EXECUTIVE SUMMARY

Cities and settlements, which often are hubs of rapid economic development and population growth, generate thousands of tons of municipal solid waste that must be managed daily. Low collection coverage, unavailable transport services, and a lack of suitable treatment and disposal facilities are responsible for unsatisfactory solid waste management, leading to water, land and air pollution, and for putting people and the environment at risk.

Among all, the problem of disposal is very important. In most Developing Countries the use of appropriate treatment and disposal technologies is rare. Some commonly used disposals are: open and uncontrolled dumping instead of sanitary landfill and burning instead of controlled incineration. A particular case is that of Saharawi refugee camps (South Algeria), characterised by aspects typical both of Developing Countries and of emergency situations. In Saharawi refugees camps people produce 0.15 kg/day per capita of solid waste, with a density of 170 kg/m$^3$, constituted for about the 95% of packing. Actually solid waste is burnt in an open area, exposing people to health hazards, adding to the already severe problem of air pollution and creating opportunities for spread of diseases.

An appropriate solution for disposal is landfill in which waste are unloaded, spread into thin layers, compacted and covered whit inert material. To meet the minimum standards for environmental protection and to allow the proper operation of landfill it is necessary to carry out some routine operations like: waste reception, waste deposition and general site maintenance and control like environmental monitoring, leachate, gas and odours control. Landfill with simple daily operations can be an effective disposal technique. It permits sustainable waste disposal without serious environmental impacts because of waste composition and climate conditions.

INTRODUCTION

Human activities create waste, and it is the way these wastes are handled, stored, collected and disposed of, which can pose risks to the environment and to public health. The management of solid waste is an important concern in developing and emergency conditions, e.g. those of a refugee camp, where solid waste management infrastructure and services are far from achieving basic standards in terms of hygiene, efficient collection and disposal (Collivignarelli, 2004).

These situations are characterized by: difficulties in evaluating and choosing the most appropriate solution with respect to the specific operating conditions, inadequate service coverage, operational inefficiencies of services, limited utilization of recycling activities, inadequate management of non industrial hazardous waste, and inadequate landfill disposal. Moreover, developing and emergency
conditions are characterized by difficulties in evaluating and choosing the most appropriate solution with respect to the specific operating conditions. This paper analyzes several problems related with solid waste disposal and it describes an appropriate solution for Saharawi refugees camps, South Algeria.

**WASTE MANAGEMENT AND DISPOSAL IN DEVELOPING COUNTRIES**

Management of solid waste is one of the major challenges worldwide. Inadequate collection, recycling or treatment and uncontrolled disposal of waste in dumps lead to severe hazards, such as health risks and environmental pollution. This situation is especially serious in Developing Countries where inadequate waste disposal can be very dangerous for environment and human health.

The typical municipal solid waste stream will contain general wastes (organics and recyclables), special wastes (household hazardous, medical, and industrial waste), and construction and demolition debris.

Most adverse environmental impacts from solid waste management are rooted in inadequate or incomplete collection and recovery of recyclable or reusable wastes, as well as codisposal of hazardous wastes. Impacts are also due to inappropriate siting, design, operation, or maintenance of dumps and landfills. In fact, improper waste management activities can (U.S. Agency for International Development Bureau for Africa, 2006):

- Increase disease transmission or otherwise threaten public health. Rotting organic materials pose great public health risks, including serving as breeding grounds for disease vectors. Waste handlers and waste pickers are especially vulnerable and may also become vectors, contracting and transmitting diseases when human or animal excreta or medical wastes are in the waste stream. Risks of poisoning, cancer, birth defects, and other ailments are also high.

- Contaminate ground and surface water. Solid waste streams can bleed toxic materials and pathogenic organisms into the leachate of dumps and landfills. If the landfill is unlined, this runoff can contaminate ground or surface water, depending on the drainage system and the composition of the underlying soils. Many toxic materials, once placed in the general solid waste stream, can be treated or removed only with expensive advanced technologies. Even after organic and biological elements are treated, the final product remains harmful.

- Create greenhouse gas emissions and other air pollutants. When organic wastes are disposed of in deep dumps or landfills, they undergo anaerobic degradation and become significant sources of methane, a gas with 21 times the effect of carbon dioxide in trapping heat in the atmosphere. Garbage is often burned in residential areas and in landfills to reduce volume and uncover metals. Burning creates thick smoke that contains carbon monoxide, soot and nitrogen oxides, all of which are hazardous to human health and degrade urban air quality. Combustion of polyvinyl chlorides (PVCs) generates highly carcinogenic dioxins.

