D-Lab Waste

Fall ‘15

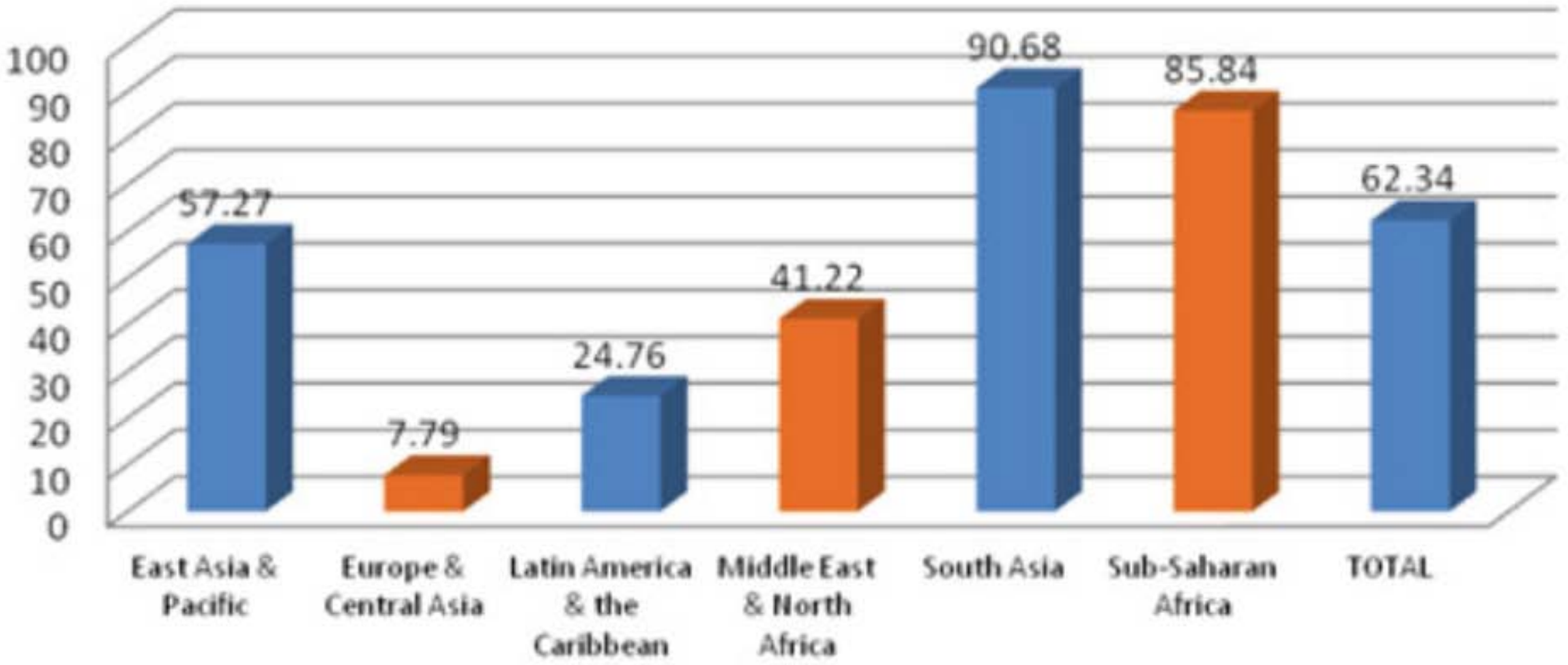
Massachusetts Institute of Technology

D-Lab

Landfilling wrap-up

- Challenges
- Technologies for development contexts
- Future

% of population in developing countries without access to minimum waste management service



Source: Mavropoulos, Antonis. "Wasted Health: The Tragic Case of Dumpsites." International Solid Waste Association. June 2015. Used with permission.

Source: ISWA, “The tragic case of dumpsites”

Materials in products

Q&A

What will happen with all trash on the landfill?

Does it need any additional chemical manipulations?

LFMR

Does recycled stuff go to landfills?

How many tons of trash Boston produces per day?

Materials Management Goals
2020 Goals:

1. Reduce solid waste disposal by 30 percent by 2020, from 6,550,000 tons of disposal in 2008 to 4,550,000 tons of disposal by 2020.
2. Continue to divert toxic substances from the solid waste stream.

Information Source: Massachusetts 2010-220 Solid Waste Master Plan

674 pounds per person

Information Source: Commonwealth Magazine, Winter 2015 Edition

How long does it take for that trash to disappear?

