5. Solid Waste Management

Inappropriately managed waste from households, market places, health-care facilities, and human activity can attract rodents and insects, and can harbour pathogens. An environment free from solid waste is essential to life, health and dignity.

Introduction

The importance of solid waste management in refugee settings

1. UNHCR and WASH actors must ensure that the environment inhabited by refugees is free from wastes that are a public health risk. This is regardless of whether the refugees are living in camps, collective centres, spontaneous unplanned camps, with host families, in rented accommodation, or they are occupying land or buildings.
2. Inappropriately managed domestic waste can attract rodents and insects, and can harbour pathogenic organisms. Hazardous substances found in domestic wastes such lead-acid batteries, used paints and oils, and broken electrical equipment can have a major impact on public health. Exposure to wastes, particularly when they are burned, can cause various other diseases including cancers. Toxic waste materials can contaminate surface water, groundwater, soil and air which causes more problems for humans, other species and ecosystems.
3. The psychological benefits of proper solid waste management should not be underestimated. The timely removal of waste is an important contribution to lifting the morale of a refugee population.

A comprehensive public health approach

4. An efficient solid waste management programme should be planned as part of the larger preventative health strategy for the refugee population. Messages concerning the importance of an environment free from human wastes must be incorporated into the community health and education programmes. The link between unmanaged solid waste and disease vectors, and hazardous wastes and disease, must be clearly understood by all.

The importance of seeking expert professional advice

5. The implementation of solid waste collection, treatment, disposal and recycling programmes in refugee contexts can be complicated by additional constraints that include:

   i). Inappropriate sites that are difficult to access with waste collection vehicles;
   ii). Lack of adequate final waste disposal sites;
   iii). Lack of adequate and safe waste collection and processing equipment;
   iv). Unfamiliarity or unwillingness of the population to use waste collection containers, or reduce, recycle or reuse.
   v). Complex environmental or public health legislation controlling waste activities.
   vi). Complex urban environments.
   vii). Reliance on existing waste facilities that have been poorly managed for decades.

   In large refugee settings it is essential to seek expert advice from professionals who are familiar with the context. Solid waste vehicles, waste containers, processing equipment, treatment and disposal technology that work well in one context may completely fail in another. In all cases, the approaches used must build on

local practice, and the expertise of local specialists.

6. Assistance can be sought locally from sources such as government departments, the UN system, NGOs, universities, consultants or contractors. If these cannot meet the need, UNHCR Headquarters assistance should be requested.

The importance of respecting UNHCR's WASH philosophy and principles

7. In addition to the guidance in this chapter, all solid waste management programmes must be designed and carried out in full accordance with UNHCR's general WASH principles including (please click the links below or consult the relevant section in Chapter 2 for more information).

   - Safety and protection
   - A timely and adequate response
   - Participation of stakeholders
   - Universal access
   - Child friendly facilities
   - Designs and construction that meet minimum quality standards
   - Value for money and cost effectiveness
   - Appropriate technology selection
   - Durable solutions
   - Reinforcing the capacity of stakeholders
   - Monitoring the effectiveness of WASH interventions
   - Protecting the environment
   - Planning for contingencies

Priority actions

An immediate response to solid waste

8. UNHCR and WASH actors must ensure that solid waste management systems are established from the outset of a refugee emergency. The speed at which they are established must be given the same emphasis as provision of safe water supply and sanitation. The provision of basic systems (for example cleaning up wastes of public health importance and designating places where domestic waste can be stored for bi-weekly collection) is better than delayed provision of improved systems.

Triage of existing wastes and clean-up campaigns

9. During a refugee emergency, unmanaged wastes may start to accumulate posing a public health risk. In all settings and phases it is recommended that UNHCR and WASH actors use the waste hierarchy system (see **section 5.41**) to rapidly triage wastes into those that are a public health risk and need to be dealt with immediately, and those that are relatively inert and need a medium term approach. Sanitation brigades may be mobilized to clean up wastes from locations of high risk. UNHCR and WASH actors must ensure that these brigades are provided with appropriate tools and personal protective equipment for the tasks they are performing (see **sections 8.12 – 8.13**). In addition, any wastes that are collected must be disposed of safely in a location that does not pose further risks to public health or the environment. Following an initial clean-up campaign, street sweepers and waste collectors may need to be

employed on a permanent basis to ensure public areas of the refugee setting are kept free from wastes (see **section 5.17**).

Protection of existing water supplies and the environment

10. UNHCR and WASH actors must ensure that any dumped wastes, waste collection points, transfer stations, sorting plants, composting plants, disposal pits, or sanitary landfills do not leech contaminants into surface water or shallow groundwater sources that may be used for drinking. Rainwater and stormwater should be diverted away from the wastes to reduce the risk of leechates contaminating soils and water sources (see **section 5.112**). The selection of sanitary landfill sites must be carried out in full cooperation with the local authorities and population (see **section 5.113**). The siting of permanent landfills for populations >20,000 persons must be based on a study evaluating risks to the environment and hydrogeology (**see section 5.114**).

Solid waste container coverage targets

11. In many planned settlements it is common for UNHCR site planners to layout shelters in communities of 16 families following the UNHCR master planning approach (see **section 1.33**). In all settings, it is recommended that UNHCR and WASH actors ensure that waste collection points are conveniently located on the basis of one waste collection point for every group of 16 families.

12. Identification of waste collection points should ideally be undertaken within the first three (3) days of the response in collaboration with each group of 16 families. Each communal waste collection point should be clearly marked so that everyone is aware of the agreed designated location. The group of 16 families should also understand that in order to be able to run an efficient service, it is only possible to collect wastes from designated points and it will be their responsibility to move any additional waste piles to the agreed location.

13. As soon as is possible, the designated waste collection points should be equipped with durable waste containers. During the emergency phase UNHCR and WASH actors should plan for at least 200 litres of waste container volume per 16 families. If manual emptying of wastes is being undertaken the weight of fully loaded containers should not exceed 80kg (see **section 5.67**).

14. During the care and maintenance phase, the volume of waste containers allocated to communal waste collection points should be re-evaluated based on a comprehensive assessment of the types and volumes of wastes being created (see **section 5.24 and 5.65**).

15. In settings where refugees are integrated into the host population, UNHCR and WASH actors should ensure that the refugee population receives the same quality of waste collection services as the host population prior to the influx. More guidance for urban settings can be found in **section 5.67**.

The best guarantee that people will dispose of their household wastes is to create designated waste collection points within convenient distances and commence waste collection services as quickly as possible.

16. Waste container coverage and condition should be tracked on a weekly basis as part of the emergency WASH monitoring system. Provision of waste containers should be scaled up if coverage is behind target.

17. Waste containers should also be allocated to public institutions. Waste containers should be available within convenient distances in all public areas spaced on a grid every 50m - see box below. In communal areas the refugees should be encouraged to organise their own street sweeping activities, however in public areas it will be necessary to employ street sweeping staff to ensure that litter and other wastes are cleaned up and moved to waste containers, where they can be conveniently managed. Plan for at least one street sweeper per 1,000 refugees.

Box: Waste container coverage targets for public institutions

Institution	100 litre container
Schools	1 per classroom 1/50m in public areas
Health facilities	1 per room 1/50m in public areas
Market areas	1/50m in public areas
Feeding centres	1 per room 1/50m in public areas
Transit centres	1/50m in public areas
Offices	1 per room 1/50m in public areas

Planning for long term waste management from the start

18. The most expensive mistakes are typically made during the start of the refugee emergency, especially if attention is not given to waste activities or wastes are dumped or stockpiled 'out of sight, out of mind'. This leads to subsequent work to move the wastes to a final disposal site.

19. It is UNHCR's experience that the average lifetime of a refugee camp is 17 years. Since it is almost impossible to estimate the duration of most emergencies, UNHCR and WASH actors should start to consider the selection and construction of long term solid waste processing and disposal facilities as early as possible. Well planned solid waste programmes from the start of the emergency can save a lot of headaches later.

Working in collaboration with local service providers and local authorities

20. It is highly critical that UNHCR and WASH actors do not undermine or replace the local authorities or service providers responsible for solid waste management. In all scenarios, solid waste management should be carried out in close collaboration with national actors and in full compliance with national solid waste and environmental legislation. Where possible, existing services should be extended to the refugee population. In urban settings, local authorities or service providers responsible for solid waste management may be overwhelmed by the additional burden created by


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the refugee population and may require support to bring back service levels to the same as before the refugee influx.

Waste collection frequency

21. UNHCR and WASH actors should ensure that waste containers are emptied and cleaned at least twice a week, or more frequently if required. In temperate climates, fly eggs laid in organic wastes can develop into maggots in 4 days and adult flies can emerge after 8 days. It is estimated that 1kg of organic waste can serve for the reproduction of 70,000 flies. For these reasons, collection twice a week is a bare minimum to ensure the breeding cycle of flies within the refugee setting is eliminated.

Figure 5-1 Spraying for vectors, Gaza

Waste collection timing

22. It is generally inefficient for waste collection vehicles to be sitting in traffic jams when they could be out collecting wastes and so waste collection routes are typically scheduled so that collection in locations with the greatest traffic problems are scheduled for collection during the time of day with the least amount of traffic (typically the early hours of the morning). Collection routes that have less problems with traffic jams can be scheduled for later in the morning. Collection vehicle maintenance activities are usually scheduled for the time of the day when waste collection activities are not taking place – typically when there are high levels of traffic congestion in the afternoons. The efficient scheduling of waste collection may not be problem in planned refugee sites, however it is an important factor if the refugee population are located in an urban setting. Even with adequate maintenance, waste collection programmes should have sufficient waste collection vehicles resources to allow for the downtime of at least 20% of the waste collection fleet.

Figure 5-2 Communal container, Jordan

Incorporating assessment of solid waste into observation walks

23. An observation walk of the refugee site does not have to take long, and can easily be incorporated into the general needs assessment schedule. For safety and security reasons it should generally be undertaken using a member of the refugee population as a guide. This also allows the possibility to pose questions and collect first-hand information about problems and solutions related to waste management.

During the observation walk, try to visit as much as possible of the existing waste infrastructure in addition to places where waste dumping is taking place. Try also to obtain an even balance of places the guide wants to show you and places they may not want you to see.

Assessing waste types and quantities through the use of waste surveys

24. During the stabilisation phase it is important to take a moment to fully understand the types and volumes of wastes that are being generated in the refugee setting. Solid waste generation rates vary considerably depending upon the country, culture, geographic setting, emergency context and degree of economic development. In industrious nations the population may create up to 2 kg of waste per person per day. This waste is typically of low density containing a high proportion of paper and plastic packaging. In many refugee settings, waste generation is lower of between 0.3 to 1.0kg per person per day and the waste is much denser containing a greater proportion of organic matter – see the boxes on the right hand side. In all settings, once the types and characteristics of the waste are known, an efficient and effective programme can be designed for each waste type that may include interventions for reduction, reuse, recycling and disposal. At the most basic level it is essential to know the accumulation rate and the bulk density for planning purposes.

25. The most reliable method of determining the waste accumulation rate, and bulk density is through direct sampling. At the start of a programme it is recommended that waste sampling is undertaken in four to eight randomly selected community waste collection points that are representative of each of the main socio-economic groups in the refugee setting. In order to assess the rate at which waste is being created it is first necessary to establish a baseline by cleaning all wastes from the selected locations and then assessing the amount of waste that accumulates during a known duration (typically half a week). A rapid census is also required at each collection point to understand how many people are generating the waste.

Box: Typical daily per capita urban waste creation rates

Location	Rate (kg/cap/day)
India	0.3 to 0.55
Guatemala	0.3 to 0.6
Philippines	0.4
Brazil	0.54
Indonesia	0.6
Mexico	0.68
Chile	0.9 to 1.2
Fiji	0.91
Singapore	1.0
France	1.43
Hong Kong	1.68
Australia	1.87
South Korea	2.0
New Zealand	2.0

Source: Diaz L.F., Savage G.M, Eggerth L.L. (2005) '*Solid Waste Management'*, United Nations Environment Programme, UNEP, Geneva.

