HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES

ENVIRONMENTAL HYGIENE

Dr. Edit KASZAB

associate professor

MATE – Institute of Aquaculture and Environmental Safety

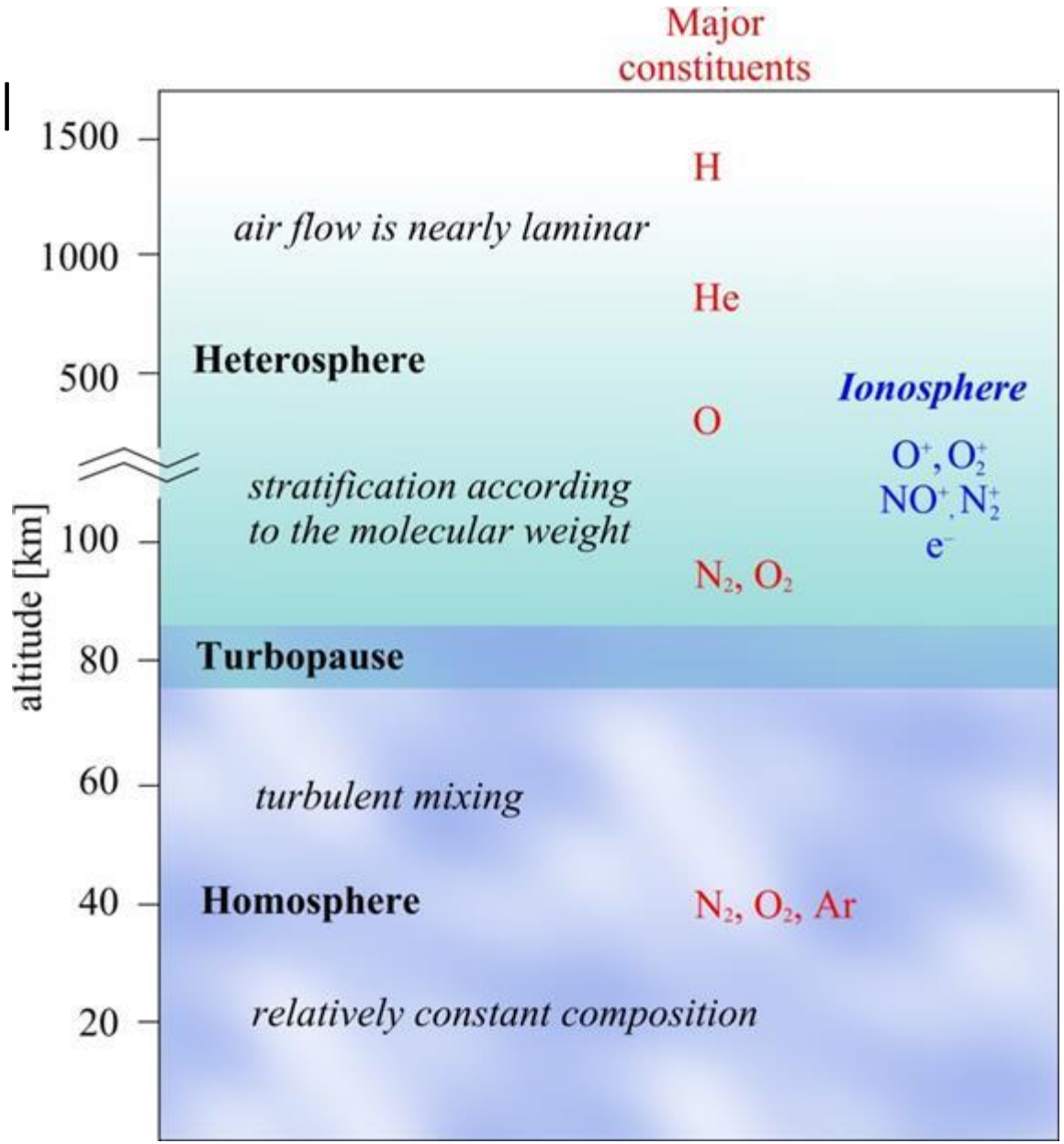
Department of Environmental Safety

Air hygiene – measure the invisible?

- The hygiene of atmosphere studying air-related issues to protect health and prevent disease.
- **Activities of air hygiene:**
  - Measurement of air quality
  - Evaluation of the effects of air quality on human health
  - Applied air hygiene
- **Air quality:** The degree to which air is polluted; the type and maximum concentration of man-produced pollutants that should be permitted in the atmosphere.
- **Air safety:** Any measure, technique or design intended to reduce the risk of harm posed by either moving vehicles or projectiles above the earth's surface or pollutants to the earth's atmosphere.

The vertical structure of the athmosphere according to chemical composition

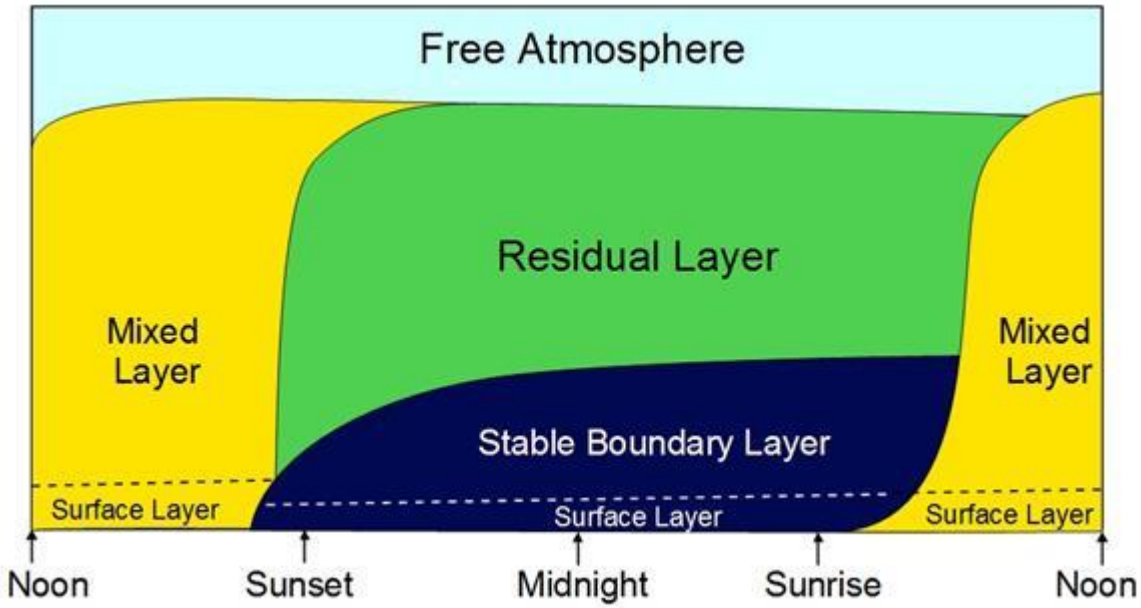
- Two layers:
- The lower layer, up to an altitude of about 80 km is the homosphere, (continuous turbulent mixing the composition of the atmosphere is relatively constant for chemical species which have long mean residence times).
- A thin transition layer, called turbopause.
- Above the turbopause, in the heterosphere, the molecular diffusion dominates and the chemical composition of the atmosphere becomes stratified and varies according to the molecular mass of chemical species



Source: Lagzi et al.: Atmospheric chemistry (2013)

The planetary boundary layer

- The lowest level of the atmosphere – the bottom layer of the troposphere – called planetary boundary layer (PBL) is directly and strongly influenced by the underlying surface (Stull, 1988). Within the PBL the convective air motions generate intense turbulent mixing.
- The upper boundary of PBL is statically stable (temperature inversion).
- Interactions between the atmosphere and the surface take place in the PBL.
- Timescale of atmospheric response to surface forcing is an hour or less.
- Atmospheric variables (wind speed, temperature, water vapor content etc.) show great variability and fluctuation and the vertical mixing is strong.
- **Planetary boundary layer has great importance in dispersion, dilution and deposition of air pollutants.**



The structure of the planetary boundary layer

The composition of the atmosphere

Chemical species				Sources					
Name	Formula	Concentration	Residence time	Biogenic	Anthropogenic	Photochemical	Volcanic	Radiogenic	Other
Nitrogen	N_2	78.084%	1.6×10^{7} years	✓			✓		
Oxygen	O_2	20.946%	3×10^{3}–10^{4} years	✓					
Argon	Ar	0.934%						✓	
Water vapour*	H_2O	0–4% (0– 40 000 ppm)	10 days	✓	✓		✓		(1)
Carbon dioxide	CO_2	3.94×10^{-2}% (394 ppm)	20–150 years	✓	✓		✓		
Neon	Ne	1.818×10^{-3}% (18.18 ppm)					✓?		
Helium	He	5.24×10^{-4}% (5.24 ppm)	10^{7} years					✓	
Methane	CH_4	1.79×10^{-4}% (1.79 ppm)	10 years	✓	✓				
Krypton	Kr	1.14×10^{-4}% (1.14 ppm)						✓	
Hydrogen	H_2	5.3×10^{-5}% (0.53 ppm)	2 years	✓	✓				(2)
Nitrous oxide	N_2O	3.25×10^{-5}% (0.325 ppm)	150 years	✓	✓				
Carbon-monoxide	CO	$5–25\times10^{-6}$% (0.05–0.25 ppm)	0.2–0.5 year	✓	✓				
Xenon	Xe	8.7×10^{-6}% (0.087 ppm)							
Ozone	O_3	$1–5\times10^{-6}$% (0.01–0.05 ppm)	weeks - months			✓			
Nitrogen-dioxide	NO_2	$0.1–5\times10^{-7}$% (0.001–0.05 ppm)	8–10 days	✓	✓	✓			
Ammonia	NH_3	$0.01–1\times10^{-7}$% (0.0001–0.01 ppm)	~5 days	✓	✓				
Sulphur-dioxide	SO_2	$0.003–3\times10^{-7}$% ($0.03–30\times10^{-3}$ ppm)	~2 days		✓	✓	✓		
Hydrogen-sulphide	H_2S	$0.01–6\times10^{-8}$% ($0.01–0.6\times10^{-3}$ ppm)	~0.5 day	✓	✓		✓		

Aerodisperse system

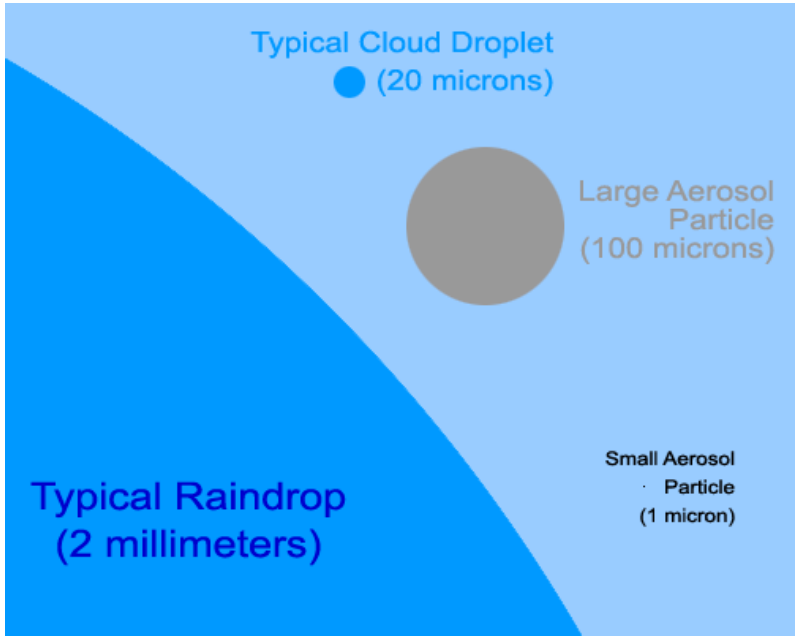
Nominal molecular weight: 28.973 g / mol

Source: Lagzi et al.: Atmospheric chemistry (2013)

Trace materials

- Trace gases and **aerosols**
- Small amount, important role
- Their quantity may be specific to the area, altitude, origin of the air masses, etc.

- **Aerosol**: Suspended matter, or more generally all solid, liquid or waving particles in the atmosphere are called aerosols. Aerosol particles can be classified according to
  - their genesis,
  - the origin,
  - the particle size,
  - their optical and physical properties,
  - the chemical composition,
  - and their impact on the climate system.

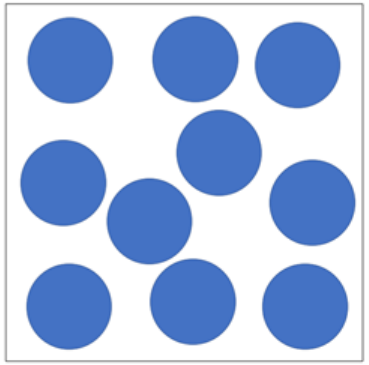
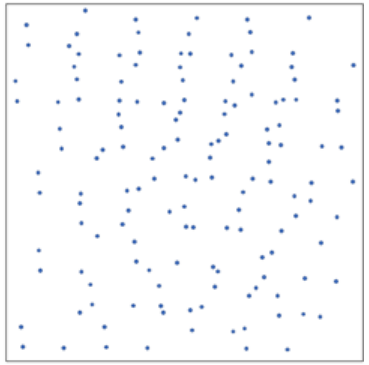


Aerosol types (based on particle size)

- The metrics that are most commonly used to describe particulate matter (PM) are the number concentration and the mass concentration.

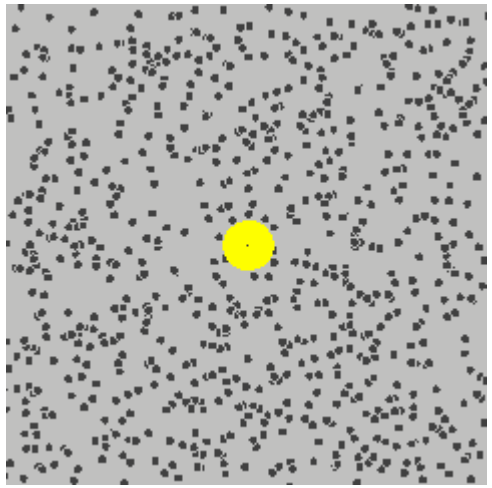
Mass distribution:

- Coarse particulate matter - with an aerodynamic diameter of 10 µm or less (**PM10**),
- Fine particulate matter, with a diameter of 2.5 µm or less (**PM2.5**).
- Ultrafine particles (**UFPs**) are all particles with a diameter of 100nm or less.

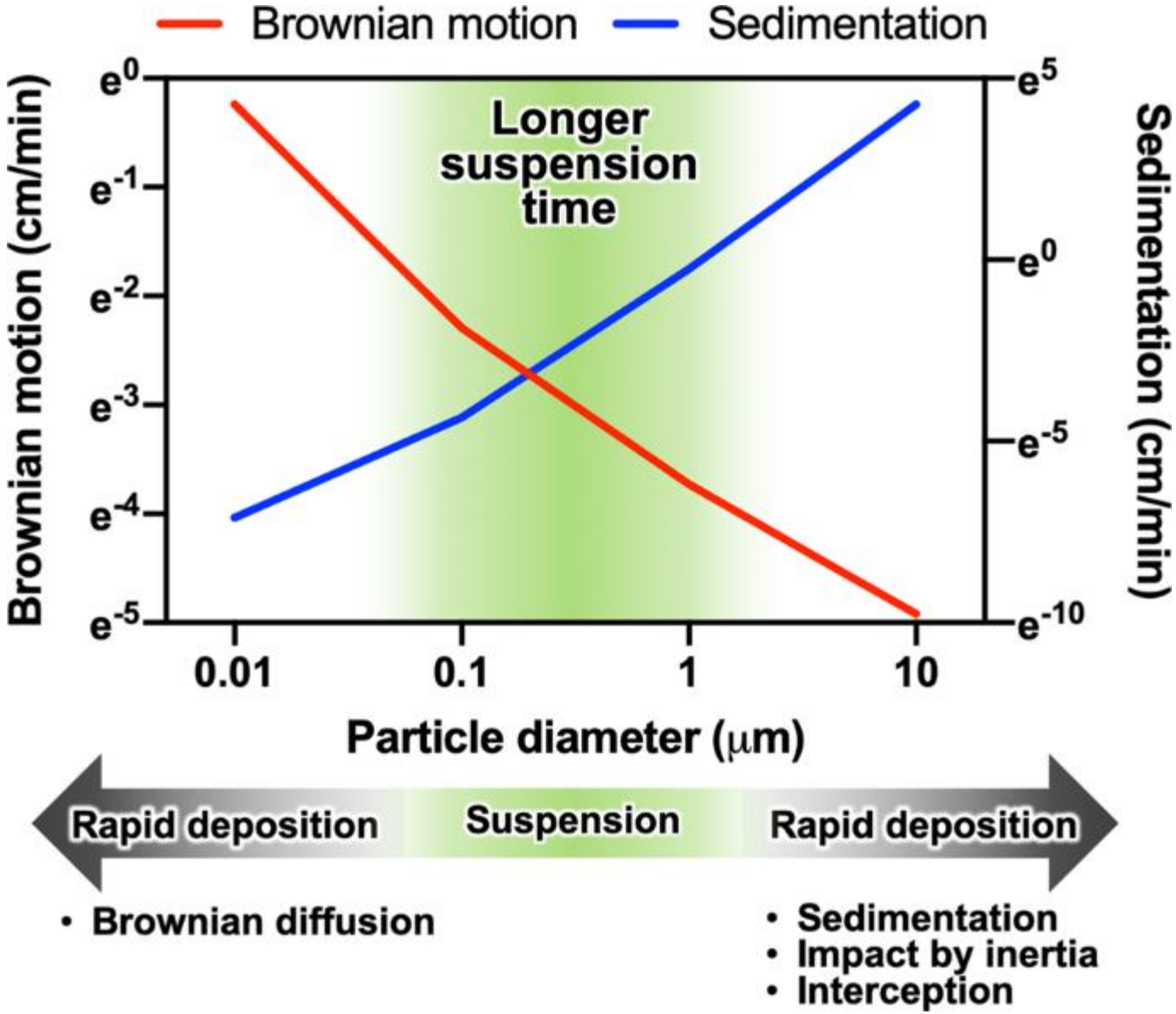
	10 µm (Coarse)	2.5 µm (Fine)	0.1 µm (Ultrafine)
			
Total mass	1	1	1
Particle number	1	64	1,000,000
Surface area per particle	1	0.0625	0.0001
Total surface area per mass	1	4	100
	• Filtered in proximal airway • May irritate skin, mucosa	• Reaches peripheral airway • Cannot enter systemic circulation	• Higher adsorbed toxic material on surface • May enter systemic circulation

Kwon et al. 2020

Size and fate



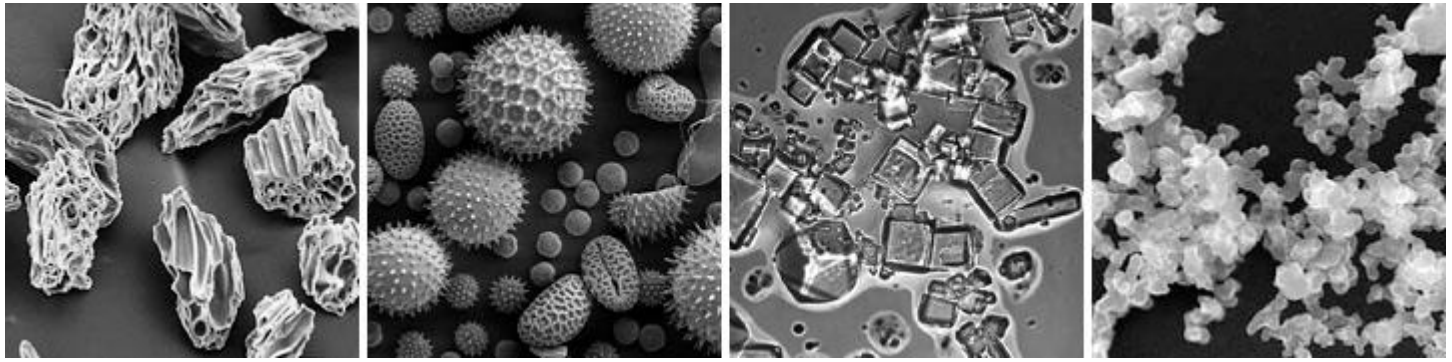
- Ultrafine particles are rapidly deposited by Brownian diffusion, especially particles <20 nm. Large coarse particles are deposited by sedimentation, impact by inertia, and interception. Particles between 30 nm and 1 µm tend to have longer atmospheric lifetimes because they are less likely to be deposited in either way. These particles accumulate in the atmosphere due to the long suspension time and are thus called the accumulation mode.



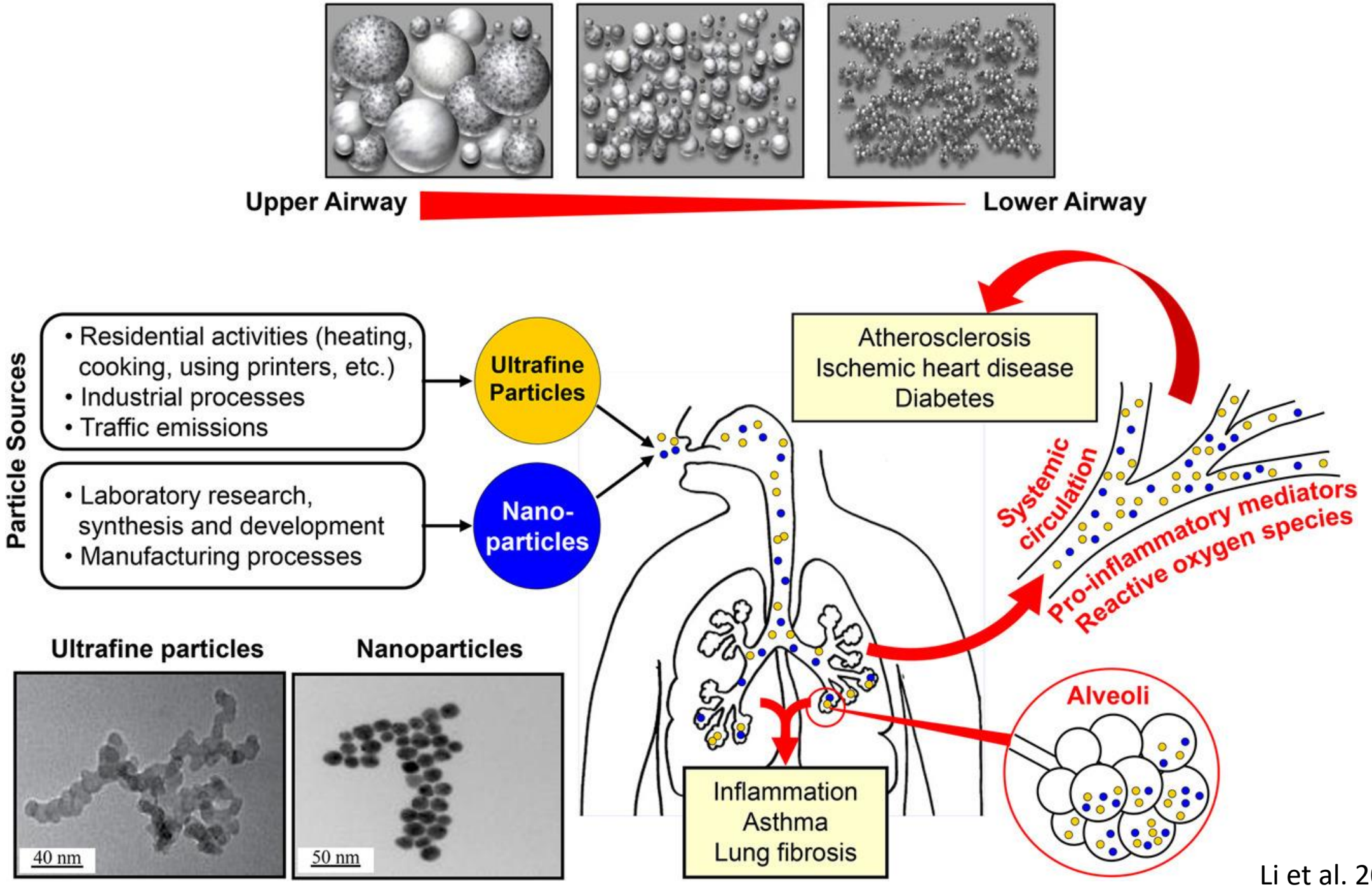
Kwon et al. 2020

Variety of aerosol types

The wide variety of aerosol shapes. From left to right: volcanic ash, pollen, sea salt, and soot. [Micrographs courtesy USGS, UMBC (Chere Petty), and Arizona State University (Peter Buseck).]



Desert dust, volatile organic compounds from vegetation, smoke from forest fires, and volcanic ash are natural sources of aerosols. (Photographs copyright (left to right) Western Sahara Project, Jonathan Jessup, Vox, and Ludie Cochrane.)