Glass Bottle.....	1 million years
Monofilament Fishing Line…	600 years
Plastic Beverage Bottles……	450 years
Disposable Diapers……	450 years
Aluminum Can.....	80-200 years
Foamed Plastic Buoy……	80 years
Foamed Plastic Cups……	50 years
Rubber-Boot Sole.....	50-80 years
Tin Cans……	50 years
Leather.....	50 years
Nylon Fabric.....	30-40 years
Plastic Film Container.....	20-30 years
Plastic Bag.....	10-20 years
Cigarette Butt.....	1-5 years
Wool Sock.....	1-5 years
Plywood……..	1-3 years
Waxed Milk Carton……	3 months
Apple Core……..	2 months
Newspaper……..	6 weeks
Orange or Banana Peel.....	2-5 weeks
Paper Towel……..	2-4 weeks

Information Source: U.S. National Park Service; Mote Marine Lab, Sarasota, FL.

How to get recycling bins in the Cambridge/Boston area?

Who is responsible for the recycling process in US?

Responsibilities:

- EPA (federal)
- State governments
- Local governments

Recycling Pickup:

- **Boston Public Works**
- **Cambridge Department of Public Works**

Recycling Processing:

- **Casella Recycling**
- **Save That Stuff, Inc.**
- **Waste Management**

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Courtesy of Jordon Cooper on Flickr. CC BY-NC-SA.

Waste

United Nations Environment Program
According to the Basel Convention:

"'*Wastes' are substances or objects, which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law*"

United Nations Statistics Division, Glossary of Environment Statistics:

"Wastes are materials that are not prime products (that is products produced for the market) for which the initial user has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose. Wastes may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities. Residuals recycled or reused at the place of generation are excluded."

European Union under the Waste Framework Directive:

"an object the holder discards, intends to discard or is required to discard."

What do **YOU** consider waste?

How much waste do you think you produce in a week?

Waste ≠ Solid Waste ≠ MSW (Municipal Solid Waste)

OECD:

Municipal waste is collected and treated by, or for municipalities. It covers waste from households, including bulky waste, similar waste from commerce and trade, office buildings, institutions and small businesses, yard and garden, street sweepings, contents of litter containers, and market cleansing. Waste from municipal sewage networks and treatment, as well as municipal construction and demolition is excluded.

PAHO:

Solid or semi-solid waste generated in population centers including domestic and, commercial wastes, as well as those originated by the small-scale industries and institutions (including hospital and clinics); market street sweeping, and from public cleansing.

IPCC:

The IPCC includes the following in MSW: food waste; garden (yard) and park waste; paper and cardboard; wood; textiles; nappies (disposable diapers); rubber and leather; plastics; metal; glass (and pottery and china); and other (e.g., ash, dirt, dust, soil, electronic waste).

MSW in the US

Figure 5. Total MSW Generation (by material), 2013
254 Million Tons (before recycling)

