

Global Waste Management I - Questions

1) Global Carbon-cycle

The Carbon cycle includes various fluxes. Plants execute photosynthesis with the light from the sun to fixate CO_2 and release O_2 into the atmosphere. At Night plants consume during respiration O_2 and release CO_2 back into the atmosphere. Aerobic and anaerobic microorganisms in the soil use the Carbohydrates from dead plants and change it through their metabolism into coal, gas petroleum and other energy dense materials. Mineralization is the process where organic material is degraded back to CO_2 . The incineration of fossil fuels and biomass is responsible for the increasing concentration of CO_2 in the atmosphere. Carbon is also exchanged between the atmosphere and the hydrosphere.

2) How much waste is produced in Europe?

- Western Europe: Municipal waste: 428 to 730 kg/cap.yr
- Eastern Europe: Municipal waste per capita is lower than in Western Europe. A reason is the lower average income of eastern Europeans.

3) What are the three types of landfills according to EU regulations?

- 1) Landfills for hazardous waste: Only for pretreated waste. Not allowed are liquid waste, explosive material and infectious hospital waste.
- 2) Landfills for non-hazardous waste: municipal waste, non-hazardous waste and stabile, not reactive hazardous waste.
- 3) Landfills for inert waste: Waste that is biologically, chemically and physically stable.

4) Describe the enhanced weathering of bottom ash! (+reaction equations)

The most important weathering process is carbonation. The carbonate buffer is a protection against the further decrease of the pH-value and thus against a re-immobilization.



5) Name three types of in-situ aeration!

- 1) Low pressure aeration: The positive pressure differences do not exceed 0.3 bars. The low pressure aeration accelerates the biological waste stabilization. It has high air flow rates and long aeration periods.
- 2) High pressure aeration: The pressure difference is up to 6 bars. The concept of high pressure is mostly associated with the implementation of landfill mining projects and excavation of waste.

- 3) Semi-aerobic aeration: Drainage pipes are designed that only one-third of the section is filled with liquid and combined with vertical gas ventilation wells → this enhances the intrusion of the air into the inner part of the landfilled wastes.

6) What is the content of the waste framework directive?

The Waste Framework Directive 2008/98/EC provides basic concepts and definitions and lays down basic waste management principles such as the "polluter pays principle" or the "waste hierarchy".

Furthermore, the directive provides:

- Definitions of waste, waste generator, waste holder (owner), waste collection
- Definition of hazardous waste / non hazardous waste (Appendix III)
- Recycling rate: increase of the recycling rate over time.



7) What is "free leachate discharge" and which barrier of the three barrier system should take care of it?

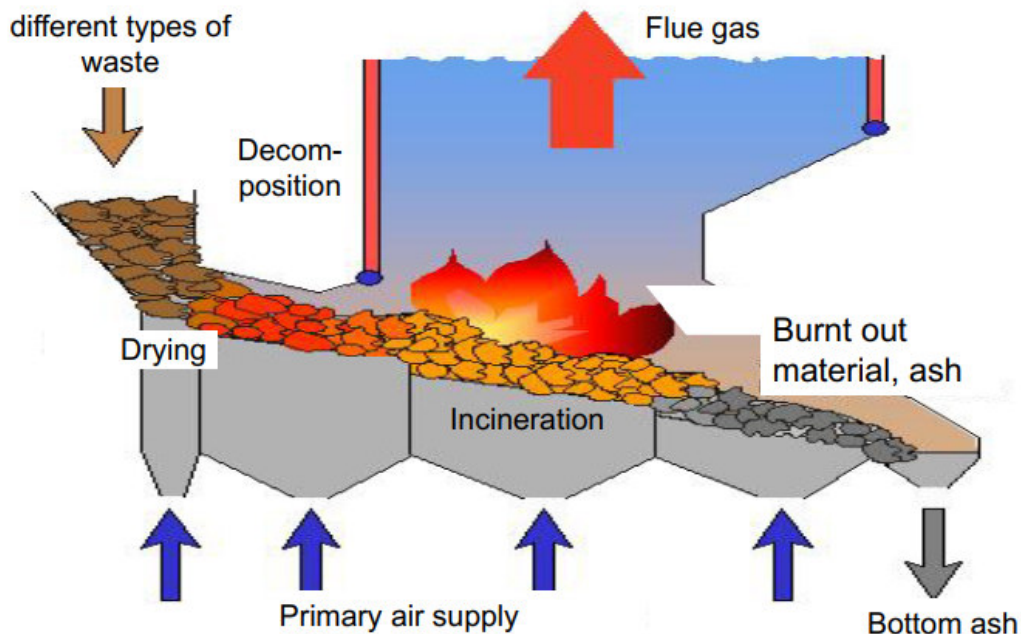
The leachate has to be drain off without technical pumping only by the force of gravity. So the landfill has to be built in such a slope that the leachate can drain into a drainage system. Also in the After-care period it is important. The second barrier should enable the free leachate. The slope of the second barrier is important.

