Environmental hygiene II.
Only 3% of the world’s water supply is freshwater, two-thirds of that frozen, forming the polar ice caps, glaciers, and icebergs.
Distribution of Earth's Water

Total global water
- Oceans: 96.5%
- Saline groundwater: 0.93%
- Saline lakes: 0.07%

Freshwater
- Freshwater: 2.5%
- Groundwater: 30.1%
  - Glaciers and ice caps: 68.6%
- Surface water and other freshwater: 1.3%

Surface water and other freshwater
- Lakes: 20.1%
- Ice and snow: 73.1%
- Atmospheric water: 0.22%
- Biological water: 0.22%
- Rivers: 0.46%
- Swamps and marshes: 2.53%
- Soil moisture: 3.52%

Personal biological requirement: 2-3 l/person/day

Water used in developed countries: 100-150 l/person/day
**Water consumption in the household**

Physiological need of drinking water: 2-3 l/person/day
(~temperature, wind, humidity, type of work)

Source: EPA [http://water.epa.gov/drink](http://water.epa.gov/drink)
Survivors receive packets of drinking water at a relief camp (in the southern Indian city of Madras Dec. 28, 2004.)

Children in a refugee camp (Iraq, 2006)
Pakistani villagers pull drinking water from a 122-meter (400-foot) well.
Collecting water is usually the job of women.
Water your yard and outdoor plants early or late in the day to reduce evaporation.

Use a shut-off nozzle on your hose.

Use plants that require less water.

Use a low flow showerhead.

Get an Energy Star labeled washing machine.

Wash only full loads.

Turn off the water while soaping hands and brushing teeth.

Turn off sink faucet while scrubbing dishes and pots.

Install new toilets that use less than 1.6 gallons per flush.

Put faucet aerators on sink faucets.

Use a broom, not a hose, to clean driveways and walkways.
SAVE WATER ... IN THE HOME

SAVE WATER ... IN THE GARDEN

DEPARTMENT OF WATER AND FORESTRY
Quality requirements of drinking water

• Free of harmful chemical and biological agents
• Should contain minerals
• Cool, refreshing, at the temperature of 12 °C
• Clean, odourless, normal taste
• Cheap, accessible in large amount
Water in nature

Source: EPA [http://water.epa.gov/drink](http://water.epa.gov/drink)
Water sources I.

Source: EPA [http://water.epa.gov/drink](http://water.epa.gov/drink)
Water sources II.

- unconfined aquifer
- confined aquifer
- impermeable bedrock
- potentiometric surface of confined aquifer
- water table
- water table well
- non-flowing artesian well
- flowing artesian well
- unconfined aquifer or water table aquifer
- confining unit (bed)
- confined aquifer

Source: EPA [http://water.epa.gov/drink](http://water.epa.gov/drink)
Bank filtration
Water quality is the physical, chemical and biological characteristics of water.

Water's physical (physical chemistry) examination is include acidity, electrical conductivity, temperature.

Water's chemical examination >>>>

Water’s microbiological examination>>>>

Biological water examination>>>
# Common water constituents and their limit values in drinking water

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Limit</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>10</td>
<td>µg/l</td>
</tr>
<tr>
<td>Cadmium</td>
<td>5,0</td>
<td>µg/l</td>
</tr>
<tr>
<td>Fluoride</td>
<td>1,5</td>
<td>mg/l</td>
</tr>
<tr>
<td>Lead</td>
<td>10</td>
<td>µg/l</td>
</tr>
<tr>
<td>Mercury</td>
<td>1,0</td>
<td>µg/l</td>
</tr>
<tr>
<td>Nitrates</td>
<td>50</td>
<td>mg/l</td>
</tr>
<tr>
<td>Nitrites</td>
<td>0,50</td>
<td>mg/l</td>
</tr>
<tr>
<td>Total trihalomethanes</td>
<td>50</td>
<td>µg/l</td>
</tr>
</tbody>
</table>
Selected water constituents and their effects on human health