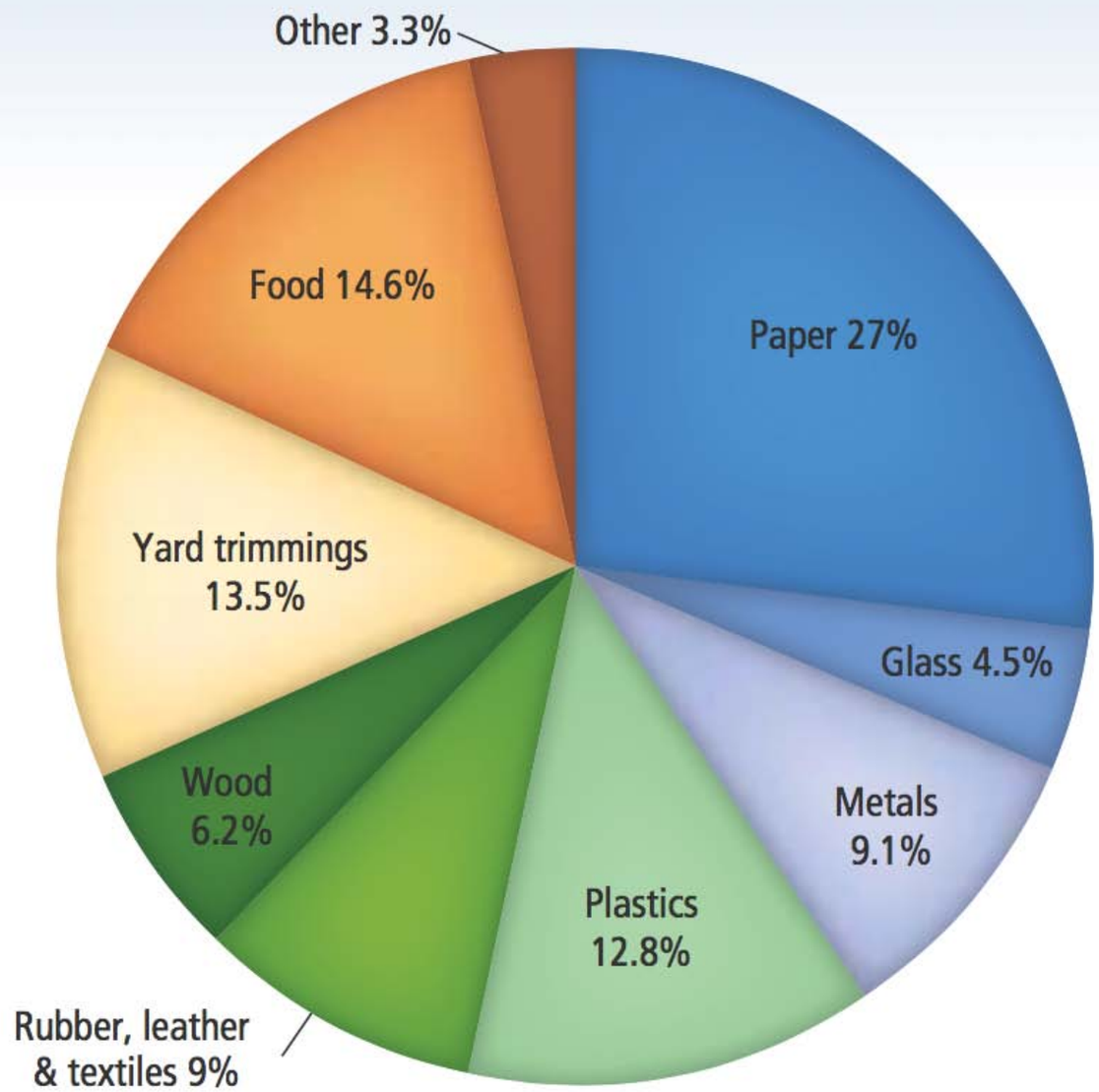
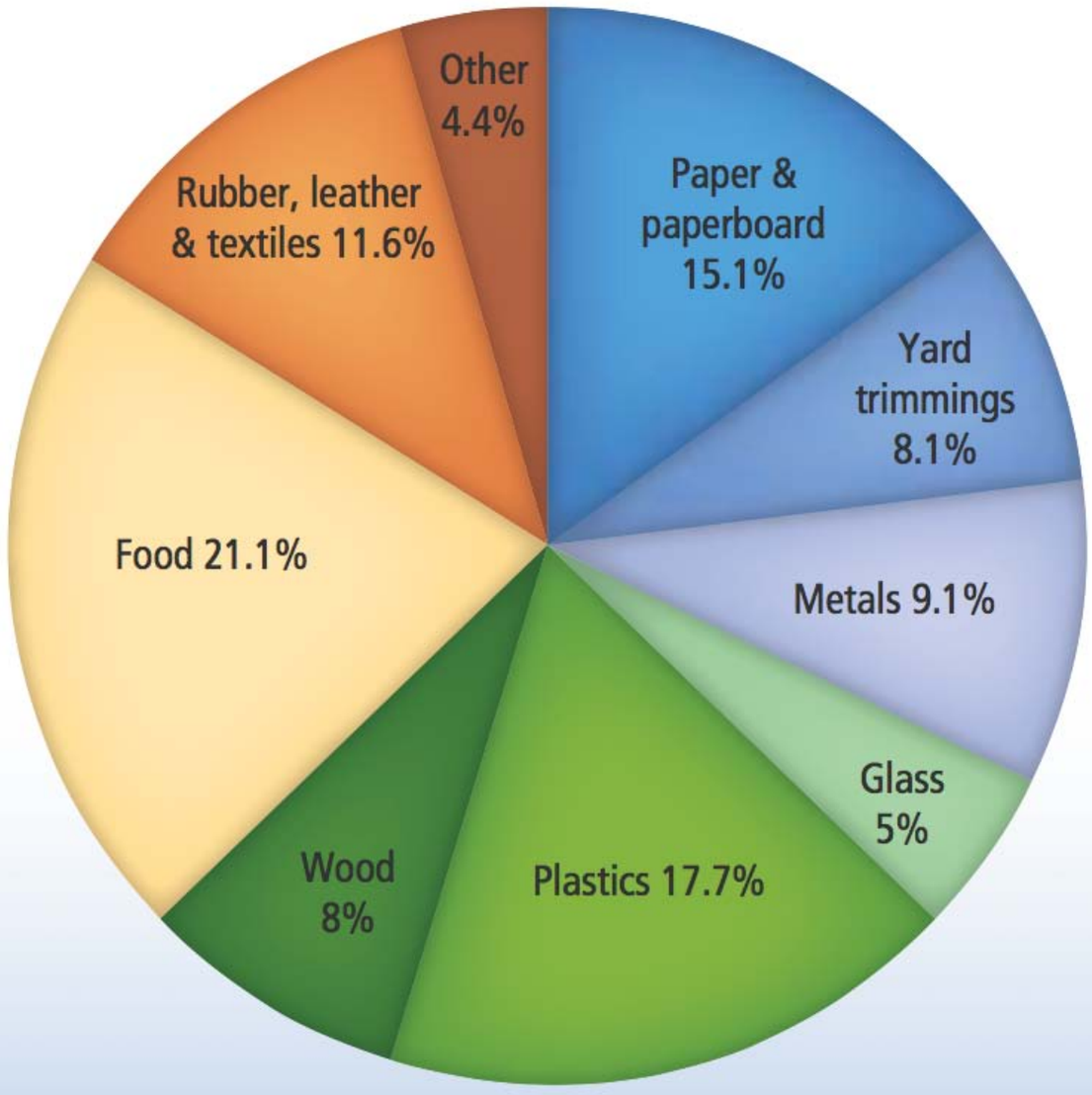


