COMPOSITION OF SOLID WASTE IN THE BERD MUNICIPAL DUMP IN TAVUSH MARZ, ARMENIA

By

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The report: “Composition of Solid Waste in the Berd Municipal Dump in Tavush Marz, Armenia” is hereby approved in partial fulfillment of the requirement for the Degree MASTER OF SCIENCE IN FORESTRY

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ABSTRACT

The problems associated with open dumping in Armenia will become more severe as the growing economy increases the production of waste materials. Management of solid waste is dependent on the composition of trash in the waste stream, but there are few data for many cities in Armenia and no standard protocol for data collection. Differences in composition and generation of wastes between Berd and the capital city of Yerevan suggest local methods of data collection are more accurate.

In the fall of 2007 and spring of 2008, the solid waste produced by Berd residents and business owners was analyzed for percent composition by both volume and weight. The methods of waste sampling can be applied to all cities at minimal cost, using hand-sorting of 0.5 m^3 samples. Waste generation rates are calculated from composition and volume data to be 0.55 kg/capita/day.

A t-test indicates there is no seasonal difference in composition. Composition studies may occur without regard to season in medium-sized cities with similar socio-economic conditions. The largest percentage of trash by volume was plastics (37%). Together, food and other biodegradable materials comprised 44.2% of the total waste sampled by weight. Organic materials have the most potential to be removed from the waste stream.

CHAPTER 1: INTRODUCTION

The U.S. Peace Corps in Armenia assigned me to teach Environmental Education at a secondary school in the isolated valley town of Berd. Berd is a beautiful town, lush with wildflowers, shrubs, and grape vines from spring through fall. A modest river cuts through the city, past the ruins of a ninth century fortress. A neglected dendropark pokes green-black boughs into the heavens atop a mountain. Cobblestone streets run through this small city along the river and up each side of the valley. The effect is spoiled, however, by the litter accumulating in every bush, poking up through potholes in the streets, and trash and raw sewage clogging the river. Trash overflows open dumpsters near apartment buildings where hostile competition between cows, pigs, donkeys, chickens, turkeys, dogs, and cats disperse the trash.

Trash is a huge problem for two main reasons. First, littering is common and socially acceptable, especially when thrown into the river. Even if littering was considered shameful, the second problem is where to put the trash. Both problems are interconnected as part of the whole solid waste management problem. For example, my sitemate designed an environmentally-themed English camp in Chinchin, and invited me to teach. After discussing the benefits of clean parks with the students, we helped our students gather trash from the park into plastic bags. On the drive home, my sitemate asked the taxi driver what to do with the trash. Before we realized what was happening, the driver braked hard, pulled over and threw the trash into the tree-lined gorge alongside the road.

After a few months of working with my assigned school, my sitemate introduced me to the Berd community union (BCU). When the Tavush (*Shamshadine* in Russian) region became a marz (distinct politcal region) ten years ago, four separate regions melded into one administrative unit with the capital in Ijevan. The purpose of the BCU is to assist the sixteen villages surrounding Berd in locating and working with organizations to reach development goals. The director of the BCU is Samvel Hovsepyan. During our first meeting, I explained to him that I was an environmental volunteer with experience in ecology and forestry and that I was looking for project opportunities. He told me that I could help by giving him a million dollars. Several weeks later, Samvel requested another meeting with me. I met with him in his office at City Hall, and he proposed a project to improve the municipal dump. He had studied in Switzerland and knew that sanitary landfills existed, but he did not information on hygiene standards or design. I explained to him that I knew nothing about landfill design either, and that leachate control systems and liners were necessary. He told me that I already knew more about it than he did. I started researching solid waste management and landfills.

Many Berd residents that I spoke with were proud of their environment, while at the same time, they did not really understand it or help to keep it clean. It is clear that a comprehensive waste management plan is not in effect, that there is no standard methodology in place for data collection, and that public education needs to be addressed as a serious part of the solution. The purpose of this report is to identify low-cost methodology to gather waste composition data and to analyze each component of the Berd waste stream to identify reduction or recycling opportunities.

Chapter 2 is a general background of Armenia for readers unfamiliar with the country. In addition to brief descriptions of the geography, climate, biodiversity, and land and soil resources, the sociopolitical history provides some insight on why Armenia is in its current situation regarding solid waste management.

Chapter 3 provides a background of the national environmental legislation and policy that affects community-level solid waste management across the country. Current practices of waste management including landfilling and recycling or reuse of materials is described at the national level. The study area of Berd in Tavush Marz is described in more detail.

Chapter 4 describes the methods used to conduct the study, including details of sample collection and classification, as well as statistical analysis methods. Calculations used to estimate local waste generation rates are also presented.

Chapter 5 presents the results and discussion. The waste stream in Berd is characterized by waste generation rates and percentage composition of each component. Each component category is described, and each component is discussed separately to clarify its effect on the waste stream and how to manage it. Seasonal variation in waste composition is addressed. Waste generation in rural Armenia is compared to urban Armenia, and finally, Armenia is compared to other countries.

Chapter 6 highlights conclusions drawn from this study. Based on those conclusions, recommendations are then provided for the improvement of local solid waste management. This chapter focuses on landfill improvement, collection of service fees, and the creation of a national public education campaign.

CHAPTER 2: ARMENIA

Of 8 million native Armenians around the world, only 3 million live in Armenia, with the rest living in 60 different countries including the Russian Federation, USA, France, Georgia, and Iran (MNP, 1999). Over 97% of Armenia's current population is native Armenian. They are admired for their strong cultural traditions in hospitality, dance, art, and music. The Armenian language consists of two versions, Eastern and Western, which have evolved from Old Armenian. Eastern Armenian is the language spoken in the Republic, and over 40 dialects can be heard in different regions (MNP, 1999). Russian is also widely spoken and understood.

Description of Armenia

The Republic of Armenia is a small country situated between 38°50-41°18N and 43°27-46°37E. Its territory covers approximately 29,742 km^2 (11,500 square miles), roughly equivalent to the U.S. state of Maryland (MNP, 1999). It is landlocked by Georgia to the north, Azerbaijan to the east and southwest, Turkey to the west, and Iran to the south (Figure 1). Armenia is a mountainous country with a maximum elevation of 4,090 m above sea level at the peak of Mount Aragats. The lowest point of elevation is 400 m above sea level at the DeBed River (CIA, 2007).

Armenia's mountains and Lake Sevan are a direct result of the country's location on a major tectonic fault between Europe and Asia (MNP, 1999). The landscape is shaped by earthquakes, volcanism, landslides, ground deformation, and hydro-geological changes (Karakhanian *et al*., 2004). The aspects and gradients of the slopes create a range of microclimate conditions that increase biodiversity.

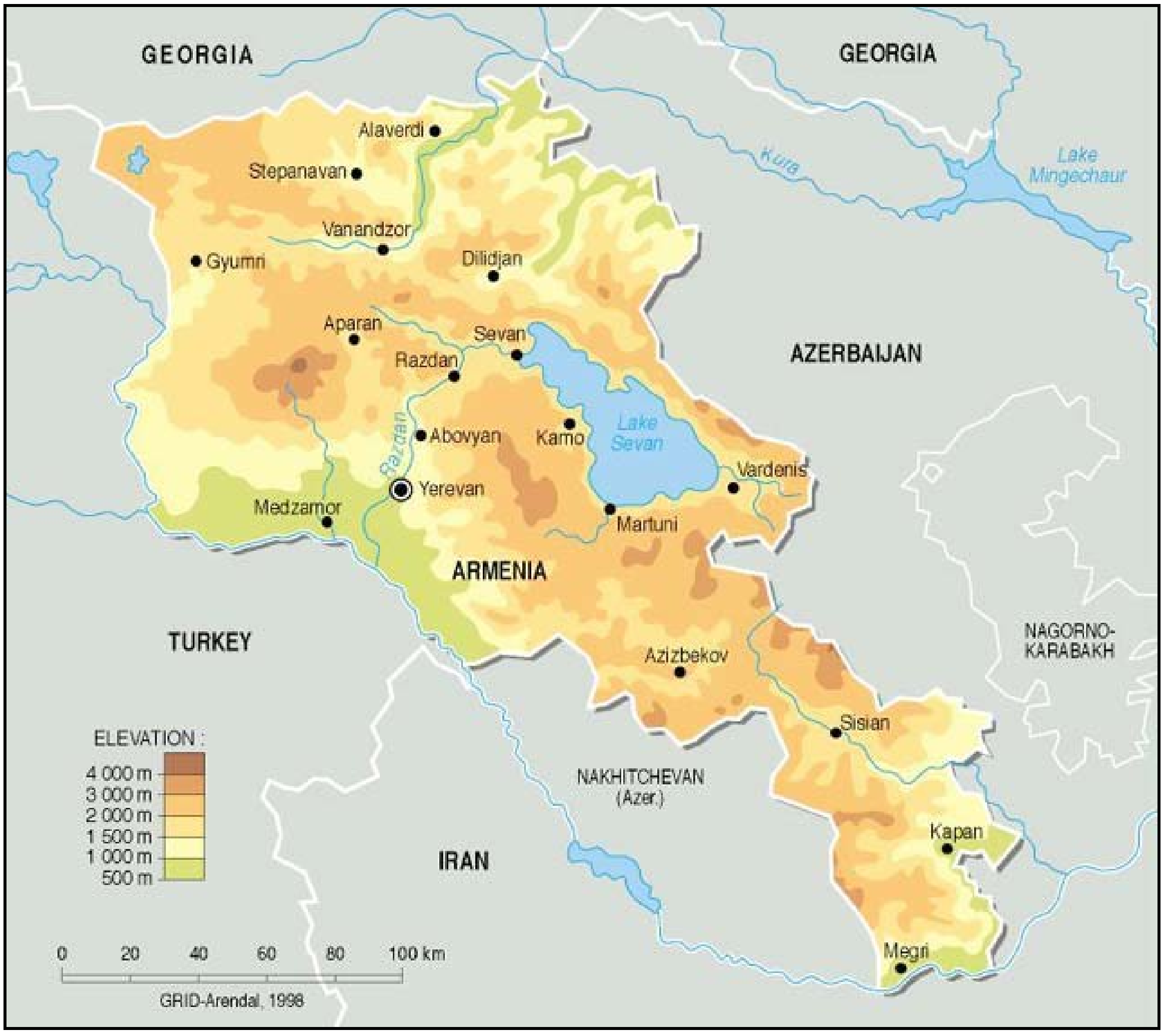

Figure 1. Geographic location of the Republic of Armenia. Source: The Times Atlas of the World. Copyright Philippe Rekacewicz, Emmanuelle Bournay, UNEP/GRID-Arendal (Appendix A).

Six major landscape zones are recognized in Armenia: deserts and semi-deserts, dry steppes, steppes, woodlands, sub-alpine and alpine lands (Figure 2). Deserts and semi-deserts occur in the Ararat Valley and lower slopes up to 1,300 m, the Vaik lowlands, and the Meghri gorge. The climate is dry and continental, with hot summers and moderately cold winters (MNP, 1999). Dry steppes and mountain steppes dominate Armenia's landscape. They are found at higher altitudes than semi-deserts, above 1500 m in the Ararat Valley, but are also found at altitudes above 800 m in deforested areas of the northeast. Patches of forest occur at altitudes between 1,500 m and 2,000 m in the northeast. The climate is warm, with dry summers and mild winters (MNP, 1999). Sub-alpine meadows occur at higher altitudes than steppes and forests, up to 2,500 m. Summers are short and cool, while winters are long and cold. Alpine meadows occupy the highest altitudes, up to 3,000 m in the north and 3,800 m in the south. With an average annual temperature of -4°C, snow cover may last for nine months of the year and some areas have permanent snow cover. Zones not falling into the above six categories comprise approximately 10% of the terrain. They are not a result of altitude and examples include wetlands, saline and alkaline lands (MNP, 1999).