- **Nitrates**: high levels may cause methemoglobinemia in infants

- **Fluoride**: low levels increase risk of caries, high levels cause fluorosis, with disorders of enamel formation and renal damage, narrow beneficial concentration range (~1-1.5 mg/l)

- **Arsenic**: may occur as a natural, geological contaminant of drinking water (as in some regions of the Hungarian Great Plains), toxic to several organ systems (arsenosis) and carcinogenic on chronic exposure

- **Chlorination by-products (trihalomethanes - THMs)**: cause unpleasant taste and odor, chronic exposure can cause kidney and liver damage and cancers

- **Iodine**: usually low in drinking water at high altitudes, low concentrations can increase incidence of goitre (hypothyroidism)

- **Calcium-oxide (CaO)**: concentration determines water hardness, „soft” water is associated with increased rates of cardiovascular disease, while hard water with increased rates of gall-, and kidney-stones.
Sources of Nitrate in Our Groundwater:

- Fertilizer
- Manure
- Waste Water Application
- Septic Systems
- Decaying Organic Matter
- Natural
„Blue baby”

Nitrite and nitrate

• Lack of pipelines, technological problems or excessive fertilizer usage may lead to this problem

• Nitrite causes methaemoglobinaemia especially in small babies („blue baby”).

• Reasons: undeveloped gastrointestinal bacterial colonisation, immature kidney, F-hemoglobin.

• Boiling the water does not eliminate the chemicals.

• Limit: nitrate: 50 mg/l, nitrite: 0,5 mg/l (0,1 mg / l if the water comes from pipelines).
Arsenic poisoning can lead to skin cancer and excessive growth of keratin on the feet

Arsenic contaminates millions of people's drinking water in West Bengal and Bangladesh
Countries with endemic fluorosis due to excess fluoride in drinking water
Water’s microbiological examination

Total bacterial count in 1 ml water (incubated at 22°C and 37°C for 24 hours).

Typically three indicator bacteria are chosen: coliforms, Escherichia coli and Pseudomonas aeruginosa.

If is needed infectious agents’ present also investigated.
Coliform bacteria are common in the environment and are generally not harmful. However, the presence of these bacteria in drinking water is usually a result of a problem with the treatment system or the pipes which distribute water, and indicates that the water may be contaminated with germs that can cause disease.

Fecal Coliform and E. coli are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes can cause short-term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms.
• **Water-borne diseases**: oral-fecal diseases transmitted through ingestion of contaminated water (cholera, typhoid fever, amebiasis)

• **Water-washed diseases**: usually oral-fecal or contact diseases resulting from inadequate personal hygiene due to lack of water (salmonellosis, amebiasis, hepatitis A and E)

• **Water-based diseases**: the pathogen spends a part of its life-cycle in water and infection occurs through ingestion or contact (schistosomiasis, dracunculiasis)

• **Water-related vector-borne diseases**: the life-cycle of a primary arthropod vector of the pathogen is connected to water (malaria, dengue, filariasis, yellow fever)

• **Water-dispersed diseases**: pathogen lives and reproduces in water and transmission occurs by dispersion of contaminated water droplets into the air and subsequent inhalation (legionellosis)
Dracunculiasis (Guinea-worm infection)
(Example for water-based diseases)
This Nigerian woman is gathering water from a local pond, which is used as a source of drinking water. But because of a Guinea worm larvae infestation, this water must be filtered to remove the water fleas that carry the parasitic larvae of the Guinea worm.