8) What are the goals of "in-situ"-aeration?

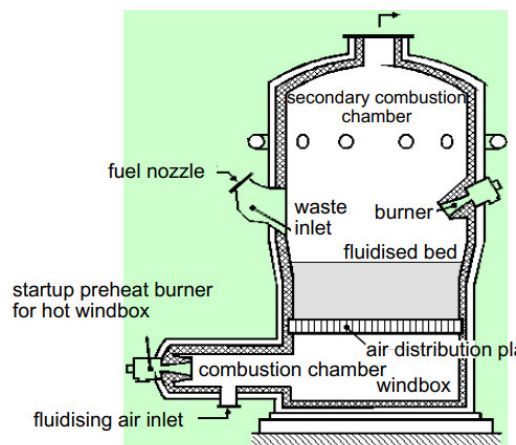
- Enhanced degradation of easily degradable organic waste
- Increase of hardly degradable organic substances
- Reduction of bio-reactivity
- Formation of humic substances
- Short term mobilization of some substances
- Reduction of leachate emissions (COD, $\text{NH}_4\text{-N}$)
- Reduction of greenhouse relevant gas emissions

9) What are the 3 most common incineration types?

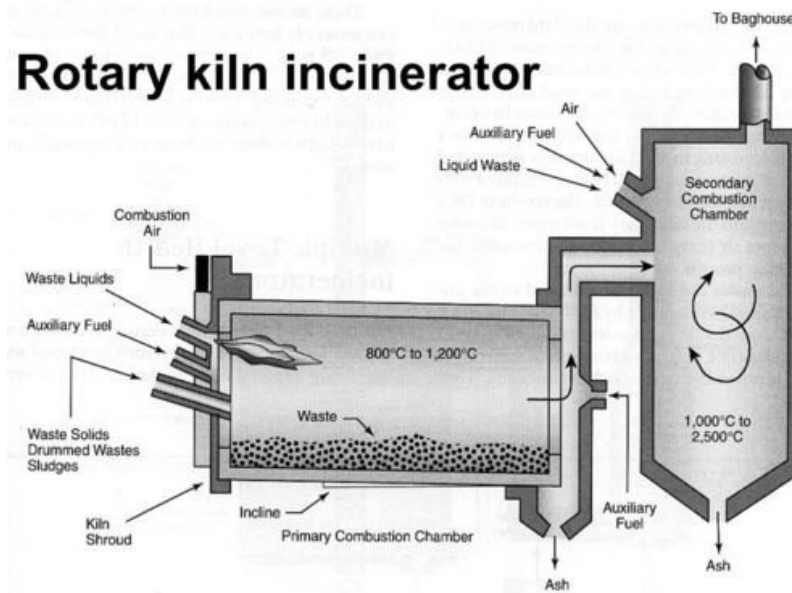
- **Grate Incinerator:** Waste is conveyed through the incineration chamber by reciprocating or rolling grate sections and traverses the different stages of the incineration (drying, de-gassing, exhaust and incineration). The conveying velocity can be controlled. The residence time (time between waste feeding and bottom ash discharge) is about 30 minutes. Purpose of incineration: oxidation of combustible substances. This is checked by the loss of ignition of the solid residues (slag and ash) and the composition of the flue gas. With modern incinerators, a loss of ignition (slag and ash) between 1% and 3% are achieved.