Figure 7. Total MSW Discards (by material), 2013
167 Million Tons (after recycling and composting)



Source: EPA's Advancing Sustainable Materials Management, 2013 report

Source: EPA's Advancing Sustainable Materials Management, 2013 report

Table 2. Generation, Recovery and Discards of Products in MSW, 2013*
(in millions of tons and percent of generation of each product)

Products	Weight Generated	Weight Recovered	Recovery as Percent of Generation	Weight Discarded
Durable goods				
Steel	15.15	4.06	26.8%	11.09
Aluminum	1.51	Not Available	Not Available	1.51
Other non-ferrous metals†	2.01	1.37	68.2%	0.64
Glass	2.28	Negligible	Negligible	2.28
Plastics	12.07	0.83	6.9%	11.24
Rubber and leather	6.66	1.24	18.6%	5.42
Wood	6.31	Negligible	Negligible	6.31
Textiles	3.86	0.47	12.2%	3.39
Other materials	1.70	1.31	77.5%	0.39
Total durable goods	51.55	9.28	18.0%	42.27
Nondurable goods				
Paper and paperboard	30.03	14.45	48.1%	15.58
Plastics	6.47	0.13	2.0%	6.34
Rubber and leather	1.06	Negligible	Negligible	1.06
Textiles	10.96	1.83	16.7%	9.13
Other materials	3.08	Negligible	Negligible	3.08
Total nondurable goods	51.60	16.41	31.8%	35.19
Containers and packaging				
Steel	2.40	1.74	72.5%	0.66
Aluminum	1.80	0.70	38.9%	1.10
Glass	9.26	3.15	34.0%	6.11
Paper and paperboard	38.56	28.95	75.1%	9.61
Plastics	13.98	2.04	14.6%	11.94
Wood	9.46	2.47	26.1%	6.99
Other materials	0.31	Negligible	Negligible	0.31
Total containers and packaging	**75.77**	**39.05**	**51.5%**	**36.72**
Other wastes				
Food, other‡	37.06	1.84	5.0%	35.22
Yard trimmings	34.20	20.60	60.2%	13.60
Miscellaneous inorganic wastes	3.93	Negligible	Negligible	3.93
Total other wastes	75.19	22.44	29.8%	52.75
Total municipal solid waste	**254.11**	**87.18**	**34.3%**	**166.93**

What about the rest of the stuff?

What are the limits?