**Dracunculiasis**
(Guinea worm infection)

People swallow the infected copepods and...
Some infectious agents transmitted by water also
An example of water-borne disease

- June 2-3. **Heavy rainfall** in the geographical area
- Public health authorities: **compulsory report** of gastroenteritisinal patients, recommendation of **boiling the water before consumption**; **supply of safe drinking water**
- 3614 patients detected with diarrhea, 179 hospitalized
- Lab tests confirmed Calici virus in 20 cases, Campylobacter in 75 cases
- Data evaluation of 459 patients on next slide
Gastroenteritis esetek száma a megbetegedés kezdete szerint, Miskolc, 2006. június (N = 459)

Az exponzició feltételezett időszaka

- kikérdezett esetek

A megbetegedés dátuma (hónap/nap)
Biological water examination

Diatoms (microscopic algae)
When to have your local water-supply tested

✓ **Test annually for coliform bacteria and nitrates.** Dug (shallow) wells are particularly vulnerable to bacterial contamination, while other types of wells with no history of problems may not need testing as often. Test for sodium, sulfates, iron, manganese, and lead every three years unless you have had recent problems with any of these contaminants.

✓ **If you suspect contamination or** if you know that potential pollution sources (farms, landfills, toxic disposal sites, etc.) are located in the vicinity of your well, you should have your water tested more frequently (i.e., twice a year).

✓ **If the taste, odor, or color of your water changes, or** if your family experiences recurrent, unexplained gastrointestinal illnesses, have your water tested.

✓ Have the water supply tested **before purchasing a new home, or** after you have done any construction or remodeling on your home.

✓ **A total coliform bacteria test is recommended after you have replaced old pipes or installed a new well or pump.** Total coliform is an indicator of septic system problems and poor well construction.

✓ **Testing for nitrates is recommended in the early months of pregnancy and again after the baby is born.**

✓ **If your well is located near industrial sites, your water should be tested for toxic metals** such as lead, mercury, arsenic, and nickel. Unless you suspect that your water is contaminated, routine annual testing for these metals may not be practical since the tests are expensive.

Source: EPA [http://water.epa.gov/drink](http://water.epa.gov/drink)
Solar Bottle: works with the sun to allow UV-A radiation and increased temperature to destroy pathogenic organisms in drinking water (Swiss product)
Chemical, biological and physical pollution

- **Inorganic chemical compounds**: heavy metals, mercury, lead, nickel, cyanide (pl. a Tisza 2000. évi, Romániából érkező szennyezése)

- **Organic chemical compounds**: oil, detergents, fertilizers, pesticides

- **Physical pollution**: radiating materials, heat pollution

- **Biological pollution**
Pollution of river Tisza in 2000.

- 2000. January 30th. Baia Mare – 1000 m³ cianide
- 2000. March 10. Heavy metals (Cu, Zn, Pb)
- 2000. March 27. Lead pollution
Rew sewage and industrial waste flows into the U.S. from Mexico as New River passes to California.
This particular beach is located just south of the Tijuana river outlet and north of the Mexican Border.
China: in 278 towns there is no any kind of sewage treatment (it mean more than half of the Chinese population)
Wastewater treatment plant

- **Mechanical cleaning** (filtration of solid components, settling)
- **Biological cleansing**
- **Chemical cleansing**
The basic processes involved in sewage treatment

**Primary treatment**
- Screens
- Grit chamber
- Sedimentation tank

**Secondary treatment**
- Aeration tank
- Return Activated biosolids
- Waste Biosolids

**Post-treatment processes**
- Disinfection (chlorine, ozone, UV etc..)
- Dechlorination...
- Potable water

Source: EPA – How wastewater treatment works: The basics
http://water.epa.gov/drink
Secondary Sewage Treatment

Screen for debris removal

Raw sewage from sewer system

Primary Sedimentation Tank

Primary Sedimentation Tank

Aeration Tank

Air Pump

Activated Sludge

Secondary Sedimentation Tank

Some sludge is returned to provide bacteria to aeration tank. Remainder is further decomposed by bacteria in digester.