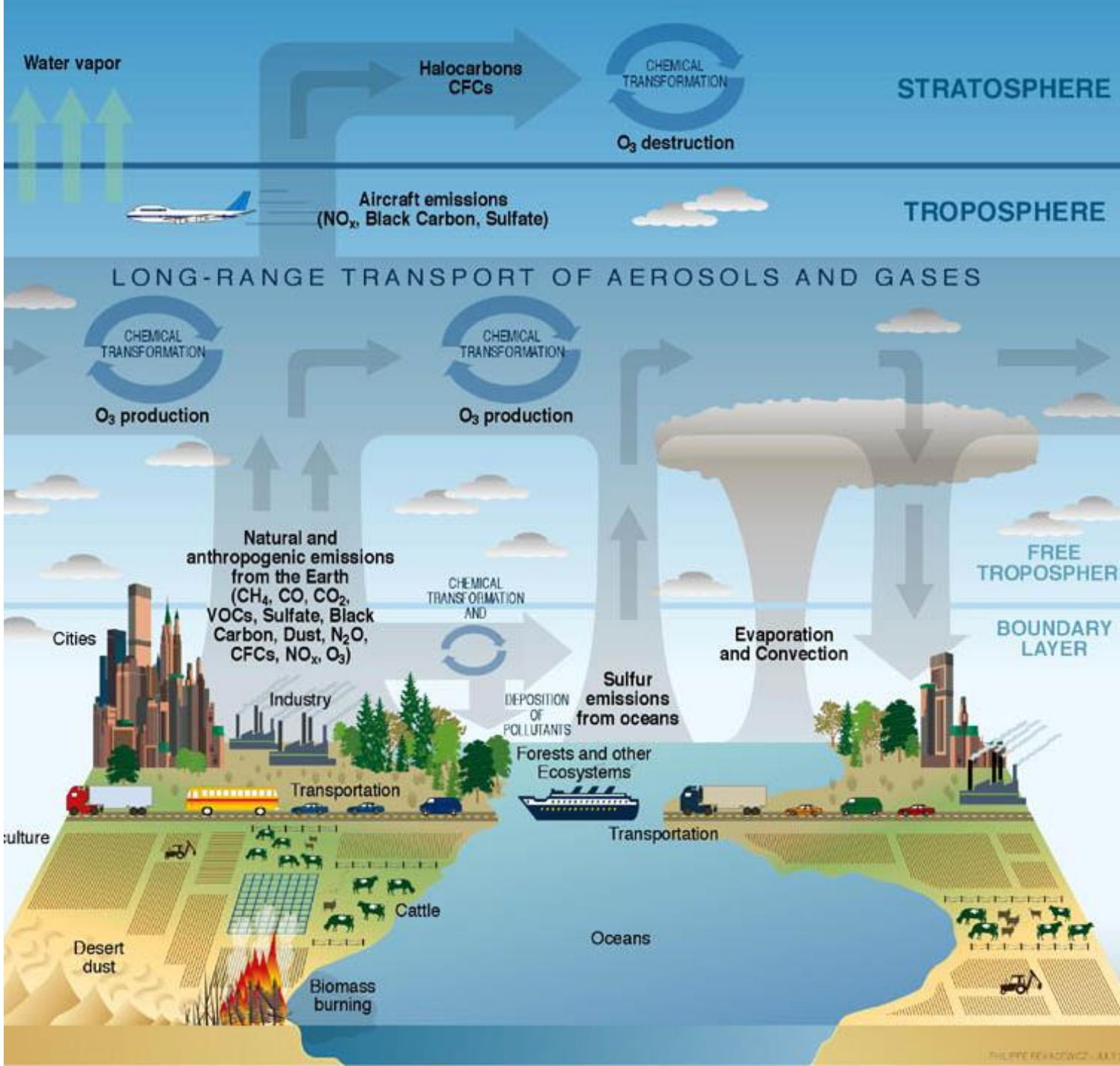

Upper Airway
Lower Airway
Particle Sources
• Residential activities (heating, cooking, using printers, etc.)
• Industrial processes
• Traffic emissions
• Laboratory research, synthesis and development
• Manufacturing processes
Ultrafine Particles
Nano-particles
Atherosclerosis
Ischemic heart disease
Diabetes
Systemic circulation
Pro-inflammatory mediators
Reactive oxygen species
Alveoli
Inflammation
Asthma
Lung fibrosis
Ultrafine particles
Nanoparticles
40 nm
50 nm

Li et al. 2016

Effects of aerosols

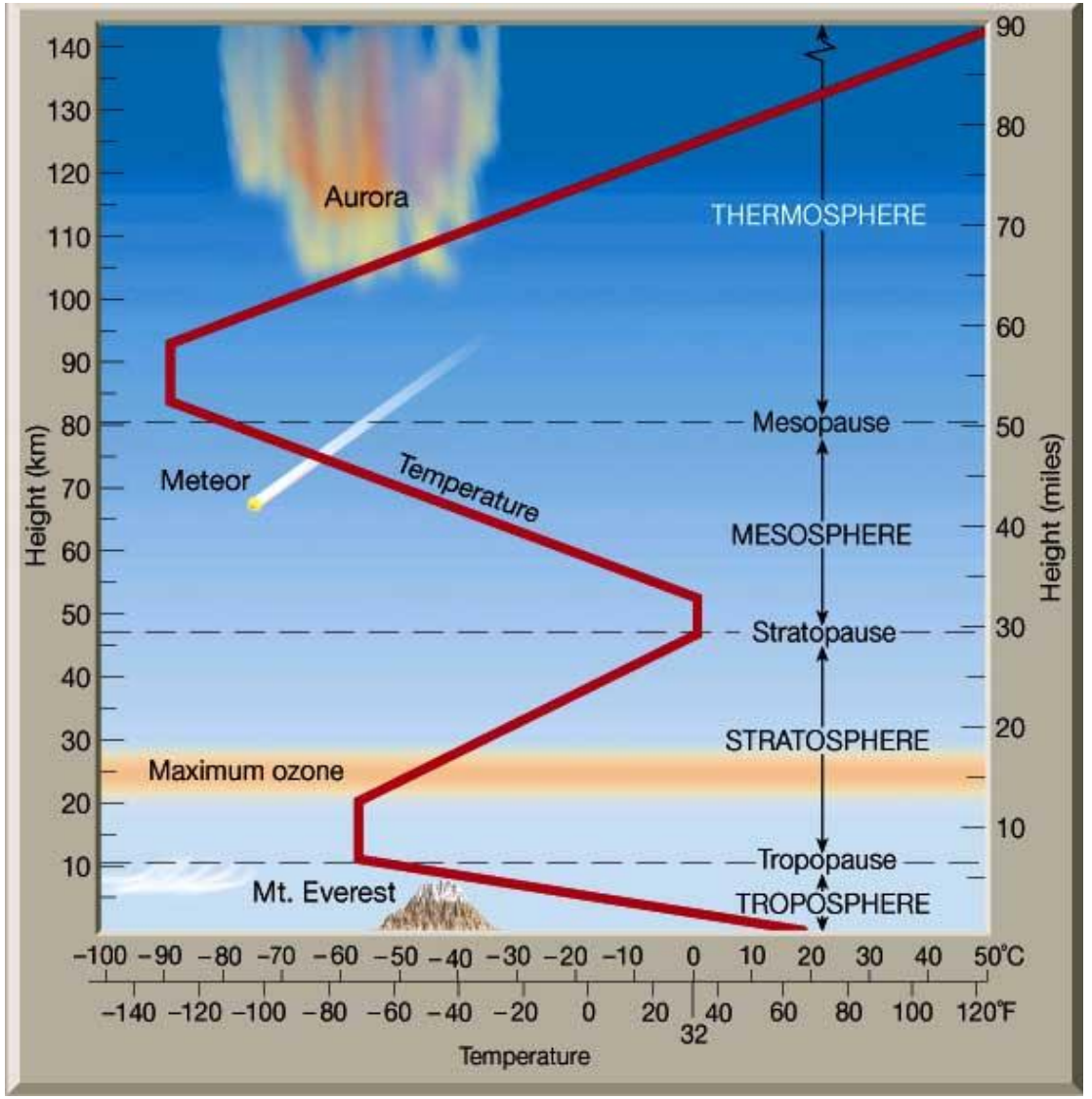
- Aerosols affect directly our environment as they are responsible, for instance, for health problems and acid rain.
- Have a direct radiative forcing because they scatter and absorb solar and infrared radiation in the atmosphere
- **Alter warm, ice and mixed-phase cloud formation processes** by increasing droplet number concentrations and ice particle concentrations.

→ Climate change



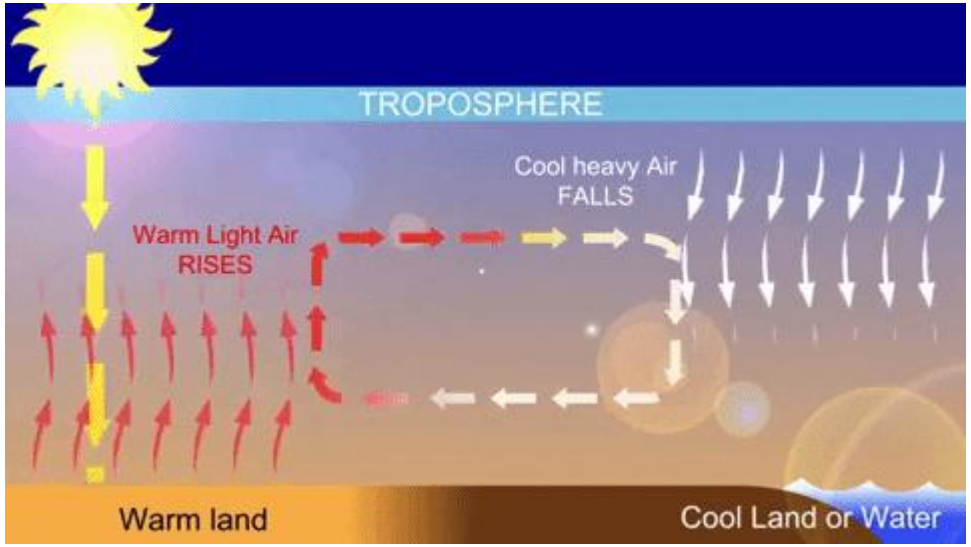
The physical properties of atmosphere

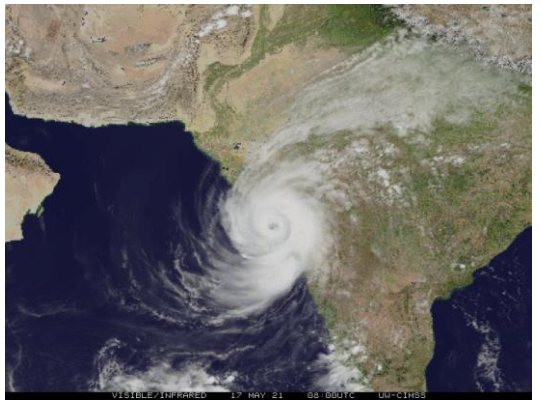
- **Temperature** (solar radiation, terrestrial radiation, chemical reactions, air currents)
- Based on the variation of temperature with height, the atmosphere can be divided to different layers



The physical properties of atmosphere

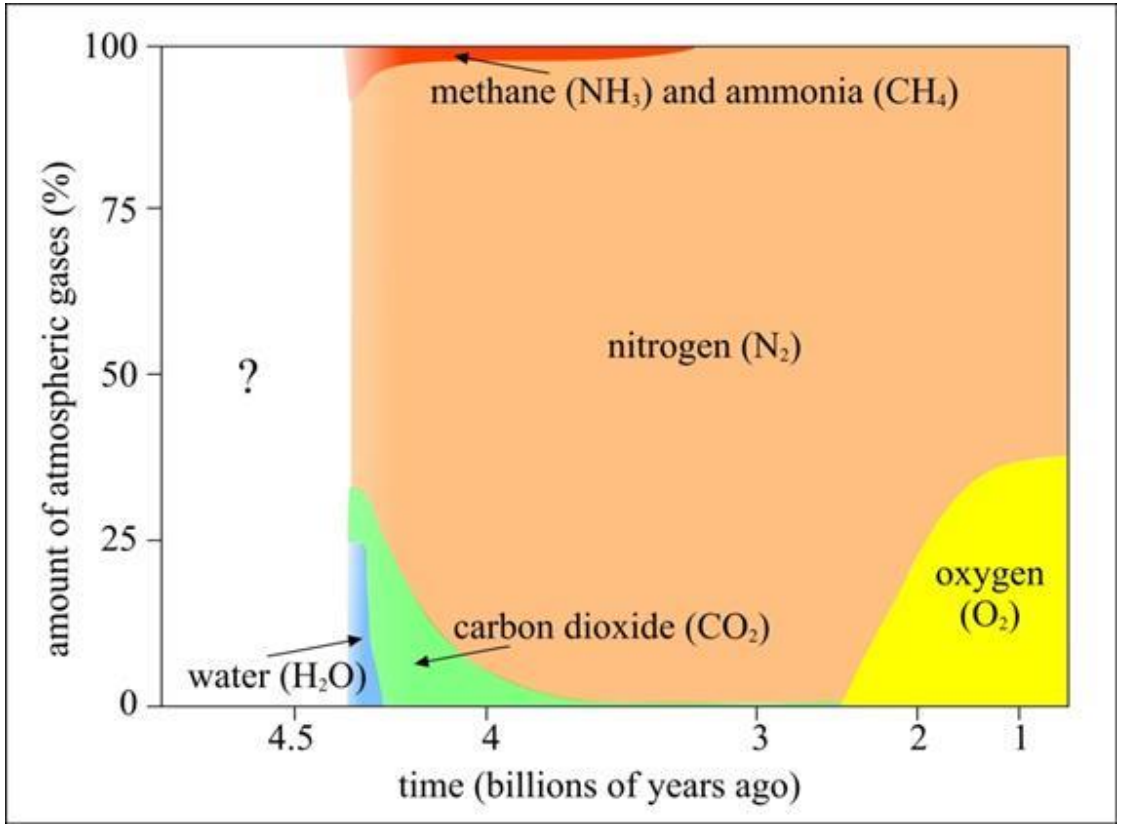
- **Wind**: the perceptible natural movement of the air, especially in the form of a current of air blowing from a particular direction
- Atmospheric pressure: the force exerted on a surface by the air above it as gravity pulls it to Earth.
- Cyclones
- Humidity: absolute and relative humidity, dew point
- Atmospheric electricity



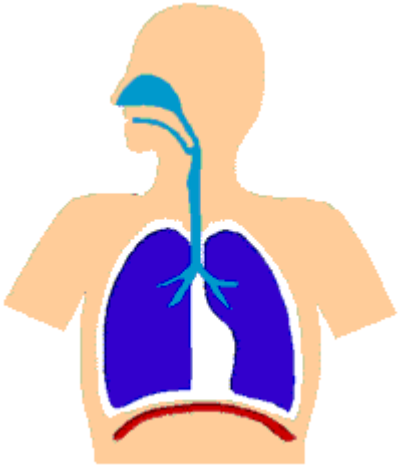


The biological aspects of atmosphere

- Atmosphere as a biotope
- Oxygen was first produced in the atmosphere by photochemical dissociation of water vapour by intense ultraviolet radiation:
- $2H_2O$ + UV radiation → $2H_2 + O_2$.
- Because of the Urey self-regulation of this process byshielding H_2O vapor with O_2, O_3, and CO_2, primitive oxygen levels cannot exceed O_2 0.001 present atmospheric level (P.A.L.).
- Around 2.5 billion years ago: photosynthesis
- $CO_2 + H_2O$ + sunlight → organic compounds + O_2
- Around 1 billion years ago: Pasteur point was reached (a level of oxygen (about 0.3% by volume which is less than 1% of Present Atmospheric Level or PAL) above which facultative aerobic microorganisms and facultative anaerobes adapt from fermentation to aerobic respiration).
- As the atmospheric oxygen reached 1–2% of present oxygen level, ozone (O_3) could form to shield Earth's surface from intense ultraviolet radiation:
- $2O_2$ + UV radiation → $O_3 + O$



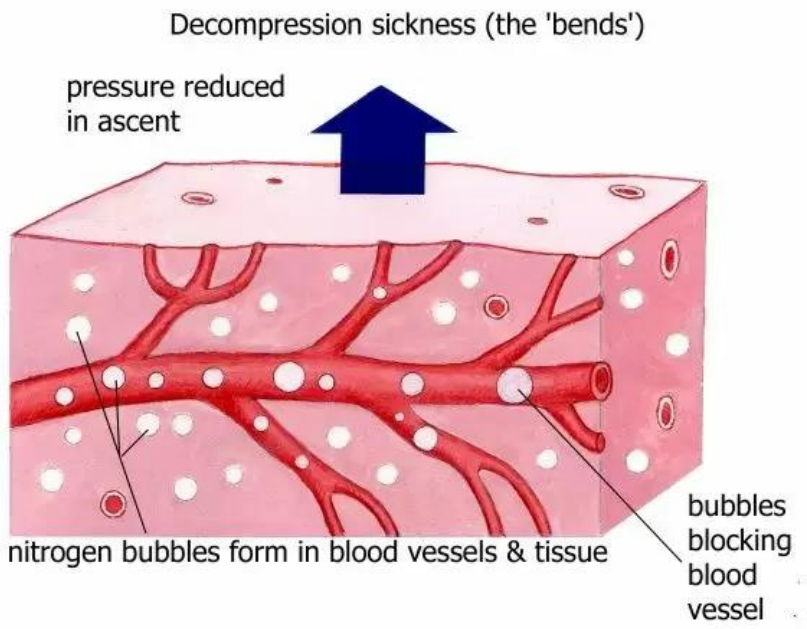
Respiration



- Internal respiration - involves gas exchange between the blood and body cells.
- External respiration - the breathing process. It involves inhalation and exhalation gases.
  - The process of breathing (inhalation and exhalation), also called ventilation
- Cellular respiration - the metabolic processes of converting the energy stored in biological molecules to usable energy in the form of ATP.
- Factors with an effect on respiration:
  - Oxygen level
  - Partial pressure of oxygen
  - Atmospheric pressure
  - Lung volume
- 16-18x breath/min. 0.5 L : 12 m^3/day

Atmospheric effects on health and well being

- Effect of oxygen concentration (<7%, death!)
- Effect of carbon dioxide concentration
- Effect of air pressure (barotrauma, caisson disease – decompression sickness)
- Effect of air temperature (15-25˚C)
- Effect of air humidity
- Effect of air movement (below 0.3 m / s)
- Effect of atmospheric electricity



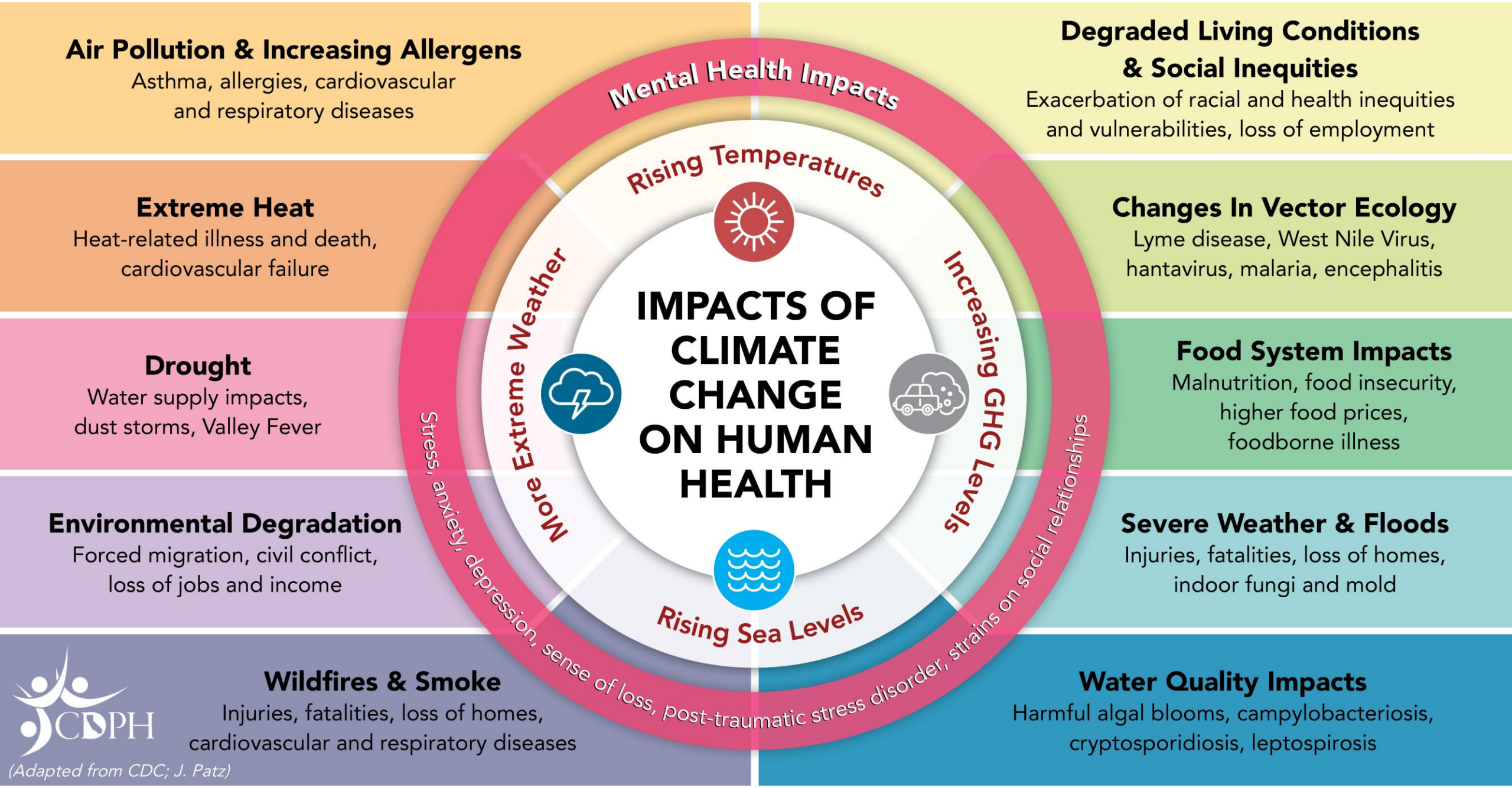
Weather

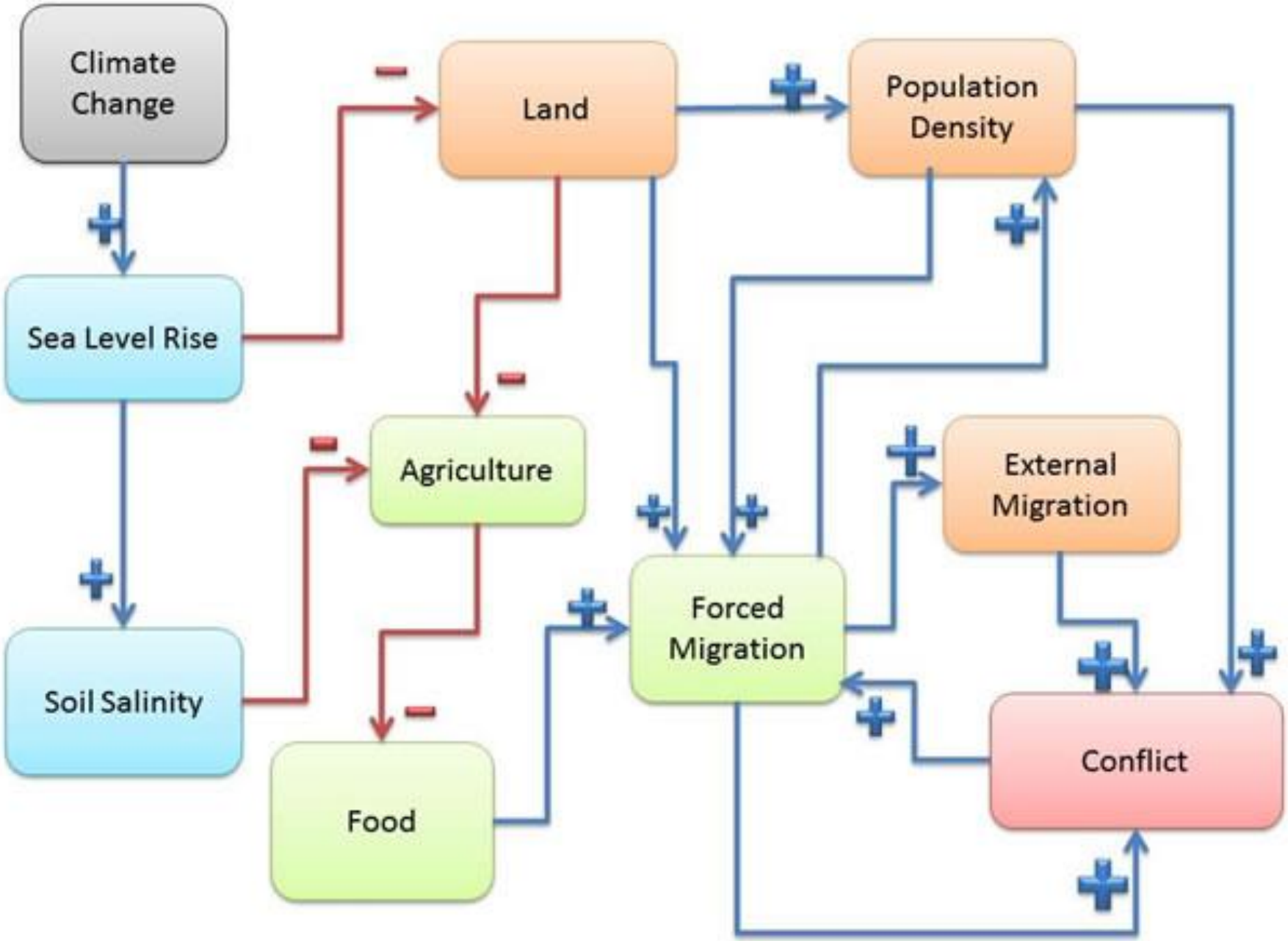
State of the atmosphere at a particular place during a short period of time. It involves such atmospheric phenomena as temperature, humidity, precipitation (type and amount), air pressure, wind, and cloud cover. Weather has an effect on well being and health. **Weather** differs from **climate.**

Effect on our health – increased mortality under extreme weather conditions

Climate: the synthesis of weather conditions (solar radiation, temperature, humidity, precipitation (type, frequency, and amount), atmospheric pressure, and wind (speed and direction)) that have prevailed over a given area during a long time period—generally 30 years.