Box: Typical urban waste bulk density values

Country	Density (Kg/m3)
United States	100
United Kingdom	150
Singapore	175
Tunisia	175
South Korea	200 to 450
Nigeria	250
Thailand	250
Mexico	300 to 500
Tanzania	330
Burma	400
Indonesia	400
Sri Lanka	400
India	400 to600
Pakistan	500
Bangladesh	600
Nepal	600

Source: Diaz L.F., Savage G.M, Eggerth L.L. (2005) '*Solid Waste Management',* United Nations Environment Programme, UNEP, Geneva.

26. Wastes that have accumulated during the evaluation period (half week) should be collected in containers or sacks, labelled with the location, and brought back to the sanitation yard for analysis. Before the waste is sorted it should be weighed, and its uncompressed volume should be measured by filling a waste container of known volume. This allows an estimation of the waste bulk density to be calculated which is an important factor when planning collection.

Figure 5-3 Waste composition analysis

27. Once the total weight and volume of waste created is known, the waste production rate should be calculated by dividing these figures by the population that uses each collection point. The figure should then be divided further by the waste accumulation period (in this case 3 days) to end up with an average daily waste creation rate in terms of kg per person per day.

Solid waste accumulation rates vary from context and can be anything from 0.35 kg to several kgs per person per day. In a refugee population of over 40,000 people this can quickly add up to many tons of waste that is generated per day.

Box: Example waste analysis by percentage and weight

Waste constituent	Kg	%
1. Paper	55.5	14%
2. Metal	19.8	5%
3. Glass	15.8	4%
4. Textiles	11.9	3%
5. Plastics and rubber	7.9	2%
6. Bones	4.0	1%
7. Misc combustible	7.9	2%
8. Misc incombustible	15.8	4%
9. Inert matter <10mm	39.6	10%
10. Organic >50mm	39.6	10%
11. Organic 10-50mm	138.7	35%
12. Organic <10mm	39.6	10%
TOTAL	396.2	100%
DENSITY (kg/m^3)		387.4

Note
The presence of additional wastes should be noted such as light industrial wastes, batteries, used vehicle oils, paints, solvents, varnishes, aerosols, and broken electrical apparatus (inc. strip lights).

28. Once the overall waste density and daily waste production rate has been calculated the waste

should be manually separated into their constituent types (see the example in box above) and the weight of each constituent can be recorded. A sieve should be used to grade the organic wastes into >50mm, 10mm-50mm and <10mm. It is important to recognize that the waste analysis undertaken will generally be an under-estimate of the total waste that is being generated. A significant amount of waste may have already been reused or recycled either by the household themselves or by waste scavengers before analysis. However this does give a good indication of the amount of waste that needs to be managed by the WASH agency.

29. Once analysis of the waste composition analysis has been completed, a plan should be established for each waste constituent. In general there are four options available including

    1. Landfill
    2. Sort, recycle, compost, reuse
    3. Incineration
    4. Do nothing

    A cost-benefit analysis should be used for each waste constituent to identify the technical requirements, cost, public health impacts, environmental impacts, and social impacts of the options available. The wastes should also be prioritized into those that are a risk to public health or the environment and need addressing immediately and those that are relatively inert and need a longer term approach.

30. Due to the changing nature of refugee emergencies, UNHCR and WASH actors should aim to conduct a waste survey at least once every 6 months to modify and update the waste management programme to the evolving circumstances.

Waste types, characteristics & management options

Characteristic and management of domestic solid wastes

31. Domestic waste is defined as non-liquid waste material arising from domestic activities. Domestic wastes in refugee settings typically account for up to 75% of the total amount of waste to be managed and can contain such items as food wastes, packaging waste, rags, paper, glass, metal, plastic, rubber, animal wastes, dust, sand, ash and floor sweepings. In addition, small quantities of special wastes may be encountered such as batteries, used vehicle oils, paints, solvents, varnishes, aerosols and broken electrical apparatus. In settings where sanitation is limited, the waste may also contain excreta.

Figure 5-4 Overflowing waste containers

Characteristics and management of market and commercial wastes

32. Markets may create large amounts of waste including product packaging waste (paper, plastic), animal slaughter wastes, perished fruit and vegetable

wastes, food stall waste and floor sweepings.

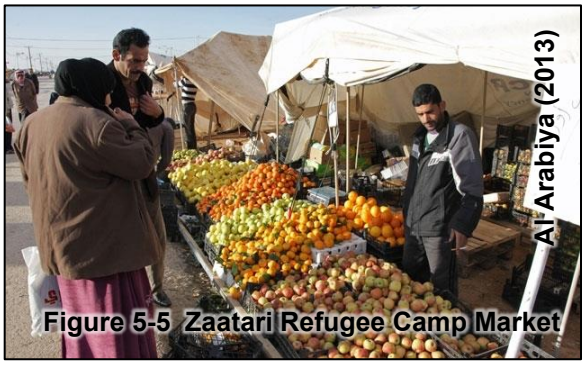

Figure 5-5 Zaatari Refugee Camp Market

33. UNHCR and WASH actors should work with market vendors and small businesses to design a waste management plan that deals safely with each type of waste and ensures that public health risks, disease vectors, smells, flies and other nuisances are minimized. At a minimum this should entail that each market vendor has their own 100 litre waste container and public waste containers are positioned throughout the entire market area at a minimum interval of every 50m.

Figure 5-6 Zaatari Refugee Camp Market

34. In most settings, paid cleaners will be required to sweep any litter that is created and bring the wastes to a centralized collection point. It is often advantageous to position a large volume bulk refuse container or construct a transfer station near the market area (or in fact any area that is a large producer of waste).

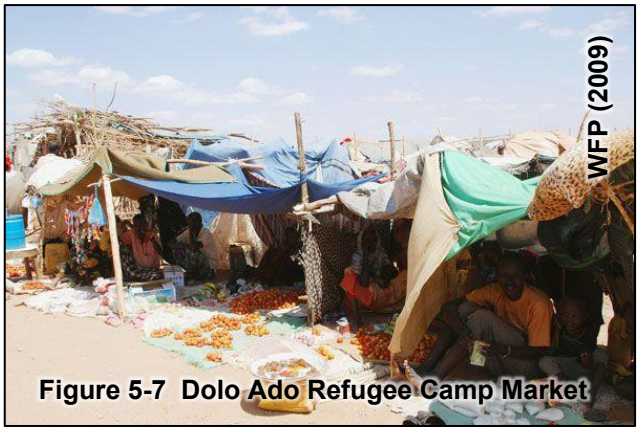

Figure 5-7 Dolo Ado Refugee Camp Market

35. A high proportion of market wastes are organic in nature and UNHCR and WASH actors are strongly encourage to facilitate separate collection of spoiled organic wastes directly from vendors. In temperate climates, market wastes should not be allowed to fester and should be collected daily. It is highly desirable that separate collection of 'wet' putrescible mixed waste for landfilling and 'dry' (paper, plastic packaging) wastes is organised in market settings. Ideally the organic waste stream should be diverted from being disposed in the landfill through a programme of composting (see **section 5.53**). Additional infrastructure may need to be constructed in animal slaughter or fish market areas to allow the area to be washed, cleaned and disinfected. This may require the construction of dedicated soak pits equipped with grease traps.

Figure 5-8 Zaatari Refugee Camp Market

Characteristics and management of hazardous wastes

36. In all refugee contexts, UNHCR and WASH actors must ensure that hazardous wastes from domestic or small-scale commercial activities are adequately managed. Examples of these wastes include used motor oils (a source of heavy metals), antifreeze, car batteries (containing lead, mercury and acid), discarded tyres (containing complex synthetic rubber compounds), used oils (containing various synthetic compounds), asbestos, oil-based paints, paint thinners, wood preservatives, pesticides, or electronic waste (a source of hazardous materials including cadmium, mercury, arsenic and lead). Great care must be taken as even small quantities of these wastes can cause significant risks. In all cases, UNHCR and WASH actors must ensure that steps are taken to ensure these wastes do not enter the general mixed domestic waste stream where they can pose a danger to the health and safety of workers, scavengers, or the environment.

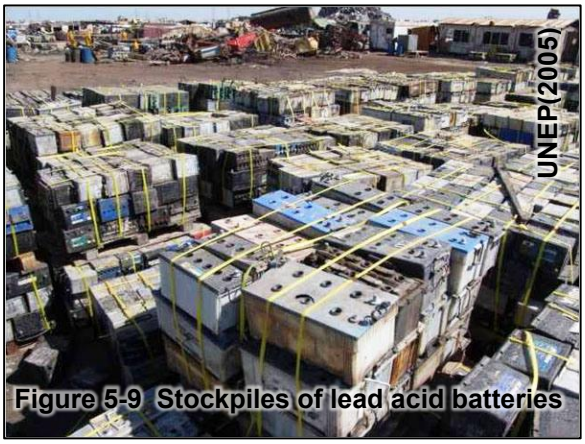

Figure 5-9 Stockpiles of lead acid batteries

37. In every setting, UNHCR and WASH actors should facilitate the separate collection of these wastes at source. Every context is different however strategies to ensure that these wastes do not enter the domestic waste stream including establishing hazardous waste collection points, facilitating separation of hazardous wastes from the domestic waste stream during collection, door-to-door collection, use of incentives (e.g. small gifts, or cash for certain types of hazardous wastes such as car batteries), outlawing certain types of harmful products.

38. In every setting, UNHCR and WASH actors should ensure that facilities exist for the safe collection, bulk storage and transfer of these wastes to competent authorities where they can be dealt with safely. All hazardous wastes should be clearly labelled during storage and transportation with the name, date and type of waste in addition to internationally recognized hazard warning symbols. In all cases, UNHCR and WASH actors should seek expert advice related to the handling, moving, storage and transportation of hazardous wastes.

In all settings, UNHCR and WASH actors s must make special provision for the separate collection of special domestic wastes including car, motorcycle or small domestic batteries, used vehicle oils, paints, solvents, varnishes, aerosols, pesticides, asbestos, and broken electrical apparatus. These wastes even in small quantities can cause large damage to the environment and they must not be allowed to enter the domestic waste stream.

Characteristics and management of medical wastes

39. Medical waste is generally defined as all infectious and non-infectious waste material arising from health-care related activities. In all settings, UNHCR and WASH actors must ensure that medical wastes are segregated at source and treated appropriately without risk to staff, patients or the public environment regardless of the emergency setting or type of health-care facility (temporary, permanent or mobile). More information concerning the safe management of the different types of medical wastes can be found in **section 5.128**.

Evaluation of public health risks along each waste management chain

40. UNHCR and WASH actors must ensure that each of the different types of wastes are stored, collected, transported, treated, reused, or disposed in a way that does not expose refugees or sanitary workers to harmful pathogens or substances, minimizes offensive odours in populated areas and minimizes the impact on the environment. Sanitary surveys (**see Annex**) of each step of the solid waste management chains should be carried out to assess public health risks and formulate a prioritised plan of action. Copies of recent sanitary surveys should be included in the site WASH plan/strategy.

Reduction, recycling and reuse in refugee settings

The waste hierarchy

41. The waste hierarchy is a classification of waste management options in order of their public health and environmental importance. It has been adopted in various forms by most industrialized countries through international conventions.