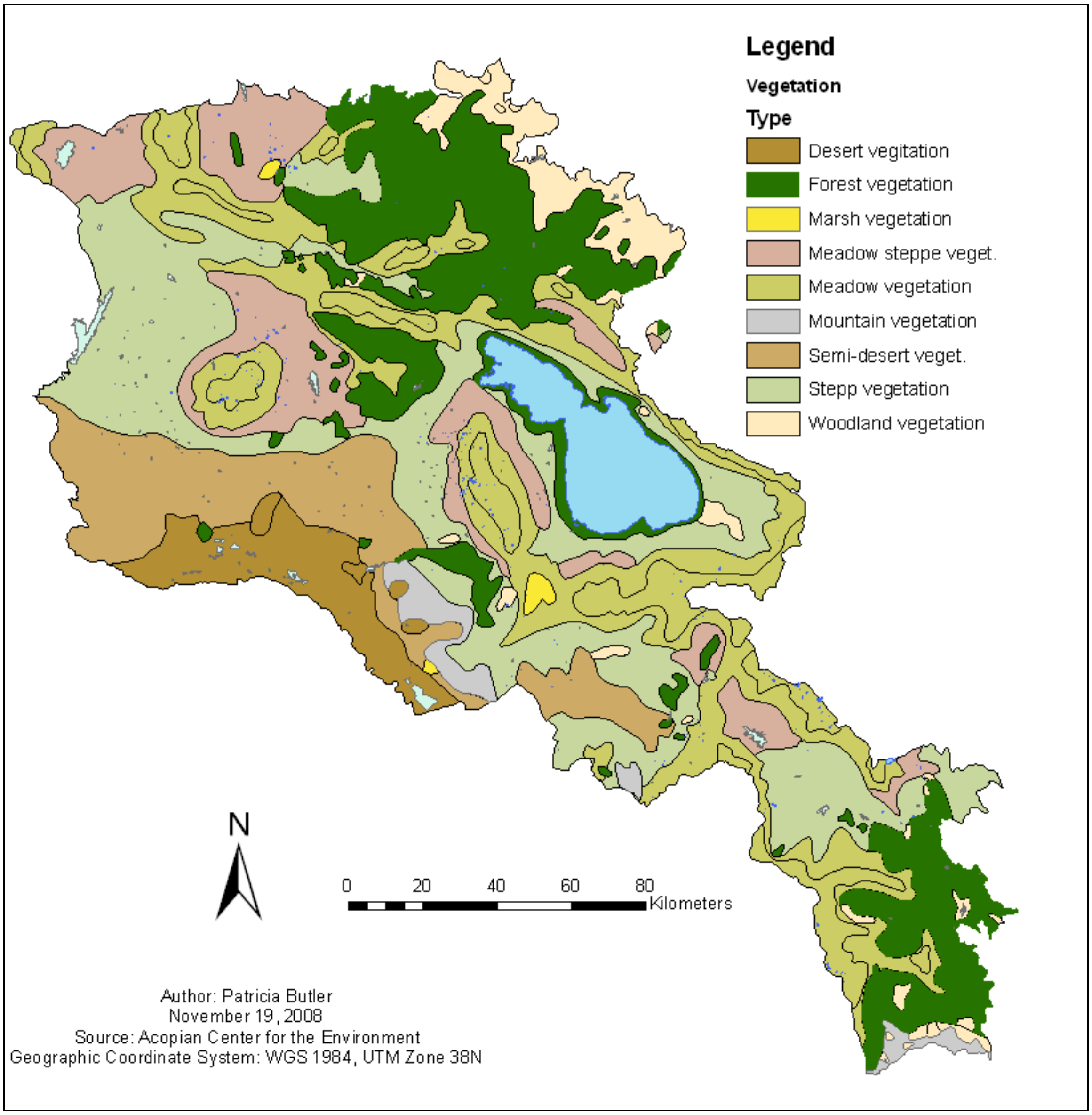

Figure 2. Geographic regions with vegetation types.

Climate

The country is located in the sub-tropical zone. Annual precipitation ranges from 250 mm at lower elevations to 900 mm at higher elevations (Table 1) (AUA, 1998). Relative humidity averages 60%, ranging from 44% in summer to 80% in winter (MNP, 1999). The average annual temperature ranges from 2.7°C on Mt. Aragats to 14°C at Meghri in the northeast. Winter averages range from -3.1°C to -18.9°C (MNP, 1999).

Table 1. Temperature and precipitation averages (Source: MNP, 1999).

Altitude Zone	Average monthly temp in summer (°C)	Annual precipitation (mm)
Low level	24-26	250-300
Mid level	15-20	400-600
High level	10-15	700-900
Average		**600**

Water Resources

The country receives a total of 18 km^3 of water throughout the year, mainly from rainfall, most of which is lost by evaporation. Two major river systems are present in the Kur and Arax Basins. The total annual flow in rivers is 7 km^3, but this amount may fall to 5 km^3 in dry years. The rivers are a critical resource for water supply, irrigation, and for hydroelectric power generation, which currently provides up to 1.7 million kW per year. Armenia also has a small number of lakes and one of the largest alpine lakes in the world, Lake Sevan. It is located at 1,916 m above sea level between a series of mountain ranges and contains 80% of Armenian water resources. In addition to the rivers and lakes, a number of reservoirs have been constructed to help regulate water supply (MNP, 1999).

Biodiversity

Armenia is included within the borders of the Caucasus biodiversity "hotspot," an area of 580,000 km^2 located between the Black and Caspian Seas (CEPF, 2003). The density of higher flora species can exceed 100 species per square kilometer - one of the highest densities in the world. Armenia's flora includes about 3,500 species from 150 genera of vascular plants (MNP, 2003). Medicinal, oil, honey, and decorative species, as well as those containing tanning and resinous substances are frequently collected for traditional uses (MNP, 2003).

There are more than 17,500 species of animals, including more than 500 species of vertebrates. These species are under constant threat, however, because of anthropogenic activities. Fuel wood collection, illegal logging, poaching, overgrazing of livestock on meadows and pastures and unsustainable water management have led to the increase of invasive exotic species, deforestation, and a decrease in wildlife habitat (MNP, 2003; CEPF, 2003). Over 300 animal species are considered declining or rare, 490 species are on the edge of extinction, including 66 species of birds and 18 species of mammals. Armenian mouflon (*Ovis orientalis gmelinii*), wild goat (*Capra aegagrus*), European otter (*Lutra lutra*), marbled polecat (*Vormela peregusna*), brown bear (*Ursus arctos*), and Pallas' cat (*Felis manul*) are currently most threatened (MNP, 2003). The striped hyena (*Hyaena hyaena*) and the Caucasian birch mouse (*Sicista caucasica*) are considered critically endangered in Armenia (CEPF, 2003).

Agriculture

Wheat (*Triticum*), barley (*Hordeum*), and rye (*Secale*) have a close genetic history with their wild crop relatives in the Armenian Plateau. Beans (*Phaseolus*), lentils (*Lens*), garden pea (*Pisum*), apple (*Malus*), pear (*Pyrus*), apricot (*Armeniaca*), black currant (*Rigbes*), almond (*Amygdalus*), spinach (*Spinacia*), carrot (*Daucus*), alfalfa (*Medicago*), and clover (*Trifolium*) have been cultivated for centuries (MNP, 2003).

Forest Resources

Two distinct periods of severe deforestation occurred in the 20th century. The latest, from 1992 to 1995 was a result of blockades by Turkey and Azerbaijan, the energy crisis, and war. The energy crisis forced many communities to obtain up to half of their household energy needs from cutting trees (MNP, 1999). During the energy crisis, approximately 30,000 ha of forests were cut down and many stands lost the ability to regenerate naturally (UNDP, 1998). Although deforestation for fuel wood has slowed since gas and electricity have become available, deforestation is assumed to continue (MNP, 1999). Only eight percent of Armenia remains as forest, and of the remaining forest cover, 62% is located in the northeast (Moreno-Sanchez and Sayadyan, 2005).

Armenia's remaining forests are dominated by broadleaf deciduous trees. A mix of oak (*Quercus spp*.), beech (*Fagus orientalis*) and hornbeam (*Carpinus betulus*) compose 81.3% of the forest cover. Other broadleaf deciduous trees represent 10.9% of the forest cover and include hornbeam coppice (*Carpinus caucasica*), lime (*Tilia Cordata*), ash (*Fraxinus excelsior*), and maple (*Acer spp*.). Areas of evergreen occur less commonly; pines (*Pinus spp.*) comprise 5.3% of the forest cover, primarily in plantations; juniper (*Juniperus spp*.) represents 2.5% (Moreno-Sanchez and Sayadyan, 2005).

Sociopolitical Environment

The modern territory of Armenia is the portion of historic Armenia that Russia annexed in 1828. Armenia declared independence in 1918, but became the Soviet Socialist Republic of Armenia only two years later and the Nagorno-Karabakh territory was given to Soviet Azerbaijan. In 1988, Armenia disputed Azerbaijan's ownership of Mountainous Nagorno-Karabakh. With the dissolution of the Soviet Union, both Armenia and Azerbaijan declared independence in 1991, and the conflict over Nagorno-Karabakh escalated. Armenia held possession of the territory when a cease-fire agreement was reached in 1994. Occasional violations of the cease-fire agreement are reminders of the hostilities and political tension that continue today. The blockades imposed by Turkey and Azerbaijan continue to restrict Armenia's trade (CIA, 2007).

The Spitak earthquake of 1988 also contributed to a national economic crisis. Many cities and villages were either destroyed completely or sustained substantial damage to the infrastructure, including roads, railways, gas, electricity, water supply and the environment. Industry and food production declined resulting in widespread unemployment and famine. Centralized supplies of gas, hot water, heating and electricity were disrupted (MNP, 1999).

As a result of both the earthquake and the breakup of the Soviet Union, the GNP fell from 4.5 billion USD in 1989 to 652 million USD in 1994 (MNP, 1999). The economy was on the edge of total collapse. International foreign aid, foreign and domestic business investments, capital construction, renewed production, decentralization and state support for social welfare contributed to economic recovery and an increase in GNP that averaged above 13% per year in recent years (CIA, 2008; MNP, 1999).

The nuclear power plant at Metsamor provides 40% of the country's electricity and hydropower produces 25% of electricity. Armenia has no natural gas production of its own. Gas is imported from Russia through Georgia by tanker trucks (Adonz, 1999). Construction of a pipeline from Iran to Armenia is scheduled to be completed by January 2009, and will mark an important new strategy for both economic growth and political allies for Armenia.

As the economy improves and trade expands, the quality of life for many Armenians should improve. Great care must be taken to ensure that effects of the growing economy are positive. There is potential for negative effects to result as well. In particular, as the economy increases, the production of waste materials can be expected to increase and exacerbate problems associated with open dumping. Management of solid waste is dependent on knowledge of the composition of the waste stream, but there is little data for most of the cities in Armenia and no appropriate methodology for data collection.

CHAPTER 3: SOLID WASTE MANAGEMENT IN ARMENIA

Municipal solid waste (MSW) management in Armenia is a result of the country's difficult sociopolitical and economic history. As the economy strengthens, more waste will appear in the trash stream, compounding a problem deep-rooted in legislative, financial, and social neglect. MSW is defined by Buenrostro *et al.* (2001) as "all the solid waste generated within the administrative boundaries of a municipality, regardless of its physical and chemical characteristics and source of generation." MSW can be subdivided into three main types: urban, industrial, and rural, which each produce different compositions of waste. In developed countries, each category is treated appropriately to minimize damage to the environment or human health, but in developing countries these wastes are often disposed of together in the municipality's only landfill.

Environmental Legislation

There is no comprehensive national body of law concerning municipal waste management, nor is waste management a priority for the Ministry of Urban Development (Arzumanyan, 2004). The creation of the Ministry of Nature Protection (MNP) in 1991 provided general institutional and legislative policies on nature conservation and environmental protection (Darbinyan and Ashikyan, 2002). The Law on Environmental Protection and Natural Resource Payments allocates funds specifically for financing environmental protection activities. However, the Ministry of Finance refuses to allow the Ministry of Nature Protection to set up an environmental fund and the payments are probably applied to other budgets. The lack of cooperation among ministries has hindered efforts to improve environmental protection (Darbinyan and Ashikyan, 2002).

The provision of solid waste management services, including the organization, transportation, disposal of solid waste and the collection of service fees from the population was allocated to the local government units (LGUs) in 1997 by Presidential Decree No. 728 “On State Management in RA Marzes” and Government Decree #51. The LGUs are in a position where local financial resources are limited and there is no guidance for consistent management (Arzumanyan, 2004).

The 1999 reform of Law No. 270 “On Environmental and Natural Resource Payments” provided the first stringent legal basis for environmental charges. Article 4 of Law No. 270 provides that environmental payments include those for discharges of twenty pollutants into the environment, for placement of production and consumption waste in the environment, and for environmentally harmful products. Non-toxic waste charge rates are 600 Armenian drams (AMD) per metric ton (approximately 2.00 U.S. dollars [USD]/ton) and many enterprises probably misclassify toxic waste into this category to reduce costs of disposal. Despite probable misclassification, the amount of hazardous waste has increased during recent years (Schucht and Mazur, 2004).

There is no treatment of hazardous wastes and the environmental charges are imposed on violations of on-site storage and landfill disposal of industrial waste (Schucht and Mazur, 2004). Households do not pay pollution charges because they pay for the removal and disposal of household waste through waste collection user fees. Industrial and municipal wastes are disposed of together in open landfills that do not conform to environmental or sanitation landfill standards such as those that exist for the European Union.

Landfilling and Waste Generation

In all, Armenia has 45 urban landfills and 429 rural landfills, covering about 1,500 ha of land. Landfills are located two to eighteen kilometers from towns and villages. The landfills are not equipped to prevent the leaching of hazardous substances into the soil or groundwater supply (ECECEP, 2007). About 900 villages are not covered by any municipal waste management (ECECEP, 2007) and choose open sites away from homes as dumps (Doane *et al.*, 2000). These dumps are at risk for uncontrolled, low-temperature fires, which results in significant air pollution (MNP, 2003; Schucht and Mazur, 2004). Rural communities that do not have a landfill may pay a fee to use the landfill of another community (Doane *et al.,* 2000).

Municipal wastes are collected by old garbage trucks or tractors and trailers and transported to dumps. It is estimated that Armenia would need 700 collection vehicles, but has only 380 vehicles, of which 130 are found in Yerevan. Many are in need of repair or replacement (ECECEP, 2007). The study area, Berd, has two trucks.

Fees are set annually and differ from community to community, but on average are less than 100 AMD (0.30 USD) per capita/month. This assumes that monthly solid waste generation is approximately 35 kg per capita and the cost of removal of one cubic meter of solid waste is approximately 3,000 AMD (9.00 USD). In many communities, only a fraction of the money owed for solid waste collection and disposal is collected. Customers who sign individual contracts with the service provider pay their fees more often than customers serviced without a contract (RTI, 2006). The average collection rate for user fees in all cities is 47 percent. To make up for lost fees, some cities may be using money budgeted for street cleaning to cover waste disposal costs, and other cities are using money from other portions of the city budget (RTI, 2006).