Sludge Digester

Sludge dumped into ocean or burned or used for landfill or injected into deepwells or used for fertilizer

Chlorinator

To Natural Waters
Natural wastewater management techniques

• Wetland
• Constructed pond
• Reed bed
• Combination of the above
Watering vegetables with domestic water in South Africa.
Water, Soil, Waste & Sewage

Solid waste & sewage

Soil

Waters
Soil hygiene, waste problems

- Air 25%
- Water 25%
- Mineral Particles 45%
- Organic Matter 5%
  - Organisms 10%
  - Roots 10%
  - Humus 80%

Related images:
- Garbage landfill
- Human digestive system
- Gas production from composting
Dr Muffadal Ezzi, senior research scientist tests soil for pollution using the innovative Safe Soil Tester™ (United Kingdom)
Sources of pollution

Human waste

• *Municipal solid waste*: trash/garbage from streets and households  (Hungary: $3 \times 10^6$ t / year)

• *Agricultural and industrial non-hazardous waste*  
  (Hungary: $90 \times 10^6$ t / year)

• *Hazardous waste*: chemical, mechanical & food industries, health care services  (Hungary: $2 \times 10^6$ t / year)
• **Inorganic pollutants**

• **Organic pollutants:** (detergents, pesticides, fossil fuels, phenol… etc.)

• **Radioactive pollutants** (radon)

• **Microbial agents:** fungi, helminthic ova (playgrounds!), bacteria (S. typhi), spores (Cl. tetani), protozoans

**Spores and helminthic ova in the soil may remain infective for years!**
## Inorganic pollution

<table>
<thead>
<tr>
<th>Contaminants</th>
<th>Agricultural</th>
<th>Residential</th>
<th>Industrial</th>
<th>Natural</th>
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<tbody>
<tr>
<td>Antimony</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Arsenic</td>
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<td></td>
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</tr>
<tr>
<td>Asbestos</td>
<td></td>
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</tr>
<tr>
<td>Barium</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Beryllium</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Cadmium</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Chromium</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Copper</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cyanide</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Fluoride</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Lead</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Mercury</td>
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<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Nickel</td>
<td></td>
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</tr>
<tr>
<td>Nitrate</td>
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<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Nitrite</td>
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</tr>
<tr>
<td>Selenium</td>
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</tr>
<tr>
<td>Thallium</td>
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</tr>
<tr>
<td>Chlorine</td>
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</tr>
<tr>
<td>Iron</td>
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<tr>
<td>Manganese</td>
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<tr>
<td>Silver</td>
<td></td>
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</tr>
<tr>
<td>Sodium</td>
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<tr>
<td>Sulfate</td>
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</tr>
<tr>
<td>Zinc</td>
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<td></td>
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</table>

Source: EPA [http://epa.gov](http://epa.gov)
## Organic pollution I.

<table>
<thead>
<tr>
<th>Contaminants</th>
<th>Agricultural</th>
<th>Residential</th>
<th>Industrial</th>
<th>Natural</th>
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</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>✔</td>
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<tr>
<td>Cis-1,2-Dichloroethylene</td>
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<tr>
<td>1,2-Dichloroethane</td>
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<tr>
<td>1,1-Dichloroethylene</td>
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<td>Dichloromethane</td>
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<td>Tetrachloroethylene</td>
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<tr>
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<tr>
<td>Trichloroethylene</td>
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<tr>
<td>Vinyl Chloride</td>
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</tbody>
</table>

- **POP** indicates persistent organic pollutants.