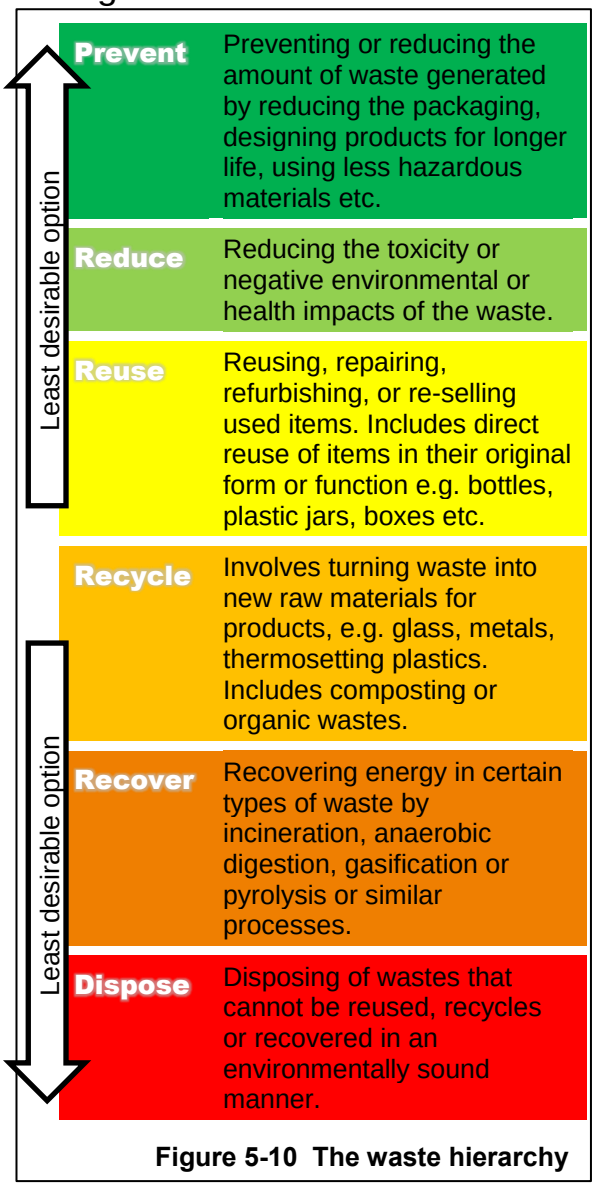

Figure 5-10 The waste hierarchy

42. The waste hierarchy is a useful tool for helping UNHCR and WASH actors prioritize waste interventions in refugee settings. For example, activities that prevent the generation of waste should be prioritized over recycling. In addition, the waste hierarchy shows us that interventions that reduce the toxicity or negative impacts of waste must be


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prioritized over interventions to reuse, recycle or dispose of waste. An example of this in a refugee setting is prioritisation of the correct management of medical wastes or toxic special wastes of which small quantities can have a major impact on public health and the environment (e.g. such as lead-acid batteries, household batteries, used engine oils, used paints, varnishes and oils, broken electrical equipment). Getting this right must be a greater priority for UNHCR and WASH actors than the day-to-day management of relatively inert household wastes that have a lower impact on public health and the environment.

Waste prevention

43. Any efforts to reduce the amount of waste that is generated can greatly reduce the burden and cost of waste collection, processing and disposal. Following the waste assessment (see **section 5.24**) it is important to look at each type of waste and identify steps to reduce the amount that is generated.

Figure 5-11 Emergency packaging wastes

44. One practical step that can be taken by UNHCR and WASH actors is to ensure that all items that are distributed to the refugee population are free from any unnecessary packaging. UNHCR and WASH actors may wish to work with representatives of the refugee population to change practices related to certain types of problematic wastes – e.g. plastic bags from market vendors. Alternatively, the refugee population can be empowered to create their own legislation preventing certain types of waste.

Waste reuse and recycling

45. Waste reuse involves repairing, refurbishing, re-selling or reusing items in their original form or function e.g. bottles, plastic jars, boxes. In refugee settings there may be a significant market for the repair of broken goods, or the sale of used goods. In all settings, UNHCR and WASH actors should examine what support can be done to strengthen or reinvigorate these essential services.

46. Not all "waste" is waste and in most refugee settings, metals, glass and plastic in addition to any materials that can be burned (wood, cardboard, paper, rubber and plastic) are usually scavenged very quickly. Recycling and reuse is also very common at the household level particularly any materials that can be burned (wood, cardboard, paper, rubber and plastic), any material that can be fed to animals, or any material (metal, glass, plastic) that can be turned into something else.

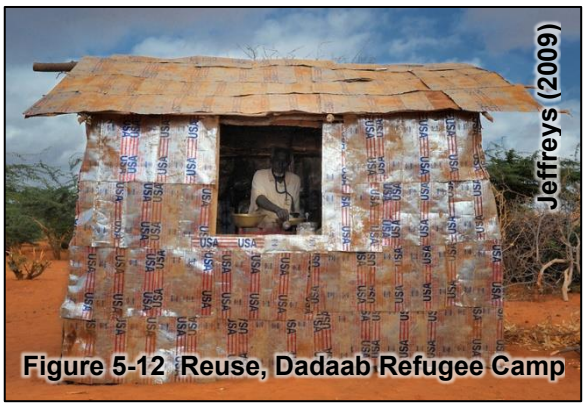

Figure 5-12 Reuse, Dadaab Refugee Camp

47. Due to the social and economic nature of recycling, it should always be organised in close collaboration with representatives of the refugee population and preferably directly by the refugee population themselves. UNHCR and WASH actors may wish to support or facilitate the process by creating or reinforcing market linkages with recycling companies outside of the refugee setting - for example in the Burmese refugee camps along the Thai-Burma border, the IRC facilitates monthly visits of recycling wholesalers for the purchase of recyclable materials.

Oxfam GB (2009)

Figure 5-13 Recycling prices , Indonesia

Recycling of glass

48. Glass is one of the easiest and most profitable resources that can be recovered. New glass objects can be produced using as much as 80−100 per cent recycled glass. The price per ton of recovered glass depends on its cleanliness and colour. Clear glass can be recolored and therefore fetches a higher price than mixed glass. For clear glass to fetch a high price, absolutely no coloured glass should contaminate the lot. In some refugee settings, UNHCR and WASH actors may consider small-scale income generation initiatives cleaning waste glass and creating decorative objects such as tumblers or candle-holders. With some investment a glass workshop can be established to melt glass and blow it into decorative objects.


Clusttersinafrica.blogspot.com (2012)

Figure 5-14 Glass bead production

Recycling of metal

49. The recycling of metal tins and cans can also be profitable. Scavengers often use heavy−duty tin openers or scissors to remove the top and bottom rims of the cans and to cut the remaining tube into rectangular pieces of sheeting which can easily be cleaned, flattened and bundled. Aluminium cans from soft drinks also have

very high retail value because of the high quality of aluminium used. They are either crushed and stored in large sacks or used directly in producing decorative objects (see Figure 5-16). In some refugee settings, UNHCR and WASH actors may consider supporting or establishing cooperatives to produce decorative objects such as toys, jewellery or candle-holders. Fancy and artistic pieces of work can be produced by hammering the metal plates on wooden or steel moulds.

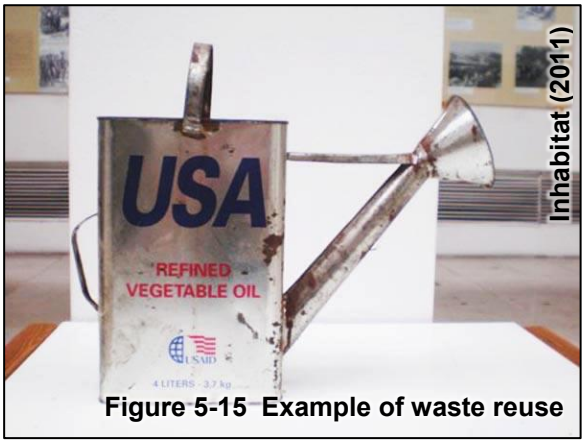

Figure 5-15 Example of waste reuse

Figure 5-16 Toy car from tin can

Recycling of paper

50. The manufacture of paper from new raw materials requires a lot of energy and so recycling paper can be a profitable. The price per ton of recovered paper depends on the type, grade and cleanliness. It is an advantage to make sure the different grades are not mixed to get the best price. Typical classifications include cardboard newspaper, office paper, magazines, and waxed or plasticized paper packaging. Most printed paper needs to be de-inked which may lower the price. Magazines and newspaper can be used in paper-mache to create decorative objects.

Recycling of plastics

51. There are two main types of plastic found in quantity in refugee settings; thermoplastics and thermosets. Only thermoplastics (such as PVC, polypropylene and polyethylene) can be moulded after heating and keep their shape at normal temperatures are therefore profitable for recycling. Thermosets that are typically used in kitchen items, or electrical appliances, have no recyclable value. The price per ton of thermoplastics depends on the cleanliness, type, quality and colour. Washing, drying and sorting plastics into colour increase its value. Typically plastics are sold on to waste dealers with extruder/pelletizer machines which partly melts the plastic and presses it out into strings which are then chopped into pellets. Bags of coloured recycled pellets are then sold to the manufacturers of low−quality plastic objects, such as cups, dolls, toys and packing containers. Plastics that are recovered earlier in the waste stream require significantly less cleaning. By the time plastics have arrived at a dumpsite, the effort and time required to sort and clean the plastic may render the recycling process unviable.

Recycling of rubber

52. The main source of rubber in a refugee setting is used car or bicycle tyres. These can be used to manufacture sandals, straps, or even small waste containers. Sandals from recycled car tyres are widely accepted because of their durability.

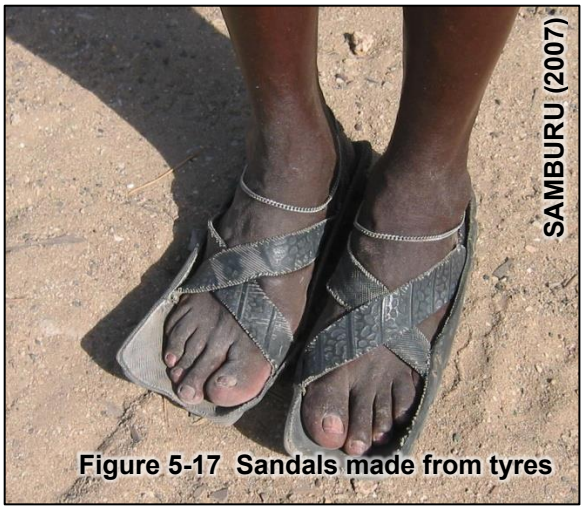

Figure 5-17 Sandals made from tyres

Recycling of organic wastes

53. Organic waste is usually the largest waste component in refugee settings and in some circumstances can be as much as 70% of the waste created. Aerobic composting is a natural process by which microorganisms convert organic wastes into a beneficial compost material which can be used to condition and fertilize soil. The process can take between three and ten weeks and involves careful control of the moisture and air content.

54. In many refugee settings the costs associated with large scale centralized composting projects may be uneconomical, especially if there are no significant agricultural activities within 5km of the composting locations. The reality is that with escalating transportation costs, most waste composting projects cannot be expected to make a profit. However, even if there is no market for composted waste, there is still a small operational and environmental saving in ensuring this material gets diverted from the domestic waste stream and is not dumped in a landfill. In most refugee settings, the best approach is often promoting and facilitating composting at the household level in collaboration with nutrition interventions such as kitchen gardens. This not only has the advantage of productively using organic wastes, but also allows household to produce crops for nutritional supplementation or small income generation purposes.

Figure 5-18 Small refugee kitchen garden

55. For these reasons it is highly recommended that UNHCR and WASH actors support, educate and encourage refugee populations to source separate and generate compost at the household level before wastes even enter the waste stream. Every ton of organic material that is prevented from entering the waste stream at the household level is a ton of waste that is saved from collection, transportation, handling, processing and disposal / reuse. Small investments in supporting household composting

can yield large savings in programme expenditure.

Figure 5-19 Small refugee kitchen garden

Manual waste sorting

56. Manual sorting of wastes at a centralized level can be reasonably successful provided that some degree of source separation has been facilitated at the household and communal level. At a most basic level, this requires the refugee population is sufficiently informed and motivated to source separated their wastes into 'wet' putrescible mixed household wastes that should go straight to the landfill and 'dry' non-putrescible waste that may be later sorted into paper, rags, plastics, glass and metals.

The most important aspect of manual sorting is the comfort, safety and dignity of the waste sorters. UNHCR and WASH actors must ensure that waste sorting is carried out in complete safety.

57. Manual sorting requires at a minimum a clean yard area onto which the waste can be tipped and bins into which the materials can be manually sorted (paper, glass, metal, plastic etc.). Improved setups use a sorting table with large corner holes into which wastes can be sorted into bins without bending over.