Recycling, Reduction, and Re-use

Reduction of wastes at source is the most efficient management option because there is no need to transport, handle, recycle, or dispose of the material. Social customs and attitudes are the limiting factor for this option. Not only in Armenia, but all over the world, producers need to reduce unnecessary packaging materials, and consumers should choose goods with less packaging waste over those with higher amounts. Five hundred billion to one trillion plastic bags are consumed every year in the world (Cobb, 2003). Using reusable bags made of cloth or recycled materials will decrease environmental pollution and landfill waste.

Informal or illegal reuse and recycling is more prevalent than legal recycling. Scavenging occurs directly at the dump, where paper and cardboard, glass, and metals are reclaimed. Arzumanyan (2004) reports that nearly all of the combustible wastes are reclaimed during the winter to fuel fires, including toxic combustibles such as rubber and plastics. Scrap metals are recycled by private enterprises; because it is illegal, authorities have no data on the quantity or economics of these enterprises (Arzumanyan, 2004). According to Deputy Head of State Environmental Inspection, polyethylene (PET) bottles and plastic bags are widely used and disposed of inappropriately. Arzumanyan (2004) reports the existence of illegal enterprises that produce plastic basins, sewage pipes, and shoe soles from processed plastic waste. There is no data on volume, quality or toxicity of the illegally rendered plastics.

Formal recycling opportunities in Armenia are rare. Legal recycling exists only for glass bottles and paper. There are ten registered paper recycling facilities in Yerevan and some major beverage companies reuse glass bottles collected from restaurants and stores (Arzumanyan, 2004). Glass is also exported to “Ksani Glass” in Georgia to be recycled (EFN, 2007). Paper recycling is currently being conducted by the 50x50 LTD, which processes secondary raw paper into new hygienic paper and satisfies up to 70% of the domestic market demand (650,000 sheets/year) (MUD, 2008).

Study Area: Berd, Tavush Marz

Armenia is divided into 11 distinct marzes (provinces). Berd is a 2,953 ha town located at 40°53N, 45°23E, 923 meters above sea level in Tavush Marz, 192 kilometers northeast of Yerevan, 60 kilometers east of Ijevan, and approximately 14 kilometers west of the Azerbaijan border (Figure 3). The official 2002 census reported a population of 8,663; an estimated 2,000 residents are continually absent, usually working in Russia. The military base supports temporary residents not included in the census. There are 3,200 households and 2,096 apartment units in Berd (RTI, 2006).

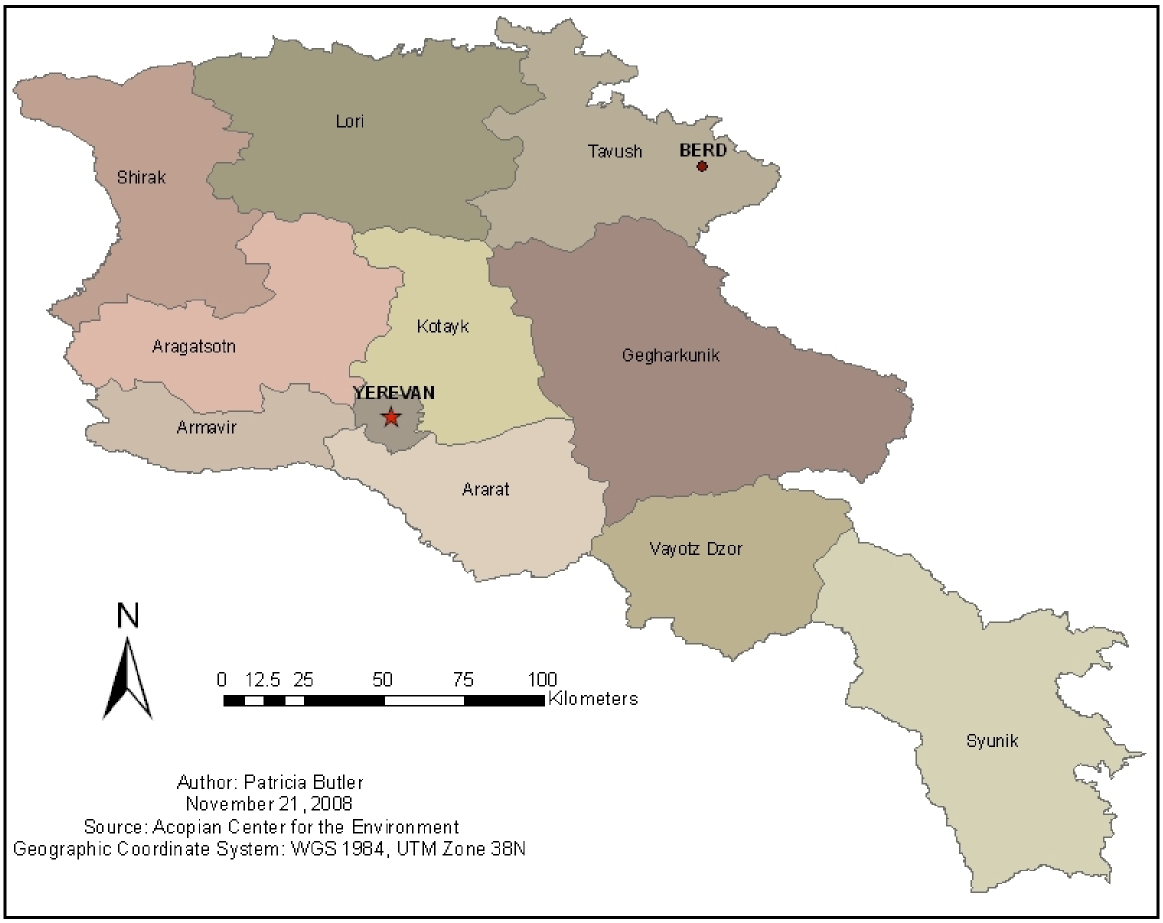

Figure 3. Political divisions (marzes) of Armenia.

Together, agriculture (40%) and small commercial enterprises (30%) make up a majority of the local economy. The remaining contributors are transportation, light industry, and services. Although the official unemployment rate is five percent, local estimates place it at seventy percent (RTI, 2006).

The dump is located approximately 4 km from the town and occupies approximately 5 ha with no official boundaries (Figure 4). Wind and animals spread garbage to the surrounding fields and river. Three nearby villages deposit a load of trash into the landfill approximately one time per year. These villages do not have regular trash collection of any kind, but there is usually a collection that occurs as part of Shabhat Oriak, a "spring-cleaning" day.

Figure 4. Berd municipal dump (Photo by Patricia Butler).

Garbage collection is conducted by the CJSC “Jramatakararum & Barekargum,” a municipal company that is funded solely by user fees. Half (49.38%) of the Berd population has waste collection service. Two vehicles collect solid wastes two to three times per week, so that a truck works everyday (RTI, 2006) (Figure 5).

Figure 5. City laborers with trash collection vehicle (Photo by Patricia Butler).

Larger vehicles cannot service some of the more difficult roads, and some roads are completely inaccessible to smaller vehicles. Using generation rate of 0.35 kg/capita, Cointreau-Levine (1994) calculates that a vehicle with a capacity of two tons or ten cubic meters is capable of servicing 10,000 people. In August of 2008, Berd received a new compactor garbage truck with a capacity of 10 cubic meters from USAID. This truck is adequate for handling all of Berd’s wastes, if roads were not a limiting factor.

CHAPTER 4. METHODS

Armenia currently has ineffective policy and insufficient funding for waste management. The problems caused by open dumping will become more severe as the growing economy increases the production of waste materials. Management of solid waste is dependent on the composition of trash in the waste stream, but there are few data for most of the cities in Armenia and inadequate protocol for data collection. This study had three main objectives. The first objective was to refine sampling methodology that is appropriate for other small- and medium- sized cities in Armenia. The second objective was to provide information on the physical trash stream of Berd and to investigate if there is a seasonal difference in trash composition that would affect the timing of a municipal waste study. The third objective was to enable city planners to address waste management at the local level by discussing appropriate measures to improve the conditions of landfills, increase collection of landfill taxes and collection fees, and increase public awareness as part of a comprehensive management plan.

In general, the methods used were described in “Solid waste landfills in middle- to lower- income developing countries” by Rushbrook and Pugh (1999). Modifications were made as necessary to further accommodate the use of local materials, municipal schedules, and to reduce cost.

Collection of Samples

Wastes, including biohazardous wastes from medical facilities, are collected daily by the trash service and are deposited in Berd’s only dump. In this study, samples were collected every weekday within a sampling period on days the trucks were not out of service due to mechanical failure. Garbage is not collected on Saturdays or Sundays. A total of 30 samples were collected over two sampling seasons. The first sampling season occurred at the height of crop harvesting in 2007 between October 23 and November 30. The second sampling season occurred in 2008 between March 17 and April 4 when produce is was less available. During each season, fifteen samples from the city of Berd were measured and classified at a rate of one sample per day. The total volume of trash in each sample was 0.5 m^3. The samples were randomly taken and represented commercial and market wastes as well as domestic waste sources.

Rushbrook and Pugh (1999) recommend that samples be analyzed within the day of collection to avoid weight error by moisture loss, but offer no advice regarding rainy days. I collected samples on rainy and snowy days. The increase in moisture increased sample weights, but the relative amounts of waste by type were probably consistent.

Samples were collected directly from the garbage collection vehicle after it had completed pickups, but before it transported the collection to the dump. The garbage collection vehicle brought the garbage to the sorting area in a garage near City Hall. Samples were sorted completely on the day of collection to minimize errors from moisture loss. I climbed up into the truck, picked a spot at random, and collected everything in potato sacks from that location down to one meter before choosing another location for collection (Figure 6).

The full potato sacks were dumped into the measuring box of 0.5m^3. The box was rocked back and forth and side to side three times during filling to settle the contents without compacting them. Once the box was full, garbage from the previous day's sample was added to the truck and the truck left for the dump. The waste was sorted by composite type into eleven labeled ten-liter buckets to measure volume. As a bucket became full, the bucket and contents were weighed with hanging scales. Volume and weight (kg) were recorded on data sheets and the total weight was subtracted from the bucket weight to find the weight of the constituents. The complete data set is available in Appendix B. The bucket was then emptied into a potato sack, which was eventually dumped into my designated dumpster, which was picked up after I obtained my sample the next day. When the box neared empty, it was tipped on its side and the small-sized garbage was moved out of the box by hands and scrapers. The top of the tipped-over box was used as a sorting surface where all identifiable trash, including pieces smaller than 10mm, was sorted into the constituent buckets. The constituent categories were: paper; glass; metals; plastics; food; wood, bones, and straw; other putrescibles (*i.e.* yard waste, flowers, soil); leather and rubber; textiles; rocks; Styrofoam; diapers; and cigarette butts.

Figure 6. Collecting samples from the garbage truck (Photo by Arayik Babayan).

Statistical Analysis

Data were entered into Microsoft Excel. The volumes and weights of all the buckets measure for each constituent were added together daily to calculate the total weight for each constituent. The total weights of all constituents in a sample were added together to calculate the weight of the entire sample.

In sample analysis, components of a population are usually defined from the whole population and are the basic units that comprise and define the population. The central limit theorem assumes that either the component is distributed normally or that the averages taken from their distributions are distributed normally. With a population of solid waste, however, the components are not defined by the population and each component only represents a proportion of the sample size (Klee, 1993). For example, in one waste sample a glass jar can be different in weight and shape from a broken mirror, but both make up the same component category “glass and other ceramics,” and that component is limited by the total sample size ($0.5m^3$). SAS was used to perform a Shapiro-Wilk test for normality. With alpha as 0.05 and the calculated p-value as 0.0001, the null hypothesis that the data are normally distributed is rejected. Proportions of constituents were calculated by dividing the total weights of all constituents by the total weight of the sample. The proportions were made nearly normal by arcsine transformation. Transformed data from both sampling periods were analyzed with a Student’s t-test.

Waste Generation

The average weight of 30 samples of 500 liters is 92.09 kg. The total weight of waste generated in Berd that reached the collection vehicle is estimated by multiplying the total sample weight by 20, which is the number of 0.5 m^3 boxes that can fit in a 10 m^3 truck, assuming that the volume of garbage does not exceed capacity due to overflow (20 x 92.09 kg = 1821.88 kg).

Waste collection service is provided to 49.38% of the population. The total weight of solid waste collected is divided by the number of people served (3,290) to calculate the total weight of waste produced by each person per day (0.55 kg/person). That number is multiplied by the portion of the population not being served by waste removal (3,373 people not served x 0.55 kg/person = 1867.97 kg). This estimate is added to the known weight of generation for a total amount of trash generated by all Berd residents. The city of Berd generates a total of 3,690 kg/day.

CHAPTER 5: RESULTS AND DISCUSSION

The methods used in this study allow analysis of the relative importance of each component of the waste stream, the subject of the first section of this chapter. I then discuss seasonal variability. The final section compares waste generation in Berd to the capital city, and Armenia to other countries in order to highlight differences that show locally-obtained data to be critical in community waste management. Later in the chapter, this methodology is applied within the context of a comprehensive management plan, and general recommendations on landfill improvement and community outreach are made.

Composition of Waste in Berd

The total daily volume of waste collected in Berd is estimated to be ten cubic meters. If only half of the population benefits from solid waste removal service, then the total volume of waste generated in Berd is twenty cubic meters with a total weight of 3,690 kg/day. This assumes that there is no loss from scavenging at the collection site before collection occurred, that the density of waste did not increase due to normal compression processes while in the container, and that the 51% of residents not receiving waste removal services do not contribute to the municipal waste collected in common areas, such as dumpsters at intersections or garbage cans lining city streets. However, it is very likely that the above three assumptions are false and that the volume is overestimated by at least one third (Rushbrook and Pugh, 1999).