Effect on our health →


Air Pollution & Increasing Allergens
Asthma, allergies, cardiovascular and respiratory diseases
Extreme Heat
Heat-related illness and death, cardiovascular failure
Drought
Water supply impacts, dust storms, Valley Fever
Environmental Degradation
Forced migration, civil conflict, loss of jobs and income
Wildfires & Smoke
Injuries, fatalities, loss of homes, cardiovascular and respiratory diseases
Degraded Living Conditions & Social Inequities
Exacerbation of racial and health inequities and vulnerabilities, loss of employment
Changes In Vector Ecology
Lyme disease, West Nile Virus, hantavirus, malaria, encephalitis
Food System Impacts
Malnutrition, food insecurity, higher food prices, foodborne illness
Severe Weather & Floods
Injuries, fatalities, loss of homes, indoor fungi and mold
Water Quality Impacts
Harmful algal blooms, campylobacteriosis, cryptosporidiosis, leptospirosis
Mental Health Impacts
Rising Temperatures
More Extreme Weather
Increasing GHG Levels
Rising Sea Levels
Stress, anxiety, depression, sense of loss, post-traumatic stress disorder, strains on social relationships
IMPACTS OF CLIMATE CHANGE ON HUMAN HEALTH
CDPH
(Adapted from CDC; J. Patz)



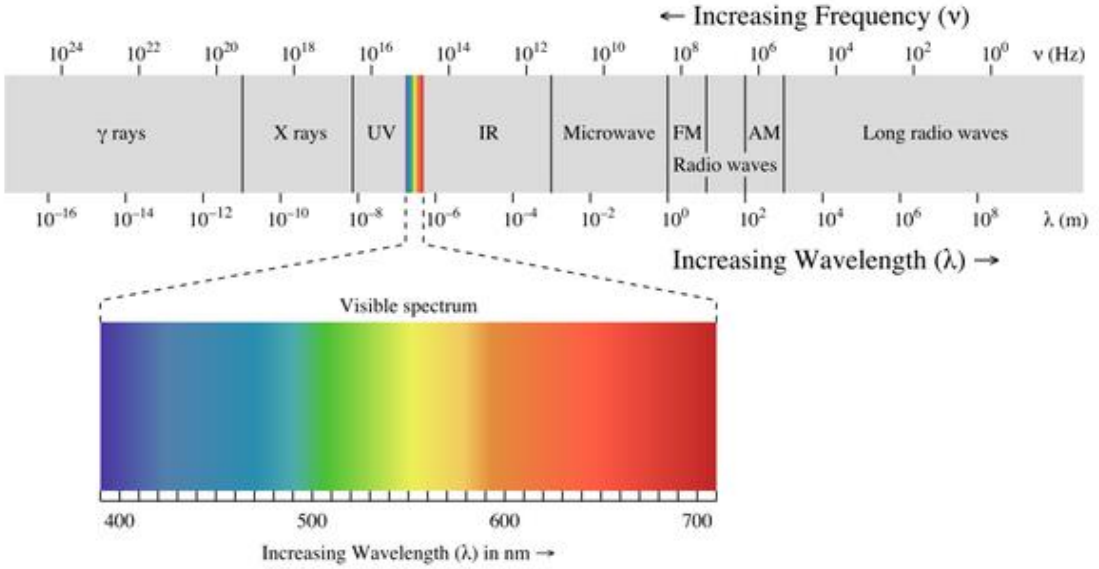
ICE Case Studies
Number 229, December, 2010

Climatic levels

- **Scale**:
  - Macroclimate: the overall climate of a region usually a large geographic area (arctic, temperate, tropic, continental…)
  - Mesoclimate (local climate) - the climate at an intermediate geographic scale (downtown district, large park, farm, wooded area…)
  - Microclimate - the suite of climatic conditions measured in localized areas e.g. in a household
- **Type**:
  - Natural
  - Artificial
- **Acclimatization**: The process in which an individual organism adjusts to a change in its environment (such as a change in altitude, temperature, humidity, photoperiod, or pH), allowing it to maintain fitness across a range of environmental conditions.

Sunlight and solar radiation

- Biological effect in influenced by the wavelength and the energy
- Shorter waves carry **more** energy than longer waves.
- Light: Infrared, visible and ultraviolet
- Infrared: 700 nm – 1 mm
- Visible light - wavelengths from 3800 nanometers (violet) to 700 nanometers (red).
- Ultraviolet (UV) light (290-400nm).
  - UVC (100-280 nm)
  - UVB (280-315 nm)
  - UVA (315-400 nm)
- Not constant (sunspots, flares)



Air pollution

Physical, chemical or biological changes in the properties of environmental elements which have an adverse effect on the health, survival or well-being of humans and/or other living organisms.

Environmental Pollutants: Substances or mixtures of substances, their degradation products, which, if released into the environment, may adversely affect the condition of environmental elements or harmful to human health or have a negative effect on environmental use.

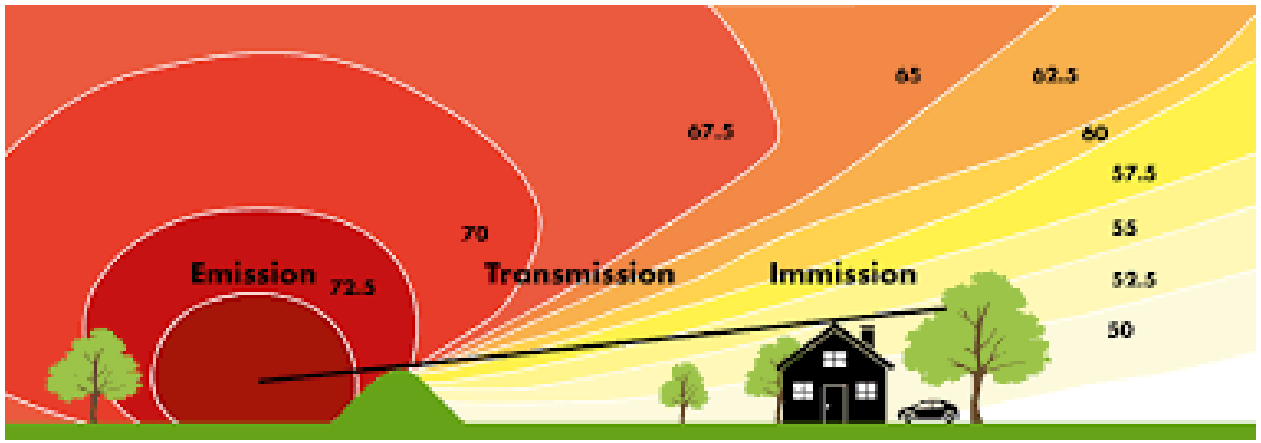
Air pollution

- Strong correlation with energy consumption
- First smog disasters – between the 1st and 2nd World War
- After the II World War, the main factors are
  - Increasing number of vehicles → increasing traffic
  - Chemical industry

  → Contaminated regions → Global contamination

Emission, immission, transmission

- **Emission** is the release of primary pollutants from a source. Further contaminants formed from a primary contaminated are referred to as secondary contaminants (SECONDARY POLLUTION)
- **Immission** is the measurable environmental concentration of pollutants released from emission sources
- Transmission is the spread of primarily emitted contaminants in the environment

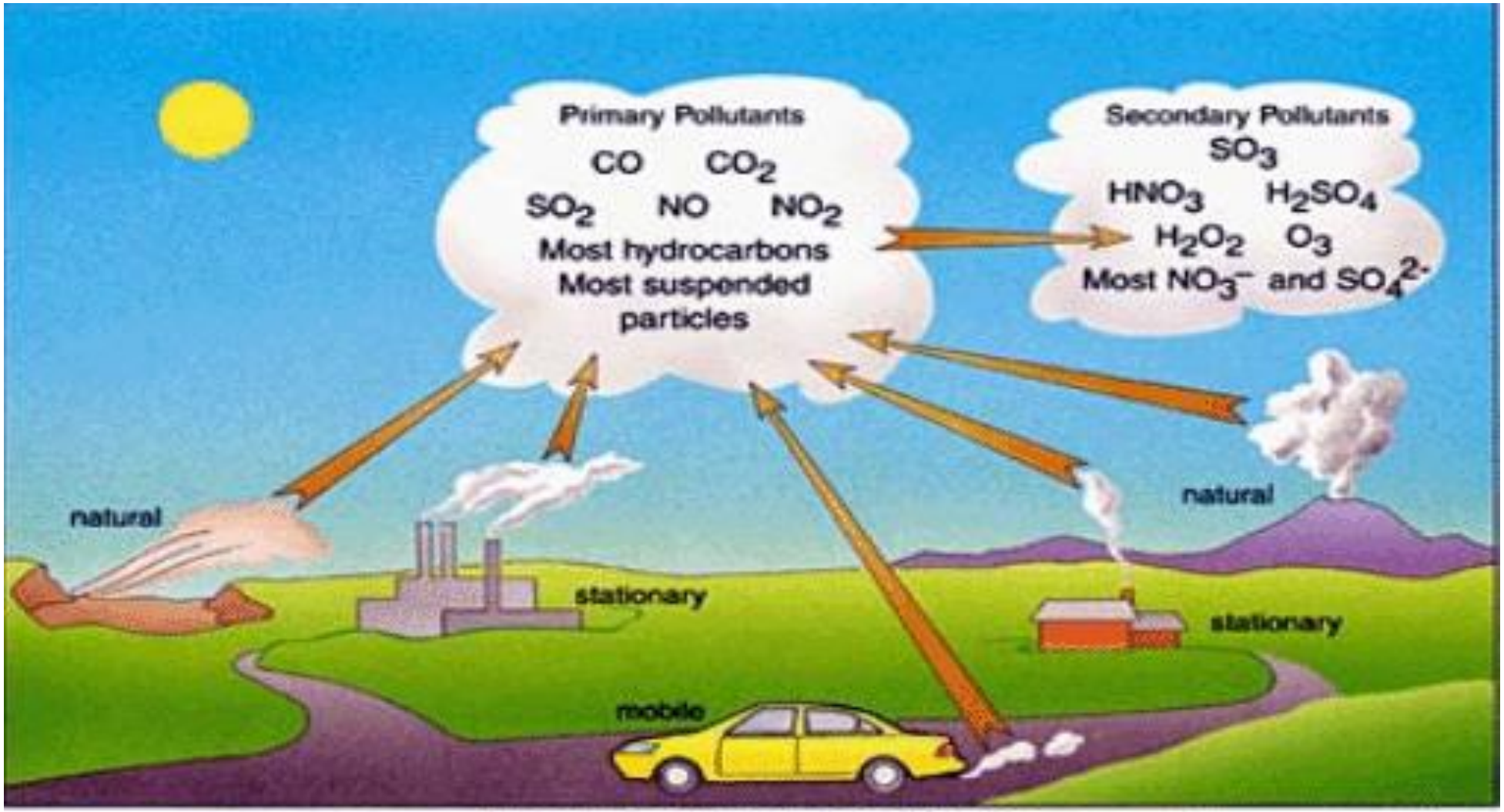


- **The source of contamination according to the spread of the pollutant**
- **POINT SOURCE (local pollution): the emission source delivers the pollutant to a given medium at a well-defined location (factory chimney, channel inlet to an open water receiver)**
- **EXPANDED SOURCE - Spatially distributed release of pollutants into the environmental element (surface, diffuse of non-point pollution): enters the medium over a large spatial extent (e.g. plant protection product, slurry, fertilizer use in agriculture and its leaching to surface water).**
- Surface source (air): any ambient air pollutant activity or material storage that is not a point or building source.

Origin of contamination

- Natural origin (waves, marine life, lithosphere, volcanic activity, flora, fauna)
- Agricultural activity (natural materials; chemicals – pesticides, artifical fertilizers)
- Artificial origin (industry, traffic…)

Air pollution



Types and sources of air pollutants

Air pollutants with threshold limit values (TLVs) 4/2011 VM decree

- Acetone
- Acrolein
- Amyl acetate
- Ammonia
- Petrol
- Benzene
- Biol. active substances
- Odour materials
- Cyclohexanone
- Metal powders and vapors
- Phenol
- Infectious agents
- Fluorides
- Formaldehyde
- Smoke, flying ash
- Hydrogen sulfide
- Mercury
- Sulfur dioxide (SO2)
- Sulfuric acid
- Chlorine

Air pollutants with threshold limit values (TLVs)

- Soot
- Methyl alcohol
- Nitrobenzene
- Nitrogen dioxide
- Nitrogen oxides
- Lead
- Ozone
- Polycyclic CHs
- Flying dust
- Sedimentary dust
- Nitric acid
- Hydrochloric acid
- Carbon dioxide
- Carbon monoxide
- Styrene
- Toluene
- Trichlorethylene
- Xylene

Major pollutants

Sulfur dioxide (SO_2)

- a gaseous air pollutant composed of sulfur and oxygen. Colorless typically pungent, irritating cough gas. SO_2 forms when sulfur-containing fuel such as coal, oil, or diesel is burned. Sulfur dioxide also converts in the atmosphere to sulfates, a major part of fine particle pollution in the eastern U.S.
- It is very soluble in water and combines with sulfuric acid. Heavier than air. It mixes with oxygen only in the presence of catalysts. It is a strong reducing agent, decolorizing some organic dyes. Toxic to living organisms. Purely inhaling causing death from suffocation, in low concentrations (0.01%) causes symptoms of poisoning with heavy breathing. Vegetation is extremely sensitive to it.

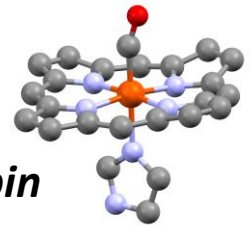
Nitrogen oxides (NO, NO_2, NO_x)

- Natural sources: lightning, or from the activity of aerobic soil bacteria
- Typical emissions: fossil fuels, energy production, transportation
- Nitric oxide (Nitrogen monoxide): colorless gas, low solubility in water, heavier than air. A neurotransmitter, it is involved in various physiological processes. Bound by the hemoglobin in the blood. Highly reactive – immediatelly convert to nitrogen dioxide
- Nitrogen dioxide: reddish-brown gas, heavier than air. Very reactive, soluble in water. Oxidizes to nitric acid in the presence of water. It plays an important role in atmospheric processes (ozone formation, smog, precursor of nitrate compounds)

Fluorides

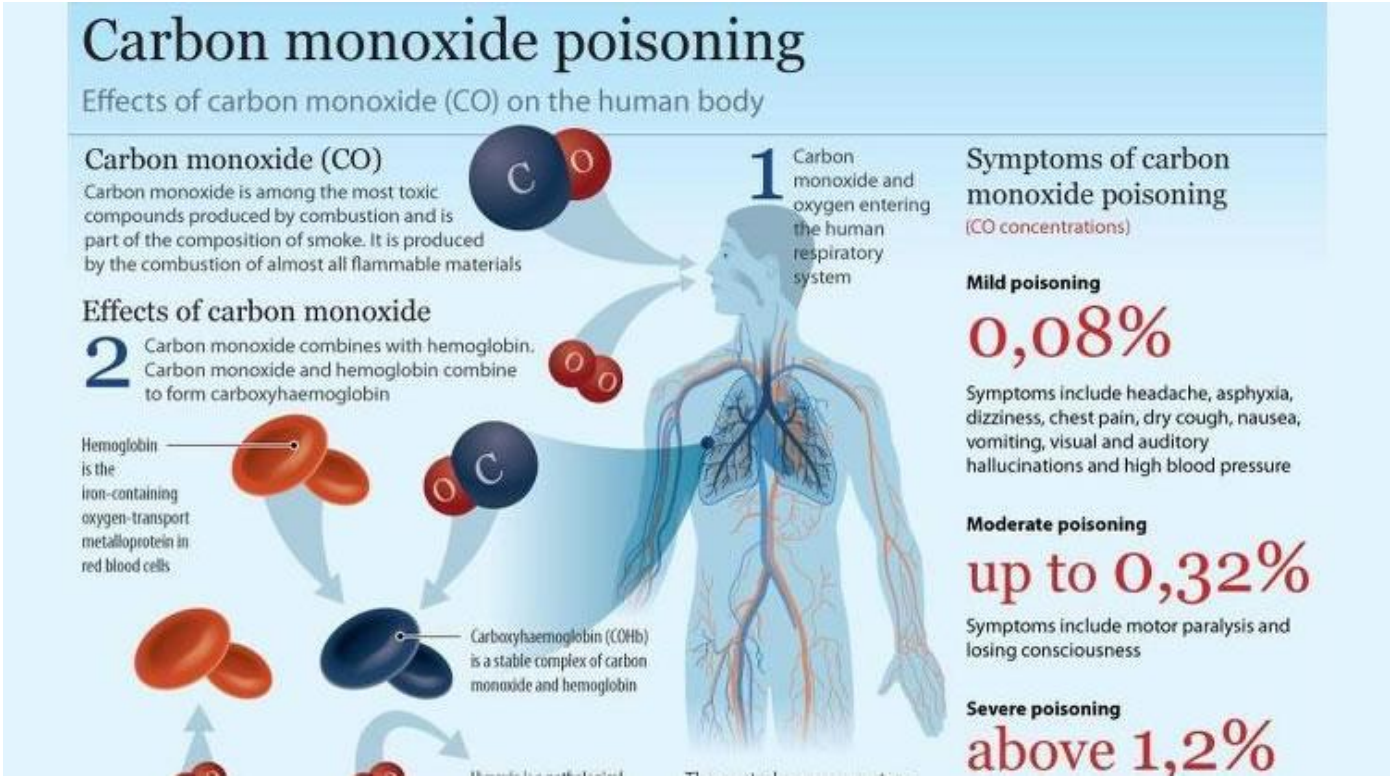
- Elemental fluorine is a yellowish-green gas with a pungent odor that is heavier than air. The most reactive of all elements. Extremely reactive with hydrogen and decomposes water. Hydrogen fluoride boils at room temperature. It is miscible with water in all proportions. It dissolves glass. Fluorine and hydrogen fluoride are very toxic to living organisms. Among the fluorides, water-soluble alkali fluorides are the major air pollutants.
- HF reacts with chlorocarbons to give fluorocarbons. An important application of this reaction is the production of tetrafluoroethylene (TFE), precursor to Teflon.

Carbon monoxide (CO)



Carboxyhemoglobin

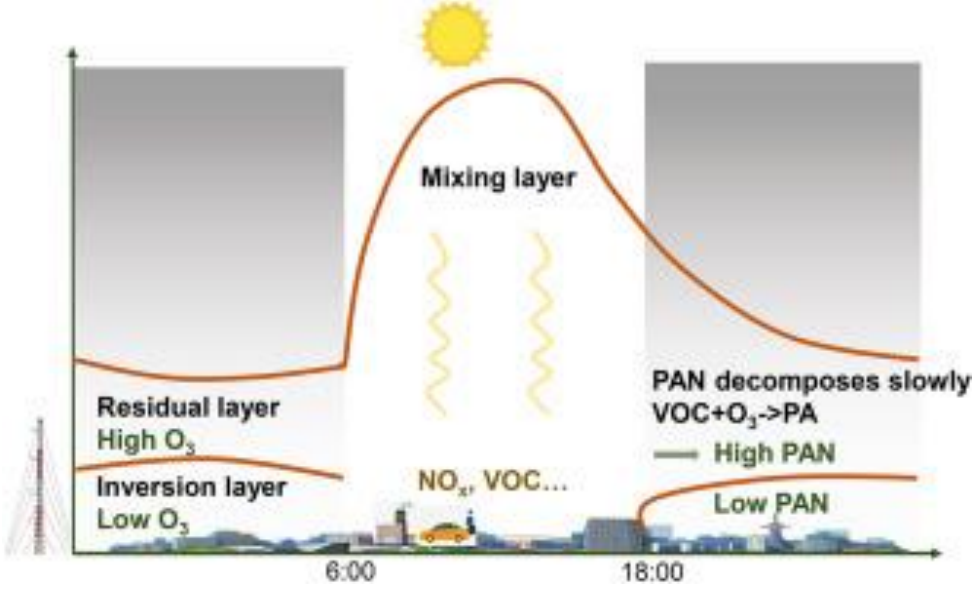
- Colorless, odorless gas, sparingly soluble in water, difficult to oxidize at room temperature. Slightly lighter than air.
- It is formed during imperfect combustion.
- Extremely toxic to humans and animals. It accumulates in the blood in the form of very stable ***Carboxyhemoglobin***.



Solid particles, Particulate matters (PM)

- Sedimentary powder (sediment or aerosestone). The precipitated powder is usually divided into water-soluble and water-insoluble and organic and inorganic fractions;
- Particulate matter (particles which remain suspended for a long time and have a diameter of less than about 10 μm)
- Aeroplanktons
- The main constituents of solid contaminants are fly ash and soot, dust from the soil surface, transport, industry. The composition varies greatly.
- We distinguish between **toxic and inert powders** (more stringent regulations apply to toxic powders). Toxic powders: powders of biologically active agricultural products, such as pesticides, fungicides, herbicides, as well as lead, which was previously largely of transport origin, as well as various carcinogenic compounds.

Photochemical oxidants



- Various organic compounds that pollute the air, as well as nitrogen oxides, react chemically with each other under the influence of sunlight, especially UV radiation

→photochemical oxidants are formed, such as ozone and peroxyacetyl nitrates (PAN).

Ozone is easily measurable→ an indicator of PANs. Ozone is a very aggressive substance due to the nascent oxygen produced by the decomposition of the O3 molecule. It causes tissue death in plants and mucosal irritation in humans. PAN materials also include carcinogens.

Heavy metals

- Lead tetraethyl was added to increase the compression tolerance of vehicles. Prolonged inhalation of lead may cause nervous system damage, adverse effects on mental abilities have been observed in children.
- Heavy metals / lead, vanadium, cadmium / accumulate in the bones and hinder their physiological development, especially in children. Some (e.g. chromium VI, cadmium) are carcinogenic!

Polycyclic aromatic hydrocarbons - PAHS

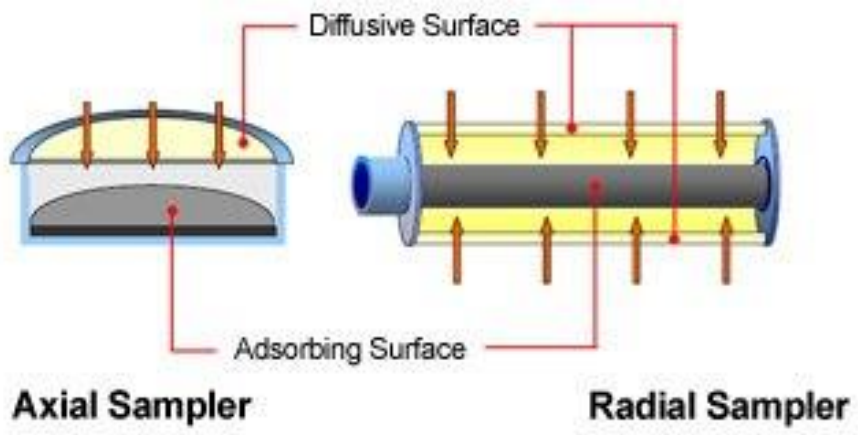
- The most common polycyclic aromatic hydrocarbons / PAHs in air are benz- (a) pyrene, 1,1,2-benzperylene, 1,2-benzanthracene and chrysene.
- The above mentioned and many other PAHs have been shown to be carcinogenic to humans. They are released into the air during imperfect combustion, bound to soot: during combustion, with exhausted gases, smoking.

Air sampling

- **Location of sampling site**
- Ambient air is not the same as indoor air and workplace air, which are subject to special regulations!
- **Emission air sample**: from a point in the technological equipment (chimney) that characterizes the operation of a given part of the technological process and quickly follows the changes in operation.
- **Immission air sample**: for the determination of ambient air pollution

Air sampling

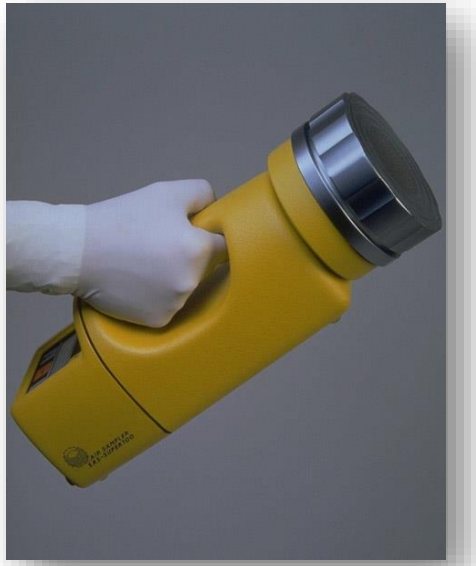
- Active and passive (diffuse) sampling mode
  - Active: calibrated pump (active air flow) E.g. Tedlar bag
  - Passive: sorbent binding of harmful substances (axial and radial sampling tubes)



Uptake/Sampling rates are higher for radial samplers than axial


SAMPLER
0005


GASTEC



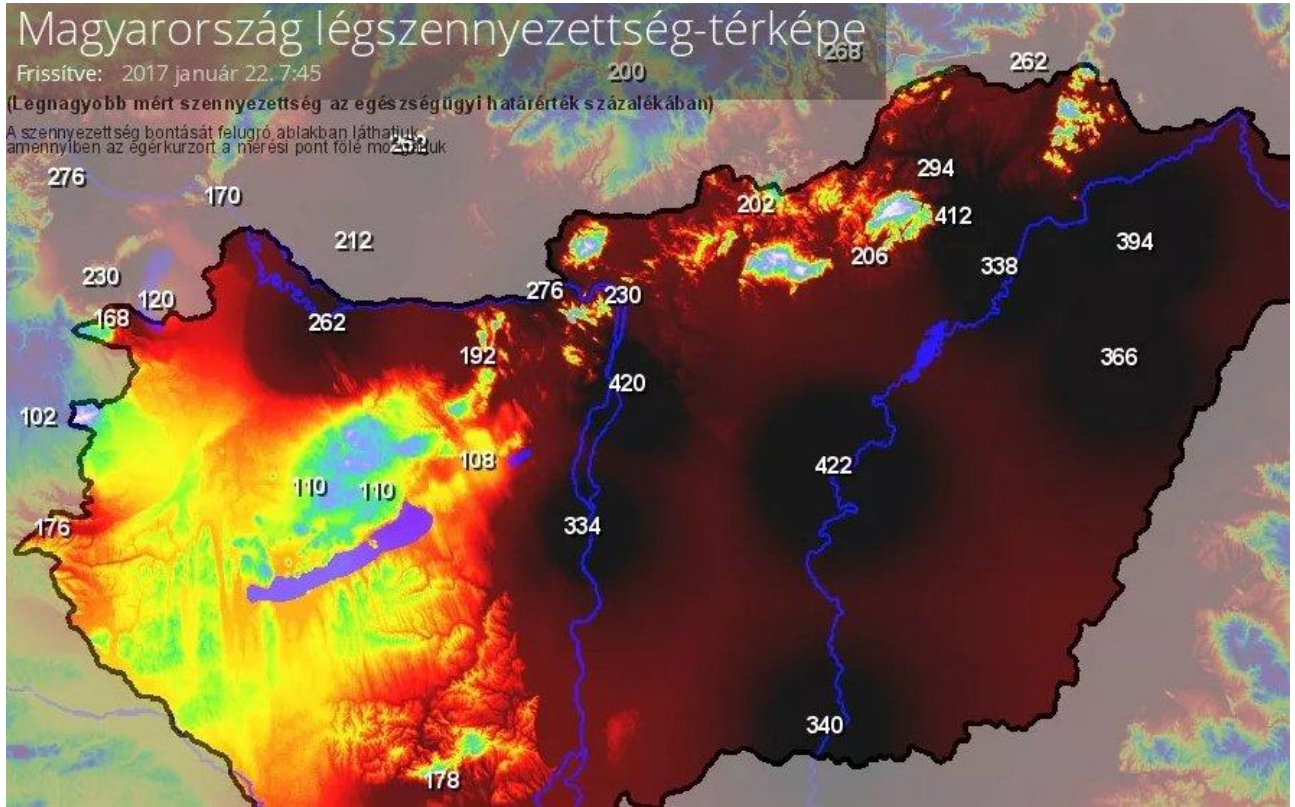
Air Quality Index (AQI)