58. Attention should be paid to identify potentially dangerous materials that may appear in the waste and may have to be handled with special care. There might be containers with dangerous liquids, gas, inflammable materials, or poisonous objects. The waste sorting area should be equipped with an enclosed section where such material can be kept separately for special disposal.

59. UNHCR and WASH actors should ensure that waste sorters have good access to hand washing and showering facilities. All waste sorters should be wearing personal protective equipment suitable for the tasks they are performing (a minimum of gloves, overalls, protective boots and face-mask) and should have received training in the infection control standard precautions. Waste handling and sorting frequently requires moving loads of waste and this should be facilitated with handcarts and wheelbarrows. The site should also have one hoist which is invaluable if the process bales of recycled materials need to be loaded into a vehicle. A set of scales is also essential to document the amount of recycled material that is produced. Finally, fire extinguishers, buckets with sand and alarm bells at several locations on the site should be placed in very visible locations, preferably suspended from posts.

Mechanized waste sorting

60. A simple conveyor system with a picking line can dramatically improve waste sorting conditions

(see Figure 5-20). Various machines exist for sorting waste including electromagnetic, fluid dynamic and visual recognition, however in most refugee settings the cost and complexity of these machines renders them unviable.

Figure 5-20 Waste recycling, Gaza

Box: Manual waste sorting rates and efficiencies

Material	Sorting Rate Kg/hr/person	Recovery Efficiency %
Paper	700 – 4,500	60 – 95
Cardboard	700 – 4,500	60 – 95
Glass	400 – 800	70 – 95
Plastic	140 – 280	80 – 95
Aluminium	45 – 55	80 – 95

Note: These rates are based on a processing stream of predominantly metal, glass and plastics.

Source: Diaz L.F., Savage G.M, Eggerth L.L. (2005) '*Solid Waste Management',* United Nations Environment Programme, UNEP, Geneva.

Working with waste scavengers

61. It is estimated that more than 2% of the population in developing countries earns their living from scavenging and it can be very difficult to prevent. In refugee settings, it is recommended that UNHCR and WASH actors work with scavengers in a way that complements on-going waste collection, rather than outlawing it. In general, any scavenging activity that removes recoverable materials from the waste stream reduces the waste disposal costs and therefore scavengers should be recognized for their contribution.

62. One way to work in a complementary way with scavengers is to define where and how scavenging can take place so that it minimises public health risk and doesn't disrupt waste collection or create additional mess than needs to be cleared up. One possibility to reduce the risk to scavengers is to institutionalize a system of household separation of wastes into 'wet' putrescible mixed household waste that should go straight to landfill and 'dry' non-putrescible waste that contains items that may be recycled e.g. paper, rags, plastics, glass, metals. Another approach is to formalise scavenging and give exclusive rights to waste collection points, provided that the allocated scavenger keeps the area tidy. Another possibility is to allow waste scavengers to recover wastes in a controlled environment for example a combined transfer station / resources recovery facility (see **section 5.104**).

Figure 5-21 Waste scavenging

63. In all cases, UNHCR and WASH actors should work with the refugee population to reduce, control and mitigate the many serious health risks associated with scavenging. UNHCR and WASH actors may consider training waste scavengers in the infection control standard precautions and providing

professional scavengers with protective clothing (in particular footwear and gloves). In all cases, the scavenging of health-care wastes must be absolutely forbidden.

Figure 5-22 Waste scavenging, Aleppo

Technical options for waste storage and collection

Household solid waste containers

64. Solid waste collection containers vary immensely from context to context and come in many materials and sizes. Typical household and communal waste container options include..

    1. Metal/plastic buckets (10-20 litres)
    2. Metal/plastic bins (20-60 litres)
    3. Reed baskets (40-80 litres)
    4. Truck tyre buckets (40-60 litres)
    5. Classic metal dustbin (~100 litres)
    6. Half oil drums (~100 litres)
    7. Complete oil drums (~200 litres)
    8. Wooden containers (40-200 litres)
    9. Plastic wheelie bins (~100 litres)
    10. Metal containers (~1m^3)
    11. Wheeled metal containers (~2m^3)
    12. Metal skips (~4m^3)
    13. Static refuse trailers (~6m^3)

    In most refugee settings it is typically the responsibility of the refugee family to organise their own waste collection at the household level with UNHCR and WASH actors undertaking responsibility for providing waste collection containers and services at the communal level. In some settings UNHCR may consider distribution of household waste containers if it encourages source separation of wastes.

Figure 5-23 Household waste, Myanmar

Communal solid waste containers

65. Solid waste containers are one of the most critical, yet most often overlooked, elements in any solid waste management programme. The root cause of many problems associated with solid waste collection can often be traced back to poor waste container selection. The choice of communal waste container should be compatible with local practice and collection mechanisms.

66. It is prudent to assess the waste generation rate (see **section 5.24**) and then slightly oversize the waste containers as the cost, time-wasted, and public health risk of cleaning up wastes from overflowing containers more than justifies the additional cost of larger containers. In addition, containers that are never 100% full reduce the risk of wind dispersion. It is recommended that a safety factor of an additional 100% is allowed to

accommodate public holidays and unavoidable service disruptions.

67. The optimal sizing of waste containers depends upon the number of household using the waste container, the collection frequency and the waste production rate. In previous guidance documents, UNHCR has recommended that WASH actors plan to install half an oil drum (100 litres of waste collection capacity) for every 10 families. Assuming collection takes place bi-weekly this provides 0.24 litres of available waste collection capacity per person per day (allowing a safety factor to prevent the container becoming completely full and facilitating wind dispersal). This may serve as a rough estimation for an initial emergency response in a non-urban setting, however as soon as possible, UNHCR and WASH actors should undertake a proper assessment of waste accumulation rates (see **section 5.24**) and should recalculate the optimum waste collection volume for the context. In general, it is recommended that the largest sized containers that are compatible with collection vehicles are installed. In planned settlements or low density, single storey settings, each waste collection point serving 16 families will typically require between 200 litres and 400 litres of waste storage capacity. In high-density urban settings, with multi-storey buildings, it is highly likely that waste container sizes will need to be between $2m^3$ and $4m^3$ per waste collection point spaced every 50m along access roads.

    Finally, it is essential that the container size and type that is selected is compatible with the collection vehicle being deployed. There is no point procuring $2m^3$ waste containers, $4m^3$ waste skips, or $6m^3$ static waste trailers if the location cannot be accessed by waste collection vehicles.

Box: Optimal waste bin size for an urban collective centre.

An urban residential housing block is accommodating 50 refugee families. Waste collection is planned for twice a week. It is estimated that the waste accumulation rate is 1.2kg / person / day and the waste density is 350 kg/m^3. What is the optimal waste container size?

The total daily volume of waste generated within the residential block is as follows

Daily waste volume (V_{day}) = N x R / ρ

where

N = the block population (50 x 6 = 300)
R = waste production rate (1.2 kg/per/day)
ρ = the average waste density (350kg/m^3)

it follows

Daily waste volume (V_{day}) = 360 / 350
Daily waste volume (V_{day}) = 1.03m^3 / day

Optimal waste bin size = V_{day} x F x SF

where

F = the frequency of collection (3.5 days)
SF = safety factor (additional 100%)
Optimal waste bin size = V_{day} x 3.5 x 2

Optimal waste bin size = 7.2m^3

In conclusion, four waste containers of $2m^3$ each need to be allocated to the residential housing block to ensure there is sufficient capacity if collection is organized twice a week.

    If manual lifting is required, then the waste containers must not weigh more than the maximum load that two labourers can safely lift onto a waste collection vehicle. This is typically around 60-80kgs. The size may need to be reduced if the waste is loaded into a

collection vehicle that is more than 2m off the ground. A much safer and more efficient primary collection system avoids manual lifting through the use of $2m^3$ wheeled metal containers, $4m^3$ metal skips or $6m^3$ static refuse trailers.

Figure 5-24 Manually loaded waste truck

In many refugee settings, 200 litre oil drums are commonly procured for use as waste containers. This practice is strongly discouraged by UNHCR as it is detrimental to the health and safety of waste collectors. These containers typically weigh 16-18kgs when empty and up to 150kg when full. If oil drums are used, they should be first cut in half (100 litres).

Waste containers should be high enough off the ground to prevent animals (goats, cows) accessing the waste yet still low enough for children of at least six years old to use. A compromise between these two competing requirements is a target height of 1 metre. In addition, the waste container cover opening and closing mechanism should be light enough that it can be operated by all users.

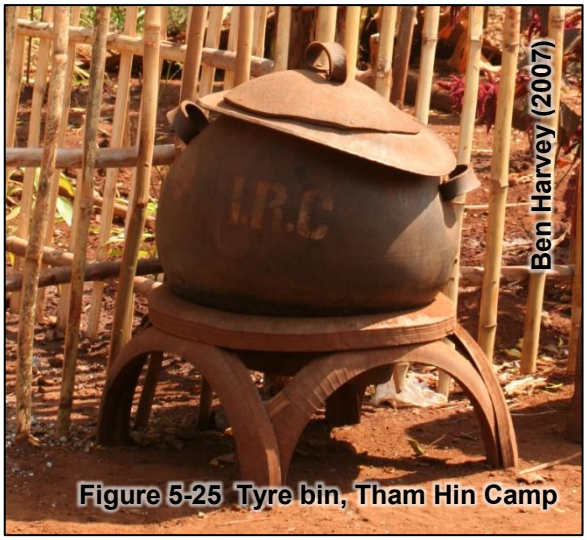

Figure 5-25 Tyre bin, Tham Hin Camp

68. The cost per ton of sweeping up wastes that have been dumped on the floor can be over ten times as much as the cost per ton of emptying waste that has been placed in a container and so it is essential that containers are conveniently located and accessible throughout the refugee setting to prevent littering, and containers are always emptied before they become full. In planned settlements one functional waste collection point should be established for each community of 16 families with provision of waste containers of sufficient volume (see **section 5.67**). In settings where the refugee population is integrated into the host population, UNHCR and WASH actors should ensure that the refugee population receives the same quality of waste collection services as the host population prior to the influx. A general guidance figure for urban settings with multi-storey buildings is provision of waste containers of sufficient volume (see **section 5.67**) placed along streets at a maximum interval of every 50m to provide access within 25m of every residence block.


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69. UNHCR and WASH actors should ensure that containers have sufficient strength to be able to hold the waste securely without deforming in addition to being able to withstand the loads exerted during loading and emptying in addition to occupational misuse (knocks and scratches). Since wastes in refugee settings are typically much denser than wastes in conventional settings, it is prudent to purchase the most durable containers possible. In addition, solid wastes can become extremely corrosive if the waste become wet. Plastic containers may be preferable to steel containers in settings that experience high rainfall.

Figure 5-26 Wooden waste bins, Indonesia

70. Fire-setting of containers is a common practice in many refugee settings either to create space in the container, for warmth, for entertainment, or by accident. In some refugee settings it may be prudent for UNHCR and WASH actors to select waste containers that are constructed from heavy sheet metal that is able to withstand repeated fires. Containers made from wood or plastic, or metallic containers with wheels, should be avoided in these settings.

Figure 5-27 Metallic bins, Ingushetia

Figure 5-28 Metallic bins, Ingushetia

UNHCR and WASH actors should, at a bare minimum, ensure that solid waste containers are durable, vector proof, weather proof, washable and robust enough to survive daily handling and use.

71. Covers on most communal waste containers are nearly always a

failure because people are unwilling to open or replace them (either because they are heavy, dirty or inconvenient). However, all solid waste containers should have covers to protect the contents from the rain, reduce littering caused by winds, and reduce vector populations and smells. Rainwater should be prevented from mixing with wastes at all costs as it causes wastes to fester, causes corrosion, and increases the gross weight of wastes putting additional load on collection and transportation equipment and staff.