The categories of trash included: paper and cardboard; glass and ceramics; metals; plastics; food wastes; wood and bone and straw; other putrescibles; leather and rubber; textiles, rocks, Styrofoam, and cigarette butts (Table 2). Hazardous materials were not classified in this study and were not observed in samples.

Table 2. Definitions of waste categories.

Paper and Cardboard	Office and colored paper, construction paper, tissue and toilet paper, newspapers, magazines, paperboard, corrugated cardboard, waxed papers
Other Putrescibles	Leaves, twigs, flowers, soil, dead animals, fecal matter, ashes
Foods	All whole foods and peels, but not bones or stony pits
Glass and Ceramics	Clear glass, colored glass, ceramics, china
Plastics	All grades of plastic bags, all types of hard and soft plastics
Metals	Ferrous and non-ferrous materials, including iron, steel, tin cans and foil, copper, brass, lead, aluminum, batteries
Wood, Bones, and Straw	Lumber, matchsticks, firewood, furniture legs, hay and broom straws, bones cooked, raw bones
Textiles	Fabrics, clothing, shoe uppers, cotton, upholstery, cords, ropes
Leather and Rubber	Tires, shoe soles, belts, gaskets, cured leather
Rocks	Rocks, asbestos, tiles
Diapers	Disposable diapers made of fluff pulp, polypropylene, polyethylene, super absorbent polymer (SAP), elastics and adhesives.
Cigarette Butts	Filters probably composed of cellulose acetate, a form of plastic
Styrofoam	Extruded or expanded polystrene foams

Foods and Other Putrescibles

The greatest component in the trash stream by weight is “other putrescibles,” closely followed by “foods” (Figure 7). Other putrescibles are defined as those non-food wastes such as leaf litter, twigs, soil, and dead flowers. In Berd, these organic wastes comprise nearly half of the weight of waste and over a quarter of the waste volume (Figure. 8).

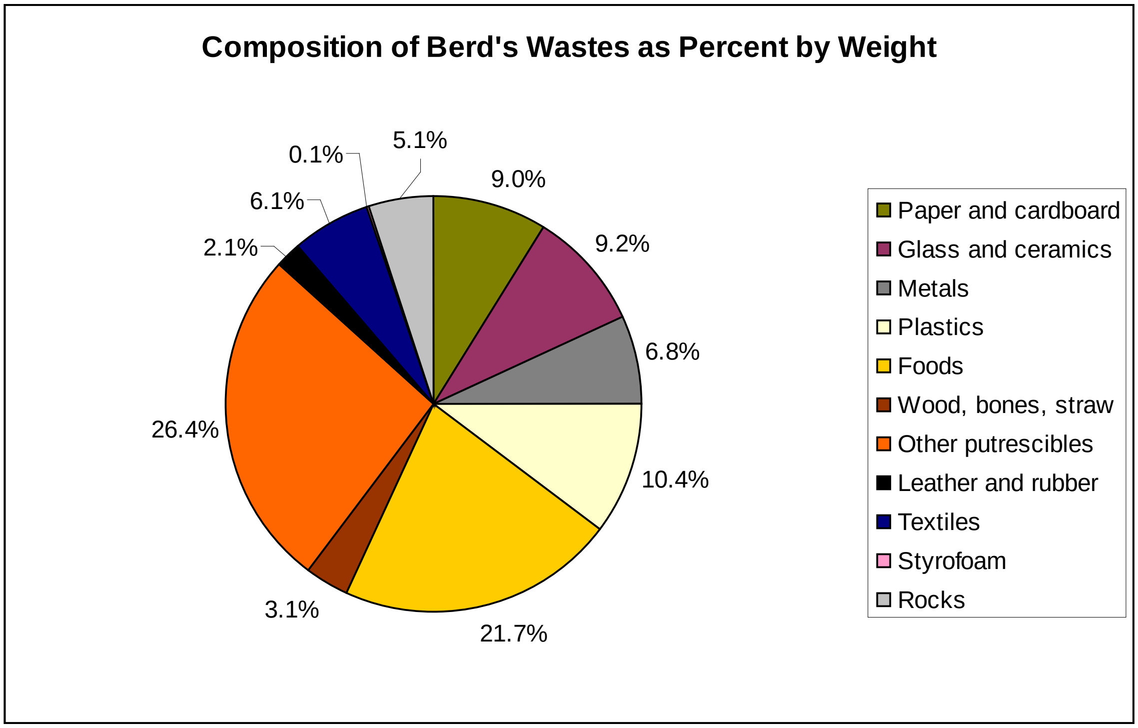

Figure 7. Composition of solid waste in Berd, Armenia by percent weight.

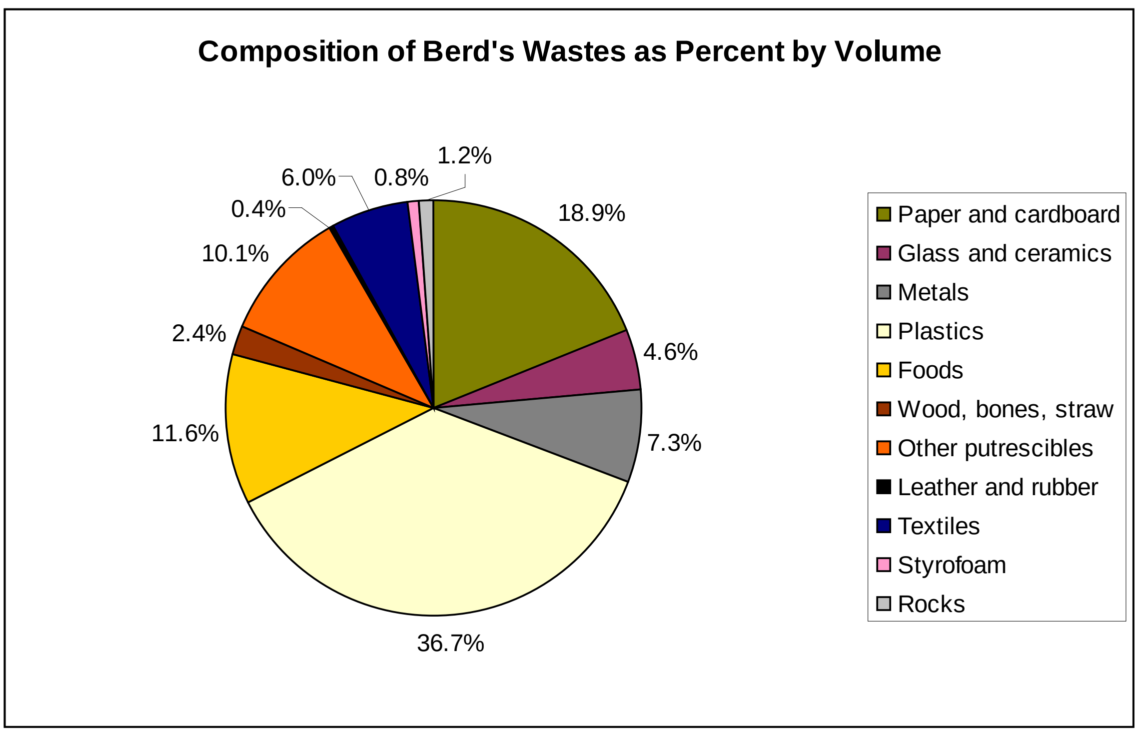

Figure 8. Composition of solid waste in Berd, Armenia by percent volume.

Organic waste has the most potential to cause environmental pollution. Degrading organic wastes directly influence the production of leachate and gas in a landfill (Bandara *et al.* 2007) and provide a medium to spread disease. However, organic wastes also have the most potential for resource recovery in the form of high quality compost. When converted into fertilizer, organic wastes can even be profitable (Hoornweg *et al.*, 1999). In addition to reducing the amount of waste entering the landfill, local composting operations reduce transport distances and related costs of collecting organic wastes. Machinery used for separating, chopping and crushing compost in larger populated areas with higher incomes is unnecessary when organic waste is collected at the household level. Common agricultural equipment such as a manure spreader and front-end loader are effective in moving and turning the compost (Frickea *et al*., 1989). Although data are inconsistent, paper, food scraps and other organics seem to be a major component of the waste stream throughout Armenia. In the past, food scraps were collected separately and used as additives for animal feed, for directly supplementing animal feed, or for composting (ECECEP, 2007).

The success of the municipal composting operation is dependent on careful sorting by the household members, therefore the biggest challenge for a successful local operation is social acceptance and participation. Intensive public outreach and education are necessary to establish communication and trust between city officials and residents. Priority should be given to reinforcing the financial and health benefits of protecting the environment and sustaining nutrient cycling (Frickea *et al*., 1989).

This type of community-wide composting has had little success in many developing countries. Some of the reasons for failure include poor planning, limited funding and social stigma. The biological process requirements are sometimes misunderstood; low quality inputs yield low quality product. Marketing planning for final compost product is often neglected (Hoornweg *et al.*, 1999).

Decentralized community composting is another option that provides an even lower-cost solution, but requires organization and public participation. Neighborhood households, schools, and markets can collaborate on compost piles on vacant land and the product can be used to fertilize public gardens (Hoornweg, 1999). However, this is unlikely to work in unfenced areas where livestock is likely to raid the compost piles.

Household composting should be encouraged for residents with yards and gardens. Small composting units can be fashioned from locally available or reused materials (*i.e.* brick waste, tiles, clay, and buckets). When properly mixed with straw and soil, the compost will not have strong odor (Hoornweg, 1999).

Plastics

Many studies on waste composition report only figures based on weight, yet volume is also important for managing some components of the waste stream, especially plastics (Figure 9). By weight, plastics make up only 10.4% of the waste stream. By volume, plastics represent the largest percentage (36.7%). The category “plastics” included all grades of plastic bags, bottles, packaging, all-weather sheeting, and all grades of hard and soft plastics from toys, appliances, and many other sources. Plastic bags and very hard plastics will not be compacted from normal transportation or storage processes with low technologies. Plastic bottles and brittle plastics have the most potential to break apart or collapse and contribute to an increase in overall density. Berd’s wastes are not intentionally compacted during collection, storage, or transportation and even brittle plastics retain more volume than compacted trash.

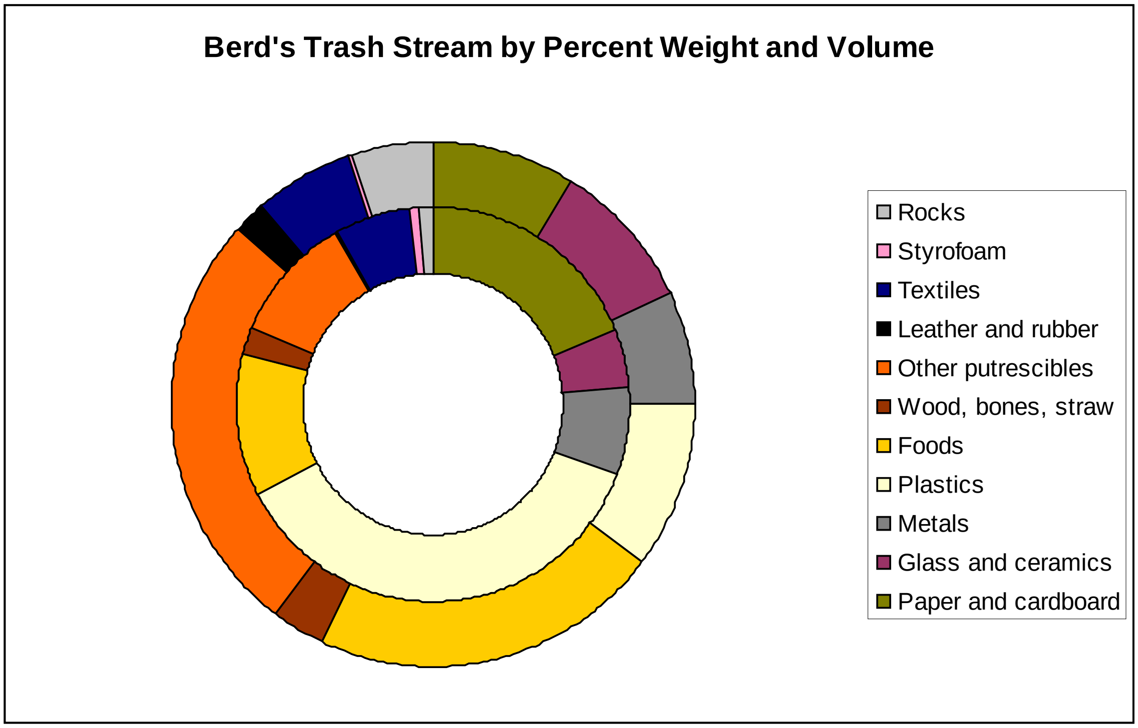

Figure 9. Volume (inner ring) and weight (outer ring) of Berd's trash stream.

Plastic bags and bottles are visible as environmental pollutants in both the waste stream and in the surrounding environment in Armenia. Some informal reuse occurs as plastic bottles and jugs are rinsed out and reused for holding benzene (gasoline), milk, wine or vodka. The reused containers are not cleaned to sanitary standards before reuse, and do not conform to safety standards for volatile liquids. This informal method cannot be encouraged due to safety considerations.

City officials and interested parties claim to make implementation of formal recycling a top priority. Throughout Western Europe, the cost of recycling products from the waste stream is not much more than the value of the recovered material, and recycling sometimes costs less (RTI, 2006). A feasibility study was conducted for plastic recycling in Vedi, Armenia. The market for processed plastics depends on export to China for a profit of 1,400 USD/ton and requires at least 105,000 USD in start-up costs, including washing (80,000 USD) and grinding (15,000-25,000 USD) equipment (Allen Stansbury, personal communication, 2008). This is not likely to occur in the private sector and managers should focus on waste reduction and public education. No-cost or low-cost projects, such as the development of brochures that encourage residents to recycle, school field trips and lessons, or a compost training seminar would increase waste awareness and reduce consumption and waste, without placing a burden on already strained city budgets.