- **Fluidized Bed Reactor:** A bed of inert material (e.g. sand or ash) on a distribution bed is fluidized with air from below and held in suspension. The waste is continuously fed into the fluidized sand bed. Because of the well mixed nature of the reactor, fluidized bed incineration systems have a uniform distribution of temperatures and oxygen, which results in stable operation. The temperature is generally between 800 and 950°C.

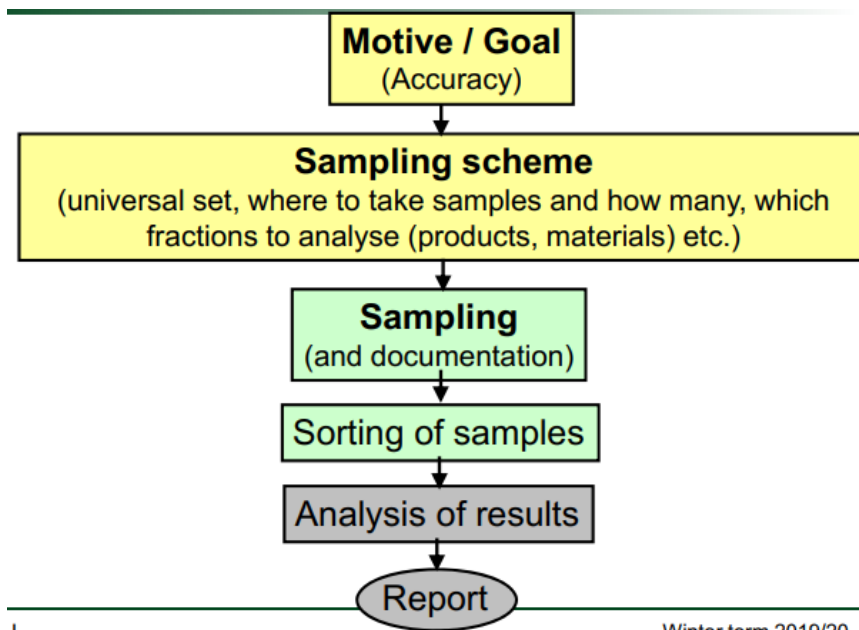


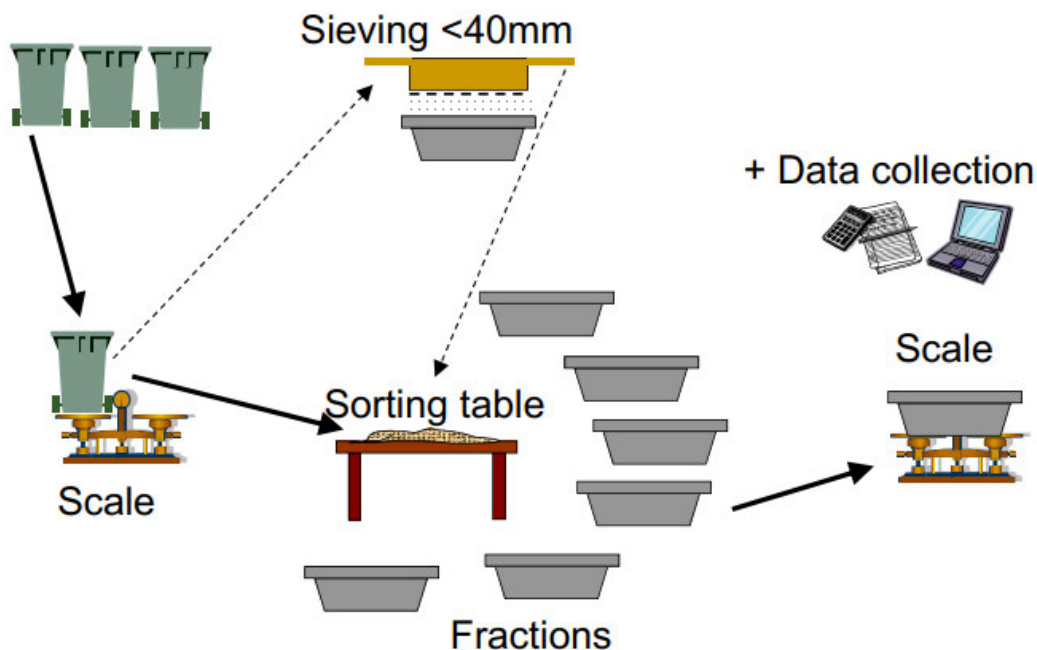
- **Rotary kiln incinerator:** The rotary kiln incinerator consists of a sloped refractory-lined cylinder which rotates slowly on its longitudinal axis. Waste moves horizontally as well as radially through the cylinder (because of rotation and slope). The flue gas is burnt in an afterburner chamber (with its own burners to heat the flue gas). One advantage is that large items can be fed as a whole (e.g. barrels filled with solvents).