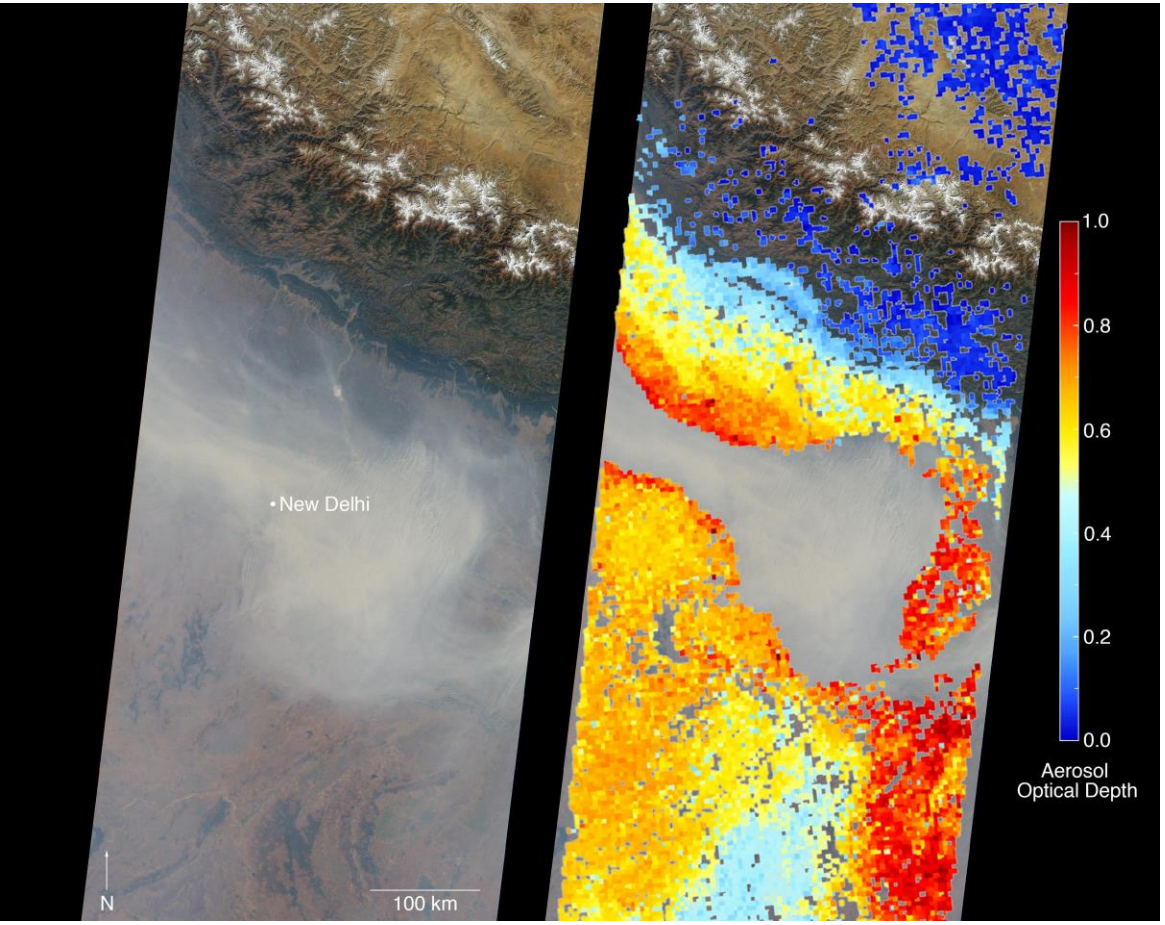
- An indicator defined on the basis of scientific literature and relevant legislation.
- It characterizes the level of air pollution in the last 24 hours for basic pollutants such as sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3) and particulate matter (PM_{10}).
- It is calculated from the maximum 1-hour concentration (SO_2, NO_2, CO), the maximum of the 8-hour moving averages (O_3) and the 24-hour average concentration (PM_{10}).

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health warnings of emergency conditions. The entire population is more likely to be affected.
Hazardous	301 to 500	Health alert: everyone may experience more serious health effects

- In Hungary the air pollution data required to calculate the AQI are provided by the database of automatic measuring stations of the National Air Pollution Measurement Network (http://www.kvvm.hu/olm)

Estimation of health effects is scientific literature.





- At left, a map of aerosol optical depth is superimposed on the image. Optical depth is a quantitative measure of the abundance of aerosols (tiny particles in the atmosphere). Optical depths for the area around New Delhi have not been calculated because the haze is so thick that the algorithm has classified the area as a cloud. In the region immediately surrounding the thick haze, optical depths approach 1.0. An optical depth of 1.0 means that only about 37 percent of direct sunlight reaches the surface due to interactions with particles in the atmosphere.
- In early November 2016, monitors at various locations in the area posted air quality index measurements as high as the 900s (the most severe ranking, "hazardous," is any air quality index measurement over 300). Thousands of schools have been closed, and a survey by the Associate Chambers of Commerce and Industry of India reports that 10 percent of the city's workers called in sick due to air-pollution-related health issues.

Smog – smoke fog

- Accumulation of contaminants under adverse weather conditions.
- Two types:
- **Los Angeles type:**
  - Sunny windless weather in summer.
  - Oxidizing components (NOX, O3, hydrocarbons)
- **London type:**
  - Overcast, humid cold weather.
  - Reducing components (SO2, carbon black, CO)

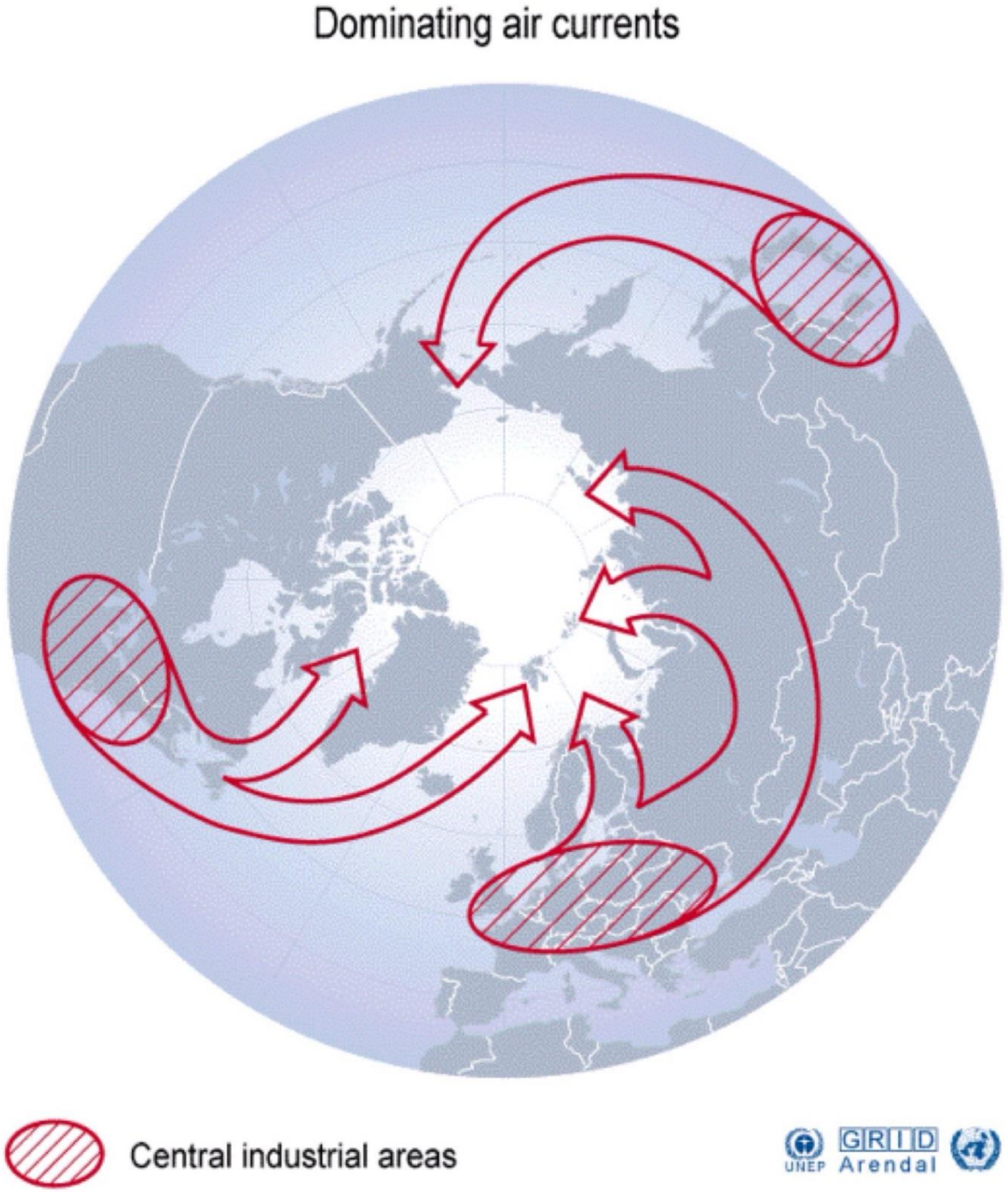
The fate of air contamination - atmospheric processes

- Circulation of pollutants
- Various effects:
- Reaction with air and other pollutants
- Cosmic effects: heat, light, UV, radioactive radiation.
- Metal ions (catalysts)
- Atmospheric water
- Oxidizing-reducing substances
- Energy requirements for reactions (light, heat, UV)
- Catabolism rather than anabolism
- Natural self-cleansing

The fate of contamination - natural self cleansing

- Three major groups
  - Contaminant is removed from the atmosphere
    - Sedimentation
    - Impaction, precipitation
    - Adsorption, absorption
    - Rain out
    - Wash out
  - Contaminant transforms (chemical degradation)
  - The concentration of contaminant decreases (dilution)
    - Wind, turbulence
    - Local geographical conditions

- Wind: disordered thermal motion of air. Factors forming a vertical wind structure:
  - Gradient force (differences in atmospheric pressure)
  - Frictional force
  - Coriolis force
  - Centrifugal force
- Turbulence: disordered motion within a flow (thermal of dynamic)



Consequences of air pollution

Biosphere and atmosphere - Forming and adaptation

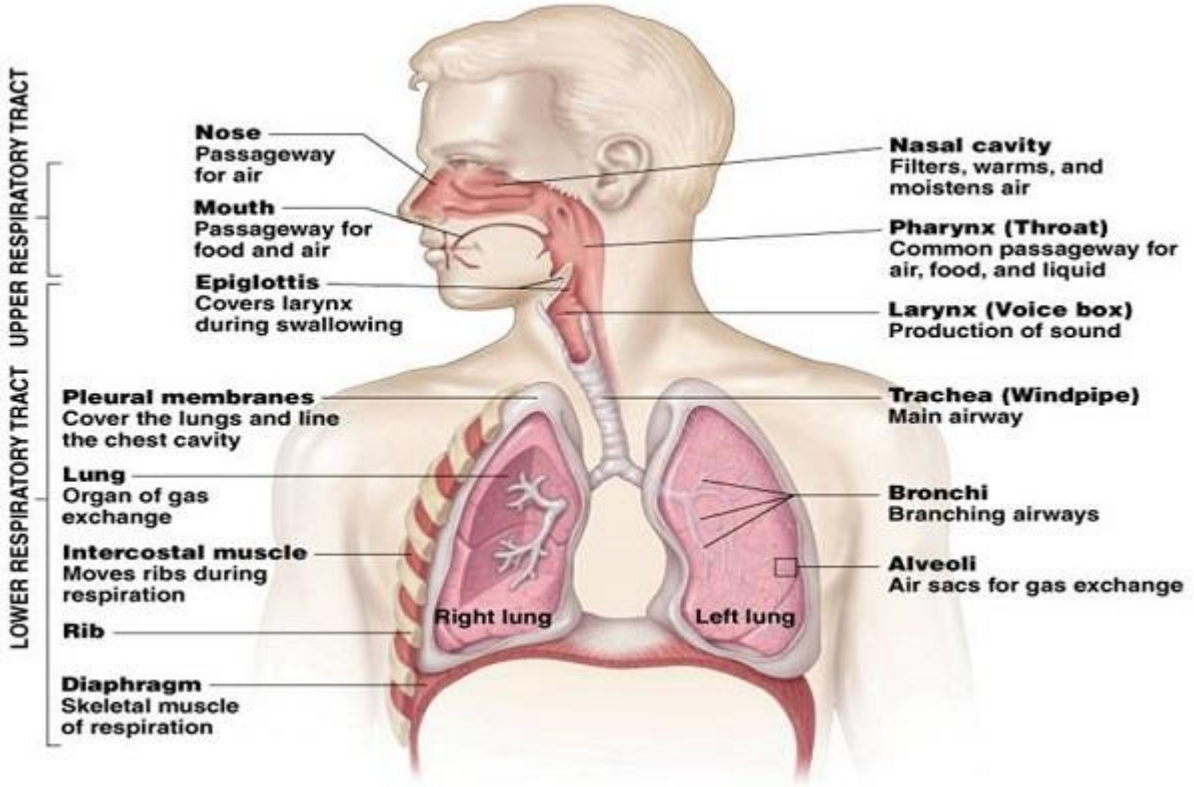
- **Plants**
  - Indicator organisms (e.g., lichens)
  - Changes in vegetation and their correlation with the type and concentration of pollution
  - Adaptation capacity of species (e.g., in agriculture)
  - Air filter and cleaning effect of vegetation
- **Animals**
  - Typical symptoms of air pollution (fluorosis, canary test)
  - Experimental animals
- **Landscape**

Monetary loss

- **Technical damage**
- Metal corrosion, dissolution, rust
- Building material weathering, stone sculptures Industrial machines, equipment, motor vehicles, industrial, public and residential buildings, line facilities
- Indirect damage: Inspection, measurement costs
- **Economic damage**
- Material goods
- Vegetation loss
- Healthcare expenses

Effect of air pollution on human health

- Effect through the respiratory track
- Skin surface contamination
- Eye and mucosa irritation
- Odour
- Sunlight and UV reducer
- The need for personal hygiene is greater
- Disturbs well being



Health consequences

- Discomfort, negative effects, changes in homeostasis, chronic disease, acute disease, death
- The effects of air pollution are depending on
- **External factors** (concentration, toxicity, synergisti, antagonistic effects, duration of exposure, periodicity, environmental factors)
- **Internal factors** (sensitivity, general condition)

- **According to the exposition**
  - Short term
  - Long term

Epidemiology – the effect of air pollution at population level

- Respiratory diseases and deaths – 20%
- Respiratory cancer and death – 20%
- Heart and cardiovascular disease and death - 10%


DEATH BY BAD AIR
India
China
2000
2,502
3,010
2005
2,634
3,321
2010
2,865
3,100
2015
3,283
3,233
Figures for deaths every day, source: Greenpeace

Thank you very much for your attention

HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES

ENVIRONMENTAL HYGIENE

Dr. Edit KASZAB

associate professor

MATE – Institute of Aquaculture and Environmental Safety

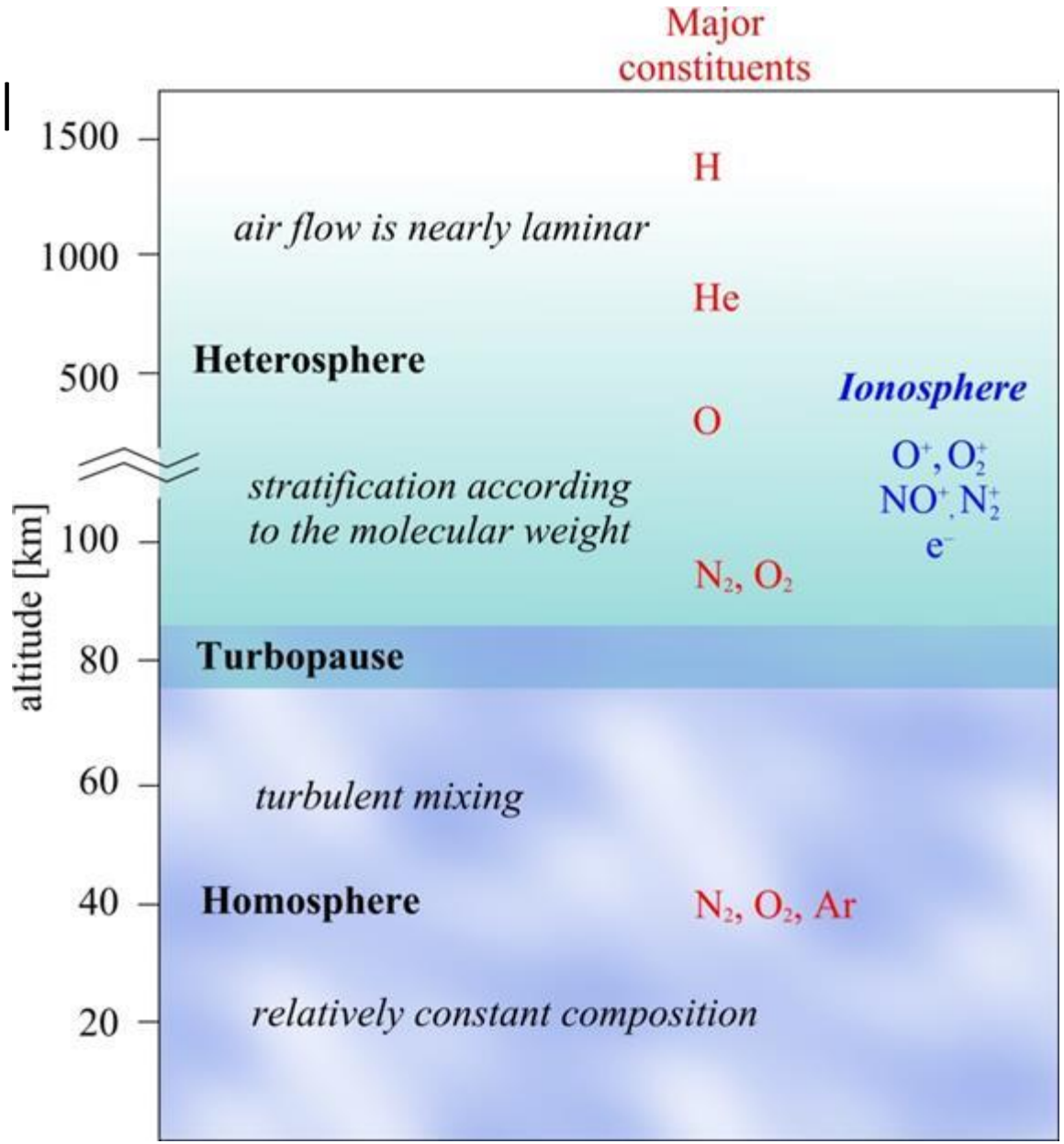
Department of Environmental Safety

Air hygiene – measure the invisible?

- The hygiene of atmosphere studying air-related issues to protect health and prevent disease.
- **Activities of air hygiene:**
  - Measurement of air quality
  - Evaluation of the effects of air quality on human health
  - Applied air hygiene
- **Air quality:** The degree to which air is polluted; the type and maximum concentration of man-produced pollutants that should be permitted in the atmosphere.
- **Air safety:** Any measure, technique or design intended to reduce the risk of harm posed by either moving vehicles or projectiles above the earth's surface or pollutants to the earth's atmosphere.

The vertical structure of the athmosphere according to chemical composition

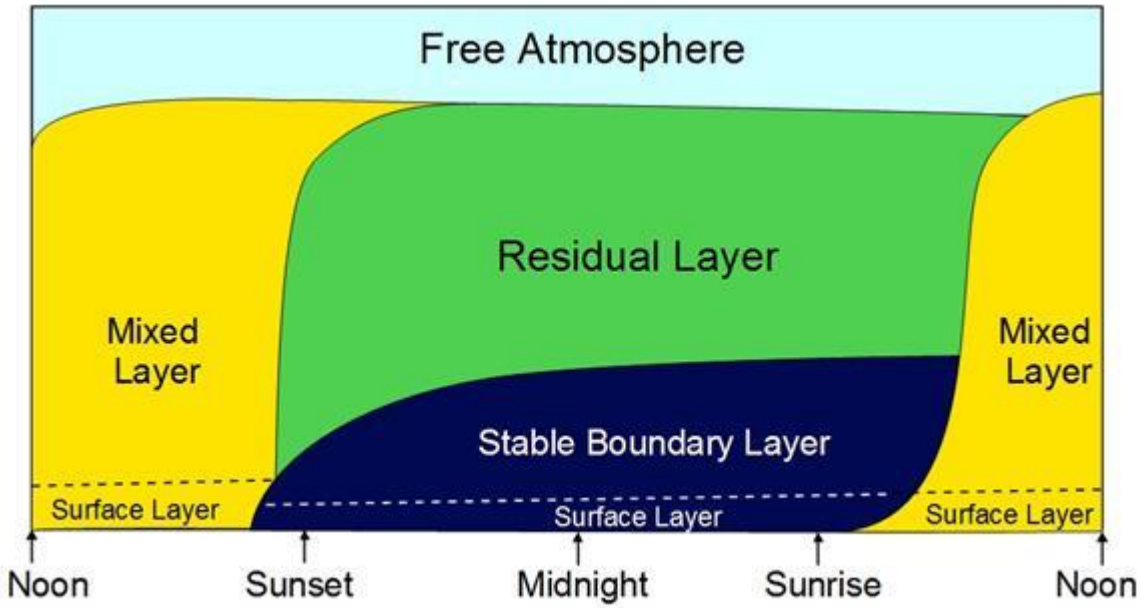
- Two layers:
- The lower layer, up to an altitude of about 80 km is the homosphere, (continuous turbulent mixing the composition of the atmosphere is relatively constant for chemical species which have long mean residence times).
- A thin transition layer, called turbopause.
- Above the turbopause, in the heterosphere, the molecular diffusion dominates and the chemical composition of the atmosphere becomes stratified and varies according to the molecular mass of chemical species



Source: Lagzi et al.: Atmospheric chemistry (2013)

The planetary boundary layer

- The lowest level of the atmosphere – the bottom layer of the troposphere – called planetary boundary layer (PBL) is directly and strongly influenced by the underlying surface (Stull, 1988). Within the PBL the convective air motions generate intense turbulent mixing.
- The upper boundary of PBL is statically stable (temperature inversion).
- Interactions between the atmosphere and the surface take place in the PBL.
- Timescale of atmospheric response to surface forcing is an hour or less.
- Atmospheric variables (wind speed, temperature, water vapor content etc.) show great variability and fluctuation and the vertical mixing is strong.
- **Planetary boundary layer has great importance in dispersion, dilution and deposition of air pollutants.**



The structure of the planetary boundary layer

The composition of the atmosphere

Chemical species				Sources					
Name	Formula	Concentration	Residence time	Biogenic	Anthropogenic	Photochemical	Volcanic	Radiogenic	Other
Nitrogen	N_2	78.084%	1.6×10^{7} years	✓			✓		
Oxygen	O_2	20.946%	3×10^{3}–10^{4} years	✓					
Argon	Ar	0.934%						✓	
Water vapour*	H_2O	0–4% (0– 40 000 ppm)	10 days	✓	✓		✓		(1)
Carbon dioxide	CO_2	3.94×10^{-2}% (394 ppm)	20–150 years	✓	✓		✓		
Neon	Ne	1.818×10^{-3}% (18.18 ppm)					✓?		
Helium	He	5.24×10^{-4}% (5.24 ppm)	10^{7} years					✓	
Methane	CH_4	1.79×10^{-4}% (1.79 ppm)	10 years	✓	✓				
Krypton	Kr	1.14×10^{-4}% (1.14 ppm)						✓	
Hydrogen	H_2	5.3×10^{-5}% (0.53 ppm)	2 years	✓	✓				(2)
Nitrous oxide	N_2O	3.25×10^{-5}% (0.325 ppm)	150 years	✓	✓				
Carbon-monoxide	CO	$5–25\times10^{-6}$% (0.05–0.25 ppm)	0.2–0.5 year	✓	✓				
Xenon	Xe	8.7×10^{-6}% (0.087 ppm)							
Ozone	O_3	$1–5\times10^{-6}$% (0.01–0.05 ppm)	weeks - months			✓			
Nitrogen-dioxide	NO_2	$0.1–5\times10^{-7}$% (0.001–0.05 ppm)	8–10 days	✓	✓	✓			
Ammonia	NH_3	$0.01–1\times10^{-7}$% (0.0001–0.01 ppm)	~5 days	✓	✓				
Sulphur-dioxide	SO_2	$0.003–3\times10^{-7}$% ($0.03–30\times10^{-3}$ ppm)	~2 days		✓	✓	✓		
Hydrogen-sulphide	H_2S	$0.01–6\times10^{-8}$% ($0.01–0.6\times10^{-3}$ ppm)	~0.5 day	✓	✓		✓		

Aerodisperse system

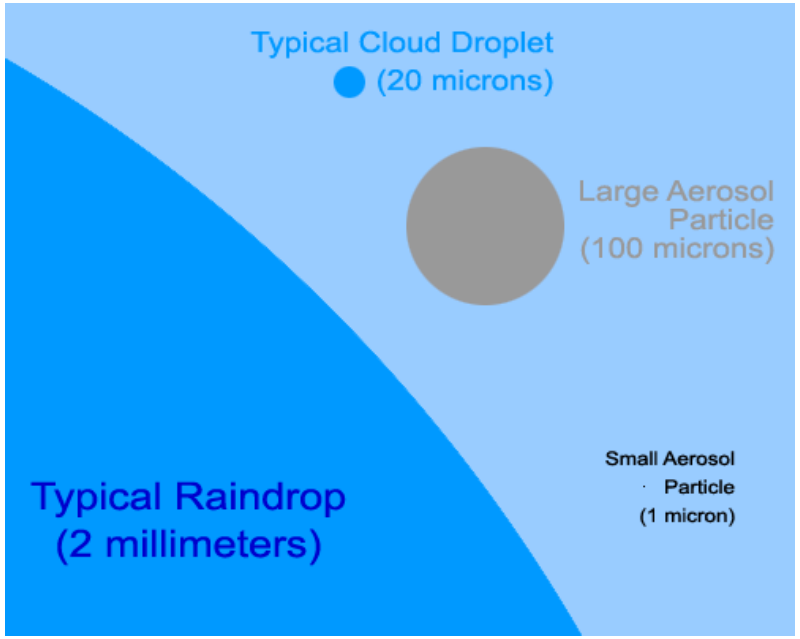
Nominal molecular weight: 28.973 g / mol

Source: Lagzi et al.: Atmospheric chemistry (2013)

Trace materials

- Trace gases and **aerosols**
- Small amount, important role
- Their quantity may be specific to the area, altitude, origin of the air masses, etc.