As an alternative of the export of processed plastic waste to China or Japan, plastics can be crushed and added to cement as aggregate. Mortars and plasters made with recycled plastics result in low thermal conductivity, low bulk density, less wear and tear on mixing machinery compared to mineral aggregates, and lower likelihood of cracking and crumbling (Ohama, 1995).

Paper

Waste papers are not being completely removed from the waste stream and added to winter fires. In fall and spring, paper and cardboard comprises nearly twenty percent of the waste stream volume in Berd. Although paper recycling occurs at a small scale in Yerevan, there is no recycling in Berd.

Wood, Bones, and Straw

Wood, bones, and straw do not comprise a significant percentage of the waste stream by either weight or volume. Wood and bones do not make good feedstock for compost because they are slow to decompose (Hoornweg, 1999), but they are combustible, and will biodegrade.

Rocks

Rocks, concrete, and asbestos sheeting comprise 5% of the composition by weight. This is a significant percentage and is somewhat surprising. Recycled coarse aggregates of cement can actually be stronger than new cement because it has already withstood a variety of environmental conditions, including cycles of freezing and thawing. Recycled aggregate results in finer particulates that decrease the load bearing quality of pavement, however, and this concrete should be used only where load bearing is not critical (Robinson *et al.,* 2004).

Seasonal Variation

Waste composition studies are rarely done in developing countries because the cost of such a study would exceed the total financial and labor resources allocated to MSWM by the local government for the year (Buenrostro *et al.* 2001). However, Al-Momani (1994) recommends that composition studies be conducted annually to keep current with shifting trends attributed to shifting socio-economic factors and the variable nature of waste sampling. Composition studies are expensive and labor-intensive. One of the goals of this study was to reduce cost without reducing accuracy.

I wanted to see if the composition of waste would differ depending on the time of year that the waste was sampled. In the fall, grape harvesting and other agricultural ventures are at a peak, and I thought there would be more food and other organic wastes during this time. The spring sampling period occurred at the end of the winter months when there is less fresh produce and more preserved foods being consumed. Food is preserved in banks, or glass jars with metal lids, or in aluminum cans. Transformed data from both sampling periods were analyzed with a Student’s t-test. There was no significant difference for any waste component between seasons for volume (Table 3) or for weight (Table 4).

Table 3. Results of t-test for winter and spring transformed data by volume.

Variable	Spring Mean	Winter Mean	Confidence $\mu_1 \neq \mu_2$	Percent
Paper and Cardboard	0.2573	0.2559	0.06	18.9
Glass and ceramics	0.2510	0.2448	0.15	4.6
Metals	0.2553	0.2562	0.04	7.3
Plastics	0.2601	0.2599	0.02	36.7
Foods	0.2549	0.2535	0.05	11.6
Wood, bones, straw	0.2402	0.2288	0.19	2.4
Other putrescibles	0.2522	0.2423	0.23	10.1
Leather and rubber	0.2153	0.2293	0.19	0.4
Textiles	0.2541	0.2564	0.08	6.0
Styrofoam	0.2128	0.2208	0.09	0.8
Rocks	0.2508	0.2469	0.09	1.2

Table 4. Results of t-test for winter and spring transformed data by weight.

Variable	Spring Mean	Winter Mean	Confidence $\mu_1 \neq \mu_2$	Percent
Paper and Cardboard	0.2544	0.2538	0.02	9.0
Glass and ceramics	0.2546	0.2446	0.25	9.2
Metals	0.2472	0.2559	0.24	6.8
Plastics	0.2574	0.2600	0.14	10.4
Foods	0.2546	0.2547	< 0.01	21.7
Wood, bones, straw	0.2388	0.2272	0.19	3.1
Other putrescibles	0.2514	0.2430	0.19	26.4
Leather and rubber	0.2314	0.2367	0.09	2.1
Textiles	0.2518	0.2576	0.20	6.1
Styrofoam	0.2462	0.2314	0.19	0.1
Rocks	0.2505	0.2467	0.09	5.1

Waste managers in small cities throughout Armenia can conduct waste studies at any time of the year, when labor and finances are available, without influencing the quality of data. It should be noted, however, that this study was conducted in only one small city over two sampling seasons, and that it is possible for different results to occur in other cities in Armenia or other developing countries due to differing socio-economic factors, such as proximity to markets, abundance of livestock and agricultural lands, average living standard, income, climate, level of education, religion and culture, and social values (Bandara, 1997). In fact, studies in Amman, Jordan have shown high seasonal and monthly variation in waste composition (Al-Momani, 1994; Burnley, 2006). Bandara *et al.* (1997) found also that residents with higher income create more waste than lower income groups.

Differences in Waste Composition in Berd and Yerevan

Yerevan is home to approximately half the country's population and does not have a comprehensive waste management plan. Four communal state enterprises and one cooperative leasing enterprise provide municipal waste services for nearly 1.5 million residents. The cost of trash removal service is covered in part by the monthly fees paid by the city's residents. The total sum collected annually from the population covers only 40 to 45% of the city's total waste management costs and the city budget pays the rest (Arzumanyan, 2004).

In Armenia, it is estimated that four times more waste is generated in urban areas than in rural villages. In urban areas, a total of 10, 200 m^3 of solid waste is collected each day. Comparatively, only 2,500 m^3 is collected in rural areas (WHO, 2001). Volume data for some smaller cities have been estimated from Yerevan rates, but this data does not include information about the waste stream components (EFN, 2007). Smaller cities with populations higher than neighboring villages, but lower than large cities generate an intermediate amount of waste. The national average from this estimate is between 247 and 285 kg per capita annually, according to 1997 census data. In Berd, the annual per capita waste generation rate is only 202 kg.

In addition to differences in waste generation rates, differences in composition between rural and urban areas exist. Figure 10 compares percent weight of waste components for Berd and Yerevan (source for Yerevan data: Arzumanyan, 2004).

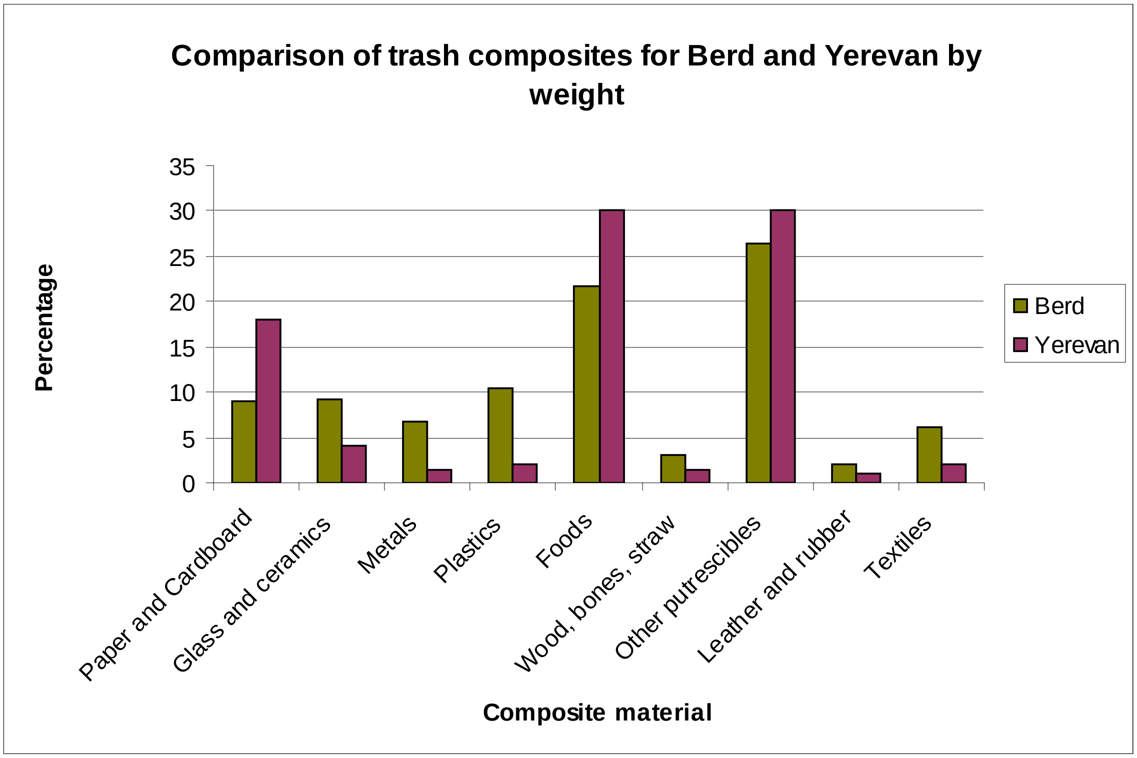

Figure 10. Composition for Yerevan (Source: Arzumanyan, 2004) and Berd.

Compared to Berd, Yerevan wastes have lower percentages of plastics, glass and ceramics, metals, wood, textiles, leather and rubber. Yerevan data on plastics is surprisingly low compare to Berd, since there is no formal recycling of plastics anywhere in the country. Some plastic wastes in Yerevan are probably streaming into the informal recycling market, which is not monitored. Yerevan has relatively higher percentages of compostable wastes that produce leachate and methane gas: foods, other putrescibles, paper and cardboard. The relatively high percentage of paper wastes can be attributed to more cardboard boxes and other consumer waste from available market products in

Yerevan, in addition to the lower incidence of burning paper products in wood stoves. The relatively higher percentage of biodegradable wastes in Yerevan can be attributed to the urban setting: availability of more food products, but little access to livestock. Berd is a smaller city, with more access to livestock and some food waste is used to supplement or support pigs, cows, chickens, horses, and donkeys. Furthermore, some of the organic waste is taken out of the waste stream after it has already made it to a communal collection point where stray cats, dogs, and livestock scavenge. In villages that do not have waste removal services, 100% of organic wastes are re-used to supplement livestock feed and soil, rocks, or yard debris are not removed from the property. Berd has slightly lower percentages of biodegradable materials and much higher percentages of leather and rubber, plastics, textiles, glass and ceramics. Because Yerevan generates more waste per capita than Berd; a smaller percentage in one of Yerevan's waste categories may still result in a higher absolute volume or weight in that category.

Differences in Waste Composition in Armenia and Other Countries

Generation of waste is directly related to economic growth and per capita income. On a global level, waste generation is increasing with economic growth and will continue to increase during the next few decades (UNDP, 1998). Azerbaijan is producing 1.5 million tons of solid waste per year. Georgia is producing 0.7 million tons per year and Armenia is exceeding one million tons per year (EFN, 2007). One report estimated that Armenia produced solid waste in the amount of 1.5 million tons per year between 1985 and 1990 (UNECE, 2000) and another reported 4.632 million cubic meters per year, of which 20% are rural sources (ADB, 2006; ECECP, 2000). In the capital city of Yerevan, 400,000 tons of municipal waste is generated annually (Arzumanyan, 2004).

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

Solid waste management depends on accurate data collection and resource-appropriate methods. At the local level, many Armenian cities use a plan that is modeled after the capital's waste management plan. Differences in composition and generation of wastes between Berd and the capital city of Yerevan suggest local methods of data collection are more accurate at the local level. Rural areas may not generate as much waste as the capital city, but medium-sized cities such as Berd are generating a significant amount, and these wastes must be managed appropriately. Resource recovery potential also differs from the capital. An effective waste management program for Berd or any other small city should be designed around the structure of the wastes in that municipality. Municipal waste planners have a responsibility to gather high quality local data using standard methodology. The methodology presented in this report is low cost, uses locally available materials, and requires a small labor force. The methods can be applied to any city and can be used to calculate accurate waste generation rates. The methodology presented in this report can be improved on by weighing the total truckload of wastes when possible. A truck scale should be used to weigh the empty truck first, and then the full truck should be weighed on every sample day. This is the most accurate method to obtain total daily city waste generation by weight.

Proper management of waste materials for any income-level country involves reducing consumption of resources, reusing materials when possible, and recycling when economically feasible (Cointreau-Levine, 1994). Waste composition and generation data for Berd may be used as part of a specific and comprehensive waste management plan. In the next section, some important recommendations for designing a comprehensive plan are presented.

Recommendations

In addition to improving data collection and reducing wastes, several important recommendations for Berd managers include measures to improve the physical properties of landfills, increase collection of user fees, increase community involvement and execute intensive public education campaigns.

Landfill improvement

Incineration is usually not feasible in low-income countries because wastes are not high enough in caloric content to sustain the incineration and more costly fuel must be added. The ash produced by incineration must then be disposed of in a sanitary landfill. The creation of a sanitary landfill is unavoidable and the disposal of solid waste in a sanitary landfill is usually the lowest cost method of safe disposal.

Legislative policy should support private waste management enterprises trying to phase in European Union standards; they do not have the financial resources or the technical expertise to comply immediately. Funding for improving landfills is the limiting factor for most cities. Rushbrook and Pugh (1999) advocate the implementation of landfill improvements on a step-by-step basis. Modestly-priced upgrades deliver short-term improvements to sub-sanitary waste landfills or dumps. Over the course of a long-term plan, the gradual improvements lead to the creation of a complete sanitary landfill.