Figure 5-29 Foot operated cover

72. In general, container lids should be light enough to allow access to the population using them, preferably without using their hands and with a mechanism for self-closing. An ideal system is the European container model that uses a large foot pedal to open the cover (see Figure 5-29) without having to touch the container. If waste containers do not have a lid (for example 4m^3 metallic skips or 6m^3 waste trailers) then another option to protect them from the rain is to construct a simple shelter (see Figure 5-33 from Tham Hin Refugee Camp). Holes should be drilled into the bottom of all waste containers to facilitate drainage of rainwater.

Wheeled waste containers

73. Many medium sized waste containers are equipped with wheels to allow the container to be manipulated into position for the lifting mechanism to engage and empty the container into the collection vehicle.

Figure 5-30 Wheeled bin – 1.5m^3

However, the tiny wheels are typically a point of weakness. Their failure can cause problems and delays to the loading procedure and a problem with the wheels can mean the whole container needs to be taken out of service and repaired. Wheel based container systems can be completely impractical in sites that are not surfaced. Wheeled containers should also not be used where there is a practice of fire-setting as they are easily damaged by heat and fire.

Figure 5-31 Wheeled bin failure, Zaatari


UNHCR/

Trailer based waste containers

74. Often the most efficient and cost-effective system for the collection and transfer of waste is the use of static waste trailers. This system is very economical as it does not require the purchase of specialised waste trucks and in many refugee settings, the same light four wheel drive vehicle that is used to bring staff to the camp to work in the mornings can be used to shuttle wastes to the landfill during the day. The system also avoids manual secondary handling of wastes. In general, this system is highly recommended by UNHCR provided that the distance to the landfill is short.

Figure 5-32 Simple waste trailer, Uganda

75. Trailers should be placed under a rain protection shelter to avoid the complications of handling wet wastes. A tarpaulin should be used to cover the wastes to avoid littering during transit. .

Figure 5-33 Rain protection, Thailand

Waste container lifting and tipping mechanisms:

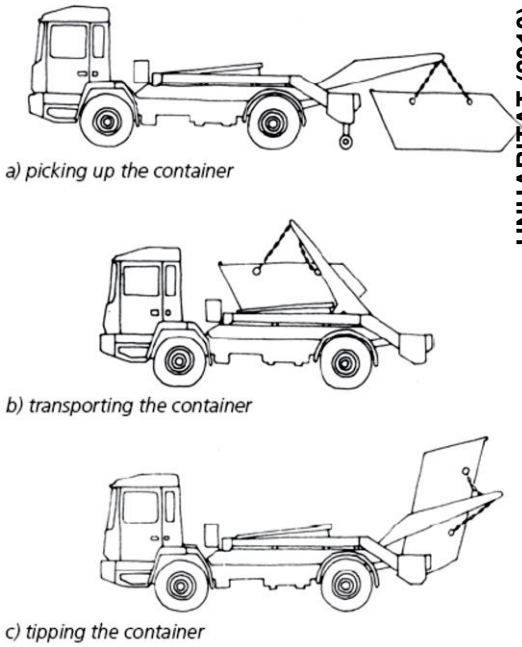
76. Manual transfer of waste (using labour and shovels, rakes, or picks) is unhygienic, time consuming and inefficient. In all settings, UNHCR and wash actors must ensure that waste is handled as little as possible, preferably only once by the user when they place their waste into the start of the waste chain.

Figure 5-34 Mechanized emptying, USA

77. Dumper placers (also known as skip-lifts or container hoists) are trucks equipped with a pair of hydraulically operated lifting arms designed to transport, place and also tip a 4m^3 metallic skip. The main disadvantage of skips is that they are generally optimized to collect rubble and waste from building sites and so if they are used for solid waste end up using only a fraction of their permissible payloads. Another disadvantage of dumper placer systems is that the designs of skips do not lend themselves to being covered so they often suffer from rain ingress, fly populations and smells. If the skip has no covers, it should be covered with a simple net during transportation to avoid littering.


T. FAEZ (2014)

Figure 5-35 Skip unloading



UNHABITAT (2010)

Figure 5-36 Dumper-placer (skip lift)

78. A major weakness of many lifting and tipping systems is that containers need to be positioned into exactly the right location so the lifting mechanism can be engaged. This can take considerable effort if the wheels on the container are damaged or access to the container is restricted. To solve this problem a crane-lift system was developed by the UN in Gaza (see Figure 5-37). The disadvantage of this system is that it is reliant on imported equipment that needs to be imported and requires specialist parts and maintenance.


UNDP (2010)

Figure 5-37 Mechanized emptying, Gaza

Waste container cleaning and disinfection

79. All waste collection containers become dirty and contaminated over time from decomposing or wet wastes and need routine cleaning to avoid harbouring of disease, attracting disease vectors and becoming a public nuisance. In all refugee settings, communal waste collection containers should be periodically cleaned using mobile cleaning crews equipped with detergent and stiff brushes. Alternatively if a swop system is in place, waste containers may be cleaned at the transfer station after emptying and before going back into service. In all settings, it is recommended that communal solid waste containers are cleaned at least once a month.

Masonry waste collection bays

80. In some refugee contexts, it is common to see masonry waste bays used for solid waste collection (see Figure 5-39). The advantage of this system is that damage or theft of containers is reduced. However, this type of system faces a major disadvantage in that wastes need to be shovelled manually from the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ground into a collection truck or cart which is slow, inefficient, unsanitary and is a public health risk to labourers. In all settings, UNHCR and WASH actors must avoid this system of waste collection. If there is a problem of damaged or missing containers, a formal investigation should be established via the camp committee.

Figure 5-38 Masonry waste bay

Figure 5-39 Masonry waste bay, Pakistan

UNHCR and WASH actors should ensure that in all settings, waste storage and transfer mechanisms are in place that prevent waste being handled or transferred manually. The most low-tech way to achieve this is with tippable static trailers.

Containers for source separation and recycling

81. During the care and maintenance phase, UNHCR and WASH actors should provide two clearly distinguishable types of waste container at each communal waste collection point. One for 'wet' putrescible household wastes for direct landfill disposal and the other for 'dry' mixed wastes that can be sorted and recycled. The size and type of containers for recyclable materials will depend greatly upon the context and the available resources within country. In many refugee settings the simplest solution to facilitate source separation and collection of recyclables is often to use exactly the same container type that is used for general waste and to paint it a different colour (e.g. green).

Figure 5-40 Recycling containers

Bulk refuse containers

82. Bulk refuse containers are typically between 30m^3 and 40m^3 and are the most economical way of hauling wastes over longer distances to a final waste disposal location that is a long distance from urban residential areas. They are typically left in situ at a transfer station to receive wastes from primary collection vehicles.

Figure 5-41 Bulk refuse container

Technical options for waste transportation

83. All waste solid waste programmes involve transferring the wastes from the point of collection to a place of sorting, treatment or final disposal. In refugee settings, transportation methods can include anything from wheelbarrows, handcarts, donkey carts, to trucks, tractors, dumper placers, mini dumpers, light vehicles with trailers, or compactor trucks. The cost of moving wastes is often the most expensive part of waste management and UNHCR and WASH actors should carefully evaluate the options available to select the most appropriate in terms of quality, efficiency and cost-effectiveness.

Communal container exchange vs. container tipping

84. In some contexts, UNHCR and WASH actors may need to make a decision between waste container tipping and waste container exchange systems of collection. In the tipping model, waste containers are lifted and emptied into the primary collection vehicle and are then returned to the same location. In the exchange model, empty containers are brought to each waste collection point and each full container is swopped with a clean empty one. Examples that use this model include the use of $4m^3$ metallic waste skips, or $6m^3$ waste trailers. The advantage of the exchange system is that there is no on-site transfer of wastes which reduces the risk of littering and contamination. In addition, bins can be routinely cleaned in a centralized location reducing the risk of disease vectors and smells. Many medical waste collection schemes use this model. The disadvantage of this system is that waste collection may be less efficient as containers may be taken back half-full and vehicles may be working at less than rated tonnage.

Primary collection vehicle size

85. The efficient transportation of waste occurs when the capacity of the waste collection vehicle is optimized to the volumes of waste that are generated and the distances over which waste is transported are kept as short as possible. For each context, it is essential to calculate the total volumes of waste generated per geographic sub-division (i.e. block or sector) and compare the cost per ton per km for each available transport option. In general, the cost per ton per km of waste transportation decreases as the volume of the transport vehicle is increased so usually the most cost-effective option is to use the largest primary collection vehicle possible that can physically access the waste collection points.

The efficient transportation of waste occurs when vehicles are loaded to their rated tonnage. Many vehicles (for example trucks or skip carriers) are designed to carry high density construction materials and therefore are inefficient for transportation of wastes with low densities unless fitted with volume extension panels.