- **Aerosol**: Suspended matter, or more generally all solid, liquid or waving particles in the atmosphere are called aerosols. Aerosol particles can be classified according to
  - their genesis,
  - the origin,
  - the particle size,
  - their optical and physical properties,
  - the chemical composition,
  - and their impact on the climate system.

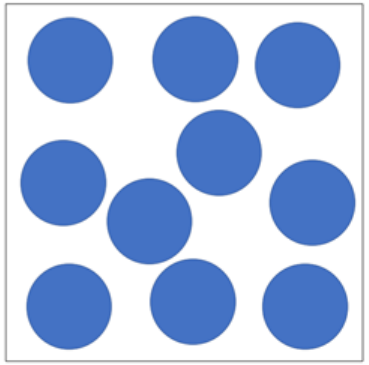
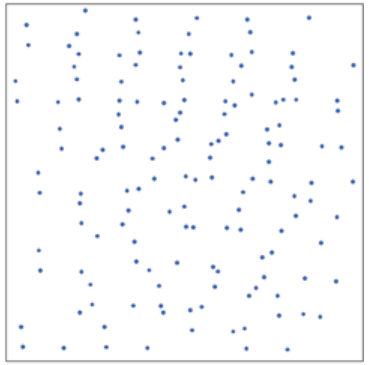


Aerosol types (based on particle size)

- The metrics that are most commonly used to describe particulate matter (PM) are the number concentration and the mass concentration.

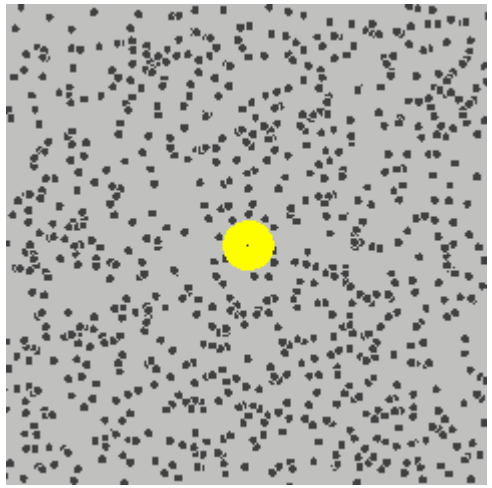
Mass distribution:

- Coarse particulate matter - with an aerodynamic diameter of 10 µm or less (**PM10**),
- Fine particulate matter, with a diameter of 2.5 µm or less (**PM2.5**).
- Ultrafine particles (**UFPs**) are all particles with a diameter of 100nm or less.

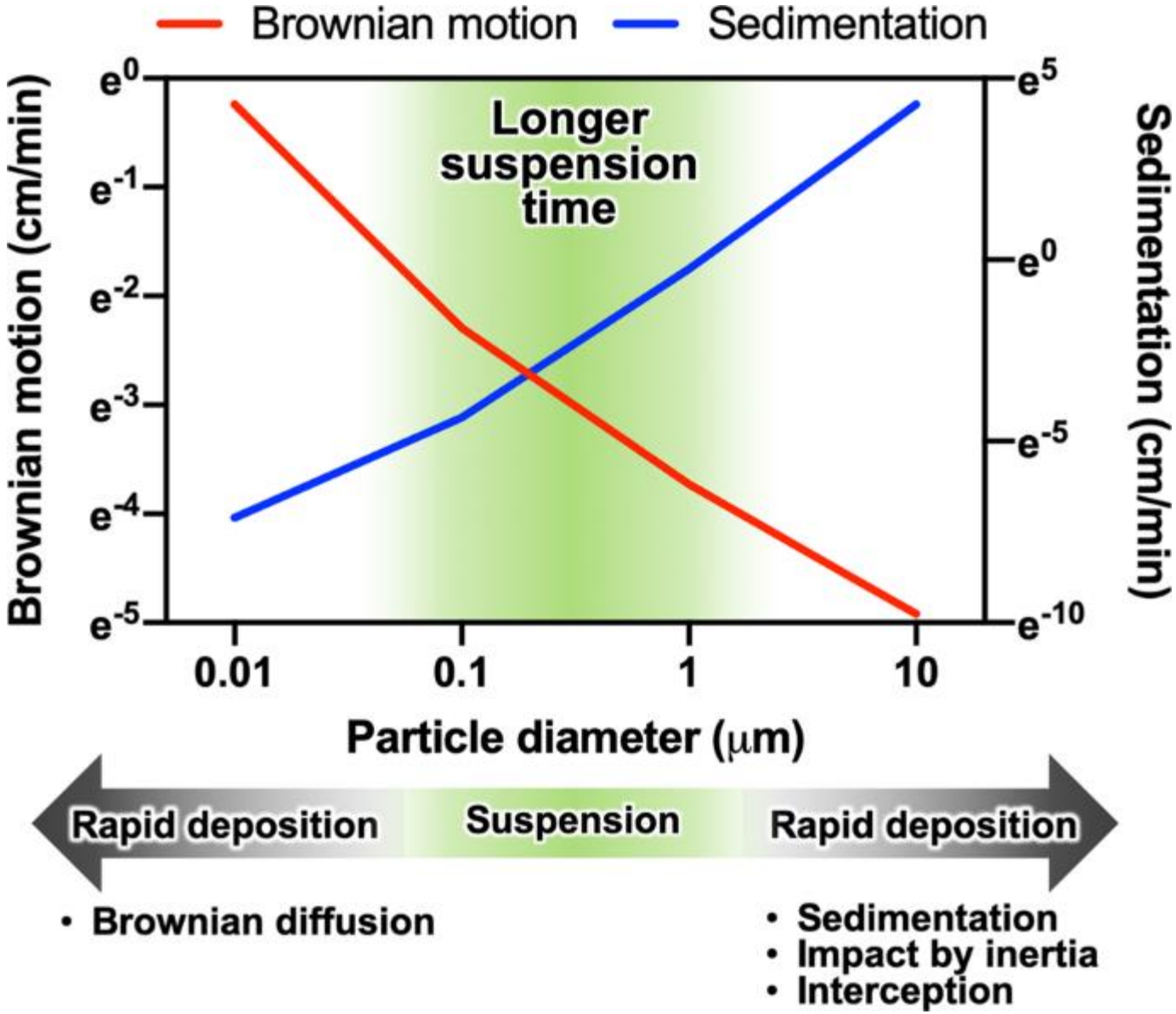
	10 µm (Coarse)	2.5 µm (Fine)	0.1 µm (Ultrafine)
			
Total mass	1	1	1
Particle number	1	64	1,000,000
Surface area per particle	1	0.0625	0.0001
Total surface area per mass	1	4	100
	• Filtered in proximal airway • May irritate skin, mucosa	• Reaches peripheral airway • Cannot enter systemic circulation	• Higher adsorbed toxic material on surface • May enter systemic circulation

Kwon et al. 2020

Size and fate



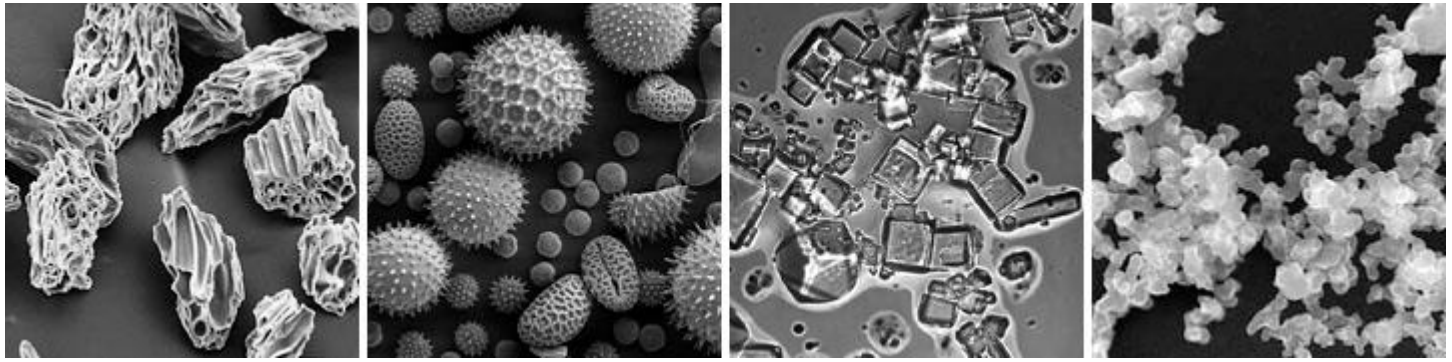
- Ultrafine particles are rapidly deposited by Brownian diffusion, especially particles <20 nm. Large coarse particles are deposited by sedimentation, impact by inertia, and interception. Particles between 30 nm and 1 µm tend to have longer atmospheric lifetimes because they are less likely to be deposited in either way. These particles accumulate in the atmosphere due to the long suspension time and are thus called the accumulation mode.



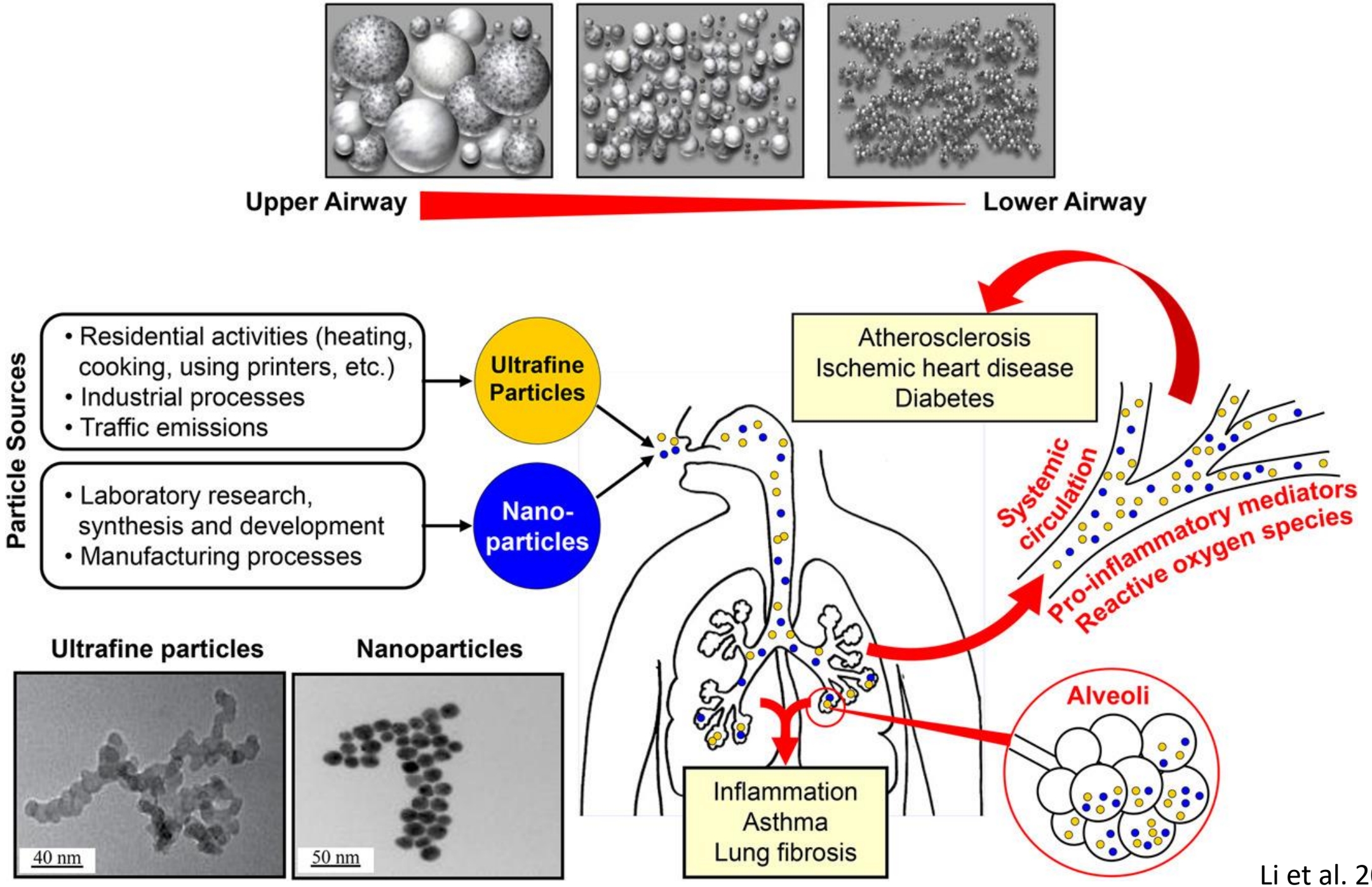
Kwon et al. 2020

Variety of aerosol types

The wide variety of aerosol shapes. From left to right: volcanic ash, pollen, sea salt, and soot. [Micrographs courtesy USGS, UMBC (Chere Petty), and Arizona State University (Peter Buseck).]



Desert dust, volatile organic compounds from vegetation, smoke from forest fires, and volcanic ash are natural sources of aerosols. (Photographs copyright (left to right) Western Sahara Project, Jonathan Jessup, Vox, and Ludie Cochrane.)

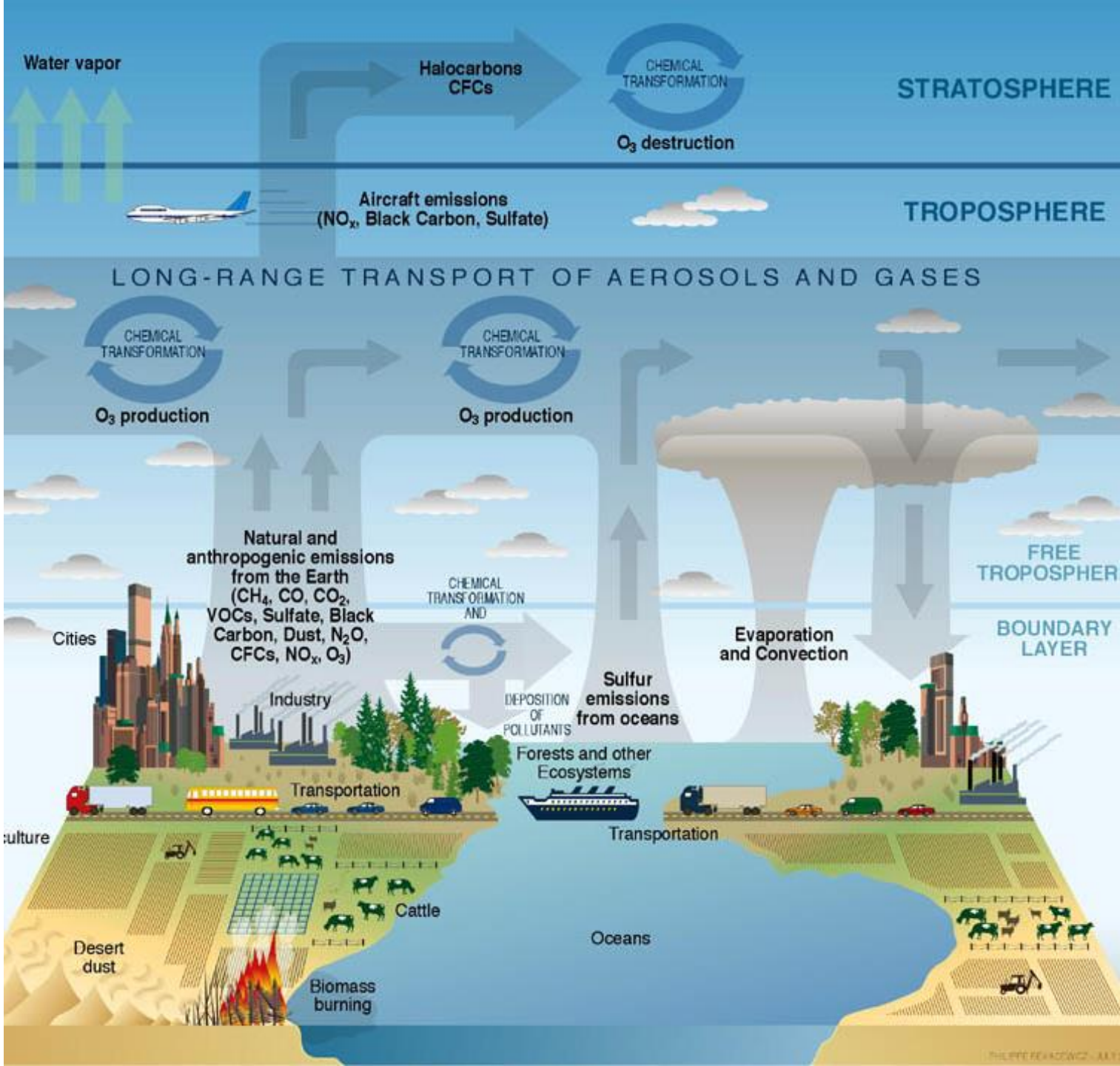

Upper Airway
Lower Airway
Particle Sources
• Residential activities (heating, cooking, using printers, etc.)
• Industrial processes
• Traffic emissions
• Laboratory research, synthesis and development
• Manufacturing processes
Ultrafine Particles
Nano-particles
Atherosclerosis
Ischemic heart disease
Diabetes
Systemic circulation
Pro-inflammatory mediators
Reactive oxygen species
Alveoli
Inflammation
Asthma
Lung fibrosis
Ultrafine particles
Nanoparticles
40 nm
50 nm

Li et al. 2016

Effects of aerosols

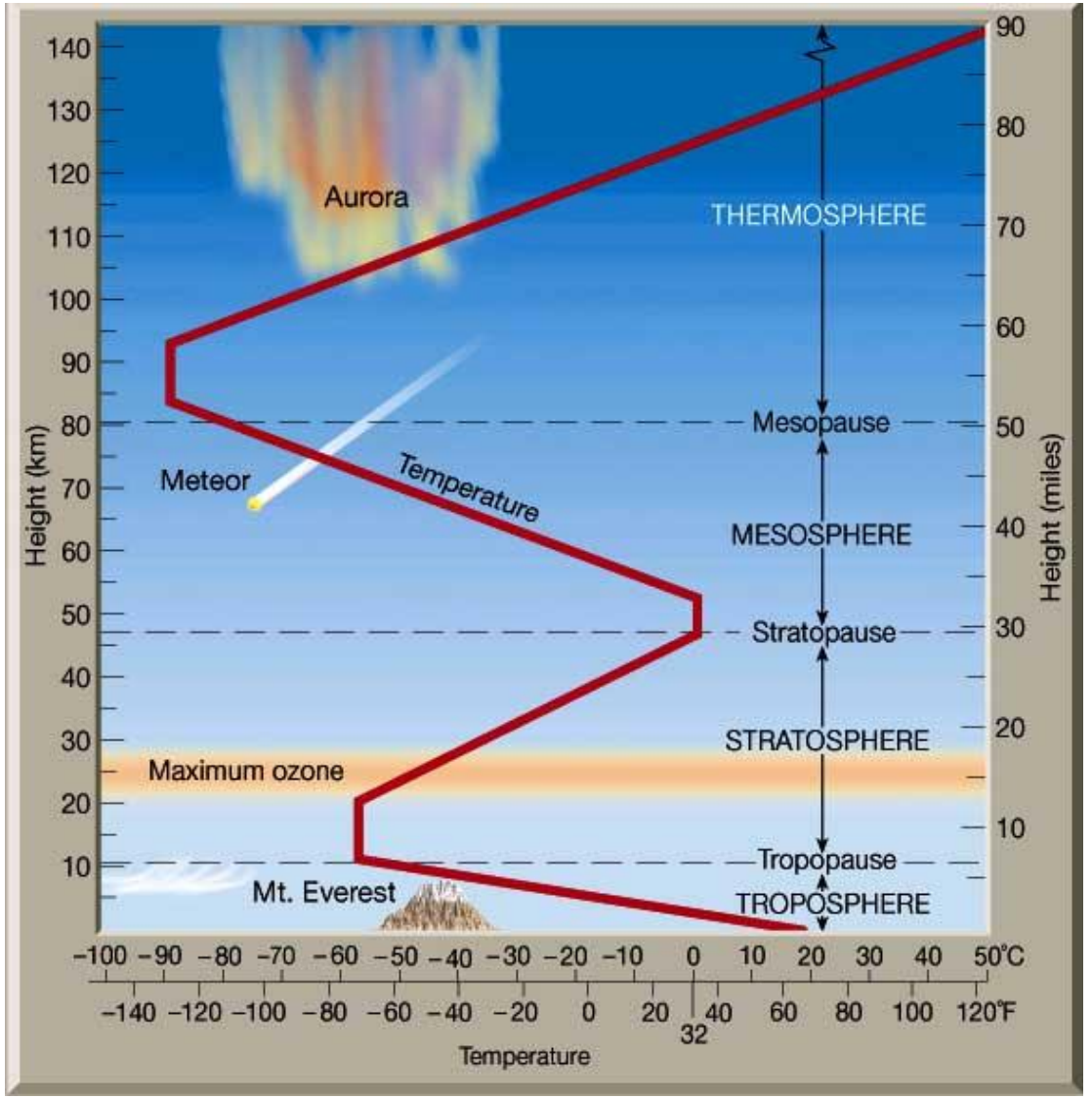
- Aerosols affect directly our environment as they are responsible, for instance, for health problems and acid rain.
- Have a direct radiative forcing because they scatter and absorb solar and infrared radiation in the atmosphere
- **Alter warm, ice and mixed-phase cloud formation processes** by increasing droplet number concentrations and ice particle concentrations.

→ Climate change



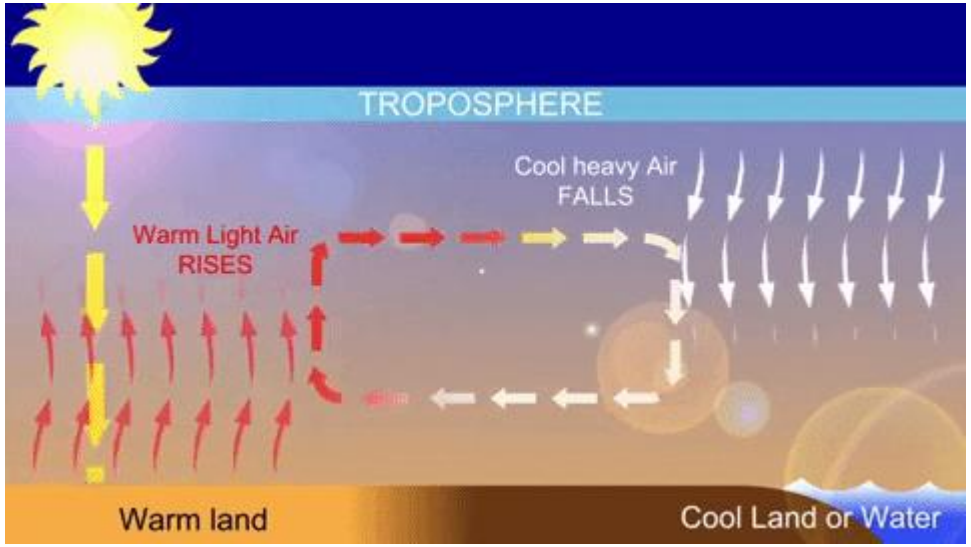
The physical properties of atmosphere

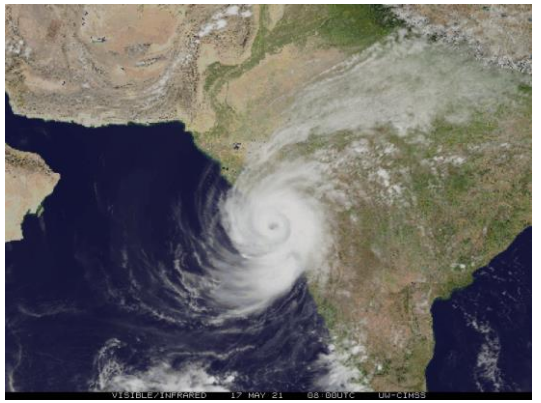
- **Temperature** (solar radiation, terrestrial radiation, chemical reactions, air currents)
- Based on the variation of temperature with height, the atmosphere can be divided to different layers



The physical properties of atmosphere

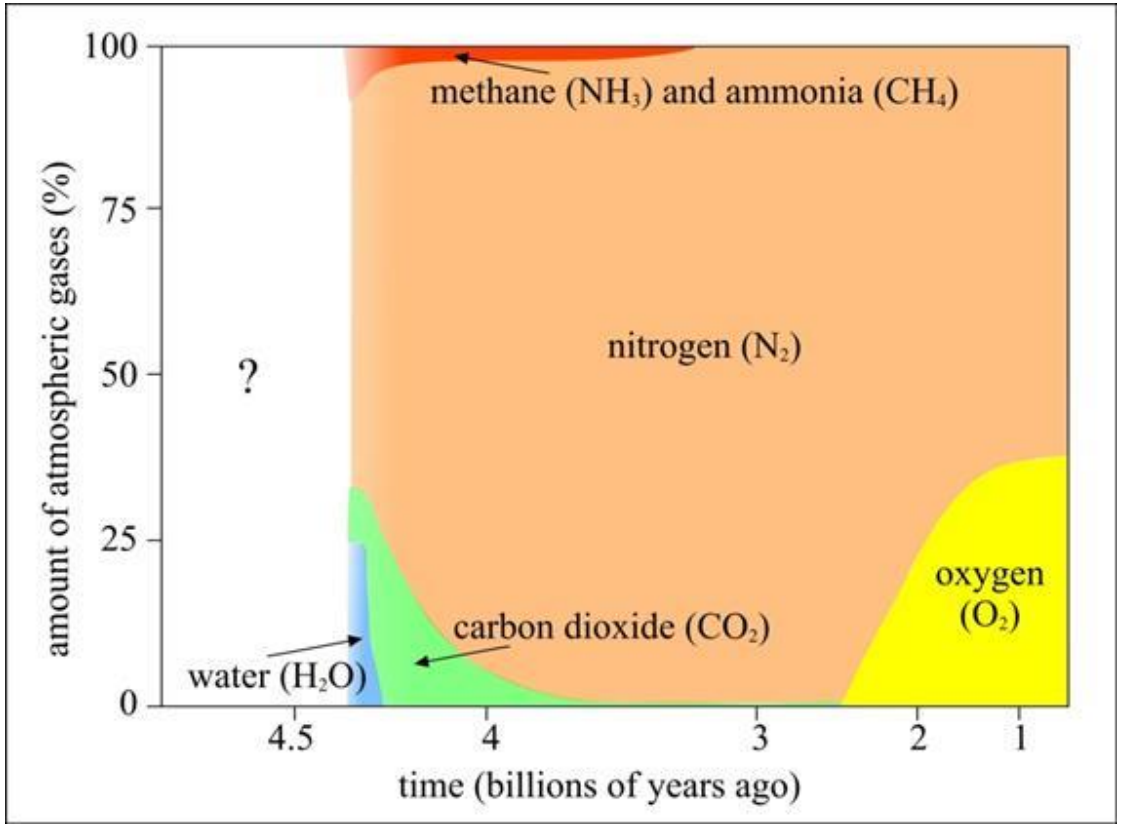
- **Wind**: the perceptible natural movement of the air, especially in the form of a current of air blowing from a particular direction
- Atmospheric pressure: the force exerted on a surface by the air above it as gravity pulls it to Earth.
- Cyclones
- Humidity: absolute and relative humidity, dew point
- Atmospheric electricity