10) What is a waste separation analysis?

In order to obtain data on waste amounts and composition one possibility is to carry out a waste separation analysis (WSA). It is a quantitative and qualitative determination of waste fractions obtained by sorting of waste. A waste separation analysis consists of the sorting and an analysis of spot samples.





11) What is a PAYT System?

Pay as you throw (PAYT) is a fee system for the collection management of waste. Users are charged a rate based on how much waste they present for collection to the municipality or local authority. The user has to be identified or the bin, which identifies the user. A variety of models exist depending on the region and municipality. Waste is measured by weight or size while units are identified using different types of bags, tags or containers. Services for waste diversion, like recycling and composting, are often provided free of charge where pay-as-you-throw systems are implemented.

PAYT types:

- a) Full-unit pricing
- b) Partial-unit pricing
- c) Variable-rate pricing

12) What's the definition of waste?

- Wastes are by-products from human activities.
- The turnover of goods, materials and resources is determined by social processes.
- In natural, balanced systems wastes are fully reintegrated into biological cycles.

13) What waste collection schemes do you know?

- Kerbside collection: Waste is collected at the place of generation. This is highly convenient for the user. It is limited by practical aspects like the place for the bin at the property, higher costs, adequate for regular produced waste in higher quantity (e.g. residual waste, bio-waste, paper)

- Bring systems: Households transfer their waste to recycling banks (collection containers for paper, glass, metals) or to civic amenity sites. This is for bulky waste, construction waste, hazardous household waste, e-Waste and electronic equipment.

14) Describe the 2nd barrier from the three barrier concept

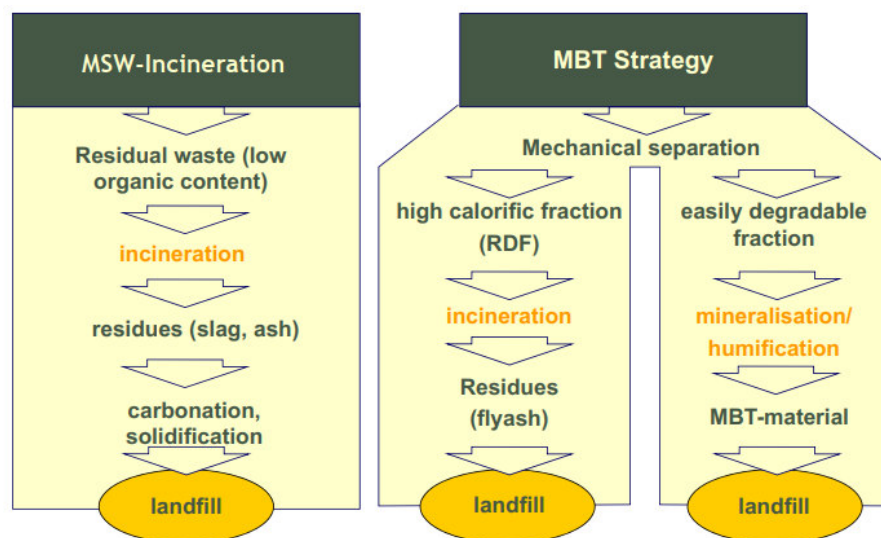
The second barrier is necessary to prevent leakage from the landfill into the groundwater. It is important that the cover and the rock the landfill is built on have a low permeability. It is beneficial if the second cover can absorb highly toxic compounds. It should be of a decent thickness. The leachate has to freely drain off from the landfill body without technical pumping. This means an unhindered drainage of leachate from the landfill bottom by force of gravity, also during the after-care period.