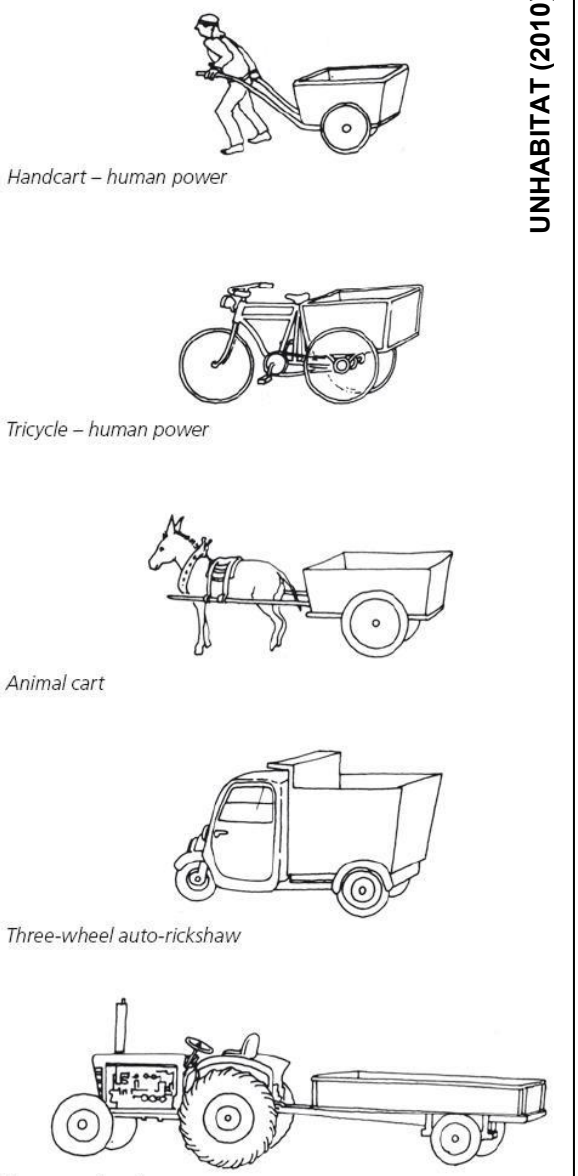

Figure 5-42 Waste collection vehicles

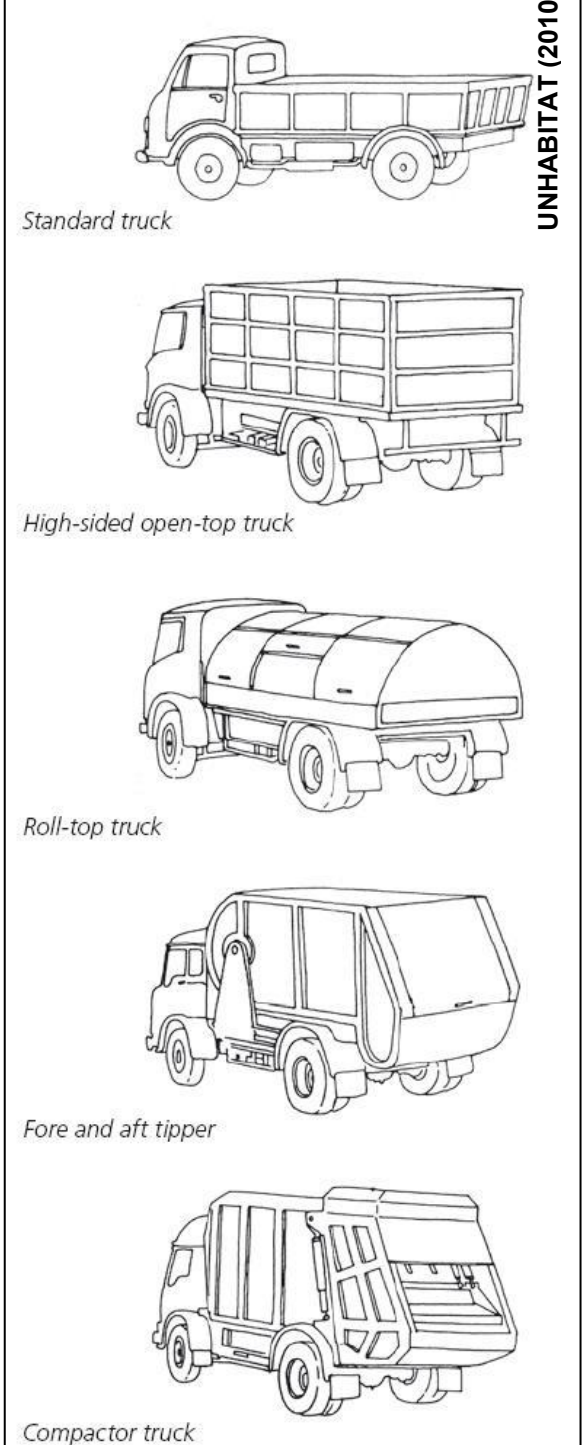

Figure 5-43 Waste collection vehicles

86. In many high-density settings, it may not be possible for large waste collection vehicles (e.g. waste collection trucks) to directly access the waste collection points. If access is difficult, primary collection may have to be undertaken using manual labour or small carts that are able to negotiate the narrow access passageways. In this case, groups of waste containers that can be comfortably and safely lifted or transported by a single person (60-80 litres) should be located within 25m of every household.

Wheelbarrows

87. Wheelbarrows are generally cheap and found in almost every corner of the world in some shape or form. They can be locally manufactured and are generally very easy to manoeuvre, even in rough unpaved terrain. However, wheelbarrows should only be

considered for special clean-up campaigns as they are too small and too inefficient to form part of the day-to-day waste collection system. The use of wheelbarrows also requires manual loading and puts waste personnel at risk from direct contact with wastes.

Figure 5-44 Wheelbarrow clean-up, Bangui

Figure 5-45 Wheelbarrow, Pakistan

Handcarts

88. Handcarts can be an efficient and cost-effective option in refugee settings under the following conditions:

    Limited access: The size and manoeuvrability of small waste collection carts are well suited to narrow, unplanned, unpaved refugee settlements, or locations that cannot be accessed with motorized vehicles.

    Flat terrain: Due to the problems in controlling and braking loaded handcarts on steep terrain, they are best suited to high density refugee settings that are flat and don't have too many potholes or rough roads.

    Low labour costs: If haulage distances are small, the cost per ton for collection may be cheaper than using motorized collection. However, manual waste collection using handcarts is unproductive if the waste collection points can be accessed by a larger vehicle or waste needs to be moved over large distances.

    Litter sweeping: Handcarts are desirable if manual collection is used to pick litter from the ground in public locations.

Figure 5-46 Modern sweeping cart

89. In all cases where handcarts are deployed, the most productive system is to establish transfer stations as close as possible (within 500m) to the zones of operation. If there is no space to establish transfer stations handcarts may be coordinated to 'meet up' with larger waste collection trucks at designated locations and times in the day.

90. There are many different types of handcarts for waste collection however the optimum design is where the centre of gravity of the load is directly over the wheels (i.e. the wheels are placed in the centre of the cart) and the cart is balanced. This means that all the user has to do is to push the load, rather than lift and push the load

Some handcarts may have more than two wheels so that all the user needs to do is to propel the vehicle forward. The most reoccurring problem with handcarts is typically associated with poor quality bearings and poor structural quality. The wheels should be as large as possible to allow the cart to ride over potholes.

Figure 5-47 Waste collection handcart

91. Containerized handcarts allow waste collectors to classify, sort and recycle waste on the move. This has a beneficial effect of also reducing the amount of waste entering the waste system. Waste collectors may be motivated to separate recyclable materials if the proceeds from the sale of this material is allowed to supplement their income.

Figure 5-48 Containerized handcart

92. The mechanism for transferring the waste from the handcart to the waste transfer container should be quick, easy, convenient and hygienic and should not involve handling the waste. Most handcarts are emptied by tipping the whole handcart, or by tipping individual bins loaded onto the handcart. A split level system can facilitate transfer into a bulk refuse container (see **section 5.104**).

Tricycles

93. Tricycles and waste rickshaws are used extensively throughout Asia and can carry loads on flat terrain of up to half a ton. These designs rely on standard bicycle wheels and bicycle parts and can be cost efficient to operate and maintain if labour costs are low. Waste tricycles are often overloaded and often have ineffective brakes.

Figure 5-49 Waste tricycle

Animal carts

94. Animal carts can be designed to carry volumes of $2m^3$ to $4m^3$ and loads of up to a ton and may be cheaper than motor vehicles for primary waste collection under distances of 3km. The use of animal carts should be combined with transfer stations if the waste disposal site is over 3km. Animal carts may be inappropriate in high density urban refugee settings where the presence of animals may present a public health risk. UNHCR and WASH actors should always ensure that animals are not malnourished, abused, or mistreated.

Figure 5-50 Donkey cart, Gaza

Motorized tricycles

95. Motorized two-stroke tricycles are a common means of transportation in Asia and a viable solution for waste transportation. Motorized tricycles can be useful in unplanned refugee settings where larger motorized vehicles

Figure 5-51 Motorized tricycle

are unable to travel. They can carry loads of up to half a ton with a range of up to 10km. Motorized tricycles do not function well on poorly maintained roads or landfill access roads and so may require some form of transfer network.

Pickup trucks and trailers

96. Often the most efficient and cost-effective system for the collection and transfer of waste is the use of static waste trailers. This system is often economical as it does not require the purchase of specialised motorized waste vehicles. In many refugee settings, the same light four wheel drive vehicles that are used to bring staff to the camp to work in the mornings can be used to shuttle wastes to the landfill during the day. Vehicles with 4 wheel drive should be used as access to most landfill sites can be difficult under wet conditions. Trailers should be easy to manoeuvre and tip. Split levels may be installed to reduce the height to which waste has to be lifted to fill the trailer.

Figure 5-52 Small pickup waste trailer

Commercial trucks

97. Motorized trucks of various shapes, sizes and tonnage are typically available in almost all refugee settings all over the world. However, they are generally not optimized for the transport of waste and require volume extension panels to be fitted so that they can be used up to their rated tonnage. The problem with this is that it often makes it difficult for waste to be loaded. Where possible, UNHCR and WASH actors should use tipping trucks to prevent the public health risks associated with manually unloading waste. The trucks should be able to tip to at

least 80 degrees so that the waste can slide out cleanly without sticking.

Figure 5-53 Tipping waste truck

98. Loading height is another important factor for truck selection. If the truck is to be loaded manually, the chassis and sides of the truck should be low enough to avoid the risk of having to lift the solid waste to great heights which increasing the fatigue of the loaders and makes the operation hazardous from the risk of wastes falling on the labourers' heads. Additional labourers may also be required to stand in the rear of the truck to receive the waste also increasing the costs of waste operations.

Figure 5-54 Manual loading of waste

99. The working conditions for waste trucks are often arduous as they often have to negotiate rough and soft ground at landfill sites, in addition to congested traffic. All trucks should have a functional four wheel drive gearbox and should be rugged enough to cope with the terrain they are operating. All trucks should be covered during transportation to avoid littering. This can be as simple as covering the waste in netting attached in each corner.

Tractors and trailers

100. Tractors and trailers are very commonly used for waste collection in refugee settings. Tractors have a large advantage in that they are able to operate in very poor ground conditions and they can also be easily equipped with front loader, grader and backhoe attachments for maintaining landfills. The combination of a single tractor and multiple trailer waste collection units can be a very cost efficient setup. Tractors can travel at a maximum speed of 15km/hr and so are not suited to transporting wastes over distances of 5km.

Figure 5-55 Waste tractor, Uganda

Dumper placers (skip-lifts)

101. Dumper placers (also known as skip-lifts or container hoists) are trucks equipped with a pair of hydraulically operated lifting arms designed to transport, place and also tip a 4m^3 metallic skip. Their disadvantage is that they are generally optimized to collect rubble from building sites and so

are not optimised for waste collection, using only a fraction of their permissible tonnage. Skips should be covered with nets during transportation to avoid littering.

Figure 5-56 Dumper-placer (skip lift)

Compactor trucks

102. Trucks equipped with compaction mechanisms are only viable in settings where the weight density is low, typically due to the presence of large amounts of paper and plastic packaging. In most refugee settings, any paper and plastic is quickly scavenged and the density can be as much as five times as industrialized nations. Compaction mechanisms have a reputation of adding a layer of cost and complexity to waste operations. In most refugee settings UNHCR and WASH actors will not need to consider compactor trucks.

Figure 5-57 Compactor truck

Transfer trucks

103. Transportation costs make up a significant proportion of waste management programmes and in many cases it is more cost efficient for large trucks to make the final journey to the waste disposal site. Bulk refuse carriers typically have a body capacity of up to 40m^3. The most efficient types are articulated so multiple container bodies can be filled while the cab and driver are performing haulage.

Figure 5-58 Waste transfer truck

Figure 5-59 Waste transfer truck

Transfer stations

104. As a general rule, a transfer station should be installed if a waste collection vehicle is spending more than 15% of its time on haulage rather than collection. Transfer stations are usually sited as close as possible to the waste collection area and consist of a yard area with parked bulk refuse carriers and a split level facility. The split level setup for transferring wastes is encouraged as it avoids secondary handling and results in efficient gravity transfer without the need for expensive lifting technology. Refuse transfer containers may be over 4m high and therefore it is worth selecting a site that facilitates the design of a split level

facility and takes advantage of any natural gradients.

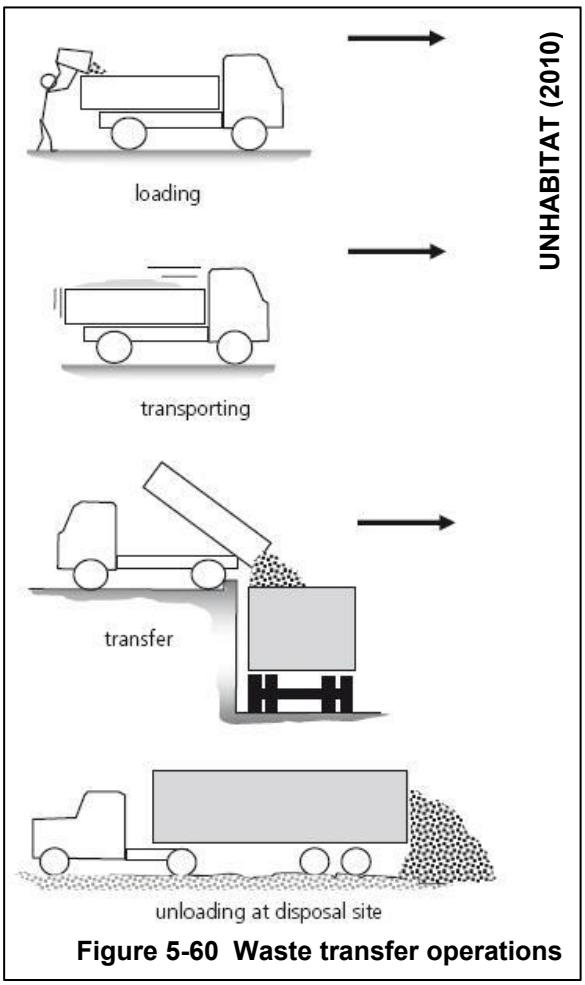

Figure 5-60 Waste transfer operations

105. Transfer stations can also be developed as combined transfer / resource recovery and recycling centres reducing the amount of waste that ends up entering the landfill. They can also be used as collection centres of common domestic hazardous wastes that must not be allowed to enter the domestic waste stream.