A lack of waste management activities can increase diseases transmission. Public health and hygienic conditions are considered very important aspects to preserve, and they make necessary a proper waste management in Saharawi refugee camp, that are still characterized by high mortality rate due to poor hygiene conditions.

**Waste Disposal Techniques in Developing Countries**

Open uncontrolled dumping is still the most common method of solid waste disposal in Developing Countries and emergency conditions (Figure 2). Dumping is the disposal of waste at an uncontrolled, uncovered site of minimal or no structural design. Degradation waste in such dumps emits greenhouse gases, like methane, toxic leachates pollute subsurface and surface waters and
enhance the risk of disease transmission to nearby residents. These dumps make very uneconomical use of the available space, allow free access to animals and flies and often produce unpleasant and hazardous smoke from slow-burning fires (SANDEC, 2008).

Open and uncontrolled dumping is linked to waste pickers’ recycling activities. In Developing Countries, the informal sector plays a major role in recovering secondary materials. The World Bank estimates that about 2% of the population in developing countries is scavengers whose livelihood consists in collecting and selling recyclable materials (SANDEC, 2008). In some countries the majority of collectors are young people less than seventeen years of age.

![Waste Scavengers of Buenos Aires](image)

*Figure 1 Waste Scavengers of Buenos Aires, Argentina. IOM/UNICEF, 2005*

Waste picking is often driven by poverty, high unemployment rates, low education level, and demand for secondary materials. Scavengers recover recyclables from the streets, bins, open dumps, and even at the disposal sites where the collected materials are unloaded. Paper, cardboard, plastic, glass, and a few metals are the main materials recovered and sold to larger distributors or directly to recycling companies. Waste pickers often suffer from health problems due to bad living conditions and exposure to waste.

Sanitary landfills are engineered disposal sites where waste is spread in layers, compacted and covered with soil or other materials to minimise air and water pollution. Modern sanitary landfills, in opposite of open dumping, collect and treat leachate and methane gas. Unfortunately sanitary landfill solution is not very common in Developing Countries (Figure 2).

![Burning](image)

*Figure 2 Burning of Waste, Developing Countries. IOM/UNICEF, 2005*

Burning is unfortunately another widespread and inappropriate method used in Developing Countries (Figure 2). It is used to reduce the volume or odours of dumped or uncollected solid waste. Open burning is the major source of toxic gas emission such as dioxins and furans.

Incineration is another solution to waste disposal in Developing Countries. It should be located away from the settlement, on the opposite side from the direction of the prevailing wind. Incineration systems should be built on an impervious base of concrete or hardened earth. Ash and any unburned refuse should be buried and covered with 40 centimetres of soil.

High-tech incinerators, in opposite of open burning, are engineered to prevent toxic emissions and make use of the excess heat to generate steam for power production or for residential heating. Like sanitary landfill, this solution is not commonly used in Development Countries.
WASTE DISPOSAL IN SAHARAWI REFUGEES CAMPS

Saharawi refugees camps represent a particular condition where an appropriated waste disposal must be planned to improve environmental and living quality protection. After the Moroccan occupation in 1975, people living in Western Sahara began to move to the hinterland of Tindouf in Algeria. Since 1979, more than 250,000 people have been living in refugee camps, under very bad conditions, living only thanks to humanitarian aids from world communities. The refugee camps are situated in the western part of the Sahara desert. They are divided into 4 districts (Wilaya) named after the refugees' abandoned towns and villages in Western Sahara: El Ayoun, Smara, Dahlia and Auserd. Each district is sub-divided into 6 or 7 villages (called “daira”), and each village is divided into 4 quarters (hays) (OXFAM Belgium, 1995). Each one of those four camps hosts approximately 70,000-80,000 Saharawi.

This study was developed in the Wilaya of Smara where 80,000 people live divided into 7 dairas. The consumption of food coming from humanitarian aids causes the generation of a lot of solid waste that creates environmental impact and health risks. A production of 0.15 kg/day per capita of solid waste, with a density of 170 kg/m³, constituted for about the 95% of packing like plastic, paper, rubber, wood, textile, ferrous and not ferrous material; moreover organic fraction is not present.