15) Name five tasks of a landfill cover

- Minimization of leachate
- suitable conditions for root and vegetation growth
- minimizing the methane emissions by enhancing the methane oxidation
- biofilter effect to reduce odour emissions
- integration into the landscape
- sanitary effects (keep rats, insects and other animals away)
- prevent erosion from wind and water
- avoid dust formation, prevent dispersal of paper and plastics by wind
- ensure slope stability to avoid landslides

16) Which pre-treatment methods do you know and what are their advantages?

The pre-treatment of waste is an important factor for the first barrier. This inner barrier quality will still be active after landfill closure and even later when technical barriers such as the base lining systems are no longer functioning. There are two main methods for pre-treatment. The first one is the thermal treatment (incineration) and the second one is the mechanical-biological treatment.



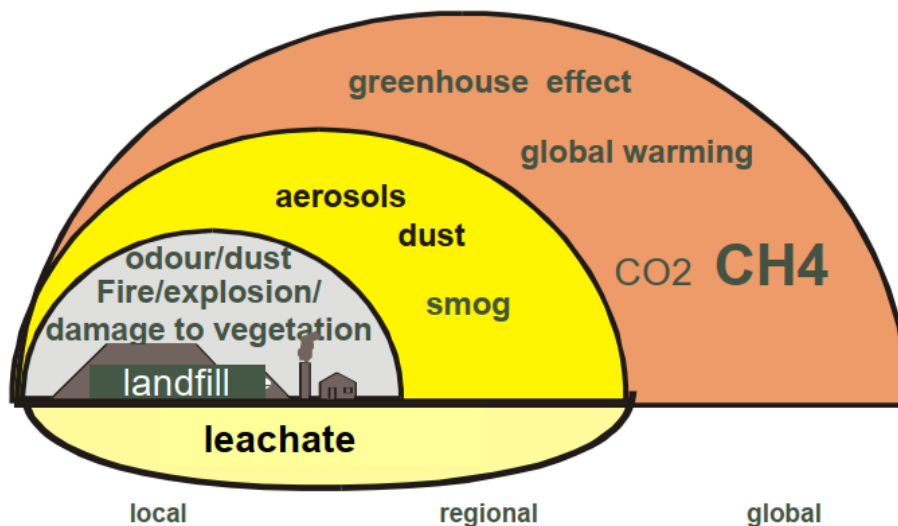
Purposes of thermal treatment

- reducing the amount of waste which has to be landfilled
- destruction of organic substances
- destruction of toxic organic substances
- aggregation of inorganic substances
- complete disinfection (e.g. of infectious waste)
- substitution of fossil fuels (reduction of CO₂-emissions and conservation of resources)

Purposes of mechanical-biological treatment

- reduction and stabilization of organic substances
- better input-control at landfills
- reduction of gas generation (methane gas production reduced by up to 95 %)
- reduction of leachate (amount and concentrations)
- lower consumption of landfill volumes
- lower settlement
- reduction of harmful substances
- use of thermally valuable compounds

17) What are the global and regional impacts of waste management?



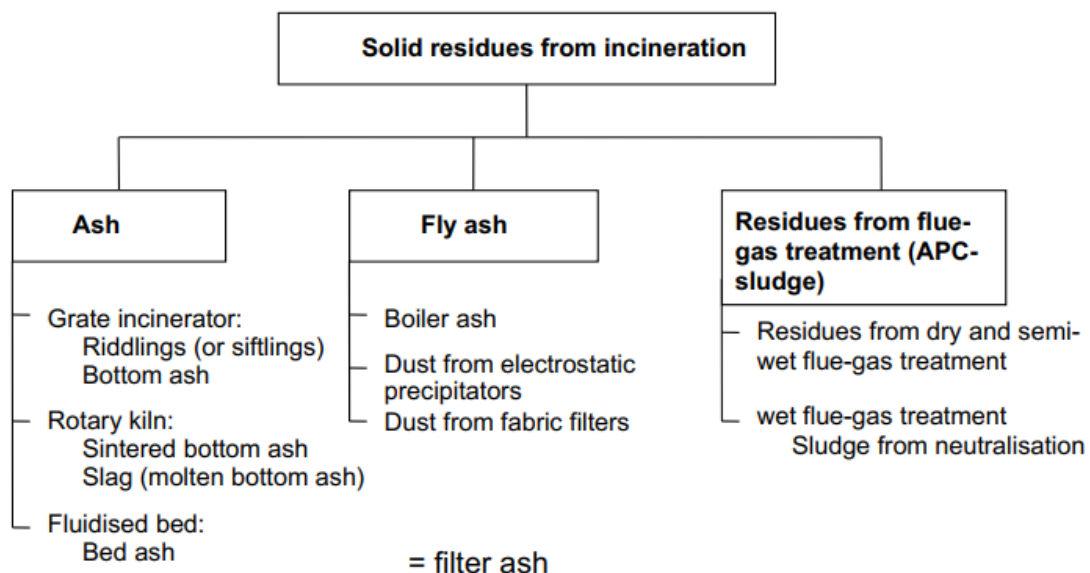
18) What is kerbside collection?