Cities tend to neglect the same important standards: a fence to prevent fly-away, covering deposits with soil, leachate control, and fire suppression (RTI, 2006). The Berd municipal dump is no exception. At a daily waste generation rate of 0.7 kg/capita, one

200 hp bulldozer can serve 570,000 people and spread, compact, and cover 400 tons per day (Cointreau-Levine, 1994), however there is not current practice of covering or compacting Berd's wastes. This neglect is the result of the improper design of the dump, which has no cavity depth and allows refuse to accumulate on a steep slope. Construction costs for a new four hectare sanitary landfill that will serve 10,000 people for 30 years are estimated to be 240,000 USD (Allen Stansbury, personal communication, 2008). Siting criteria for a sanitary landfill were analyzed and are presented in Appendix C.

Trees and shrubs, such as blackberry (*Rubus armeniacus*), can be planted around the perimeter of the landfill to reduce wind-dispersal of garbage. This is an alternative to expensive fencing, which authorities resist utilizing due to fear of theft.

User Fees and Landfill Taxes

One of the most important improvements that service providers need to make is to increase the collection of service fees. The average fee collection rate across the country is 47% (RTI, 2006). Berd's rate of fee collection was reported in one paper to be 91% (RTI, 2006) and in another to be 80%, the highest in the country. This level of fee collection contradicts levels reported by the director of the water sanitation and development office. The director reported that only 30% of fees were collected, and that this low collection rate is one of the biggest problems in providing good solid waste removal services (Raffiq Sahimyan, personal communication, 2007). RTI also reports that data collected from municipalities may not be accurate because many of the private enterprises paid to clean streets from city budgets also provide the solid waste removal services, which is officially funded only from user fees. Some of the expenses of waste removal may be paid for by the city through unauthorized channels. Discrepancies in data are likely to occur when an outside interest threatens the security of the local municipality because of general mistrust and the low level of transparency common in Armenian bureaucracy. False reporting is also likely to occur if expected benefits are threatened by realistic data reporting. I used figures from my contact at the municipality rather than figures from RTI, because based on my position and the level of trust I gained, I felt the former to be more accurate.

Service to the entire community is in the public interest. Resource-poor communities which are not aware of the importance of public cleanliness tend to resist paying fees, which may be why two-thirds of Berd residents do not pay (Cointreau-Levine, 1994). It is not feasible to try to discern between community members who bring refuse to communal dumpsters, and those who do not. Community members may claim that they do not contribute to the wastes being collected and then refuse to pay. It is possible that they do not, in fact, contribute to the communal container, but the alternative is unregulated dumping. For this reason, all residents within service areas should be charged to encourage proper disposal of wastes in a sanitary landfill.

Currently, service fees in Berd are 100 dram/capita/month. Disposal of one ton of waste into a landfill in Yerevan costs 60 AMD (0.20 USD) (EFN, 2007). An increase in the fee amount in a medium-sized town, Yeghednadzor resulted in no change in the per capita rate of fees collected, which suggests that it is not the rate, but the quality of service that is more important (RTI, 2006). Presently, waste is not collected in some residential areas because of road conditions at higher altitudes and the cost of fuel. The limitations of the large new garbage truck donated by USAID should not be used as an excuse to continue ignoring these neighborhoods. The small tractor trailer should be maintained and operated for those areas, and as service extends to the separate residences further from town, collection of user fees must be strict.

Landfill tax collection must also be improved. Taxes are collected from large business producing a large amount of waste, such as construction companies and restaurants. The funds collected would help pay for landfill construction and maintenance as well as create a closer relationship between waste generation and waste disposal for industries. Challenges exist in balancing the enforcement of taxes and fees with the enforcement of sanitary landfilling rather than illicit dumping.

Public Education and Promotion

Indiscriminate dumping and littering, especially into the rivers and reservoirs, lead to pollution that requires clean-up costs of two to three times the cost of direct collection (Cointreau-Levine, 1994). Furthermore, littering decreases aesthetic quality and tourism potential. Contaminated waterways transport heavy metals, pesticides, and other biocides to gardens, orchards, and public drinking water reservoirs to threaten human health. Education and incentives that promote these ideas are necessary to convince the general public to participate in management processes. De Young *et al.* (1993) found that presenting a combination of environmental and economic benefits to households resulted in more behavior change than either incentive alone. Public seminars, secondary school curriculum, brochures, radio and television advertisements should be the base of an intensive campaign to discourage plastic bag consumption and littering, to promote payment of service fees, and to encourage recycling and the separation of organic wastes at the household level. Brochures have already been created for distribution in Berd can be copied and used for other communities (Appendix D).

Incentives must play a large role in the campaign; monetary and other direct benefits should be focused on both the public sector and the industrial sector. It is not enough that local groups and organizations promote these values; governmental and non-governmental organizations must also play a strict and powerful role. The local government must seriously enforce local ordinances regarding littering and dumping, and impose fines on those who violate these ordinances. Municipally-owned and privately-owned waste removal services must work with the community and the municipality to identify opportunities for improvement.

These recommendations can be gradually incorporated into a comprehensive management plan that is appropriate at the local level in Berd, Armenia. Specific actions can be taken immediately that are low cost, high priority management options (Table 5). Low cost improvements made now, such as increasing payments of user fees, will facilitate the implementation of lower priority actions.

Table 5. Solid waste management action timeline.

Area to be Improved	Recommended Action	Relative Cost	Priority
Landfill	Cover with Soil Daily	Medium	1
	Plant Blackberry Bushes Around Perimeter	Low	1
	Stake out official boundary	Low	1
	Site new location	High	3
Fees	Announce beginning of enforcement period to public	Low	1
	Provide incentive: fines	Low	2
	Expand service area	High	3
Education	Distribute brochures	Medium	1
	Secondary School Curriculum	Medium	2
	Public Seminars	High	1
	Compost Workshops	High	2
	Regional Ad Campaign	High	3

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APPENDIX A

Armenia, topographic map

Click here, or on the graphic, for full resolution.

Sources	The Times Atlas of the World
Link to web-site	http://www.grida.no/
Cartographer/ Designer	Philippe Rekacewicz, Emmanuelle Bournay, UNEP/GRID-Arendal
Appears in	Topographic maps
Published	July 97
Feedback/Comment/Inquiry	Feedback form
Search for other graphics	With related subjects Covering the same geographic area
Use constraints	Using the graphics and referring to them is encouraged, and please use them in presentations, web pages, newspapers, blogs and reports. **For any form of publication, please include this link: http://maps.grida.no/go/graphic/armenia_topographic_map** **Please give the cartographer/designer/author credit** (in this case *Philippe Rekacewicz, Emmanuelle Bournay, UNEP/GRID-Arendal*) and give **full recognition to the data sources** used in the graphic.

APPENDIX B

Appendix 1.1. Composition of Berd wastes by Volume (liters)

Sample ID	Paper and cardboard	Glass and ceramics	Metals	Plastics	Foods	Wood, bones, straw	Other putrescibles	Leather and rubber	Textiles	Rocks	Styrofoam	Diapers	Cigarette butts
Fall 1	70	21	36	190	69	3	52	24	25	1	10	7	0
Fall 2	117	13	17	200	67	4	29.5	3	20	2	10	0	0
Fall 3	123	11	21	173	65	10.5	33	4	35	4	2	1	0.5
Fall 4	110	10.25	20	218	46	5	43	4	10.5	2.5	22	3	1.5
Fall 5	85.5	11	21	173	75	12	23	22	45	1.5	10	19	0.5
Fall 6	47	10	19	190	38	10	140	4	29	5	0.3	6	0.25
Fall 7	68	14	11	133	107	1.5	129	5	17	0.5	1	7	1
Fall 8	95	16	12.5	183	89	8	59	2	28	2	0.1	5	0.25
Fall 9	123.25	23	14	175	58	3	73	1	24	4	0	0	1
Fall 10	47	23	27	185	74	10	92	5	33	1	3	8	0
Fall 11	60	14	30	181	63	20	24	53	30	1	1	6	0.25
Fall 12	67	11	42	220	124	6	53	4	35	2	0.25	14	0.5
Fall 13	88	6	40	113	14	35	80	93	17	4	0	7	1
Fall 14	44	28	49	191	43	10	85	7	28	3	0.1	4	1
Fall 15	132	58	20	120	34	1	110	0	3	0	0	3	0.5
Spring 1	118	15	36	180	107	4	36	5	20	20	0	10	0.25
Spring 2	109	93	34	150	17	2	59	8	27	2	0	0	1
Spring 3	53	22	24	204	45	4	88	3	22	6	0	9	0.25
Spring 4	99	14	28	164	39	13	31	45.5	25	3	0.25	3	0.25
Spring 5	52	3	45	98	11	70	209	7	21	9	1	0	0.5
Spring 6	38	10	28	156	49	5	15	4	71	21	4	5	0.25
Spring 7	35	24	56	102	38	7	203	7	24	12	2	0	1
Spring 8	110	50.5	28	174	34	3	20	3	30	6	0.5	2	0.25
Spring 9	65	22	87	166	50	5	90	4	15	9	0	7	0.5
Spring 10	85	20	44	176	27	17	83	5	30	10	0	7	5
Spring 11	158	24	22	196	24	31	24	1	18	3	0.5	1	3
Spring 12	98	24	66	126	30	12	40	10	30	2	22	4	0.25
Spring 13	59	23	51	193	45	10	90	1	30	15	0	10	1
Spring 14	123	18	26	163	60	4	47	1	40	5	12	5	0.5
Spring 15	115	7	46	155	52	3	18	17	40	7	12	3	1

Appendix 1.2. Composition of Berd wastes by Weight (kg)

Sample ID	Paper and cardboard	Glass and ceramics	Metals	Plastics	Foods	Wood, bones, straw	Other putrescibles	Leather and rubber	Textiles	Rocks	Styro-foam	Diapers	Cigarette butts
Fall 1	2.975	8.225	5.15	6.225	19.98	0.525	7.175	2.65	3	0.9	0.1	2.45	0
Fall 2	8.5	6.85	2.65	13.85	24.68	0.725	13.4	0.875	4.95	2.05	0.1	0	0
Fall 3	15.655	5.45	2.375	11.26	21.63	3.95	10.45	1.025	7.55	3.55	0.05	0.08	0.1
Fall 4	19.61	4.9	2.555	19.255	19.4	0.825	16.525	0.825	3.255	1.75	0.405	2	0.3
Fall 5	18.7	4.305	3.935	15.42	31.15	4.105	9.275	6.03	12.3	1.905	0.105	7.4	0.25
Fall 6	8.46	6.475	3.475	14.365	15.98	2.275	60.705	1.525	10.355	5.5	0.1	2.9	0.25
Fall 7	10.3	6.75	2.55	10.4	39.63	0.625	35.875	1.225	5.1	0.75	0.05	2.35	0.15
Fall 8	10.975	7.55	3.55	12.45	34.68	2.025	21.05	0.575	6.5	1.65	0	2.65	0.1
Fall 9	13.525	8.625	8.45	11.925	21.7	0.725	17.2	0.275	7.65	3.1	0	0	0.1
Fall 10	9.75	10.525	7.2	13.65	27.7	3.925	34.7	1.325	8.7	1.1	0.1	3	0
Fall 11	12.05	5.8	6.775	14	22.73	7.9	10.425	6.875	10.2	0.65	0.05	2.5	0.05
Fall 12	7.1	4.8	7.225	13.2	44.93	1.825	19.4	0.725	9.5	2.3	0.05	4.55	0.3
Fall 13	7.3	2.775	6.85	6.25	4.75	6.95	20.5	11.025	3.65	3.7	0	2.45	0.15
Fall 14	3.15	9.625	22.725	8.4	15.58	3.575	27.725	1.575	4.3	4.15	0.05	1.6	0.2
Fall 15	11.05	20.2	2.85	4.7	11.55	0.425	24.975	0	0.7	0	0	1.35	0.1
Spring 1	7.1	5.4	5.1	7.4	26.53	0.675	15.45	1.275	3.6	20.8	0	2.7	0
Spring 2	12.35	34.55	6.5	7.35	5.15	0.475	15.5	2.275	3.7	1.8	0	0	0.2
Spring 3	3.1	7.275	4.625	8.65	17.18	1.475	29.125	0.675	3.45	5.3	0	2.1	0.055
Spring 4	6.15	5.45	2.825	7.65	16.6	1.9	7.85	5.25	4.35	1.3	0	1.3	0.1
Spring 5	2.45	1.675	8.95	5.25	4.35	18.225	87.375	1.325	4.35	6.475	0.05	0	0
Spring 6	2.5	2.325	6.325	7.15	20.48	2.075	5.9	0.875	9.05	7.875	0	1.55	0.055
Spring 7	1.7	8.625	6.3	3.85	12.55	1.575	46.325	0.925	3.25	9.45	0.05	0	0.15
Spring 8	5.275	18.75	2.775	6.175	12.75	0.675	8.25	0.825	4.35	5.675	0.05	0.45	0.05
Spring 9	3.75	7.025	8.525	5.55	22.88	0.925	14.475	0.525	2.75	6.875	0	2.2	0.1
Spring 10	5.25	7.35	7.675	6.95	11.98	3.95	39.225	1.175	5	8.475	0	1.85	0.65
Spring 11	6.8	8.975	2.3	8.15	8.625	5.425	9.175	0.05	1.9	3.075	0	0.3	0.4
Spring 12	4.875	7.875	10.875	5.5	9.375	1.7	17.05	1.825	5.2	2.225	0.55	0.5	0
Spring 13	5.3	8.55	7.5	7.725	18.18	2.525	44.275	0.375	4.95	15.25	0	1.7	0.15
Spring 14	9.35	5.9	4.65	7.025	22.28	1.025	27.575	0.15	4.75	4.975	0.125	1.625	0.1
Spring 15	5.9	3.275	8.5	7.375	15.98	0.65	8.8	3.1	5.45	4.775	0.15	0.7	0.125

APPENDIX C

Multi-criteria Decision Analysis for Landfill Siting in Armenia

GIS data (shapefiles) are from the USAID Armenian Vector Geodatabase, courtesy of Thomas Lyman and the Acopian Center for the Environment in Yerevan, Armenia. Data were analyzed using a multi-criteria decision analysis approach to produce a series of maps for municipal waste planners in Armenia to identify suitable sites for sanitary landfill development. The analysis done at this scale provides a general guide to suitable landfill placement. Final selection of any site requires a walk-through investigation to determine finer scale hydrogeologic and landscape conditions, and cost analysis. Exclusionary criteria from Rushbrook and Pugh (1999) and Lunkapis (2004) are used.