Making sense of waste numbers

a fun non-depressing game on waste limits

Amount of oil spilled in open water every year in the US

1.3 million gallons

http://www.livescience.com/9885-faq-science-history-oil-spills.html

Comparisons as volume:

≈ (0.0047 ≈ 1/211) × volume of the Empire State Building ($\approx 1.04 \times 10^6\ m^3$)

≈ (0.084 ≈ 1/12) ×
volume of steel used in the construction of the Three Gorges Dam ($\approx 58\,900\ m^3$)

≈ 2 × minimum volume of an Olympic-sized swimming pool ($2500\ m^3$)

Biggest landfill in the US by tons in place

Puente Hills 123M tons

http://www.theguardian.com/global-development/ng-interactive/2014/oct/06/world-biggest-most-dangerous-dump-sites-interactive

Comparisons:

≈ (0.027 ≈ 1/37) × world oil production mass in 2004 ($\approx 4.15 \times 10^{12}$ kg)

≈ 0.26 × mass of all humans alive ($\approx 9.3 \times 10^{11}$ lb)

≈ 0.52 × yearly mass of trash produced in the United States ($\approx 2.36 \times 10^{8}$ sh tn)

Pacific garbage patch

http://education.nationalgeographic.com/encyclopedia/great-pacific-garbage-patch/

MSW produced in the world in a year

2 billion tons

http://www.atlas.d-waste.com/

Comparisons:

≈ (0.02 ≈ 1/44) × total biomass on Earth ($\approx 8 \times 10^{13}$ kg)

≈ (0.2 ≈ 1/6) × total mass of gold in the oceans ($\approx 1 \times 10^{16}$ g)

≈ 0.44 × world oil production mass in 2004 ($\approx 4.15 \times 10^{12}$ kg)

Amount of plastic in the ocean per year

8.8 Million tons

http://www.iswa.org/fileadmin/user_upload/Calendar_2011_03_AMERICANA/Science-2015-Jambeck-768-71__2_.pdf

Comparisons:

- ≈ (0.037 ≈ 1/27) × yearly mass of trash produced in the United States ($\approx 2.36 \times 10^8$ sh tn)
- ≈ 1.3 × mass of the Great Pyramid of Giza ($\approx 6 \times 10^9$ kg)
- ≈ 1.9 × mass converted to energy by the sun in one second ($\approx 4.3 \times 10^9$ kg)

Amount of nuclear waste every year

75,000 tons

http://www.world-nuclear.org/info/Nuclear-Fuel-Cycle/Nuclear-Wastes/Radioactive-Waste-Management/

Comparisons:

- ≈ 0.45 × total mass of gold ever mined (≈ 1.5×10^{11} g)
- ≈ (0.6 to 0.9) × mass of an Aframax oil tanker (75 000 to 110 000 lg tn)
- ≈ 1.3 × mass of the Titanic (52 310 lg tn)

Amount of debris objects in space

500,000 pieces

http://www.nasa.gov/mission_pages/station/news/orbital_debris.html

Comparisons:

≈ 0.86 × current population of Macao (578 800 people)

≈ number of people who attended the Woodstock Music & Art Fair (≈ 500 000 people)

Amount of e-waste in the US per year

1’790 Million

http://www.electronicstakeback.com/wp-content/uploads/Facts_and_Figures_on_EWaste_and_Recycling.pdf

Comparisons:

- ≈ 0.26 × number of passenger cars in use in the Netherlands (≈ 7 million vehicles)
- ≈ 0.43 × number of passenger cars in use in Austria (≈ 4.2 million vehicles)
- ≈ 1.2 × number of passenger cars in use in Ireland (≈ 1.5 million vehicles)

Amount of human waste in a lifetime (~77y)

17,873 tons

http://www.greencontributor.com/index.php/human-foot-print.html

Comparisons:

- ≈ (0.4 to 0.5) × mass of a Handy size cargo ship (28 000 to 40 000 lg tn)
- ≈ (0.5 to 0.8) × mass of a Small Handy size cargo ship (20 000 to 28 000 lg tn)
- ≈ 1.4 × daily mass of trash produced in New York City ($\approx 1.2 \times 10^7$ kg)

Amount of C&D waste generated in the US per year

136 Million tons

(http://www.epa.gov/wastes/nonhaz/industrial/cd/basic.htm

Comparisons:

- ≈ (0.03 ≈ 1/34) × world oil production mass in 2004 ($\approx 4.15 \times 10^{12}$ kg)
- ≈ 0.29 × mass of all humans alive ($\approx 9.3 \times 10^{11}$ lb)
- ≈ 0.58 × yearly mass of trash produced in the United States ($\approx 2.36 \times 10^{8}$ sh tn)

How are folks all around the world handling these limits?