At present, seven dumpers for waste collection, with a capacity of 5 m³, serve the Wilaya of Smara. Each dumper passes through the main roads of the dairas and it stops at every neighbourhood in order to allow people to carry their own waste into the truck. Dumpers move the garbage in a temporary storage placed at 1 km from the Wilaya. Three trucks load the garbage placed inside the temporary storage and transport it the garbage in a dump located 3 km from the Wilaya, where it is burned.

So, actually solid waste is burnt in an open area, exposing people to health hazards, adding to the already severe problems of air pollution and creating opportunities for spread of diseases.

An appropriate solution for disposal is landfill in which waste are: unloaded, spread into thin layers, compacted and covered whit inert material (Figure 1).
Considering waste density in landfill of 0.4 t/m³ (D’Antonio, 1997) and waste production in the Wilaya of Smara of 12 t/day, we can say that everyday landfill’s volume increases of about 30 m³/day.

Landfill Site Operations
To meet the minimum standards for environmental protection and to allow the proper operation of landfill it is necessary to carry out some routine operations. The daily operations at a managed landfill fall into three general groups of activities (World Bank, 1999):
1. Waste reception;
2. Waste deposition; and
3. General site maintenance and control, like environmental monitoring, leachate, gas and odours control.

Waste reception includes: checking vehicles and loads at site entrance, segregating wastes and loads, temporary storage (e.g., construction debris) for on-site roads, record keeping and routine administration, on-site traffic control and direction to the working face.

On the contrary waste deposition means: waste placement, compaction, excavating cover material, spreading cover material, construction of on-site temporary haul roads, construction of bunds and earthworks.

In this phase the careful placement of waste is an essential aspect to a better standard of landfill operation. This is to ensure that all waste is well crushed and compacted to give the best possible filling density. This approach reduces the quantity of air remaining in the deposited wastes, which can lead to accelerated decomposition, strong odours, the propagation of surface fires, and water pollution. It prevents "bridges" and other voids that reduce stability of the waste and that could collapse.

A waste collection vehicle reverses up to the base of the working face and discharges its load. The landfill machine then spreads the waste in a thin layer (no more than 300 mm deep) up the working face. The thin layers of waste are crushed by the weight of the machine. Typically, a machine will pass over the waste between three and six times to maximize compaction. The thin layers are built
up until the waste layer is 2 m thick. The uncovered 2 m high platform is then covered at the end of the day with soil (often around 15 cm).

About general site maintenance, leachate management has a crucial importance for environment protection. The amount of leachate which should be expected depends principally on the quantity of water that enters the site as rainwater through the landfill surface.

The most widely used approach for estimating the quantities of leachate is the classic “water balance calculation” expressed as (World Bank, 1999):

\[ L = P - ET - R - AS \]

Where:
- \( L \) represents the leachate volume;
- \( P \) represents the volume of precipitation (i.e., rainfall, snowmelt water);
- \( ET \) represents the volume lost through evapotranspiration (i.e., evaporation from the ground surface and transpiration from vegetation);
- \( R \) represents the volume of surface runoff;
- \( AS \) represents the volume of moisture storage available in soils and waste.

The two factors relating to precipitation (\( P \)) and evapotranspiration (\( ET \)) tend to dominate water balance calculations. The two remaining factors, \( R \) and \( AS \), have a smaller influence and are more difficult to estimate. Therefore, for the purpose of estimating an approximate size for a leachate management system a simplified calculation has been suggested, the “climatic water balance” (Department of Water Affairs and Forestry 1998):

\[ B = R - E \]

Where:
- \( B \) represents the leachate volume;
- \( R \) represents the volume of precipitation;
- \( E \) represents the volume of evaporation from the ground surface.

When \( B \) is positive for less than one year in five for the years for which data is available, like in arid region, there should be no significant leachate generation and if no leachate management system should be necessary.

Also gas doesn’t give severe environmental problems in this context, because of waste composition.

CONCLUSION

The research identifies a sustainable and appropriate solution for waste disposal in Saharawi refugees camps where pollution and health risks generated by improper solid waste management are important issues concerning environmental management and living quality protection.

An appropriate solution for disposal is landfill where waste is unloaded, spread into thin layers, compacted and covered wit inert material. Landfill with simple daily operations can be an effective disposal technique. It permits sustainable waste disposal without serious environmental impacts because of waste composition and climate conditions.

REFERENCES