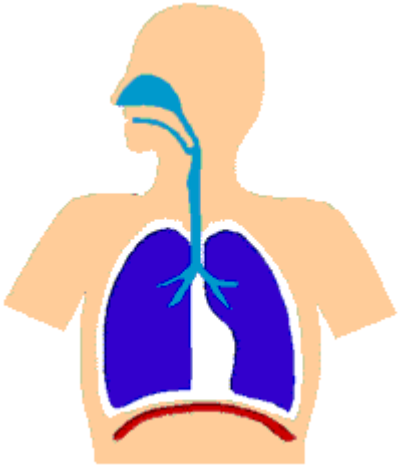


The biological aspects of atmosphere

- Atmosphere as a biotope
- Oxygen was first produced in the atmosphere by photochemical dissociation of water vapour by intense ultraviolet radiation:
- $2H_2O$ + UV radiation → $2H_2 + O_2$.
- Because of the Urey self-regulation of this process byshielding H_2O vapor with O_2, O_3, and CO_2, primitive oxygen levels cannot exceed O_2 0.001 present atmospheric level (P.A.L.).
- Around 2.5 billion years ago: photosynthesis
- $CO_2 + H_2O$ + sunlight → organic compounds + O_2
- Around 1 billion years ago: Pasteur point was reached (a level of oxygen (about 0.3% by volume which is less than 1% of Present Atmospheric Level or PAL) above which facultative aerobic microorganisms and facultative anaerobes adapt from fermentation to aerobic respiration).
- As the atmospheric oxygen reached 1–2% of present oxygen level, ozone (O_3) could form to shield Earth's surface from intense ultraviolet radiation:
- $2O_2$ + UV radiation → $O_3 + O$



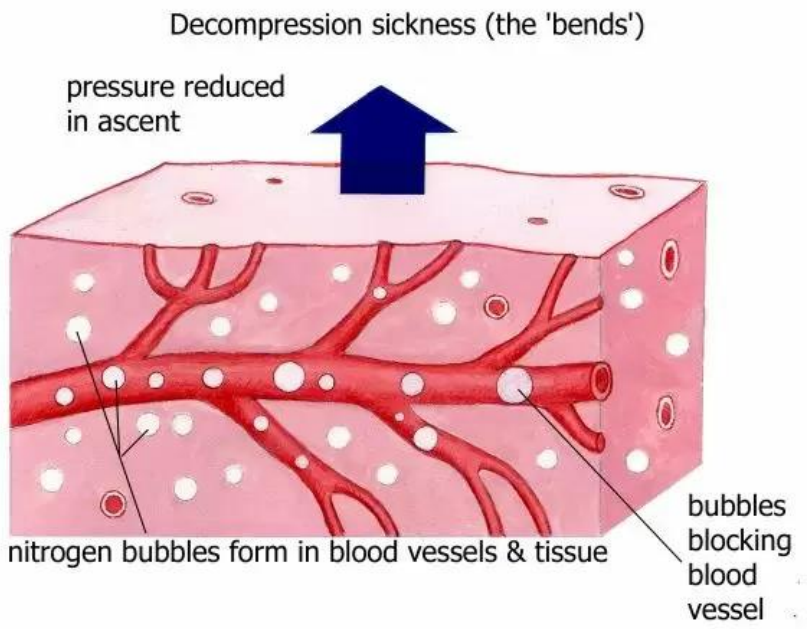
Respiration



- Internal respiration - involves gas exchange between the blood and body cells.
- External respiration - the breathing process. It involves inhalation and exhalation gases.
  - The process of breathing (inhalation and exhalation), also called ventilation
- Cellular respiration - the metabolic processes of converting the energy stored in biological molecules to usable energy in the form of ATP.
- Factors with an effect on respiration:
  - Oxygen level
  - Partial pressure of oxygen
  - Atmospheric pressure
  - Lung volume
- 16-18x breath/min. 0.5 L : 12 m^3/day

Atmospheric effects on health and well being

- Effect of oxygen concentration (<7%, death!)
- Effect of carbon dioxide concentration
- Effect of air pressure (barotrauma, caisson disease – decompression sickness)
- Effect of air temperature (15-25˚C)
- Effect of air humidity
- Effect of air movement (below 0.3 m / s)
- Effect of atmospheric electricity



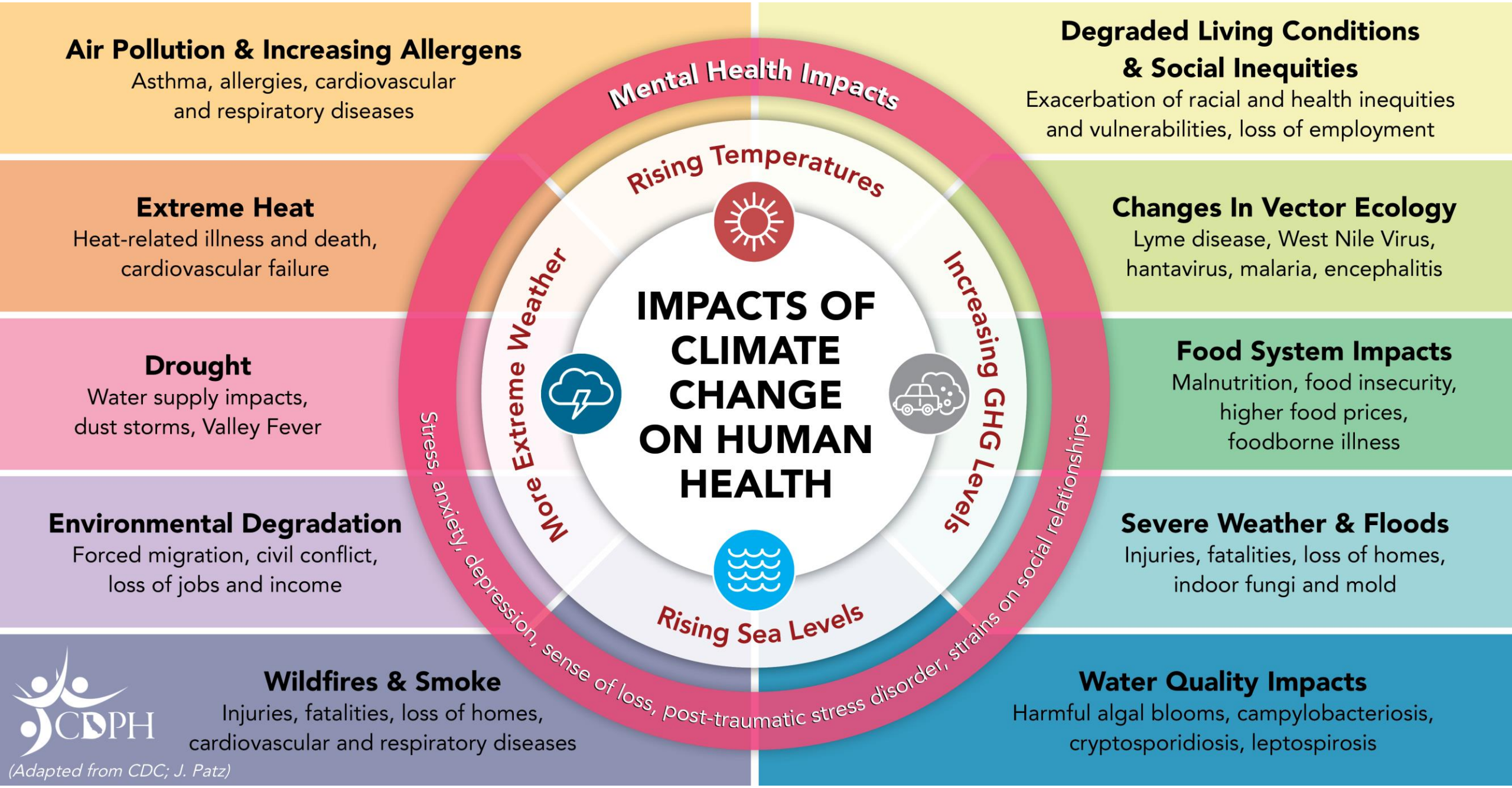
Weather

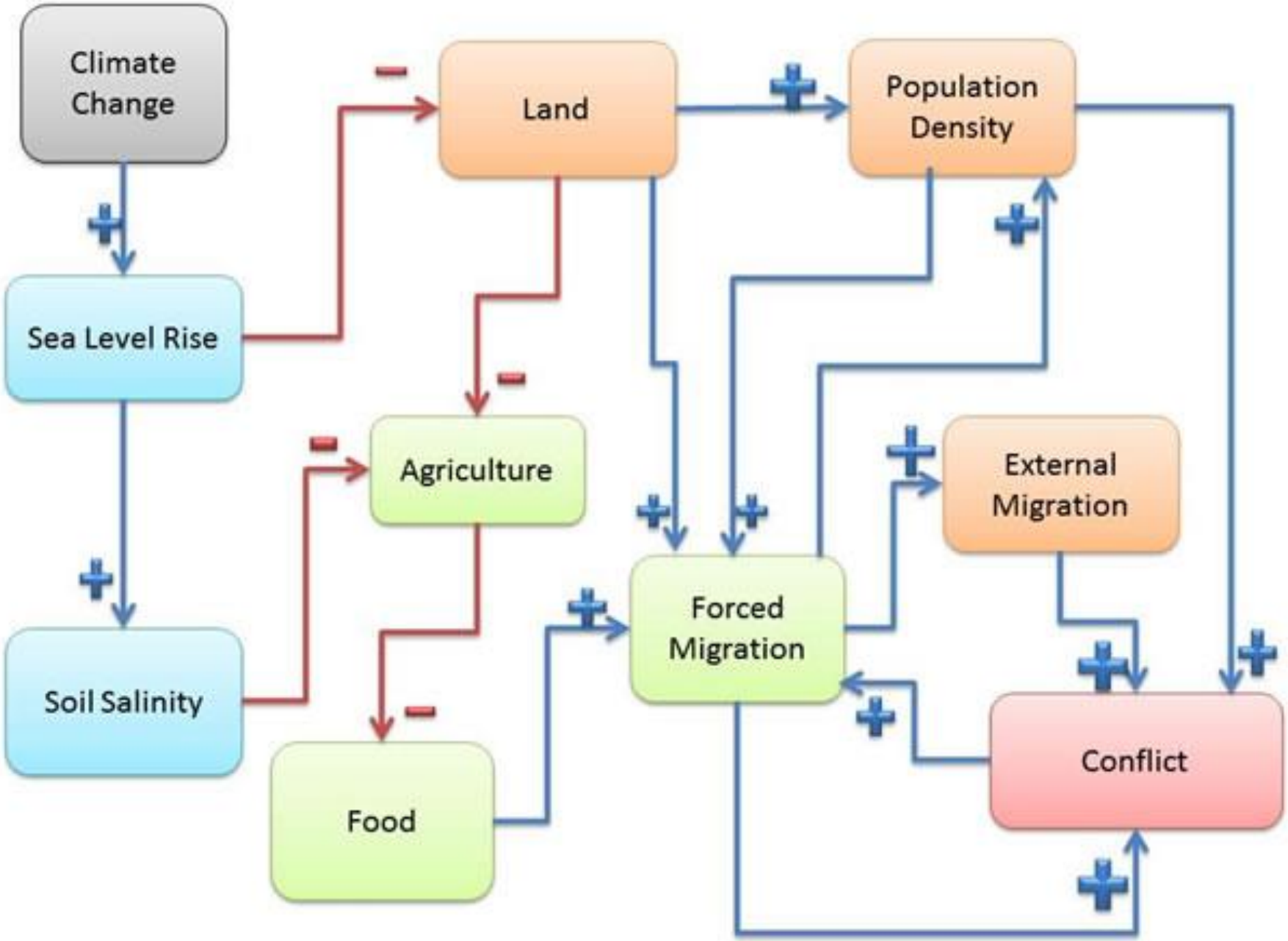
State of the atmosphere at a particular place during a short period of time. It involves such atmospheric phenomena as temperature, humidity, precipitation (type and amount), air pressure, wind, and cloud cover. Weather has an effect on well being and health. **Weather** differs from **climate.**

Effect on our health – increased mortality under extreme weather conditions

Climate: the synthesis of weather conditions (solar radiation, temperature, humidity, precipitation (type, frequency, and amount), atmospheric pressure, and wind (speed and direction)) that have prevailed over a given area during a long time period—generally 30 years.

Effect on our health →


Air Pollution & Increasing Allergens
Asthma, allergies, cardiovascular and respiratory diseases
Extreme Heat
Heat-related illness and death, cardiovascular failure
Drought
Water supply impacts, dust storms, Valley Fever
Environmental Degradation
Forced migration, civil conflict, loss of jobs and income
Wildfires & Smoke
Injuries, fatalities, loss of homes, cardiovascular and respiratory diseases
Degraded Living Conditions & Social Inequities
Exacerbation of racial and health inequities and vulnerabilities, loss of employment
Changes In Vector Ecology
Lyme disease, West Nile Virus, hantavirus, malaria, encephalitis
Food System Impacts
Malnutrition, food insecurity, higher food prices, foodborne illness
Severe Weather & Floods
Injuries, fatalities, loss of homes, indoor fungi and mold
Water Quality Impacts
Harmful algal blooms, campylobacteriosis, cryptosporidiosis, leptospirosis
Mental Health Impacts
Rising Temperatures
More Extreme Weather
Increasing GHG Levels
Rising Sea Levels
Stress, anxiety, depression, sense of loss, post-traumatic stress disorder, strains on social relationships
IMPACTS OF CLIMATE CHANGE ON HUMAN HEALTH
CDPH
(Adapted from CDC; J. Patz)



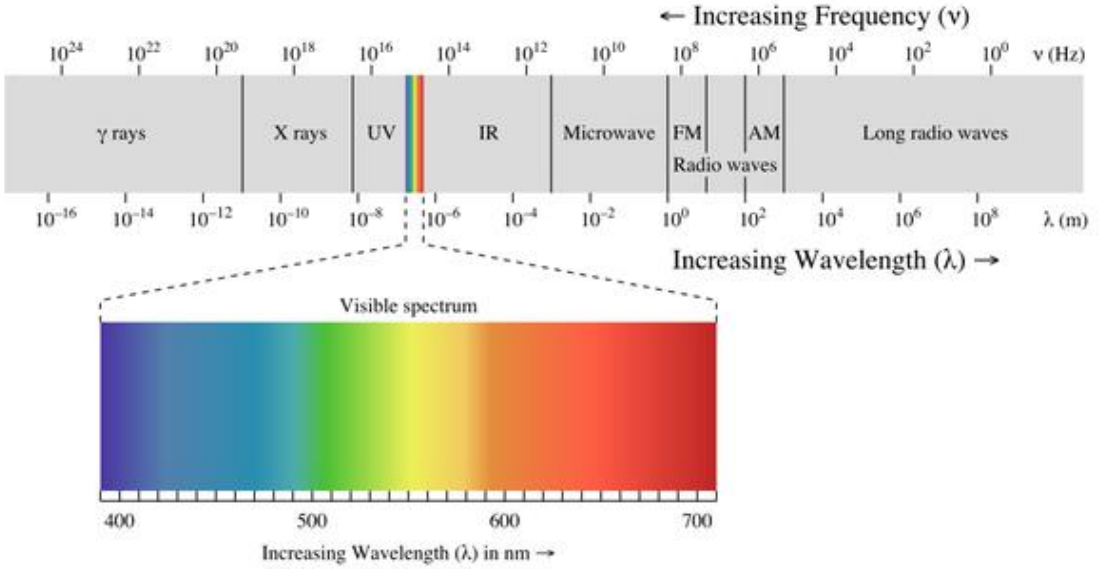
ICE Case Studies
Number 229, December, 2010

Climatic levels

- **Scale**:
  - Macroclimate: the overall climate of a region usually a large geographic area (arctic, temperate, tropic, continental…)
  - Mesoclimate (local climate) - the climate at an intermediate geographic scale (downtown district, large park, farm, wooded area…)
  - Microclimate - the suite of climatic conditions measured in localized areas e.g. in a household
- **Type**:
  - Natural
  - Artificial
- **Acclimatization**: The process in which an individual organism adjusts to a change in its environment (such as a change in altitude, temperature, humidity, photoperiod, or pH), allowing it to maintain fitness across a range of environmental conditions.

Sunlight and solar radiation

- Biological effect in influenced by the wavelength and the energy
- Shorter waves carry **more** energy than longer waves.
- Light: Infrared, visible and ultraviolet
- Infrared: 700 nm – 1 mm
- Visible light - wavelengths from 3800 nanometers (violet) to 700 nanometers (red).
- Ultraviolet (UV) light (290-400nm).
  - UVC (100-280 nm)
  - UVB (280-315 nm)
  - UVA (315-400 nm)
- Not constant (sunspots, flares)



Air pollution

Physical, chemical or biological changes in the properties of environmental elements which have an adverse effect on the health, survival or well-being of humans and/or other living organisms.

Environmental Pollutants: Substances or mixtures of substances, their degradation products, which, if released into the environment, may adversely affect the condition of environmental elements or harmful to human health or have a negative effect on environmental use.

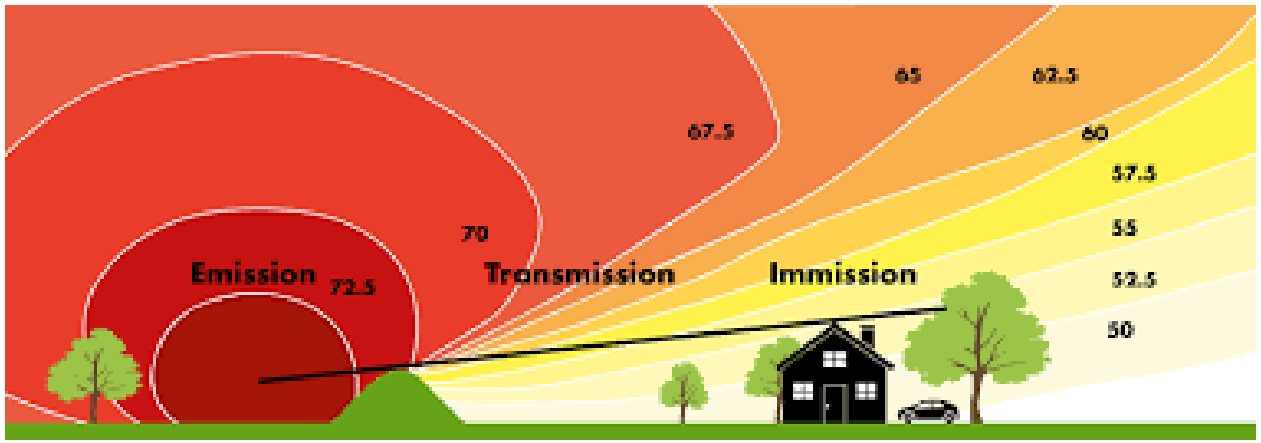
Air pollution

- Strong correlation with energy consumption
- First smog disasters – between the 1st and 2nd World War
- After the II World War, the main factors are
  - Increasing number of vehicles → increasing traffic
  - Chemical industry

  → Contaminated regions → Global contamination

Emission, immission, transmission

- **Emission** is the release of primary pollutants from a source. Further contaminants formed from a primary contaminated are referred to as secondary contaminants (SECONDARY POLLUTION)
- **Immission** is the measurable environmental concentration of pollutants released from emission sources
- Transmission is the spread of primarily emitted contaminants in the environment

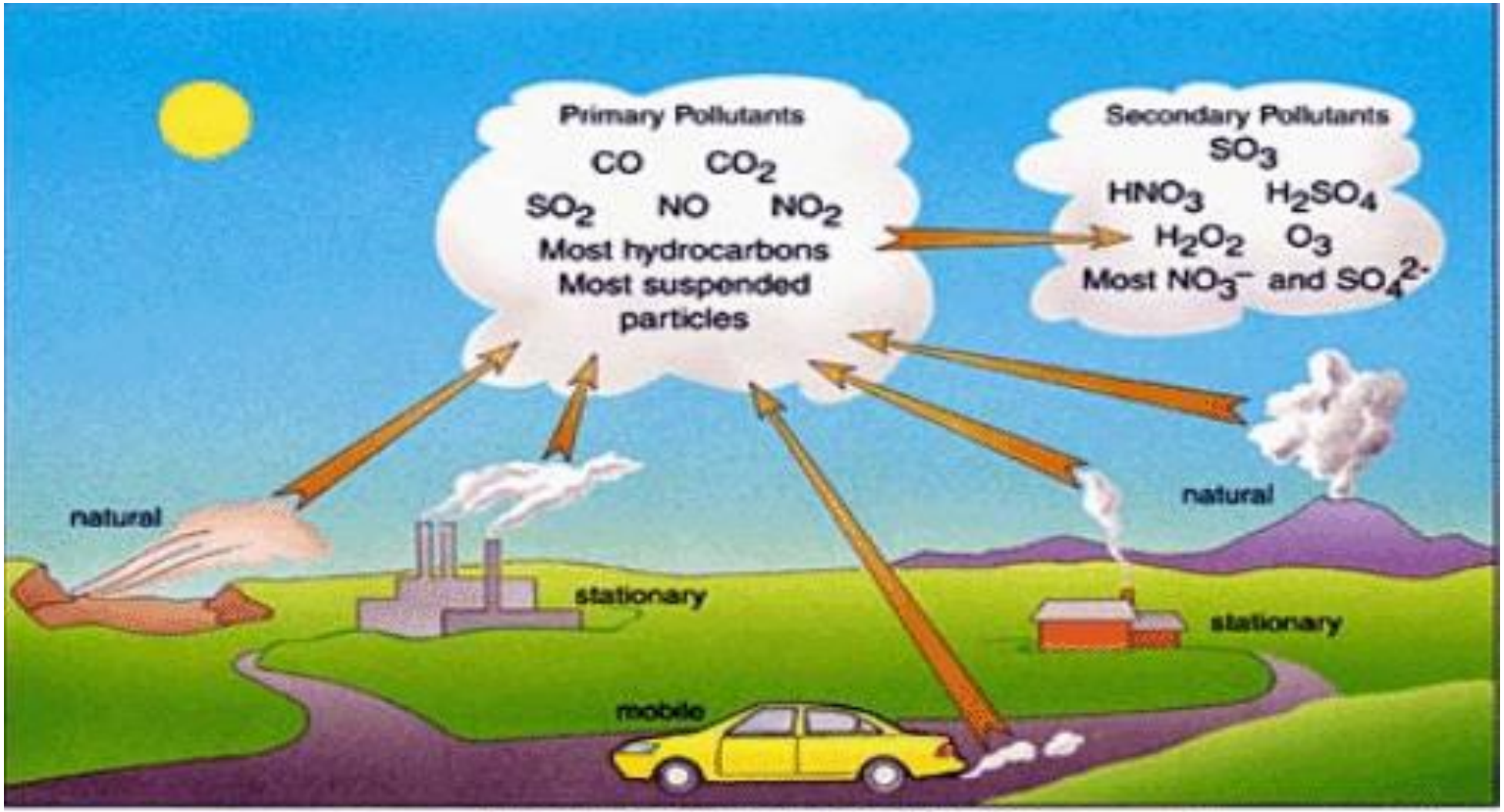


- **The source of contamination according to the spread of the pollutant**
- **POINT SOURCE (local pollution): the emission source delivers the pollutant to a given medium at a well-defined location (factory chimney, channel inlet to an open water receiver)**
- **EXPANDED SOURCE - Spatially distributed release of pollutants into the environmental element (surface, diffuse of non-point pollution): enters the medium over a large spatial extent (e.g. plant protection product, slurry, fertilizer use in agriculture and its leaching to surface water).**
- Surface source (air): any ambient air pollutant activity or material storage that is not a point or building source.

Origin of contamination

- Natural origin (waves, marine life, lithosphere, volcanic activity, flora, fauna)
- Agricultural activity (natural materials; chemicals – pesticides, artifical fertilizers)
- Artificial origin (industry, traffic…)

Air pollution



Types and sources of air pollutants

Air pollutants with threshold limit values (TLVs) 4/2011 VM decree

- Acetone
- Acrolein
- Amyl acetate
- Ammonia
- Petrol
- Benzene
- Biol. active substances
- Odour materials
- Cyclohexanone
- Metal powders and vapors
- Phenol
- Infectious agents
- Fluorides
- Formaldehyde
- Smoke, flying ash
- Hydrogen sulfide
- Mercury
- Sulfur dioxide (SO2)
- Sulfuric acid
- Chlorine

Air pollutants with threshold limit values (TLVs)

- Soot
- Methyl alcohol
- Nitrobenzene
- Nitrogen dioxide
- Nitrogen oxides
- Lead
- Ozone
- Polycyclic CHs
- Flying dust
- Sedimentary dust
- Nitric acid
- Hydrochloric acid
- Carbon dioxide
- Carbon monoxide
- Styrene
- Toluene
- Trichlorethylene
- Xylene

Major pollutants

Sulfur dioxide (SO_2)

- a gaseous air pollutant composed of sulfur and oxygen. Colorless typically pungent, irritating cough gas. SO_2 forms when sulfur-containing fuel such as coal, oil, or diesel is burned. Sulfur dioxide also converts in the atmosphere to sulfates, a major part of fine particle pollution in the eastern U.S.
- It is very soluble in water and combines with sulfuric acid. Heavier than air. It mixes with oxygen only in the presence of catalysts. It is a strong reducing agent, decolorizing some organic dyes. Toxic to living organisms. Purely inhaling causing death from suffocation, in low concentrations (0.01%) causes symptoms of poisoning with heavy breathing. Vegetation is extremely sensitive to it.