<u>Data (Shapefiles)</u>

Armenian_Marzes.shp
Armenia_regions.shp
Settlements_polygons.shp
Towns_main.shp
Roads_all.shp
Altitudes_regional.shp
Protected_areas.shp
Soils.shp
Vegetation.shp
Wetlands.shp
Rivers_all.shp
Lakes.shp
Reservoirs.shp

Hydrogeologic zones were ranked by permeability. Bedrock with low permeability is best suited for landfill placement because these rock layers deter leachate from entering aquifers and wells. A list of hydrogeologic types is presented in Table 1, and geographic distributions of the ranks are displayed in Figure C.

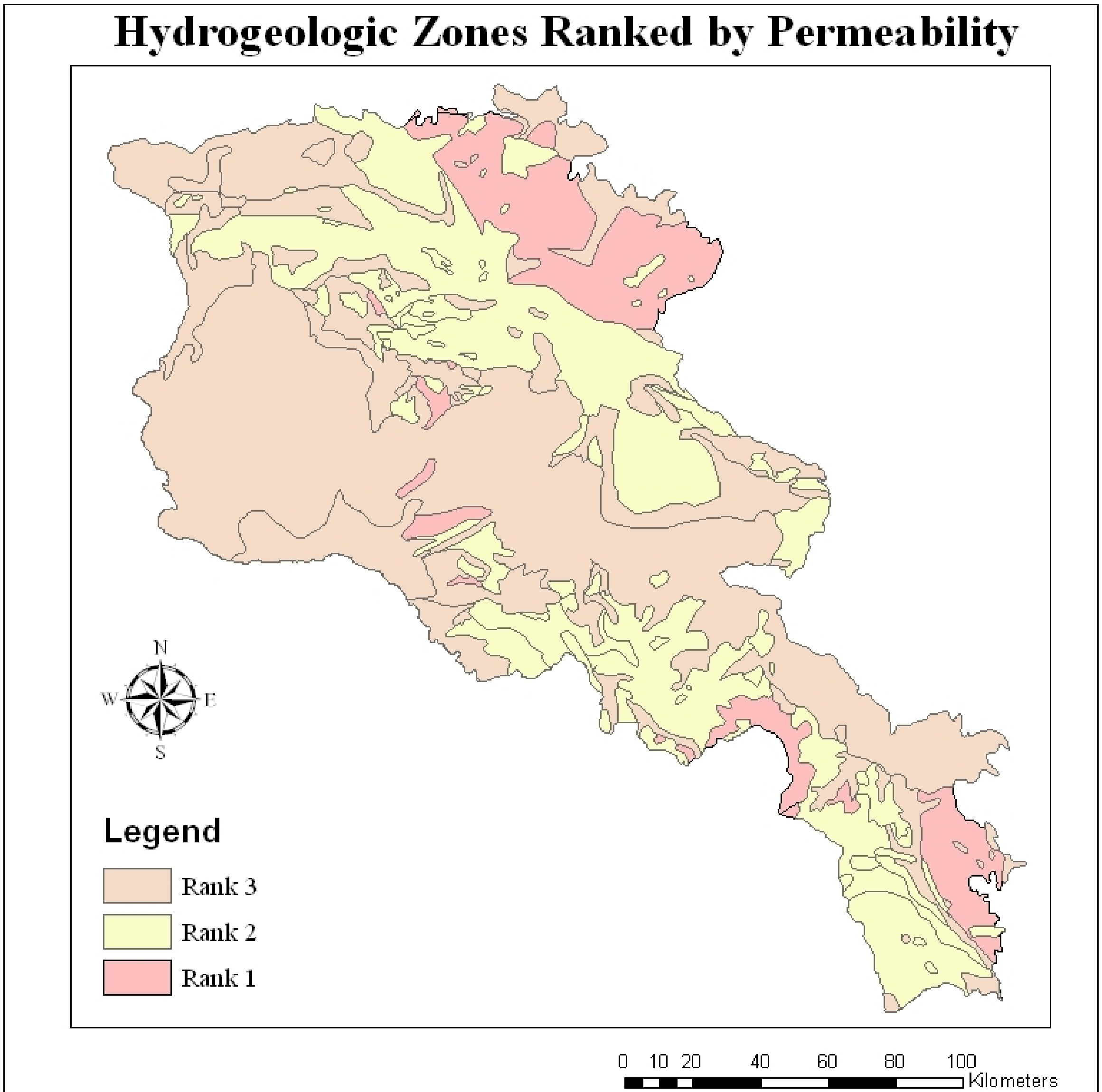
Some municipalities have only unsuitable bedrock. Synthetic liners must be used on landfills that are sited on hydrogeologic types ranked 2 and 3.

Table 1. Ranking of Hydrogeologic class by permeability.

Hydrogeologic Classes	Rank
Local water-bearing Cretaceous sedimentary	3
Local water-bearing Pliocene - Quaternary volcanic rocks	3
Local weak water-bearing Eocene sedimentary	2
Local weak water-bearing Paleozoic changed rocks	2
Local weak water-bearing, water-repellent Paleo-Meso- Cainosoic intrusive	2
Water-bearing Pliocene - Quaternary alluvial - proluvial and lake-river fo	3
Water-repellent Oligocene-Miocene sedimentary	1
Water-repellent local weak water-bearing Jurassic volcanogenic	1
Water-repellent pre-Paleozoic metamorphic rocks	1

Figure A depicts areas that have been excluded from landfill siting because of proximity to residential areas, which have been buffered to prevent siting of landfills closer than 1km. Rivers, lakes, reservoirs, wetlands, and protected areas are also excluded with a 500 meter buffer zone. The areas in green represent the remaining area that may be considered for landfill siting secondary criteria.

Figure B depicts the portion of those green areas in Figure one that are feasible economically to site a landfill. Potential sites have been limited to within 10 km of a main town, and within 2 km of a major road.



Description: This map shows hydrogeologic types ranked by degree of permeability. Rank 1 is the best type for landfills and has the lowest degree of permeability.
Data sources: Thomas Lyman and the Acopian Center for the Environment, and USAID Armenian Vector Geodatabase.
Coordinate System: WGS84 UTM 38N. Units are in meters.
Author: Patricia Butler, School of Forest Resources and Environmental Sciences, MTU, USA.
December 10, 2008.

Figure A. Hydrogeologic ranking.

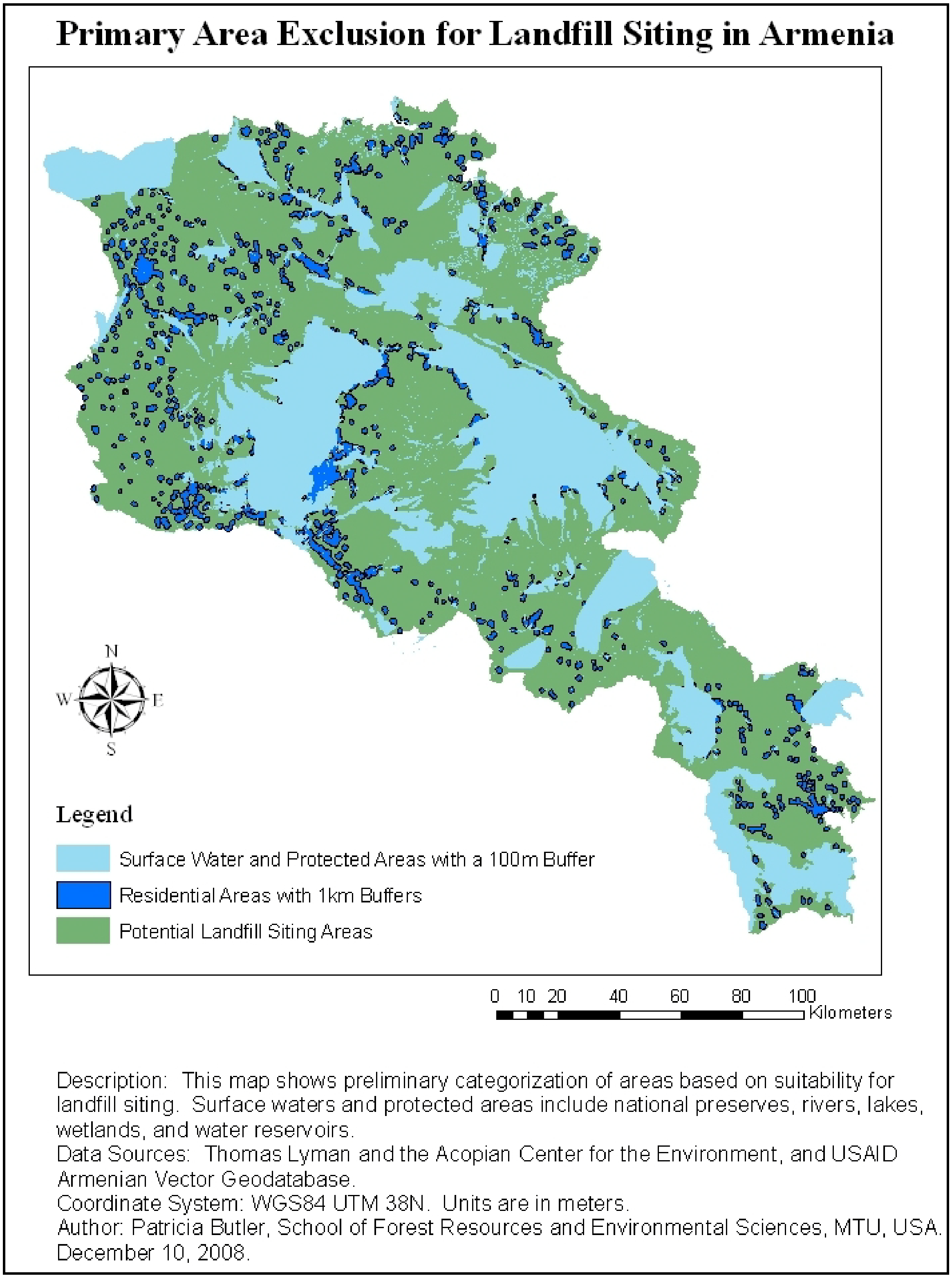
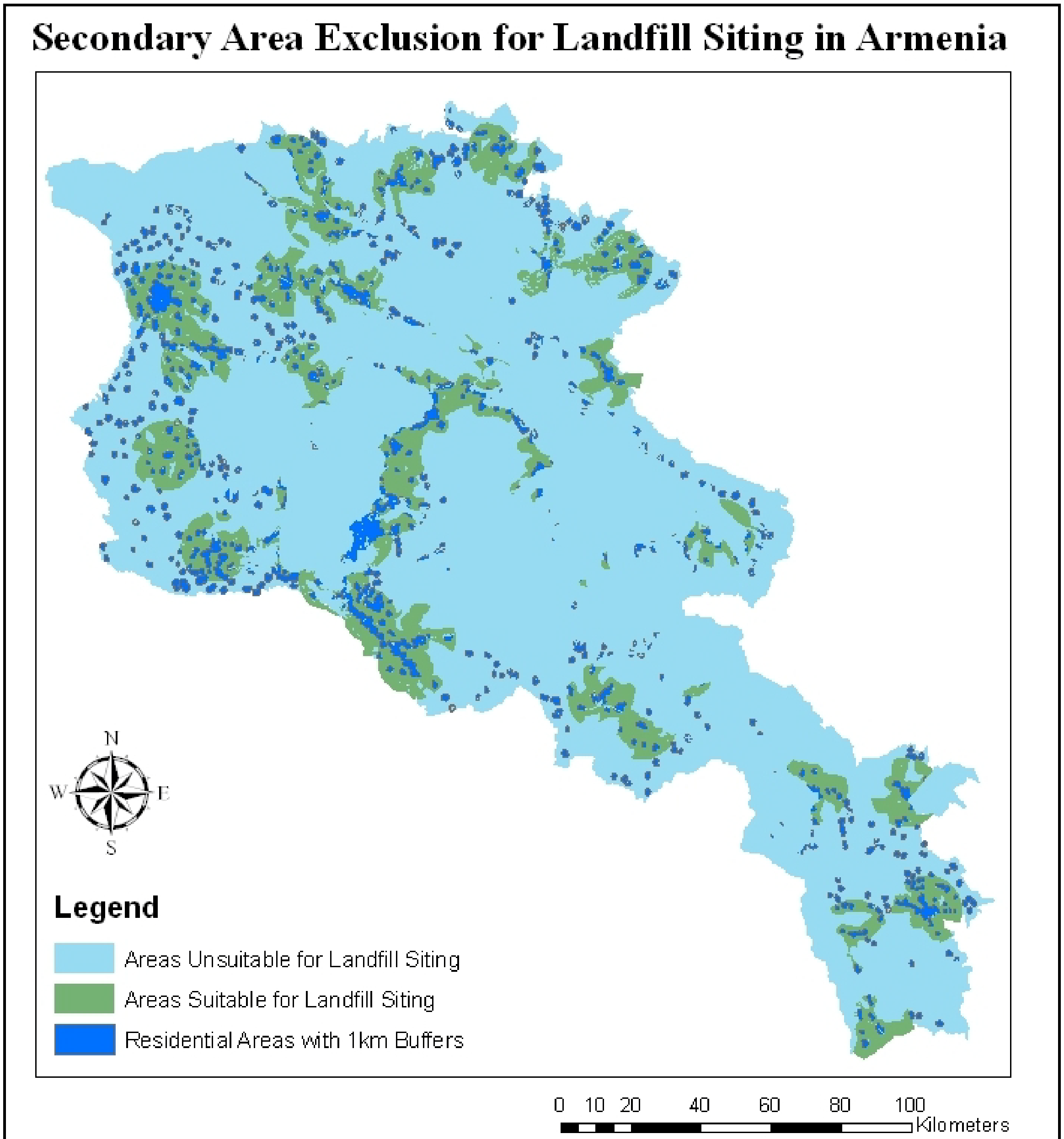


Figure B. Primary Site Identification



Description: This map shows sites that are suitable for landfill design based on secondary criteria. From the Primary sites, only those within 10km of a city and not farther than 2km from a main road are included.
Data Sources: Thomas Lyman and the Acopian Center for the Environment, and USAID Armenian Vector Geodatabase.
Coordinate System: WGS84 UTM 38N. Units are in meters.
Author: Patricia Butler, School of Forest Resources and Environmental Sciences, MTU, USA.
December 10, 2008

Figure C. Secondary Site Identification

Literature Cited

Lunkapis, G.J. (2004) *GIS as Decision Support Tool for Landfills Siting* (Map Asia Conference). Beijing, China.