Figure 5-61 Small waste transfer ramp

106. In refugee settings with over 20,000 persons, transfer stations should include facilities for changing, toilets, showers, an area for servicing vehicles or handcarts and a manager's office. As the transfer station is typically located within the residential area of the refugee settlement, it is essential that it is kept as clean as possible to reduce smells, vectors and complaints from local residents.

107. The number of transfer stations required in a refugee setting depends upon the operational range of the primary waste collection vehicles that are being deployed, and the distance between the refugee setting and the waste processing area and landfill. The need to establish a network of transfer stations depends upon the type and capacities of collection vehicle being used and the distances to the landfill. If waste collection is carried out using motorized vehicles, and the distance to the landfill is short, it may not be necessary to install a transfer station at all.

Technical options for waste disposal

Illegal / uncontrolled dumping

108. Uncontrolled / illegal dumping of solid waste in any location that has not been designated an official solid waste disposal site is common in refugee settings and is a major public health and environmental risk. UNHCR and WASH actors should ensure that waste dumping is prevented at all cost. The clean-up of uncontrolled dumping is often significantly more

costly in terms of time, public health risks, and resources than if the waste had been dealt with in the first place.

Figure 5-62 Illegal dumping, Shoafat

Legal / controlled dumping

109. A legal or controlled dumpsite is a piece of land that has been designated by the local authorities as a site onto which solid waste may be dumped. Even though it may look the same, controlled dumping is better than illegal dumping as it allows a site to be identified with the least possible public health and environmental impact and allows legislative procedures to be implemented to prosecute illegal dumping. It also allows monitoring of the size, types and volumes of wastes generated and keeps the problem in one location rather than all over the place. Over time, it may be possible to upgrade the site with surface water diversion and daily covering to prevent vectors.

Figure 5-63 Controlled dumping, Gaza

Sanitary (engineered) landfill

110. Sanitary landfill is the process of disposing of solid waste in such a way that it causes minimum impact on the environment. Once a landfill has been filled, it is possible that it can be put to use for recreation, agriculture, construction or other purposes. The landfill location is usually carefully selected to have the best hydrogeological conditions to avoid surface and groundwater pollution. Typically the site has either soils with high clay content or an impermeable rock base, in addition to a long distance to the groundwater table and no surface water sources. In a sanitary landfill, animal and insect vectors are eliminated by a daily covering with 10cm-20cm of clay soil. This also serves to kick start biological decomposition and to divert rainwater, reducing the amount of leachate that is produced within the waste. Over a period of years, the waste is decomposed by natural biological and chemical processes (principally anaerobic decomposition) to render the wastes inert. Sanitary landfill is a simple approach that requires no imported technology and is well suited to refugee settings.

Figure 5-64 Sanitary landfill daily cover

111. A common misconception is that landfills can be used to dispose of any wastes. This is completely false and UNHCR and WASH actors should ensure that

landfills only receive wastes that have been deemed 'acceptable' for the site. Special wastes such as batteries, used vehicle oils, paints, solvents, varnishes, aerosols, pesticides, asbestos, and broken electrical apparatus must not be allowed to enter the domestic waste stream and must not enter the landfill.

UNHCR and WASH actors must ensure that the lifetime of the sanitary landfill is protected in all settings through strategies to reduce the quantity of wastes that are dumped in particular separation, recycling and reuse.

112. Sanitary landfills produce a foul black liquid from the decomposition of wastes called leachate. If the leachate is contained within the landfill it is slowly treated over time by a number of biological processes. UNHCR and WASH actors must take every precaution to ensure that leachates stay within landfills and the volume of leachate produced is as small as possible by protecting the site from rainwater and stormwaters. The natural anaerobic decomposition of waste also produces copious quantities of gases including methane, carbon dioxide, hydrogen sulphide and ammonia. These can be highly explosive and should be prevented from building up by installing vent pipes. Smoking should be prohibited.

Identifying a suitable location for a landfill

113. Site selection for a sanitary landfill can be a controversial activity and must be carried out in full cooperation with the local authorities and local population. The process of site selection is generally carried out by considering a number of potential sites within the vicinity of the refugee (see box below) and selecting the best available site based on minimizing risk.

Box: Sanitary landfill site selection criteria

- ☐ **Geology:** The geology of the ground should minimize the risk of leachates passing directly into groundwater supplies.
- ☐ **Cover material:** The site should have a large quantity of clay soil available for daily cover material.
- ☐ **Distance:** For efficiency, the site should be as close as possible to the population.
- ☐ **Access:** The condition of access roads should be capable of handling waste haulage traffic.
- ☐ **Topography**: There should be no surface water features running through the site and no surface water bodies downstream.
- ☐ **Nuisances:** The site should be downwind from residential areas.
- ☐ **Potential volume:** The site should have a sufficiently space for at least 10 years of use.

Source: Flintoff F. (1976) '*Management of Solid Wastes in Developing Countries'*, WHO, Geneva.

114. The primary consideration when identifying a landfill for a refugee population is water pollution. Ideally, the geology and topography of the site will prevent all leachate from the landfill reaching water resources. If the site has no natural clay soils or impermeable natural rock barriers

then UNHCR and WASH actors should install an artificial barrier from either 30cm of imported 'puddled' clay or a PVC membrane – which can be expensive and time and resource intensive. The clay content of the soil can be rapidly assessed by visual inspection and a simple soil percolation test (**see annex**).

UNHCR and WASH actors must ensure that new landfills in settings of over 20,000 persons are subject to evaluation by a hydrogeologist. The site must be rejected if there is any risk of contaminating water supplies.

115. If the landfill site is carefully selected, well managed and strict controls are in place to ensure that surface water and hazardous wastes do not enter the site, it should be possible for the physical, biological and chemical processes present in nature to render the wastes completely inert with no negative environmental effects.

Box: Calculating the land required for a long-term sanitary landfill facility

A decision has been taken to identify a permanent landfill site for a refugee camp of 60,000 people. A detailed waste audit has shown that the landfill fraction of waste is currently 0.3 kg per person per day. A permanent landfill location is required with a design life of at least 10 years. What area of land needs to be found and developed?

Projected Pop (P) = Pop / $(1 – R)^N$

Where

Pop = the current population (60,000)
R = the population growth rate (3%)
N = the number of years (10 yrs)

It follows..

Projected Pop (P) = 60,000 / $(1\text{-}0.03)^{10}$
Projected Pop (P) = 81,364 persons

The volume of landfill waste that will be accumulated is as follows

Volume (V) = [N x P x R x 365 x F] / ρ

Where..

N = effective life of the landfill (10 yrs)
P = the projected population (81,364)
R = waste acc. rate (kg/per/day)
F = factor for daily soil cover (1.25)
ρ = compacted waste density 550kg/m^3

It follows..

Vol = [10x81,364x0.3x365x1.25] / 550
Vol = 202,485 m^3

Assuming a flat site and a landfill total height of 4m, gives a landfill area of..

Landfill area (A) = volume / depth
Landfill area (A) = 202,485 / 4
Landfill area (A) = 50,621 m^2

Assuming a square site, the dimensions of the landfill site will be..

Length (L) = Area $(A)^{0.5}$
Length (L) = $50{,}621^{0.5}$ = 225m

In conclusion, a refugee camp of 60,000 people will create 202,000 m^3 of waste and will require a landfill site of at least 225m x 225m to provide sufficient landfill space for 10 years.

Preparing a landfill

116. How the landfill is prepared depends primarily upon the topography and dimensions of the site. Typically the landfill is organised as a series of cells arranged either using the trench method (see Figure 5-65) or the area method (see Figure 5-66). A master plan for the site is prepared dividing the site into cells starting at the lowest elevation and the point furthest from the entrance. On sloped land the cells should follow the contour of the land.

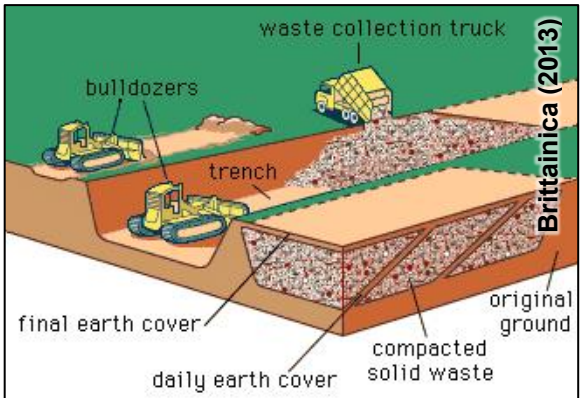

Figure 5-65 Trench method of landfilling

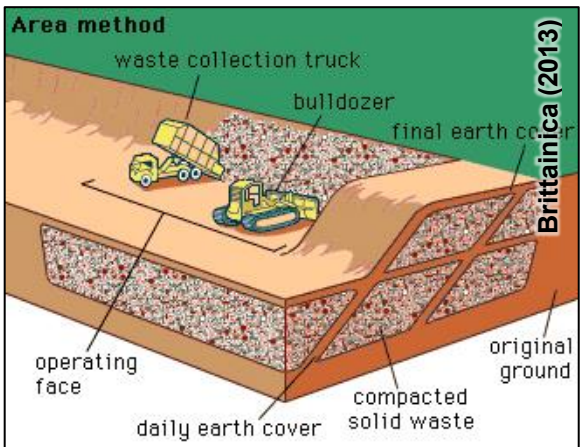

Figure 5-66 Area method of landfilling

117. The width of the cells depends upon the number of vehicles that are likely to offload their waste at the same time during peak operation In terms of management it is best to have the smallest operating face possible and even in large refugee settings it is unlikely that more than one waste collection vehicle will be arriving to offload wastes at any one time and so UNHCR and WASH actors should plan for a maximum cell width of 10m.

Figure 5-68 Dadaab Refugee Camp Landfill

118. During operation, wastes are tipped into the receiving pit and are scooped and bulldozed onto the landfill working face in successive layers of approximately 30cm. The