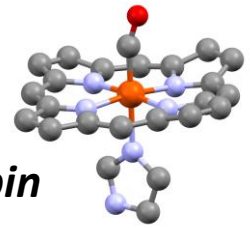
Nitrogen oxides (NO, NO_2, NO_x)

- Natural sources: lightning, or from the activity of aerobic soil bacteria
- Typical emissions: fossil fuels, energy production, transportation
- Nitric oxide (Nitrogen monoxide): colorless gas, low solubility in water, heavier than air. A neurotransmitter, it is involved in various physiological processes. Bound by the hemoglobin in the blood. Highly reactive – immediatelly convert to nitrogen dioxide
- Nitrogen dioxide: reddish-brown gas, heavier than air. Very reactive, soluble in water. Oxidizes to nitric acid in the presence of water. It plays an important role in atmospheric processes (ozone formation, smog, precursor of nitrate compounds)

Fluorides

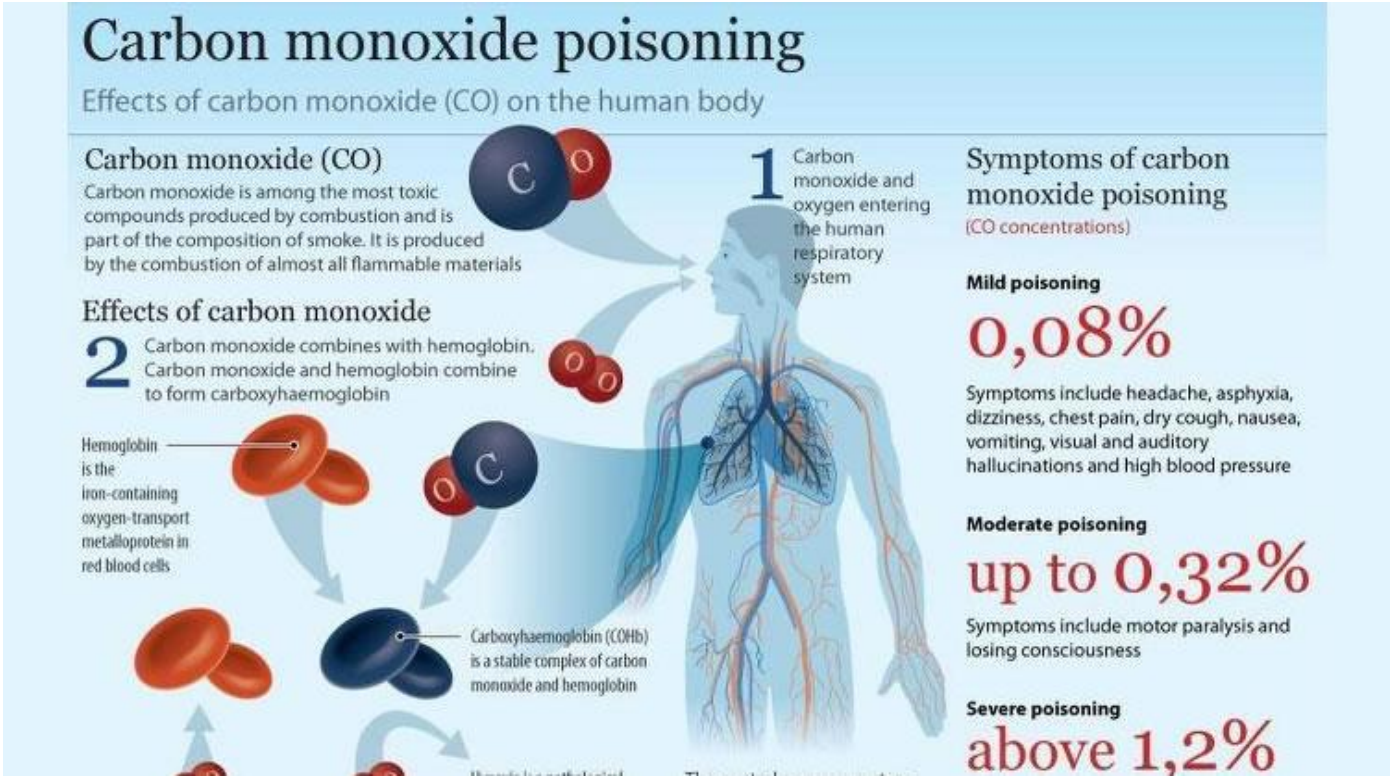
- Elemental fluorine is a yellowish-green gas with a pungent odor that is heavier than air. The most reactive of all elements. Extremely reactive with hydrogen and decomposes water. Hydrogen fluoride boils at room temperature. It is miscible with water in all proportions. It dissolves glass. Fluorine and hydrogen fluoride are very toxic to living organisms. Among the fluorides, water-soluble alkali fluorides are the major air pollutants.
- HF reacts with chlorocarbons to give fluorocarbons. An important application of this reaction is the production of tetrafluoroethylene (TFE), precursor to Teflon.

Carbon monoxide (CO)



Carboxyhemoglobin

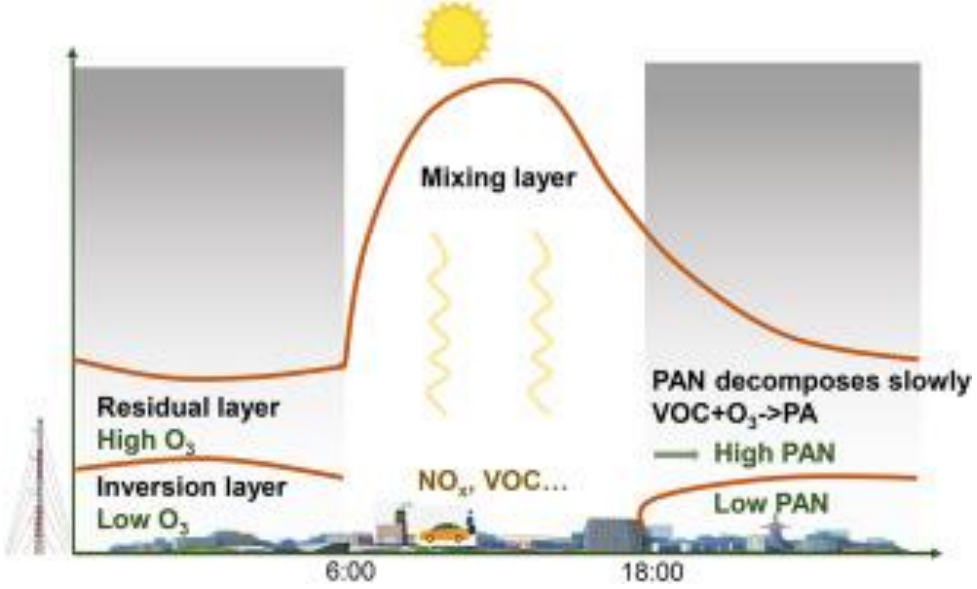
- Colorless, odorless gas, sparingly soluble in water, difficult to oxidize at room temperature. Slightly lighter than air.
- It is formed during imperfect combustion.
- Extremely toxic to humans and animals. It accumulates in the blood in the form of very stable ***Carboxyhemoglobin***.



Solid particles, Particulate matters (PM)

- Sedimentary powder (sediment or aerosestone). The precipitated powder is usually divided into water-soluble and water-insoluble and organic and inorganic fractions;
- Particulate matter (particles which remain suspended for a long time and have a diameter of less than about 10 μm)
- Aeroplanktons
- The main constituents of solid contaminants are fly ash and soot, dust from the soil surface, transport, industry. The composition varies greatly.
- We distinguish between **toxic and inert powders** (more stringent regulations apply to toxic powders). Toxic powders: powders of biologically active agricultural products, such as pesticides, fungicides, herbicides, as well as lead, which was previously largely of transport origin, as well as various carcinogenic compounds.

Photochemical oxidants



- Various organic compounds that pollute the air, as well as nitrogen oxides, react chemically with each other under the influence of sunlight, especially UV radiation

→photochemical oxidants are formed, such as ozone and peroxyacetyl nitrates (PAN).

Ozone is easily measurable→ an indicator of PANs. Ozone is a very aggressive substance due to the nascent oxygen produced by the decomposition of the O3 molecule. It causes tissue death in plants and mucosal irritation in humans. PAN materials also include carcinogens.

Heavy metals

- Lead tetraethyl was added to increase the compression tolerance of vehicles. Prolonged inhalation of lead may cause nervous system damage, adverse effects on mental abilities have been observed in children.
- Heavy metals / lead, vanadium, cadmium / accumulate in the bones and hinder their physiological development, especially in children. Some (e.g. chromium VI, cadmium) are carcinogenic!

Polycyclic aromatic hydrocarbons - PAHS

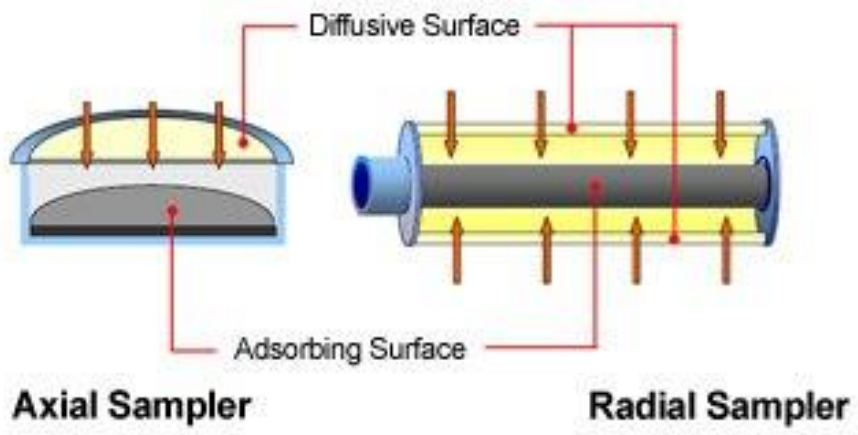
- The most common polycyclic aromatic hydrocarbons / PAHs in air are benz- (a) pyrene, 1,1,2-benzperylene, 1,2-benzanthracene and chrysene.
- The above mentioned and many other PAHs have been shown to be carcinogenic to humans. They are released into the air during imperfect combustion, bound to soot: during combustion, with exhausted gases, smoking.

Air sampling

- **Location of sampling site**
- Ambient air is not the same as indoor air and workplace air, which are subject to special regulations!
- **Emission air sample**: from a point in the technological equipment (chimney) that characterizes the operation of a given part of the technological process and quickly follows the changes in operation.
- **Immission air sample**: for the determination of ambient air pollution

Air sampling

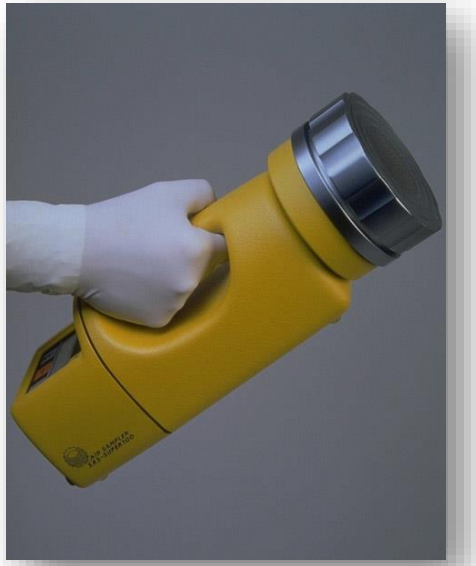
- Active and passive (diffuse) sampling mode
  - Active: calibrated pump (active air flow) E.g. Tedlar bag
  - Passive: sorbent binding of harmful substances (axial and radial sampling tubes)



Uptake/Sampling rates are higher for radial samplers than axial


SAMPLER
0005


GASTEC



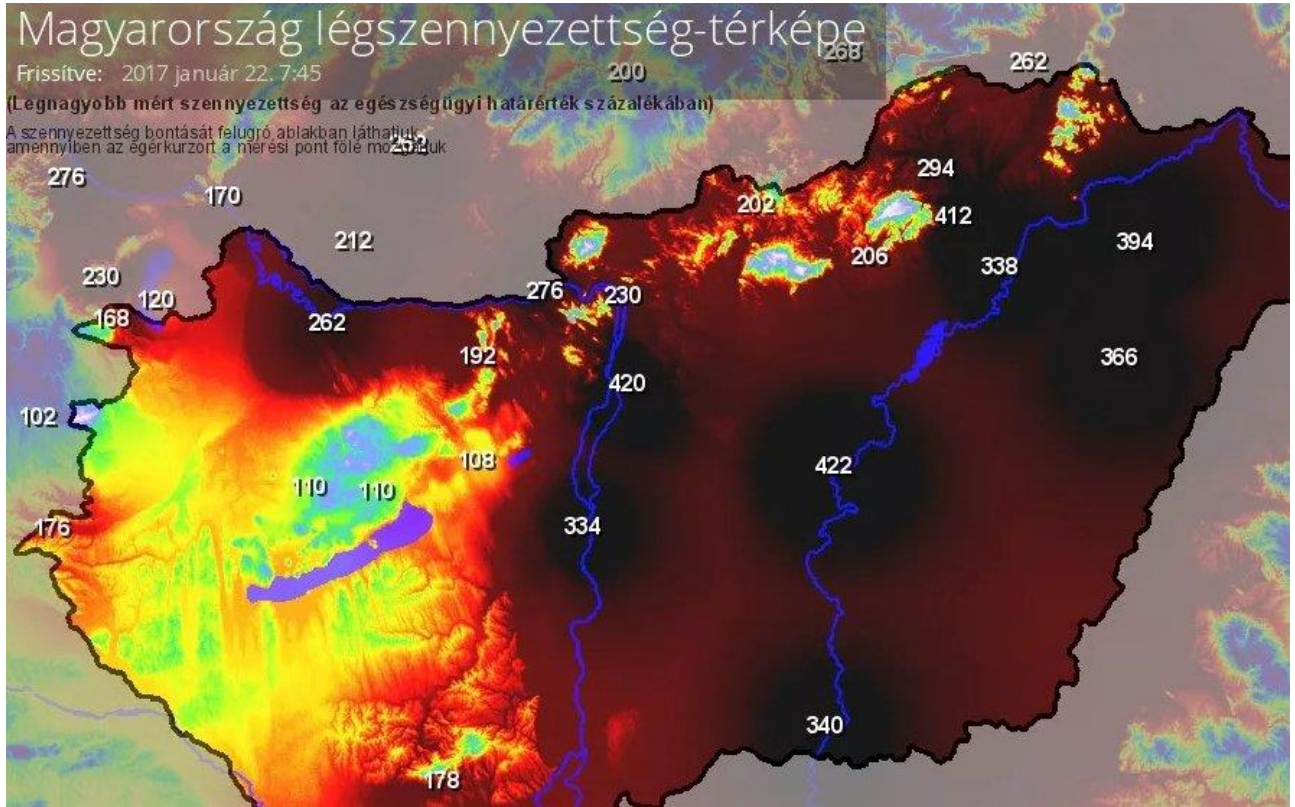
Air Quality Index (AQI)

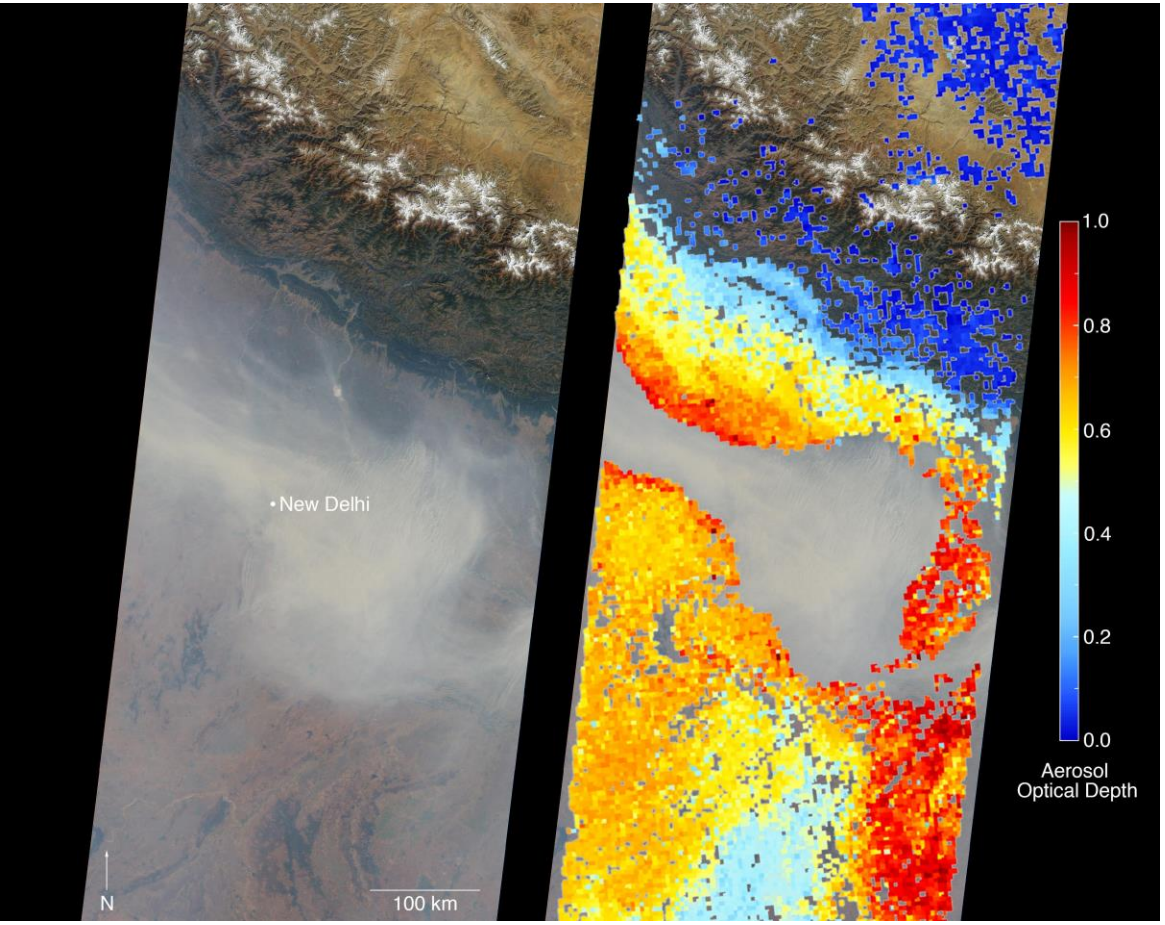
- An indicator defined on the basis of scientific literature and relevant legislation.
- It characterizes the level of air pollution in the last 24 hours for basic pollutants such as sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3) and particulate matter (PM_{10}).
- It is calculated from the maximum 1-hour concentration (SO_2, NO_2, CO), the maximum of the 8-hour moving averages (O_3) and the 24-hour average concentration (PM_{10}).

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health warnings of emergency conditions. The entire population is more likely to be affected.
Hazardous	301 to 500	Health alert: everyone may experience more serious health effects

- In Hungary the air pollution data required to calculate the AQI are provided by the database of automatic measuring stations of the National Air Pollution Measurement Network (http://www.kvvm.hu/olm)

Estimation of health effects is scientific literature.





- At left, a map of aerosol optical depth is superimposed on the image. Optical depth is a quantitative measure of the abundance of aerosols (tiny particles in the atmosphere). Optical depths for the area around New Delhi have not been calculated because the haze is so thick that the algorithm has classified the area as a cloud. In the region immediately surrounding the thick haze, optical depths approach 1.0. An optical depth of 1.0 means that only about 37 percent of direct sunlight reaches the surface due to interactions with particles in the atmosphere.
- In early November 2016, monitors at various locations in the area posted air quality index measurements as high as the 900s (the most severe ranking, "hazardous," is any air quality index measurement over 300). Thousands of schools have been closed, and a survey by the Associate Chambers of Commerce and Industry of India reports that 10 percent of the city's workers called in sick due to air-pollution-related health issues.

Smog – smoke fog

- Accumulation of contaminants under adverse weather conditions.
- Two types:
- **Los Angeles type:**
  - Sunny windless weather in summer.
  - Oxidizing components (NOX, O3, hydrocarbons)
- **London type:**
  - Overcast, humid cold weather.
  - Reducing components (SO2, carbon black, CO)

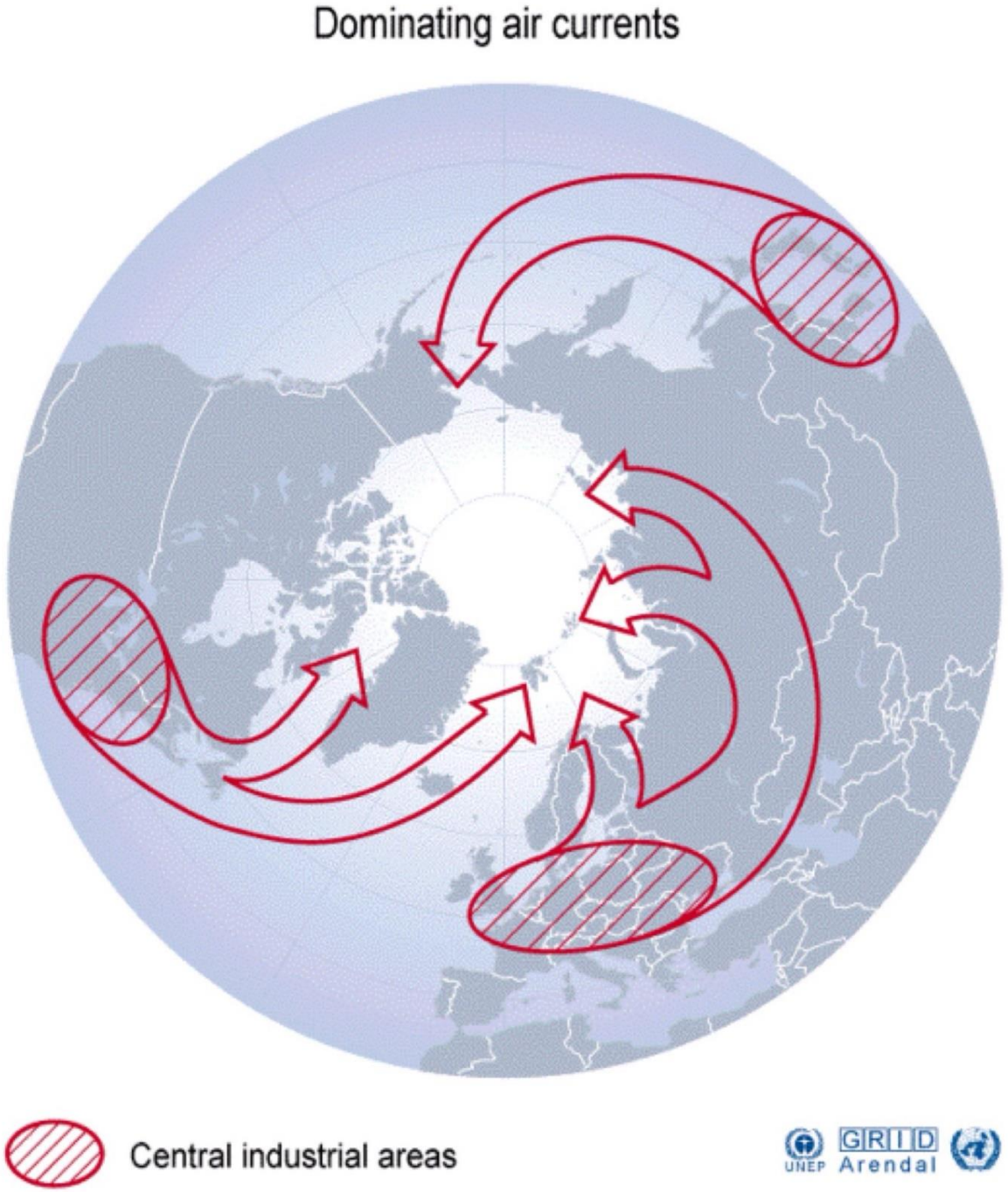
The fate of air contamination - atmospheric processes

- Circulation of pollutants
- Various effects:
- Reaction with air and other pollutants
- Cosmic effects: heat, light, UV, radioactive radiation.
- Metal ions (catalysts)
- Atmospheric water
- Oxidizing-reducing substances
- Energy requirements for reactions (light, heat, UV)
- Catabolism rather than anabolism
- Natural self-cleansing

The fate of contamination - natural self cleansing

- Three major groups
  - Contaminant is removed from the atmosphere
    - Sedimentation
    - Impaction, precipitation
    - Adsorption, absorption
    - Rain out
    - Wash out
  - Contaminant transforms (chemical degradation)
  - The concentration of contaminant decreases (dilution)
    - Wind, turbulence
    - Local geographical conditions

- Wind: disordered thermal motion of air. Factors forming a vertical wind structure:
  - Gradient force (differences in atmospheric pressure)
  - Frictional force
  - Coriolis force
  - Centrifugal force
- Turbulence: disordered motion within a flow (thermal of dynamic)