Kerbside collection is a service provided to households, typically in urban and suburban areas, of collecting and disposing of household waste and recyclables. It is usually accomplished by personnel using specially built vehicles to pick up household waste in containers acceptable to or prescribed by the municipality.

19) What is a "reactor landfill"? What are the main processes and what are the trends regarding reactor landfill in Europe?

Reactor landfills are still "the status quo" in most countries. Reactor landfills describe the landfilling of untreated municipal or industrial waste on sanitary landfills or open dumps. The degradation of the waste is dominated by anaerobic processes. The organic carbon-compounds are converted into CH_4 and CO_2 under absence of air. In Europe the disposal of untreated waste is in decline. Worldwide the reactor landfill concept is still the most applied method. In the initial acidic phase the leachate is highly polluted with readily biodegradable organic substances. After reaching a stable methane phase, over a longer period of time gas composition remains constant (60% CH_4 and 40% CO_2) and heavily degradable organic substances prevail in the leachate.

20) Name three solid residues of waste incineration!

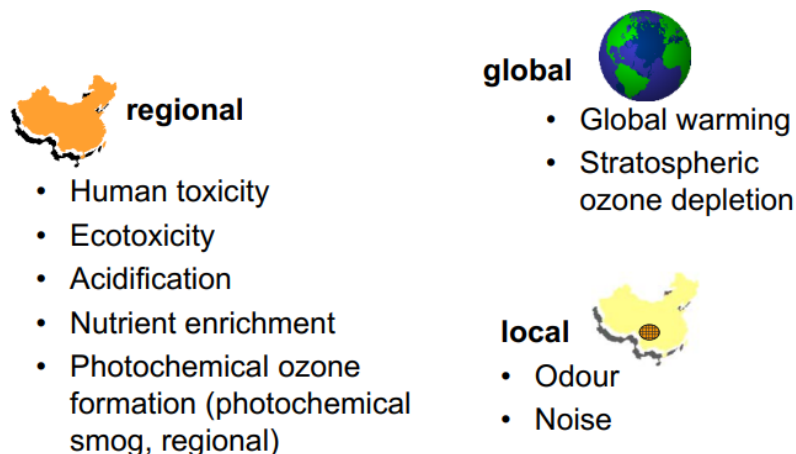


21) What are the 4 global types of landfills?

- 1) **Open dump:** On an open dump the waste is dumped without any technical or operational measures. It has a current and long-term impact on groundwater, soil and air.
- 2) **Controlled dump/Engineered landfill:** There are basic operational measures such as registration, fencing and primitive collection of leachate and compaction of waste.
- 3) **Sanitary landfill:** The sanitary landfill has proper siting and planning, collection and treatment of gas and leachate. It also has a top cover and waste registration.
- 4) **Sustainable landfill:** The concept of the sustainable landfill is to cause no harm for future generations. It has a multi barrier concept, a long-term proper siting, proper waste quality (through pre-treatment) and operation and controlling techniques.

22) What are the effects of insufficient waste management?

- **Eco-toxicity:** Adverse effects on the function and structure of ecosystems by exerting toxic effects on the organisms which live in them. A compound eco-toxicity is determined by its toxicity, its biodegradability and its ability to accumulate in living organisms. There is an acute eco-toxicity which can occur as soon as the substances are released (often death of organisms exposed) and there is a chronic eco-toxicity which appears after repeated or long-term exposure to the substance. It is often caused by substances which have a low degradability.
- **Human-toxicity:** The human-toxicity is the capacity of a substance, to exert adverse effects on particular functions or on all functions of the human organism. You can differentiate between acute or chronic effects. Various effects can appear, from skin irritation to cancer or death. Toxic substances can also accumulate in the living organisms. Most toxic substances do not cause harmful effects at the point of entry. The chemical substance must reach the critical site of action in a target organ to do its harm. The concentration of a substance and the length of time of exposure must be sufficiently high.
- **Acidification:** The acidification causes a decline of coniferous forests, increased fish mortality, corrosion damage to metals and disintegration of surface coatings and mineral building materials. It also causes mobilization of heavy metals.