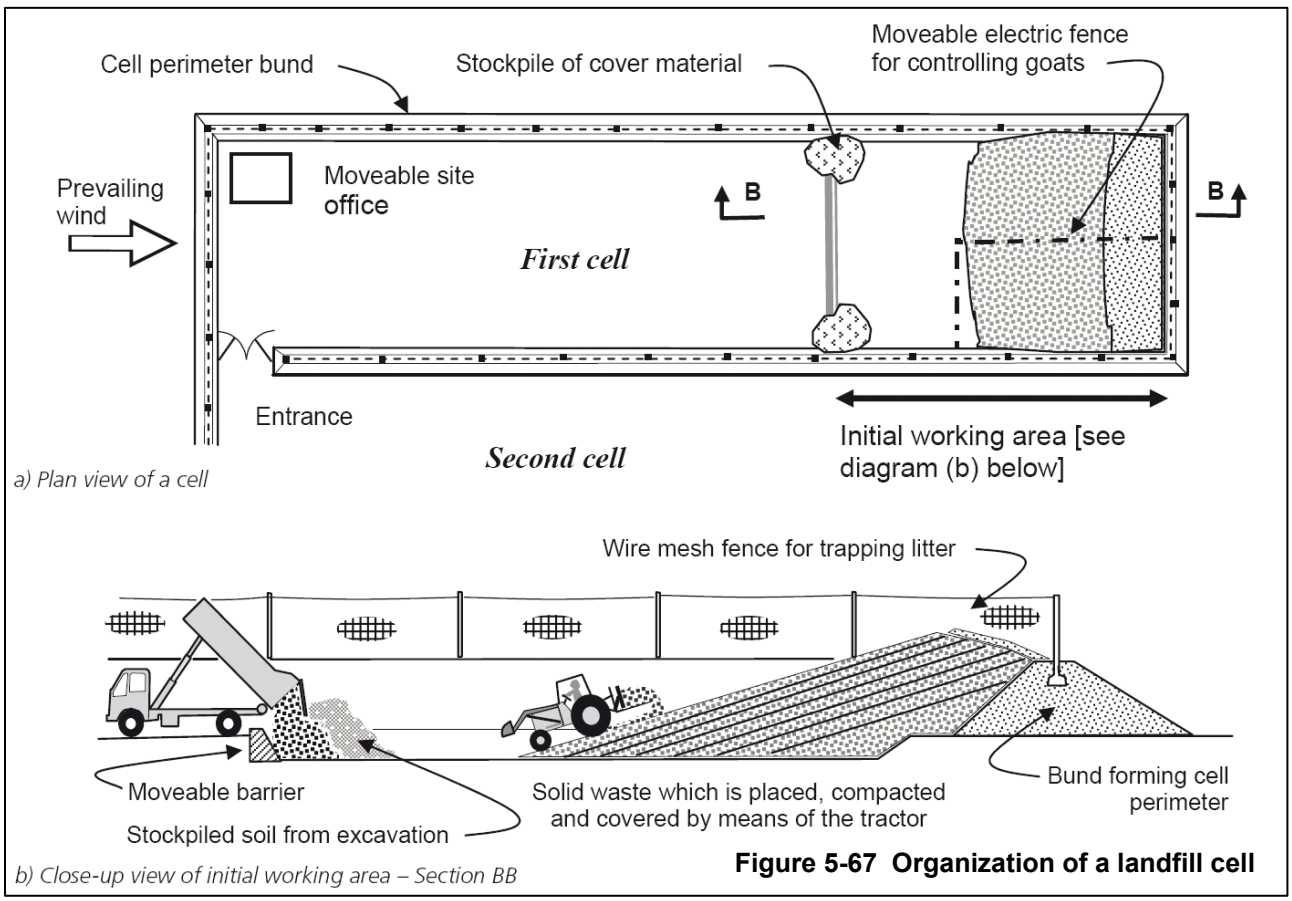

Figure 5-67 Organization of a landfill cell

slope of the working face is maintained at approximately 1:3 (greater slopes result in an undesirably large working face). As the earthmoving equipment moves backwards and forward the waste is compacted to over twice its original density. The cell is slowly built up to between 2m and 4m high. At the end of the working day, the working face is completely covered with a 0.3m layer of compacted soil to form a closed barrier. Only one cell should be in operation at any one time.

119. An important factor when managing the landfill is that there are sufficient quantities of daily soil cover material. Small landfills can require large quantities of soil cover material (see Figure 5-67) and UNHCR and WASH actors should plan for at least $1m^3$ of soil cover material for every $1m^3$ of waste that is deposited. The primary source for this cover soil is the waste cell itself. The cover soil should contain a high proportion of clay in order to prevent rainwater and surface water from entering the landfill and creating additional leachate. Finally, methane gas venting pipes should be installed to stop the build up of explosive gases under the cover soil.

Machinery required for preparing and managing a landfill

120. Heavy machinery is required for preparing cells, spreading waste material, compacting and levelling wastes, spreading soil cover material, constructing and maintaining access roads, and final capping of each cell after it is filled. The most cost-effective solution for a large refugee setting of up to 80,000 persons is to use a 75hp four-wheel drive tractor equipped with a wide front loader bucket, a rear digging bucket (backhoe), and a grader attachment. Several 6 ton capacity two-wheeled tipping trailers are also useful for moving large quantities of soil cover material. The site should have an enclosed garage, fuel storage and the cost of servicing and backup should be budgeted.

Figure 5-69 Tractor loader and backhoe

Managing a landfill

121. UNHCR and WASH actors should take every necessary step to ensure that unauthorized persons are prevented from accessing the waste site. The best way to achieve this is to work in a complementary way with waste scavengers (see **section 5.61**) to define where and how scavenging can take place and to ensure there is no waste with recoverable value in the final landfill material. All landfills should be properly fenced and guards may need to be contracted to ensure that scavenging does not take place.

122. In industrialized nations, it is possible to install sophisticated chemical, biological and physical (typically ultra-filtration) treatment processes to treat the leachates that are being produced in the

landfill. All of these measures are highly complex and are beyond the scope of most refugee settings. A much better approach is to ensure the following steps are taken to reduce leachate volumes and encourage natural biological decomposition processes. In all settings, UNHCR and WASH actors should ensure the following:

A) The site is properly sealed from groundwater resources by either a natural or artificial barrier.
B) All hazardous wastes are diverted from the landfill through screening or collection.
C) No rainwater, stormwater or surfacewater is allowed to enter the site through the application of daily soil cover and the use of diversion ditches.
D) Capped waste cells are planted with plants including grasses to encourage leachate reduction via evapotranspiration.

123. UNHCR and WASH actors should ensure that all landfills are equipped with at least three monitoring wells installed 10m, 20m and 50m in the direction of predominant groundwater flow. The water quality parameters in the box on the right hand side should be monitored once every 6 months.

124. UNHCR and WASH actors should ensure that accurate records are kept concerning the types and volumes of waste that are being disposed at the landfill. The simplest method to achieve this is to ensure that every vehicle is weighed and registered on a load cell as it enters the site.

Box: Water quality monitoring parameters for landfills

Parameter	Surface Water	Ground Water	Leachate
pH	X	X	X
Biochemical oxygen demand (BOD) (mg/l)	X	X	X
Chemical oxygen demand (COD) (mg/l)	X	X	X
Total iron (mg/l)	X	X	
Nitrates (mg/l)	X		X
Chlorides (mg/l)	X	X	X
Sulfates (mg/l)		X	X
Total colony count , (colonies/ml)	X	X	X
Conductivity, (µS/cm)			X
Total suspended solids	X		X
Heavy metal (Hg, Cd, Pb, Cr, e, Zn, Cu, i)			X

Jaramillo J. (2003) *'Guidelines for the design, construction and operation of manual sanitary landfills'.* Pan American Health Organization

Decommissioning a landfill

125. When each cell within the landfill has reached capacity and is due for decommissioning it should be completely capped with 0.5m of soil and landscaped back to its natural appearance. Plants, including grasses, may be planted into the final capping layer to stabilize the soil and reduce leachate quantities through evapotranspiration.

Waste incineration

126. Incineration is high-temperature combustion under controlled conditions. Modern high temperature incinerators, built within the last ten years, produce virtually no smoke, and completely


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neutralize any unsafe substances being burned. In addition, any heat that is produced can be turned into electricity which can be sold to offset some of the operational costs. Despite the success of modern incinerators, great care must be taken in refugee settings to ensure that the technology is appropriate. Wastes in refugee settings often have a higher density and a lower calorific value which may deem them unsuitable for incineration.

127. Any incineration that does not take place in a modern high temperature incinerator, for example the open burning of waste at a waste dump, is extremely dangerous to public health and can produce harmful or carcinogenic substances including dioxins. UNHCR and WASH actors must ensure that the burning of wastes does not take place under any circumstances.

Medical waste management in refugee settings

Medical waste segregation

128. In all settings, UNHCR and WASH actors must comply with WHO protocols to ensure that health-care wastes are segregated at the point of generation according to four categories:

- ☐ Sharps (needles, scalpels, etc.), which may be infectious or not
- ☐ Non-sharps infectious waste (anatomical waste, pathological waste, dressings, used syringes, used single-use gloves)
- ☐ Non-sharps non-infectious waste (paper, packaging, etc.)
- ☐ Hazardous waste (expired drugs, laboratory reagents, etc.).

Steps should be taken to ensure that waste is segregated and treated appropriately without risk to staff, patients or the public environment regardless of the emergency setting or type of health-care facility (temporary, permanent or mobile).

129. All healthcare waste should be collected in dedicated colour-coded and labelled containers according to its contents for safe handling. Colour-coding facilitates easy identification and segregation on the basis of waste hazard classification and suitability of treatment and disposal. Colour-coding also makes the segregation process understandable for low-skilled workers with limited literacy. It is essential that the adopted colour-coding system is used consistently throughout the health-care waste management chain (segregation, collection, storage, transport and disposal) to avoid confusion and mismanagement of the waste.

Management of sharps

130. Sharps should be placed immediately in yellow puncture-proof and covered safe sharps containers, which are regularly collected for disposal. Sharps are potentially the health-care waste item that represents the most acute potential hazard in a health-care facility. Hypodermic syringes should not be manipulated or dismantled after use and sharps boxes should be large enough so that hypodermic syringes can be inserted fully after use, complete with their needles. If puncture-

resistant containers are not available, the health-care facility may choose to adapt existing puncture-resistant containers, such as empty water, oil, or bleach bottles made from sturdy plastic. Waste containers for sharps should be available within easy arm's reach of all locations where these wastes are generated.

131. Sharps should be disposed of in a sharps pit (buried drums in small health centres or emergency structures; concrete-lined pits in other settings). In low-cost settings, burning with limited means is too complicated and too energy (fuel) consuming and it is recommended that sharps should be disposed of directly in a sharps pit. Off-site treatment in a centralised facility is not advisable for safety reasons but may be necessary in an urban area where onsite treatment is not feasible because of lack of space.

Figure 5-70 Sharps safety box

Management of non-sharp infectious medical wastes

132. Non-sharps infectious wastes should be placed immediately in yellow or red waste bags or containers (15–40-litre capacity, with lids). Containers should be collected, emptied, cleaned, disinfected and replaced after each intervention (e.g. each delivery in a maternity unit) or twice daily. Waste containers for non-sharp infectious wastes should be available within easy arm's reach of all locations where these wastes are generated.

133. Health-care waste containers should be collected frequently, not waiting until they become overflowing. When containers are collected, new or clean containers should be provided in return. Waste containers should be transported carefully to avoid spillage. Bags should be delicately handled by the neck, to prevent tearing and spillage. Any leakages or spills of medical waste should be cleared up according to infectious waste handling protocols for the clean-up of blood and other body fluids.

134. Non-sharps infectious waste should be buried on-site in a pit fitted with a sealed cover and ventilation pipe in small health-care facilities. Arrangements may be needed for disposing of placentas, according to local custom.

Figure 5-71 Unmanaged medical waste

Management of non-sharp non-infectious medical wastes

135. Non-sharps non-infectious black waste containers (20–60 litre capacity) should have fitting lids and should ideally be operated with a foot pedal to prevent contaminating hands. Waste containers should be lined with black coloured sacks and should be collected, emptied, cleaned and replaced daily. Temporary covered waste collection containers (e.g. buckets with covers, plastic drums etc.) may be used for the short-term in an emergency provided that they are durable, adequately labelled and sufficiently leak-proof to safely contain the waste from the point of creation to the point of disposal. It is recommended that there is at least one waste container in every room and at least one set of waste containers per 20 beds in a ward.

136. Non-sharps non-infectious waste should be buried in a pit or a landfill site. If space is limited, non-sharps non-infectious waste should be incinerated in a low-temperature incinerator (in emergency settings this may be a simple as an oil-drum type incinerator). Ashes and residues should be buried in a pit. Some wastes, such as pharmaceutical wastes, cannot be disposed of in low-cost settings and should be sent to a large centre for destruction or returned to the supplier. In all cases, national legislation should be followed.

Medical waste disposal sites

137. In some refugee settings it may be beneficial to establish a dedicated medical waste disposal zone at the health-care facility. If a waste-disposal zone is created, it should be situated at least 50m / 150ft (preferably downhill and downwind) from any buildings or public areas. The site should be fenced off and locked and all pits should be adequately locked and covered. The waste-disposal zone should have a water point with soap or detergent and disinfectant for handwashing or to clean and disinfect containers and tools, with facilities for wastewater disposal into a soakaway system or sewer. Ideally there should be a storage area where tools and containers can be dried and stored. The waste-disposal zone should also be located at least 30m / 90ft from groundwater sources with any pits at least 1.5m / 5ft above the groundwater table. Where an incinerator is used, it should be located to allow effective operation with minimal local air pollution in the health centre, nearby housing and crops, and it should be large enough for extension if new pits or other facilities have to be built. Surface water run-on should be managed so that no surface water enters the waste disposal zone area (this may require a surface water diversion canal).