—Para la fabricación y expendio de los abonos orgánicos a que se refiere el artículo anterior, se crea la "Corporación de Abonos Orgánicos", que será una junta integrada por cinco miembros propietarios, nombrados por el Poder Ejecutivo en la siguiente forma: tres escogidos de cada una de las ternas que al efecto suministren el Colegio de Ingenieros Agrónomos, la Cámara de Agricultura y Cámara de Industrias, uno de nombramiento del Ministerio de Salubridad Pública y otro que será el Jefe de la Sección de Granjas Experimentales del Ministerio de Agricultura e Industrias.

Artículo 3º—Para lograr la explotación citada, la Corporación de Abonos Orgánicos procederá a levantar planos y montar las fábricas de abonos orgánicos utilizando los desechos urbanos en las poblaciones que dispongan de materiales propios suficientes.

Artículo 4º—La Corporación de Abonos Orgánicos queda facultada para entrar en arreglos cuando lo considere conveniente, con los Concejos Municipales, o el Estado en su caso, a fin de establecer los sistemas de recolección y aprovechamiento de desechos más adecuados y aconsejables.

Artículo 5º—Para el cumplimiento de este decreto-ley, se autoriza a la Corporación para financiarse por medio de un empréstito, hasta por la suma de cincuenta mil colones, con la garantía del Estado. Las utilidades que la Corporación acumule serán aplicadas en la ampliación del radio de sus actividades.

Artículo 6º—Los miembros de la Corporación deberán ser personas de reconocida honorabilidad, costarricenses o no, durarán en sus funcioses 4 años y serán inamovibles para el periodo para que fueren nombrados. Deberán, además, tener conocimientos relativos a la fabricación de abonos orgánicos.

Artículo 7º—Para el cumplimiento de sus fines la Corporación se servirá del personal de la Sección de Granjas Experimentales y en caso de ser insuficiente éste, podrá nombrar personal adicional pagado de sus fondos, que trabajará bajo la jurisdicción del Jefe de la Sección de Granjas Experimentales, quien tendrá a su cargo la gestión ejecutiva del proyecto ordenada por la Corporación.

Artículo 8º—Aparte del trabajo indicado en el artículo anterior, corresponde a la Sección de Granjas Experimentales promover el aprovechamiento de desechos en las zonas rurales, dentro de las regulaciones sanitarias que dicte el Ministerio de Salubridad Pública, y la formación de Clubes del Composte entre los agricultores y los escolares, siguiendo el sistema Howard o procedimiento Indore.

Artículo 9º—La Corporación presentará anualmente al Poder Ejecutivo el presupuesto de gastos y planes de trabajo.

Artículo 10.—La Corporación someterá a la aprobación del Poder Ejecutivo un reglamento interno, dentro de los treinta días posteriores a su instalación.

Transitorio.—Con el objeto de darle una eficiente organización inicial a la "Corporación de Abonos Orgánicos", el Poder Ejecutivo se reserva el derecho de hacer el nombramiento de todos sus miembros para el ejercicio del primer período únicamente.

Dado en el Salón de Sesiones de la Junta Fundadora de la Segunda República.—San José, a los veintiún días del mes de setiembre de mil novecientos cuarenta y ocho.—JOSE FIGUERES.—*Fernando Valverde Vega.—Uladislao Gámez Solano.—Bruce Masís Diviasi.—Benjamín Núñez Vargas.—Alberto Martén Chavarría.—Francisco José Orlich Bolmarcich.—Raúl Blanco Cervantes.—Edgar Cardona Quirós.*

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278 **Clasificar los desechos**
Todos los desechos sólidos que provengan de las actividades corrientes personales, familiares o de la comunidad y de operaciones agrícolas, ganaderas, industriales o comerciales, **deberán ser separados**, recolectados, acumulados, **utilizados cuando proceda** y sujetos a tratamiento o dispuestos finalmente, por las personas responsables a fin de evitar o disminuir en lo posible la contaminación del aire, del suelo o de las aguas.

279 ***Aprovechar los desechos o disponerlos***
Queda prohibido a toda persona, natural o jurídica arrojar o acumular desechos sólidos en lugares no autorizados para el efecto, utilizar medios inadecuados para su transporte y acumulación y proceder a su utilización, tratamiento o disposición **final mediante sistemas no aprobados por el Ministerio.**

280 ***La municipalidad debe realizar la gestión por administración o contratación Los usuarios están obligados a contribuir económicamente***
El servicio de recolección, acarreo y disposición de basuras así como la limpieza de caños, acequias, alcantarillas, vías y **parajes públicos estará a cargo de las municipalidades las cuales podrán realizarlo por administración o mediante contratos con empresas o particulares**, que se otorgarán de acuerdo con las formalidades legales y que requieran para su validez la aprobación del Ministerio.

Toda persona, queda en la obligación de utilizar dicho servicio público y de **contribuir económicamente** a su financiamiento de conformidad con las disposiciones legales y reglamentaria pertinentes.

281 ***El comercio debe contar con su propio sistema pero autorizado por el MS***
Las empresas agrícolas, industriales y comerciales, deberán disponer de un sistema de separación y recolección, acumulación y disposición final de los desechos sólidos provenientes de sus operaciones, **aprobado por el Ministerio cuando por la naturaleza, o cantidad de éstos, no fuere sanitariamente aceptable el uso del sistema público o cuando éste no existiere en la localidad.**

282
Los terrenos baldíos deben estar en condiciones higiénicas

Los propietarios de terrenos desocupados en áreas urbanas están obligados a mantenerlos cerrados y en buenas condiciones higiénicas.

Quedarán obligados, asimismo, a realizar las prácticas u obras, dentro del plazo que la autoridad de salud les ordene, cuando tales terrenos constituyen un foco de contaminación ambiental.

283 *Solo los autoizados podrán recuperar desechos*

Queda prohibida la recuperación de desechos y residuos sólidos en lugares no aprobados por la autoridad de salud para tales efectos.

Quedarán obligados, asimismo, a realizar las prácticas u obras, dentro del plazo que la autoridad de salud les ordene, cuando tales terrenos constituyen un foco de contaminación ambiental.

Las personas, naturales o jurídicas, que se ocupen de la recuperación, aprovechamiento, comercio o industrialización de tales materias, deberán solicitar permiso previo a la autoridad de salud y ésta podrá otorgarlo, cuando se compruebe que los trabajos de selección, recolección y aprovechamiento de los desechos y residuos no impliquen el peligro de contaminación del ambiente o riesgos para la salud de las personas que trabajan en tales faenas o de terceros.

284 Poder de revocatoria por incumplimiento

La autorización a que se refiere el artículo anterior durará un año y podrá ser cancelada en cualquier tiempo, cuando el titular no cumpliere las disposiciones reglamentarias pertinentes o no realizare las prácticas y obras especiales que la autoridad de salud le imponga como requisitos necesarios para resguardar la salud de las personas, o el saneamiento de la operación.

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