23) What are the dangers of immediate landfilling of reactive ash?

- High temperatures in waste body
- H₂-gas formation (several explosions on landfills)
- High leachability of Aluminum, Lead and other metals
- Alkaline leachate
- Loss of secondary metal resources

The pre-treatment of bottom ashes is recommended → „weathering = „technical carbonation“

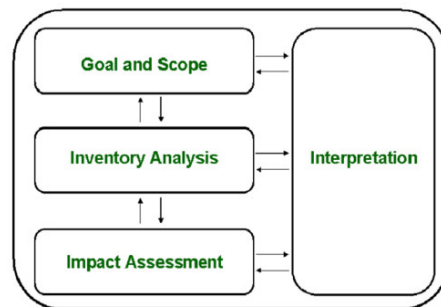
24) Capacity development

Capacity development involves the long-term, contributes to sustainable development and is demand-driven.

25) Definition of ISWM

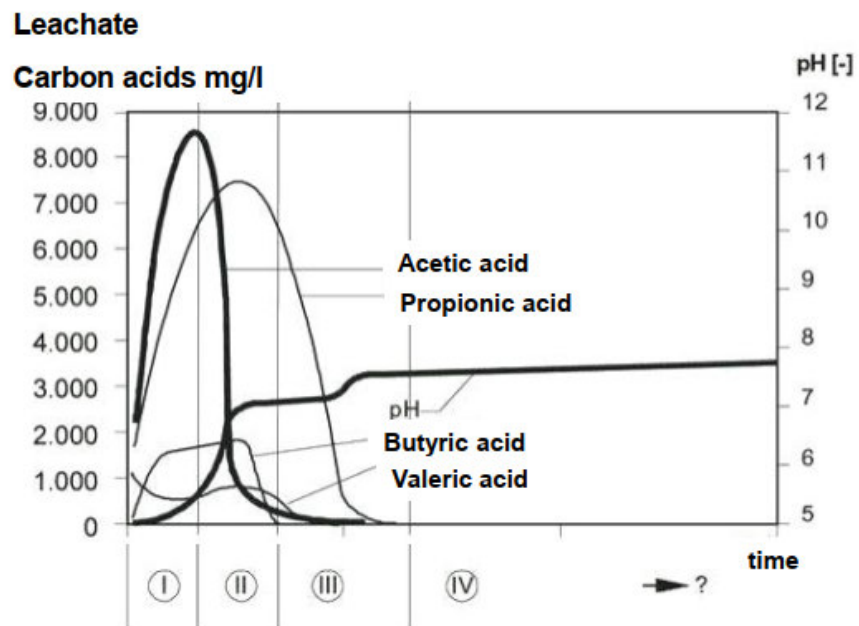
ISWM stands for “Integrated Solid Waste Management”. It is a program for prevention, recycling, composting and disposal of waste. It describes how you can most effectively protect the environment and the health of human and nature living organisms.

26) What are the steps in LCA?



- **Goal & Scope:** Describes the function of the system. All inputs and outputs of each process are relative to this functional unit. The functional unit gives the opportunity to catch the purpose of a product or a service (e.g. treating the wastewater of 1 habitant during a year).
- **Inventory Analysis:** All relevant inputs and outputs (materials, energy and elementary flows) are identified.
- **Impact Assessment:** Determine the resulting environmental impacts.
- **Interpretation:** Needs to link back to research question and goal & scope. The interpretation takes into account data quality, uncertainty and variability and limitations of the study. Trade-offs need to be highlighted. Results can be combined with results of other assessed aspects, e.g. costs, health and safety etc.

27) Phases of reactor landfilling



- I. Hydrolysis and Acidification
- II. Acetogenic phase and start of methane formation
- III. Stable methanogenic phase
- IV. Leaching