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APPENDIX D

Վերամշակի՛ր

Ներկայումս Հայաստանը ունի թափոնների վերամշակման սահմանափակ հնարավորություններ: Հոգ չէ, դու կարող ես ինքդ անել դա:

Վերանշակումը հնարավոր է անգամ, եթե չկան անհրաժեշտ հատուկ միջոցներ:

- **Կերակրի մնացորդները** կարող են պահպանվել հետագա օգտագործման, կենդանիների կերակրման, կամ կոմպոստացման համար: Դրանք աղբավայր տեղափոխելու համար ոչ մի պատճառ չկա:
- **Կոմպոստացումը** նվազեցնում է դեպի աղբավայր գնացող կենսաբանական արագ քայքայվող նյութերի քանակությունը և ի լրումն՝ օգտակար է այգիների համար պարարտանյութ ստանալու առումով:
- **Որդերի միջոցով կոմպոստացում--** Ձեռք բեր մի քանի որդ և փորձիր որդերով կոմպոստացման եղանակը: Որդեր կարելի է ձեռք բերել Սպիտակ քաղաքի կոմպոստերից:

Ստեղծի՛ր առաջ միջավայր հետագա սերունդների համար:

Հիշի՛ր, ճանապարհը դեպի ավելի մաքուր ապագա ընդգրկում է հետևյալը՝

* Աղբահանության համար վճարների ժամանակին մուծում: Կատարելով ամսական մուծումները դուք օգնումեք, որպեսզի լավագույնս սպասարկվեն աղբատար մեքենաները, դրանք ապահովվեն վառելիքով, վճարվեն այն բանվորների աշխատավարձերը, ովքեր հեռացնում են աղբը մեր բնակավայրերից և աշխատավայրերից:
* Թափոնների քանակի նվազեցում:
* Թափոնների հնարավորինս վերամշակում:
* Հնարավորին չափով բազմակի օգտագործում:
* Օրգանական նյութերի վերածում պարարտանյութի կոմպոստացման եղանակով:
* Հասցված վնասի վերականգնում:

Մաքրության պահպանում մեր համայնքներում մաքրման աշխատանքների կազմակերպման, ծառատնկումների, գետերի մաքրման և շրջակա միջավայրը բարելավելուն ուղղված ծրագրերի միջոցով:

Մեր ապագան կախված է մեր այսօր կատարած քայլերից:

<<Ջրամատակարարում և բարեկարգում>> ՓԲԸ

ՀՀ, Տավուշի մարզ, ք. Բերդ, Լևոն-Բեկի 5,
Հեռ. 2-16-20

Բերդի Համայնքների Միություն

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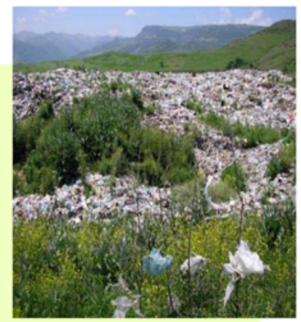
Ինչպե՞ս ենք կարող պահպանել շրջակա միջավայրը

Աղբահանության իրականացումը համայնքի կողմից



Թափոնների նվազեցման և մեր համայնքը ապրելու համար ավելի պիտանի վայրի վերածելու ուղեցույց

Թափոնները, շրջակա միջավայրը և մենք

Մեր ամենօրյա արտադրած թափոնները ինչ որ մի տեղ պետք է գնան: Հայաստանում աղբը ավելի հաճախ այրվում է, հավաքվում և տեղափոխվում է աղբավայր, կամ կուտակվում է մեր բնակավայրերի շրջակայքի աղբակույտերում:

Աղբի այրումը առողջ լուծում չէ, քանի որ արդյունքում օդը աղտոտվում է թունավոր նյութերով:

Աղբը մեր շրջակայքի աղբակույտերում թողնելը նույնպես առողջ լուծում չէ, քանզի այս դեպքում աղտոտվում են ջուրը, հողը, իսկ տեսարանը ուղղակի տգեղ է:

Սանիտարական աղբավայրերը լավագույն լուծումն են, քանի որ դրանք պաշտպանում են շրջակա ստորգետնյա ջրերը և հողը աղտոտումից: Սանիտարական աղբավայրերի հիմնադրումը և շահագործումը շատ թանկ արժե և Հայաստանում դրանցից ընդամենը մի քանի հատ կան: Շրջակա միջավայրի ապագա բարելավումը կախված է այսօր կատարած մեր քայլերից ուղղված թափոնների նվազեցմանը քանի դեռ չի ծագել դրանցից ազատվելու անհրաժեշտությունը:

Ապագայի մասին մտածելու ժամանակն է: Տնտեսության զարգացմանը զուգընթաց մեր կողմից արտադրված թափոնների քանակությունը կավելանա : Ապրանքների մատչելիությանը զուգընթաց կավելանա փաթեթավորումների և պոլիէթիլենե պարկերի քանակը :

Նվազեցրու, վերաօգտագործիր, վերամշակիր

Թափոնների հետ վարվելու խնդրում առաջին քայլը այն քանակության նվազեցումն է, որը բնականոն կերպով պետք է այրվի, կամ ուղարկվի աղբավայր: Դրան հասնելու համար գոյություն ունեն երեք եղանակներ՝ նվազեցրու՛, վերաօգտագործի՛ր, վերամշակի՛ր:

Նվազեցրու՛

Թափոնները նվազեցնելու ամենահեշտ ուղին նախօրոք մտածելն է այն մասին, թե ինչպես պիտի վարվենք դրանց հետ մինչև դրանց ի հայտ գալը:

- Նոր ապրանք գնելիս ուշադրություն դարձրեք փաթեթավորմանը: Ընտրեք այն ապրանքը, որն ունի նվազ պլաստմասսայե, թղթե, կամ այլ փաթեթավորում: Եթե այն արդեն պոլիէթիլենե պարկում է, կարիք կա՞ արդյոք այն դնել ևս մի ուրիշ պոլիէթիլենե պայուսակի մեջ: Եթե գնումներ կատարելու համար պայուսակի կարիք կա, ապա կարելի է տնից վերցնել բազմակի օգտագործման նպատակով նախատեսված պայուսակ :
- Պոլիէթիլենե պայուսակները կազմում են աղբավայր գնացող կենսաբանորեն կայուն թափոնների գերակշիռ մասը: Աշխատեք դրանց փոխարեն օգտագործել կտորից կարված պայուսակ: Ջրի տոպրակներ տրամադրող խանութները նույնպես գումար կտնտեսեն նվազեցնելով հատկացվելիք ծախսերը:

Վերաօգտագործվող կտորե գնումների պայուսակը շատ անգամ ավելի հարմար է, քան դեն նետելու դատապարտված պոլիէթիլենե պայուսակը:

Վերաօգտագործի՛ր

Շատ իրեր կարելի է օգտագործել բազմաթիվ անգամ մինչև դեն նետելը: Այս ձևը շատ տարածված է, բայց կան այլ գաղափարներ ևս իրերի բազմակի օգտագործման խնդրում՝

- **Օգտագործեք սրբիչներ, լաթեր, սպունգ, լվացման աշխատանքների համար:**
Սրանցից ձեռքի տակ ունեցեք բավարար քանակությամբ, որպեսզի միշտ ունենաք արդեն լվացված օգտագործման համար պատրաստ լաթի կտորներ, սրբիչ և այլն:

- **Օգտագործեք կտորից թաշկինակներ:**
Գնեք մեծ քանակությամբ բամբակյա թաշկինակներ ամենօրյա օգտագործման համար: Նախնական ծախսերը արագ կվերականգնվեն ձեր կողմից դեն նետելու նեթակա թղթե փոխարինիչների գնումները նվազեցնելու արդյունքում:

- **Հավաքեք և օգտագործեք մթերքների պլաստմասսայե տուփերը:**
Դրանք ավելի երկար են ծառայում քան պոլիէթիլենե տոպրակները, ջրաթափանց չեն, սառնարանում մթերքները զերծ են պահում վատ հոտերից, գտնվելով պահարանում պահպանում են դրանք չորացումից:

- **Ծախսեք ձեր գումարը վերալիցքավորվող մարտկոցներ և լիցքավորիչներ գնելու համար:**
Դուք կարող եք աշխատեցնել գրեթե ամեն ինչ սկսած լապտերներից մինչև թվային տեսախցիկ օգտագործելով վերալիցքավորվող մարտկոցներ: Վերջնական արդյունքում դրանք ավելի էժան են և նվազ վնասակար շրջակա միջավայրի համար:

Recycle

Currently Armenia is very limited by the lack of Recycling Facilities. No Problem- Recycle On Your Own!

Recycling is possible, even if we don't have recycling facilities!

Food Waste can be saved to eat later, used for livestock, or composted. There is no reason food wastes should ever make it as far as a landfill!

Composting reduces the amount of bio-degradeable materials that go into a landfill, and has the added benefit of becoming fertilizer for a garden.

Vermicomposting--Get a worm bin and some worms and practice vermicomposting. Worms are available from a Vermicomposter in Spitak.

Yard Trimmings, such as branches and grasses, in a landfill generate significantly more greenhouse gas than they would in compost piles.

Create a healthy environment for future generations.

Remember, the way to a cleaner future involves:

Paying your solid waste removal fees. By paying your monthly bill, you are helping finance the maintenance of garbage trucks, gas, and labor that is necessary to move the waste away from the places where we live and work.

Reducing what we throw away.

Recycling what we can.

Re-using as many times as possible.

Composting organic materials.

And restoring what has already been damaged.

Keep our communities clean by organizing community clean-ups, tree-plantings, river clean-ups and other projects to improve the environment.

Our Future depends on our actions Today.

Berd Water Delivery and Development Office, LTD

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How can we protect the environment?

Community Waste Management

A guide to reducing our waste and making our community a better place to live

Community Waste, the Environment, and Us

The garbage that we produce everyday must go somewhere. In Armenia, garbage is most frequently burned, collected and deposited into landfills, or left in piles around the places that we live.

Burning garbage is not a healthy solution to waste disposal because it pollutes our air with toxic substances.

Leaving garbage in piles around our community is not a healthy solution either because it pollutes the water and soil, and looks ugly.

Sanitary landfills are the best solution because they protect the surrounding groundwater and soil from becoming polluted. Sanitary landfills are very expensive to create and maintain, however, and very few exist in Armenia. The future health of the environment depends on actions that we can take today to reduce the amount of garbage that we produce before we need to throw it away.

It's time to think about our future! As our economy grows, the amount of waste we create will increase. As more products become available, they will come with much packaging and many plastic bags.

Reduce, Re-use, Recycle

The first step in managing our wastes is to minimize the amount that we would normally burn or send to the landfill. There are three ways to do this– Reduce, Re-Use, and Recycle!

Reduce

The easiest way to reduce our waste is think about what we must do with it before we acquire it.

- When buying new merchandise, consider the packaging that comes along with it. Choose merchandise that comes with less plastic, paper, or other packaging. If it's already in a plastic bag, do you need to put it in another bag? If so, take a re-usable bag with you to do your shopping.

- Plastic bags make up the most amount of non-biogradable waste that goes into a landfill. Try not to use them– instead, use a cloth or heavy duty plastic bag you bring from home. Stores that give out plastic bags will also save money by reducing the amount of bags they give out.

Re-usable cloth shopping bags are much better than throw-away plastic bags!

Re-Use

Many items can be re-used one to many times before being thrown away. This practice is already common, but here are some more ideas for re-using household items:

- **Use towels, rags, and sponges for most cleaning and wipe-ups.** Keep a large enough supply of rags and wash cloths so you will always have some clean ones.

- **Use cloth napkins.** Buy a large supply of inexpensive cotton napkins to use every day, the initial cost will be quickly offset by your reduced need to buy disposable paper substitutes.

- **Collect and use plastic food storage containers.** They are more durable than plastic bags, leak less, reduce odors in the refrigerator, keep moths out of dry goods in the cupboard.

- **Invest in rechargeable batteries and a battery charger.** You can run almost anything, from flashlights to digital cameras, with rechargeable batteries. In the long run it is cheaper for you and better for the environment.