### Examples of POP Contaminants

- Carbofuran
- Chlordane
- Dioxin
- Heptachlor

<table>
<thead>
<tr>
<th>Contaminants</th>
<th>Agricultural</th>
<th>Residential</th>
<th>Industrial</th>
<th>Natural</th>
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<td>Alachlor</td>
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<td>Atrazine</td>
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<tr>
<td>Benzo(a)pyrene</td>
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<tr>
<td>Dalapon</td>
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<tr>
<td>Dibromochloropropane (DBCP)</td>
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<tr>
<td>2,4-Dichlorophenoxyacetic</td>
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</tr>
<tr>
<td>Acid</td>
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<tr>
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<td>2,3,7,8-TCDD (Dioxin)</td>
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<tr>
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<tr>
<td>Heptachlor Epoxide</td>
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### Organic and other pollution

<table>
<thead>
<tr>
<th>Contaminants</th>
<th>Agricultural</th>
<th>Residential</th>
<th>Industrial</th>
<th>Natural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hexachlorobenzene</td>
<td>✔</td>
<td></td>
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</tr>
<tr>
<td>Hexachlorocyclo-Pentadiene</td>
<td>✔</td>
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<tr>
<td>Lindane</td>
<td>✔</td>
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<td></td>
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<tr>
<td>Methoxychlor</td>
<td>✔</td>
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<tr>
<td>Oxynyl(vydate)</td>
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<tr>
<td>Pentachlorophenol</td>
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<td>Pcloran</td>
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<tr>
<td>Polychlorinated Biphenyls (PCBs)</td>
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<tr>
<td>Simazine</td>
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<td></td>
</tr>
<tr>
<td>Silvex 2,4,5-TP</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxaphene</td>
<td>✔</td>
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### Table of Contaminants

<table>
<thead>
<tr>
<th>Contaminants</th>
<th>Agricultural</th>
<th>Residential</th>
<th>Industrial</th>
<th>Natural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkalinity</td>
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<td>Detergents</td>
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<td>Coliform Bacteria</td>
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<tr>
<td>Erosion and Sedimentation</td>
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<td>Hardness</td>
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<td>Radium</td>
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<tr>
<td>Total Dissolved Solids (TDS)</td>
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</tbody>
</table>

Source: EPA [http://epa.gov](http://epa.gov)

**POP** = Members of the „Dirty dozen” of Persistent Organic Pollutants banned internationally at the Stockholm Convention of 2001 (Not listed are: Aldrin, Dieldrin, DDT, Mirex)
Persistent Organic Pollutants (POPs) are chemical substances that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment.

POP = Members of the „Dirty dozen” of Persistent Organic Pollutants banned internationally at the Stockholm Convention of 2001. Co-signatories agree to outlaw nine of the dirty dozen chemicals, limit the use of DDT to malaria control, and curtail inadvertent production of dioxins and furans.
The „Dirty Dozen“:

1. Aldrin (insecticide)
2. Chlordane (insecticide)
3. DDT (dichloro-diphenyl-trichloroethane) (disease vector control)
4. Dieldrin (agricultural operation)
5. Endrin
6. Heptachlor (termiticide)
7. HBC (hexachlorobenzene) (solvent for pesticides)
8. Mirex (termiticide)
9. Toxaphene
10. PCBs (polychlorinated biphenyls)
11. Dioxins (polychlorinated-dibentox-p-dioxins)
12. Furans (polychlorinated-dibenzo-furans)
UNEP (UN Environmental Programme) Adds to „Dirty Dozen” List in 2009):

1. Pentabromodiphenyl ether
2. Octabromodiphenyl ether
3. Chlordecone
4. Lindane
5. Alpha-hexachlorocyclohexane
6. Beta-hexachlorocyclohexane
7. PFOS (perfluorooctanesulfonic acid, tetrabromodiphenyl ether and pentabromodiphenyl ether)
8. Hexabromobiphenyl
9. Pentachlorobenzene
Categories of health-care waste I.

- Infectious waste
  - Waste suspected to contain pathogens, e.g. laboratory cultures; waste from isolation wards; tissues (swabs), materials, or equipment that have been in contact with infected patients; excreta

- Pathological waste
  - Human tissues or fluids, e.g. body parts; blood and other body fluids; fetuses

- Sharps
  - Sharp waste, e.g. needles; infusion sets; scalpels; knives; blades; broken glass

- Pharmaceutical waste
  - Waste containing pharmaceuticals, e.g. pharmaceuticals that are expired or no longer needed; items contaminated by or containing pharmaceuticals (bottles, boxes)

- Genotoxic waste
  - Waste containing substances with genotoxic properties, e.g. waste containing cytostatic drugs (often used in cancer therapy); genotoxic chemicals
Categories of health-care waste II.