Source: "What a Waste : A Global Review of Solid Waste Management."

Comparison of Solid Waste Management Practices by Income Level (adapted from *What a Waste 1999*)

Activity	Low Income	Middle Income	High Income
Source Reduction	No organized programs, but reuse and low per capita waste generation rates are common.	Some discussion of source reduction, but rarely incorporated into an organized program.	Organized education programs emphasize the three 'R's' – reduce, reuse, and recycle. More producer responsibility & focus on product design.
Collection	Sporadic and inefficient. Service is limited to high visibility areas, the wealthy, and businesses willing to pay. High fraction of inerts and compostables impact collection–overall collection below 50%.	Improved service and increased collection from residential areas. Larger vehicle fleet and more mechanization. Collection rate varies between 50 to 80%. Transfer stations are slowly incorporated into the SWM system.	Collection rate greater than 90%. Compactor trucks and highly mechanized vehicles and transfer stations are common. Waste volume a key consideration. Aging collection workers often a consideration in system design.
Recycling	Although most recycling is through the informal sector and waste picking, recycling rates tend to be high both for local markets and for international markets and imports of materials for recycling, including hazardous goods such as e-waste and ship-breaking. Recycling markets are unregulated and include a number of 'middlemen'. Large price fluctuations.	Informal sector still involved; some high technology sorting and processing facilities. Recycling rates are still relatively high. Materials are often imported for recycling. Recycling markets are somewhat more regulated. Material prices fluctuate considerably.	Recyclable material collection services and high technology sorting and processing facilities are common and regulated. Increasing attention towards long-term markets. Overall recycling rates higher than low and middle income. Informal recycling still exists (e.g. aluminum can collection.) Extended product responsibility common.
Composting	Rarely undertaken formally even though the waste stream has a high percentage of organic material. Markets for, and awareness of, compost lacking.	Large composting plants are often unsuccessful due to contamination and operating costs (little waste separation); some small-scale composting projects at the community/ neighborhood level are more sustainable. Composting eligible for CDM projects but is not widespread. Increasing use of anaerobic digestion.	Becoming more popular at both backyard and large-scale facilities. Waste stream has a smaller portion of compostables than low- and middle-income countries. More source segregation makes composting easier. Anaerobic digestion increasing in popularity. Odor control critical.
Incineration	Not common, and generally not successful because of high capital, technical, and operation costs, high moisture content in the waste, and high percentage of inerts.	Some incinerators are used, but experiencing financial and operational difficulties. Air pollution control equipment is not advanced and often by-passed. Little or no stack emissions monitoring. Governments include incineration as a possible waste disposal option but costs prohibitive. Facilities often driven by subsidies from OECD countries on behalf of equipment suppliers.	Prevalent in areas with high land costs and low availability of land (e.g., islands). Most incinerators have some form of environmental controls and some type of energy recovery system. Governments regulate and monitor emissions. About three (or more) times the cost of landfilling per tonne.
Landfilling/ Dumping	Low-technology sites usually open dumping of wastes. High polluting to nearby aquifers, water bodies, settlements. Often receive medical waste. Waste regularly burned. Significant health impacts on local residents and workers.	Some controlled and sanitary landfills with some environmental controls. Open dumping is still common. CDM projects for landfill gas are more common.	Sanitary landfills with a combination of liners, leak detection, leachate collection systems, and gas collection and treatment systems. Often problematic to open new landfills due to concerns of neighboring residents. Post closure use of sites increasingly important, e.g. golf courses and parks.
Costs (see Annex E)	Collection costs represent 80 to 90% of the municipal solid waste management budget. Waste fees are regulated by some local governments, but the fee collection system is inefficient. Only a small proportion of budget is allocated toward disposal.	Collection costs represent 50% to 80% of the municipal solid waste management budget. Waste fees are regulated by some local and national governments, more innovation in fee collection, e.g. included in electricity or water bills. Expenditures on more mechanized collection fleets and disposal are higher than in low-income countries.	Collection costs can represent less than 10% of the budget. Large budget allocations to intermediate waste treatment facilities. Up front community participation reduces costs and increases options available to waste planners (e.g., recycling and composting).

EC.716 / EC.786 D-Lab: Waste
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