• Chemical waste
  • Waste containing chemical substances, e.g. laboratory reagents; film developer; disinfectants that are expired or no longer needed; solvents

• Wastes with high content of heavy metals
  • Batteries, broken thermometers; blood-pressure gauges; etc. heavy metals
  • Gas cylinders; gas cartridges; aerosol cans

• Pressurized containers

• Radioactive waste
  • Waste containing radioactive substances, e.g. unused liquids from radiotherapy or laboratory research; contaminated glassware, packages, or absorbent paper; urine and excreta from patients treated or tested with unsealed radionuclides; sealed sources
Health-care waste generation according to national income level

- Annual waste generation (kg/head of population)
- High-income countries:
  - all health-care waste 1.1–12.0
  - hazardous health-care waste 0.4–5.5
- Middle-income countries:
  - all health-care waste 0.8–6.0
  - hazardous health-care waste 0.3–0.4
- Low-income countries:
  - all health-care waste 0.5–3.0
Health-care waste generation according to source size

- Daily waste generation (kg/bed)
  - University hospital 4.1–8.7
  - General hospital 2.1–4.2
  - District hospital 0.5–1.8
  - Primary health-care centre 0.05–0.2
Total health-care waste generation by region

- Daily waste generation (kg/bed)

- **North America 7–10**
- Western Europe 3–6
- Latin America 3
- Eastern Asia:
  - high-income countries 2.5–4
  - middle-income countries 1.8–2.2
- Eastern Europe 1.4–2
- Eastern Mediterranean 1.3–3
Hazardous and non-hazardous solid waste disposal

Communal waste

Hazardous waste

Infectious

Toxic

Radioactive

Special transportation and storage

Disinfection

Chemical neutralization

Communal deposition

Communal incineration

Hazardous waste incineration

Special deposition
Prevention of soil pollution

• **Pesticide environmental limits**: difficult to set, basic rule is to accept concentrations in the soil that will not, with all likelihood, cause excessive accumulation in groundwater or various plants.

• **Microbe levels**: contaminated soil contains helminthic ova, coliform bacteria and clostridia in higher concentrations. These can be used as measures of the level of fecal soil contamination.

• **Nitrogen index**: defined as the ratio between inorganic and organic nitrogen. Provides information on the self-purification of the soil. **Normal value**: 0.98

• **Technical prevention**: source reduction, waste recycling, landfill deposition, incineration, hygienic burial practices and disposal of animal cadavers.
Waste neutralization

Solid waste

- Selective collection if possible (always for hazardous waste)
- Dehydration
- Transient storage
- Heat-treatment or incineration
- Biological neutralization
- Conditioning
- Chemical and physical neutralization
- Permanent storage, landfills etc…
• **Technical prevention:**
  - source reduction,
  - waste recycling,
  - landfill deposition,
  - incineration,
  - hygienic burial practices and
  - disposal of animal cadavers

**Role of public health authorities:**

- setting of **environmental limits**
- **monitoring** soil pollution
- supervision of industrial plants that **produces** large amounts of waste or hazardous waste, and of waste-management facilities
Landfill

Cross-section of an active landfill:

**Daily cover**
No landfill refuse is left exposed overnight - at the end of each day, all refuse is covered with at least six inches of compacted soil.

**Refuse cell**
Compacted garbage surrounded by soil from daily cover.

**Leachate collection**
Perforated pipes in a layer of sand collect rainwater that has filtered through the landfill (leachate).

**Plastic liner**
Prevents soil and water contamination.

**Clay barrier**
Prevents soil and water contamination.