Consequences of air pollution

Biosphere and atmosphere - Forming and adaptation

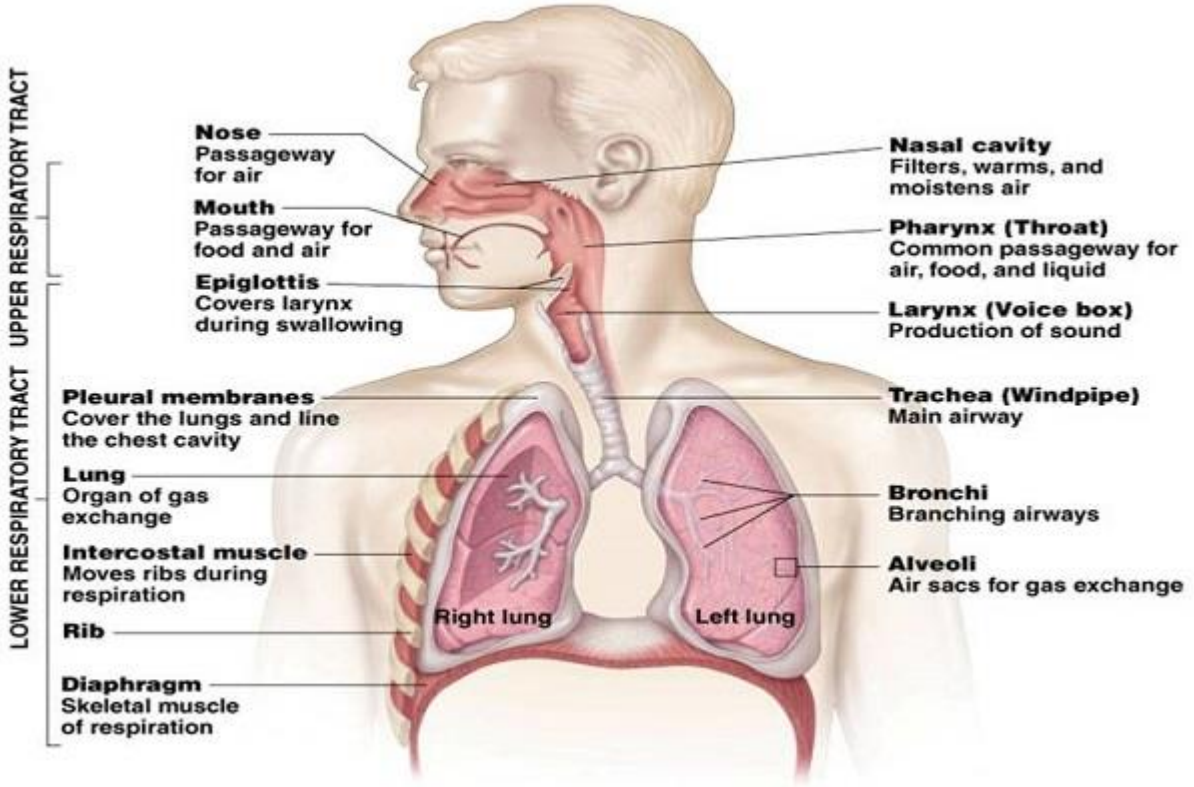
- **Plants**
  - Indicator organisms (e.g., lichens)
  - Changes in vegetation and their correlation with the type and concentration of pollution
  - Adaptation capacity of species (e.g., in agriculture)
  - Air filter and cleaning effect of vegetation
- **Animals**
  - Typical symptoms of air pollution (fluorosis, canary test)
  - Experimental animals
- **Landscape**

Monetary loss

- **Technical damage**
- Metal corrosion, dissolution, rust
- Building material weathering, stone sculptures Industrial machines, equipment, motor vehicles, industrial, public and residential buildings, line facilities
- Indirect damage: Inspection, measurement costs
- **Economic damage**
- Material goods
- Vegetation loss
- Healthcare expenses

Effect of air pollution on human health

- Effect through the respiratory track
- Skin surface contamination
- Eye and mucosa irritation
- Odour
- Sunlight and UV reducer
- The need for personal hygiene is greater
- Disturbs well being



Health consequences

- Discomfort, negative effects, changes in homeostasis, chronic disease, acute disease, death
- The effects of air pollution are depending on
- **External factors** (concentration, toxicity, synergisti, antagonistic effects, duration of exposure, periodicity, environmental factors)
- **Internal factors** (sensitivity, general condition)

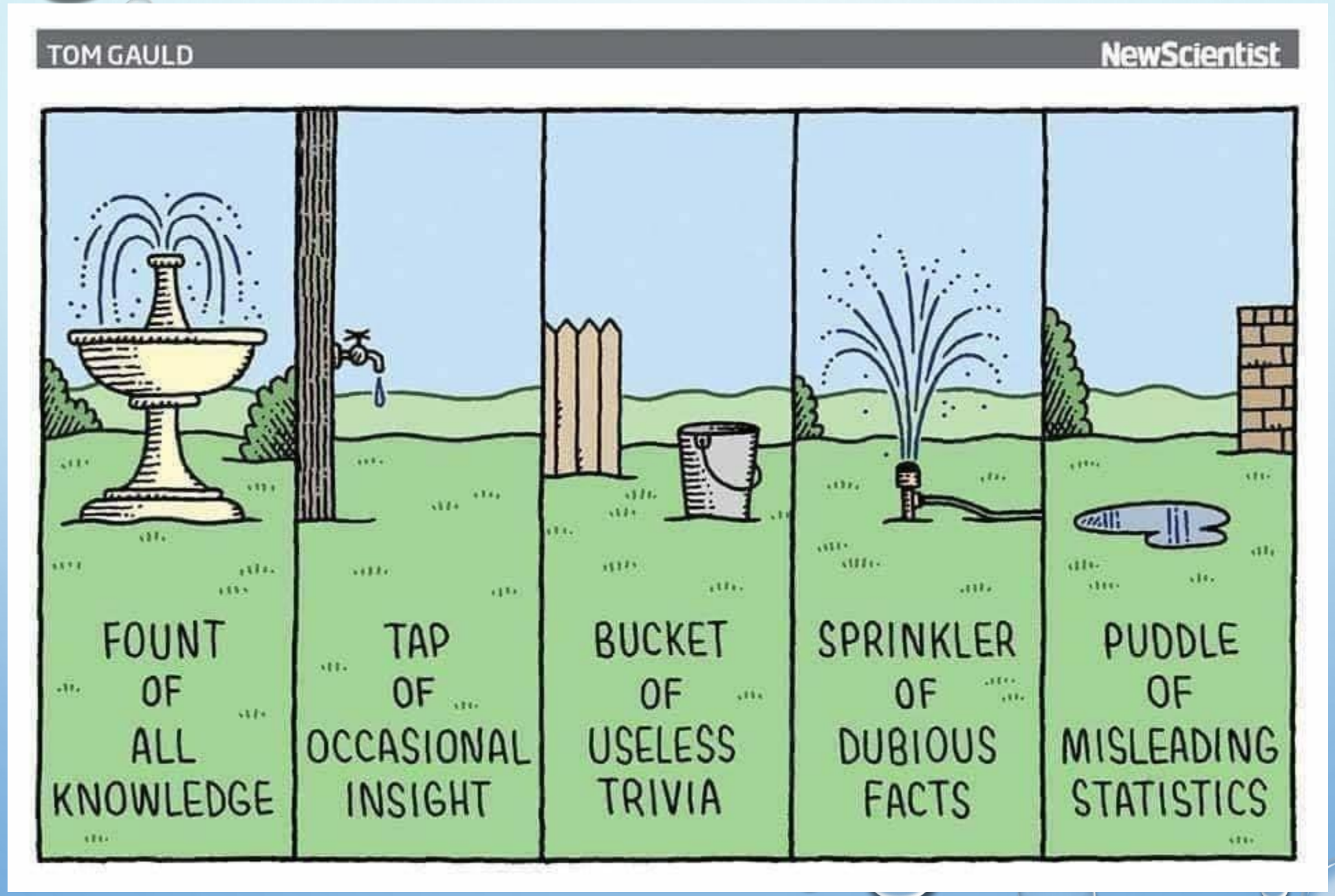
- **According to the exposition**
  - Short term
  - Long term

Epidemiology – the effect of air pollution at population level

- Respiratory diseases and deaths – 20%
- Respiratory cancer and death – 20%
- Heart and cardiovascular disease and death - 10%


DEATH BY BAD AIR
India
China
2000
2,502
3,010
2005
2,634
3,321
2010
2,865
3,100
2015
3,283
3,233
Figures for deaths every day, source: Greenpeace

Thank you very much for your attention


TOM GAULD
NewScientist
FOUNT OF ALL KNOWLEDGE
TAP OF OCCASIONAL INSIGHT
BUCKET OF USELESS TRIVIA
SPRINKLER OF DUBIOUS FACTS
PUDDLE OF MISLEADING STATISTICS

WATER HYGIENE

DR. EDIT KASZAB

ASSOCIATE PROFESSOR

DEPARTMENTT OF ENVIRONMENTAL SAFETY

DEFINITION OF WATER HYGIENE

- A discipline dealing with the health effects of various water types (drinking water, recreational water, irrigation water, etc.) and manages all water-related public health activities.
- Objective of water hygiene:
  - To prevent health damage caused by inadequate water quality
  - To prevent water contamination
  - To remove water contaminants
  - Indirect: to maintain the organoleptically acceptable water condition
  - All water types are covered by water hygiene (drinking water, recreational water, irrigation water, water used for washing dishwashing etc.)

DEFINITION OF WATER HYGIENE

- A discipline dealing with the health effects of various water types (drinking water, recreational water, irrigation water, etc.) and manages all water-related public health activities.
- Objective of water hygiene:
  - To prevent health damage caused by inadequate water quality
  - To prevent water contamination
  - To remove water contaminants
  - Indirect: to maintain the organoleptically acceptable water condition
  - All water types are covered by water hygiene (drinking water, recreational water, irrigation water, water used for washing dishwashing etc.)

REGULATION OF DRINKING WATER QUALITY

- The human right to water and sanitation
- March 1977 Mar Del Plata, UN Water conference
- THE ACTION PLAN FROM THE UNITED NATIONS WATER CONFERENCE RECOGNIZED WATER AS A RIGHT FOR THE FIRST TIME DECLARING THAT “ALL PEOPLES, WHATEVER THEIR STAGE OF DEVELOPMENT AND SOCIAL AND ECONOMIC CONDITIONS, HAVE THE RIGHT TO HAVE ACCESS TO DRINKING WATER IN QUANTITIES AND OF A QUALITY EQUAL TO THEIR BASIC NEEDS”.

WHAT IS...?

- **Sufficient**. The water supply for each person must be sufficient and continuous for personal and domestic uses. These uses ordinarily include drinking, personal sanitation, washing of clothes, food preparation, personal and household hygiene. According to the World Health Organization (WHO), between 50 and 100 litres of water per person per day are needed to ensure that most basic needs are met and few health concerns arise.
- **Safe**. The water required for each personal or domestic use must be safe, therefore free from micro-organisms, chemical substances and radiological hazards that constitute a threat to a person's health. Measures of drinking-water safety are usually defined by national and/or local standards for drinking-water quality. The World Health Organization (WHO) Guidelines for drinking-water quality provide a basis for the development of national standards that, if properly implemented, will ensure the safety of drinking-water.
- **Acceptable**. Water should be of an acceptable colour, odour and taste for each personal or domestic use. [...] All water facilities and services must be culturally appropriate and sensitive to gender, lifecycle and privacy requirements.
- Physically accessible. Everyone has the right to a water and sanitation service that is physically accessible within, or in the immediate vicinity of the household, educational institution, workplace or health institution. According to WHO, the water source has to be within 1,000 metres of the home and collection time should not exceed 30 minutes.
- **Affordable**. Water, and water facilities and services, must be affordable for all. The United Nations Development Programme (UNDP) suggests that water costs should not exceed 3 per cent of household income.

COUNCIL DIRECTIVE 98/83/EC OF 3 NOVEMBER 1998 ON THE QUALITY OF WATER INTENDED FOR HUMAN CONSUMPTION

- Member States shall set values applicable to water intended for human consumption for the parameters set out in Annex I.
- The parametric values set in accordance with Article 5 shall be complied with:
- (a) in the case of water supplied from a distribution network, at the point, within premises or an establishment, at which it emerges from the taps that are normally used for human consumption;
- (b) in the case of water supplied from a tanker, at the point at which it emerges from the tanker;
- (c) in the case of water put into bottles or containers intended for sale, at the point at which the water is put into the bottles or containers;
- (d) in the case of water used in a food-production undertaking, at the point where the water is used in the undertaking.

GOVERNMENTAL DECREE NO. 5 OF 2023 (I.12.) ON QUALITY STANDARDS FOR POTABLE WATER AND ON RULES OF QUALITY CONTROL

- applied to quality standards of water destined for human consumption (potable water) and to quality control.
- Articles 3-4 and Annex 1 contains the quality standards for potable water and determine the water take-out points where the quality of potable water must meet quality standards.
- Article 5-7 deals with risk assessment and risk management
- The manager of the potable water supply plant or the food producing enterprise must provide for the control of water quality to be carried out by an authorized laboratory, according to the rules contained in Annex 2 and in conformity with the control plan agreed with the competent authority.
- In case of exceedance of one of the limit values or if any extraordinary event, that may danger of contamination, occurs, the competent authority (National Public Health and Medical Officer Service) shall examine the reasons and order the necessary measures for quality improvement (Article 9).
- Article 15 lays down rules regarding provisional permit (maximum for 3 years) for the supply of potable water that does not meet quality standards of Part B of Annex 1, provided that the consumption of such water does not mean hazard for human health, and that potable water supply can not be ensured in other reasonable way in the interested area. If this is the case, the competent authority shall determine provisional limit value for the parameter in question. Rules regarding water treatment and substances being in touch with potable water are set forth in Article 9. Data regarding the quality of supplied potable water is public according to Article 10. The same article provides also for data collection and reporting activities.

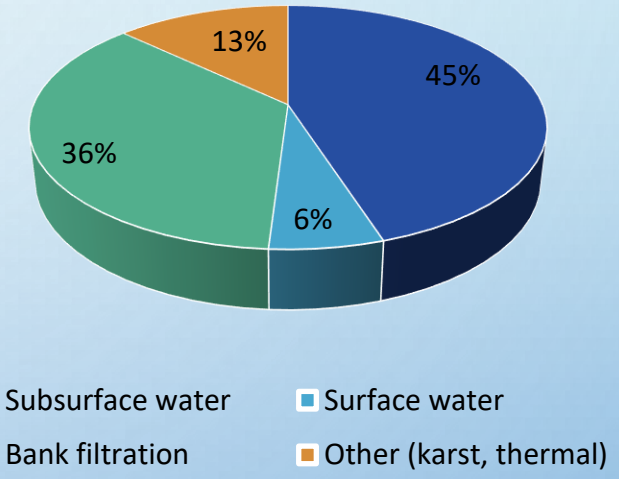
SOURCES OF WATER IN HUNGARY

- Due to its basin nature and geological structure, Hungary is rich in groundwater.
- In terms of amount, environmental and utility value, our groundwater resources have an outstanding importance in Europe.
- 95% of our drinking water supply is provided from groundwater resources, but the extraction of groundwater is also significant for industrial, agricultural, mining, energy and tourism purposes.
- Hungary has a significant supply of thermal water, which also contributes to the development of tourism.

DRINKING WATER SUPPLIES

- Surface water: 6%
  - Lakes, rivers
  - Always requires pre-treatment
- Bank filtration: 36%
  - Mixture of surface and subsurface water
  - River (80%), leaking groundwater (20%) – sand filtration
- Subsurface water: 45%
  - Groundwater (unconfined aquifer)
    - easy to access, private wells usually use it
    - Vulnerable – almost always contaminated
    - Agricultural chemization, lack of sewage system
  - Confined aquifer
    - Aquifer between two aquitards (confoning units)
    - Less vulnerable
    - Slow recharge
    - Good quality, local problems (geological contamination, e.g. arsenic, iron)
- Karst and other: 13%
  - Water flowing through soluble carbonate and evaporitic rocks called Karst
  - Karst is an important potable water source
  - Problems: high vulnerability to pollution; low spring discharge during the recession periods

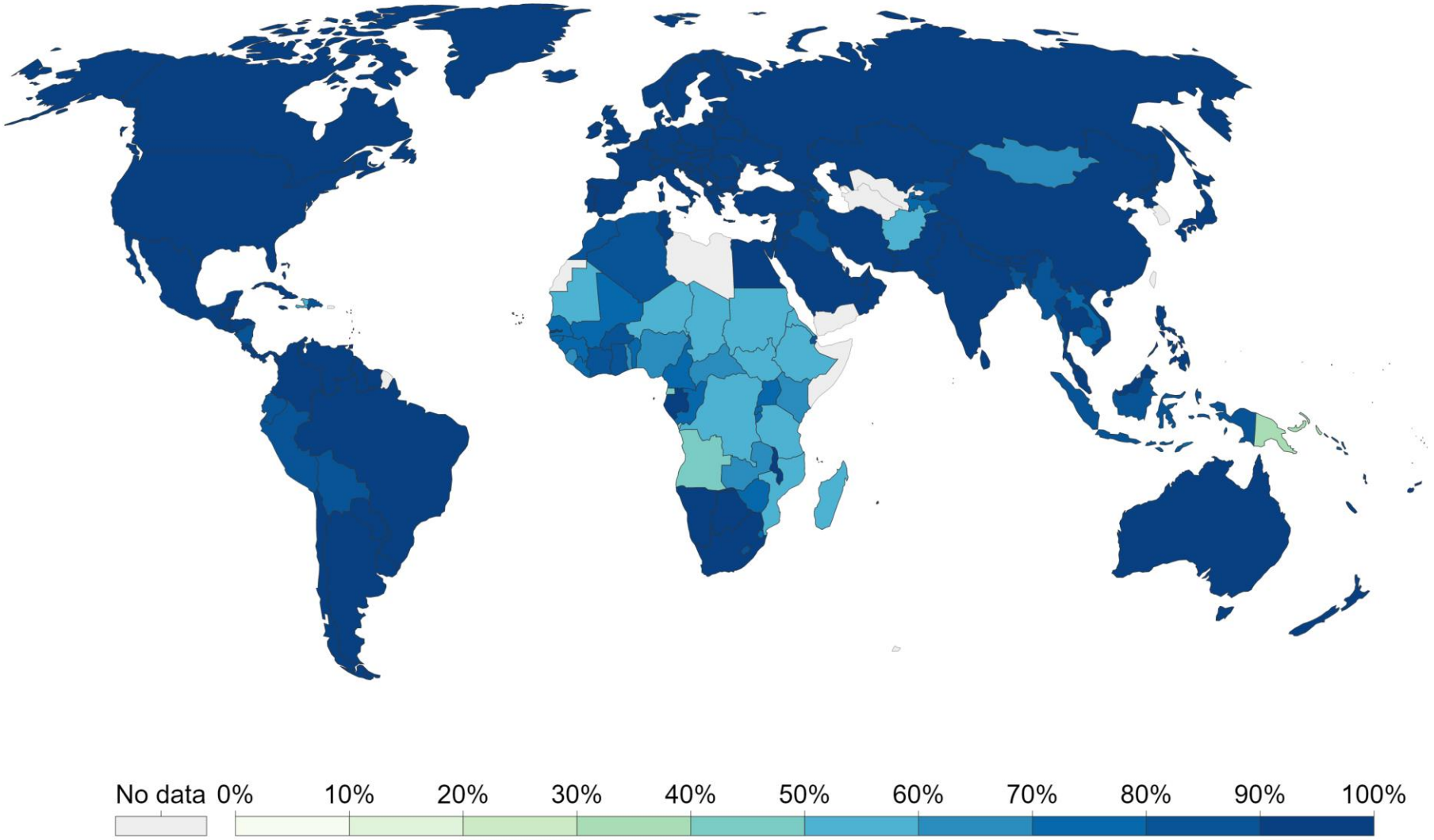
National drinking water supply according to the source of raw water



Source of data: ÁNTSZ, 2017

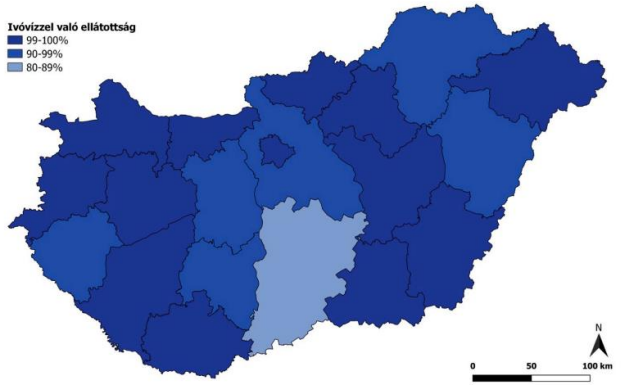
Share of the population with access to improved drinking water

Our World in Data



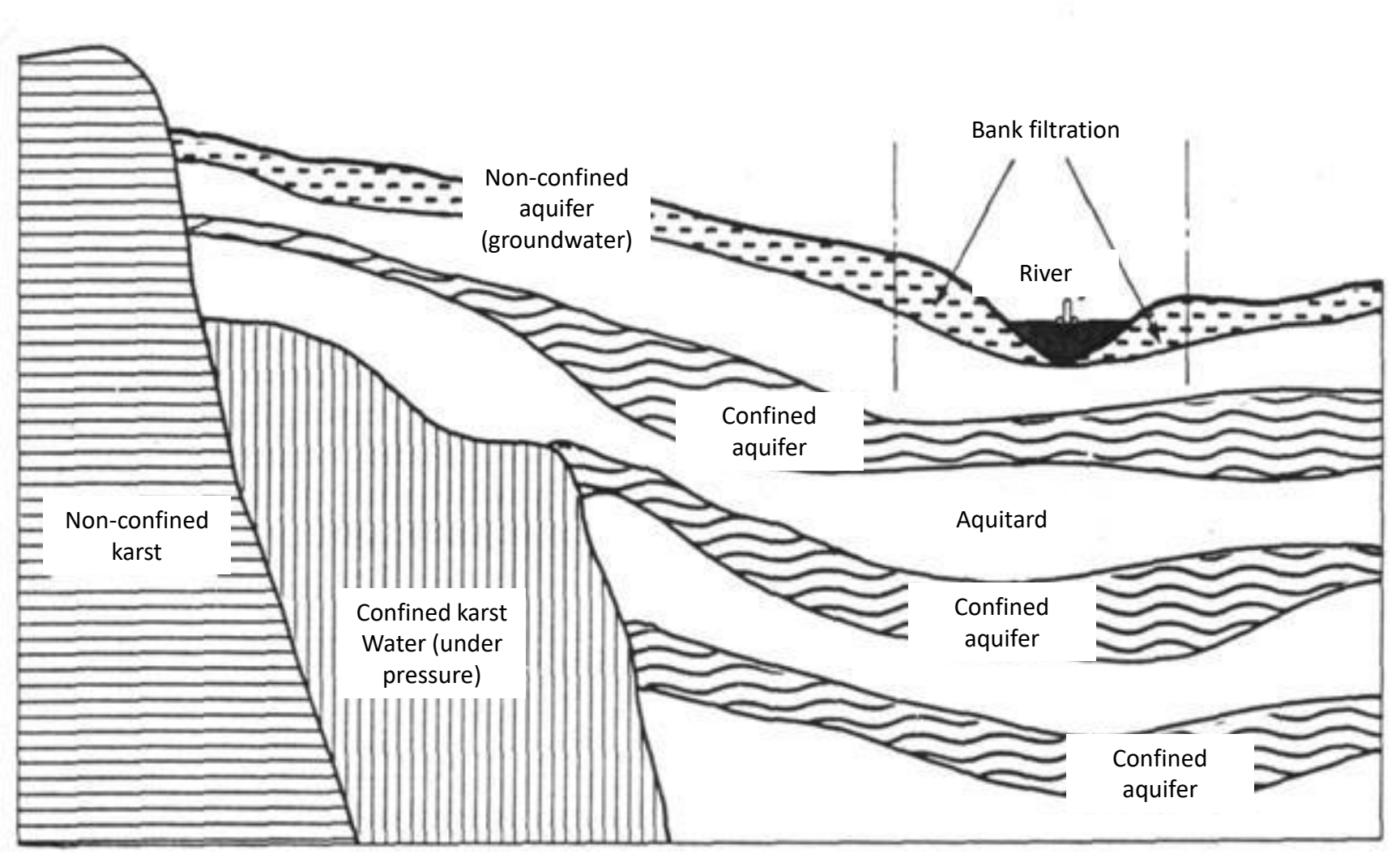
Source: WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation OurWorldInData.org/water-access
Note: An 'improved drinking water source' includes piped water on premises and other improved drinking water sources: public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection.

ACCESS TO DRINKING WATER IN HUNGARY



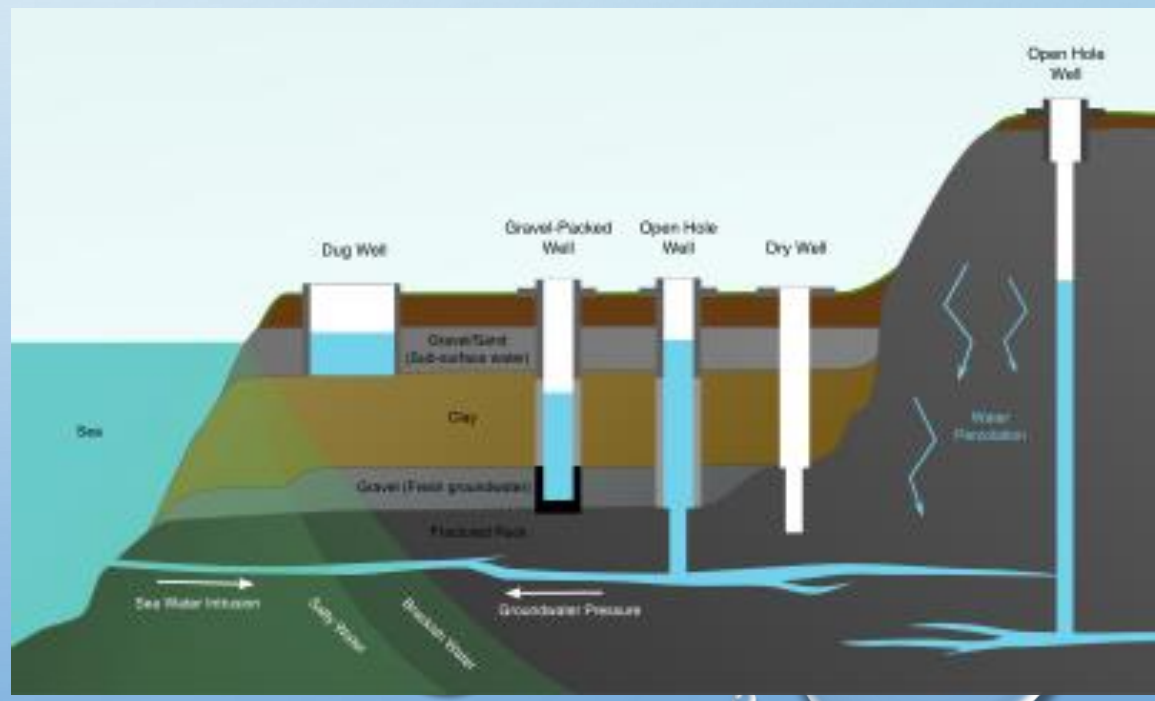
1. ábra Közüzemi ivóvízzel ellátott lakosság aránya megyénként, 2017.

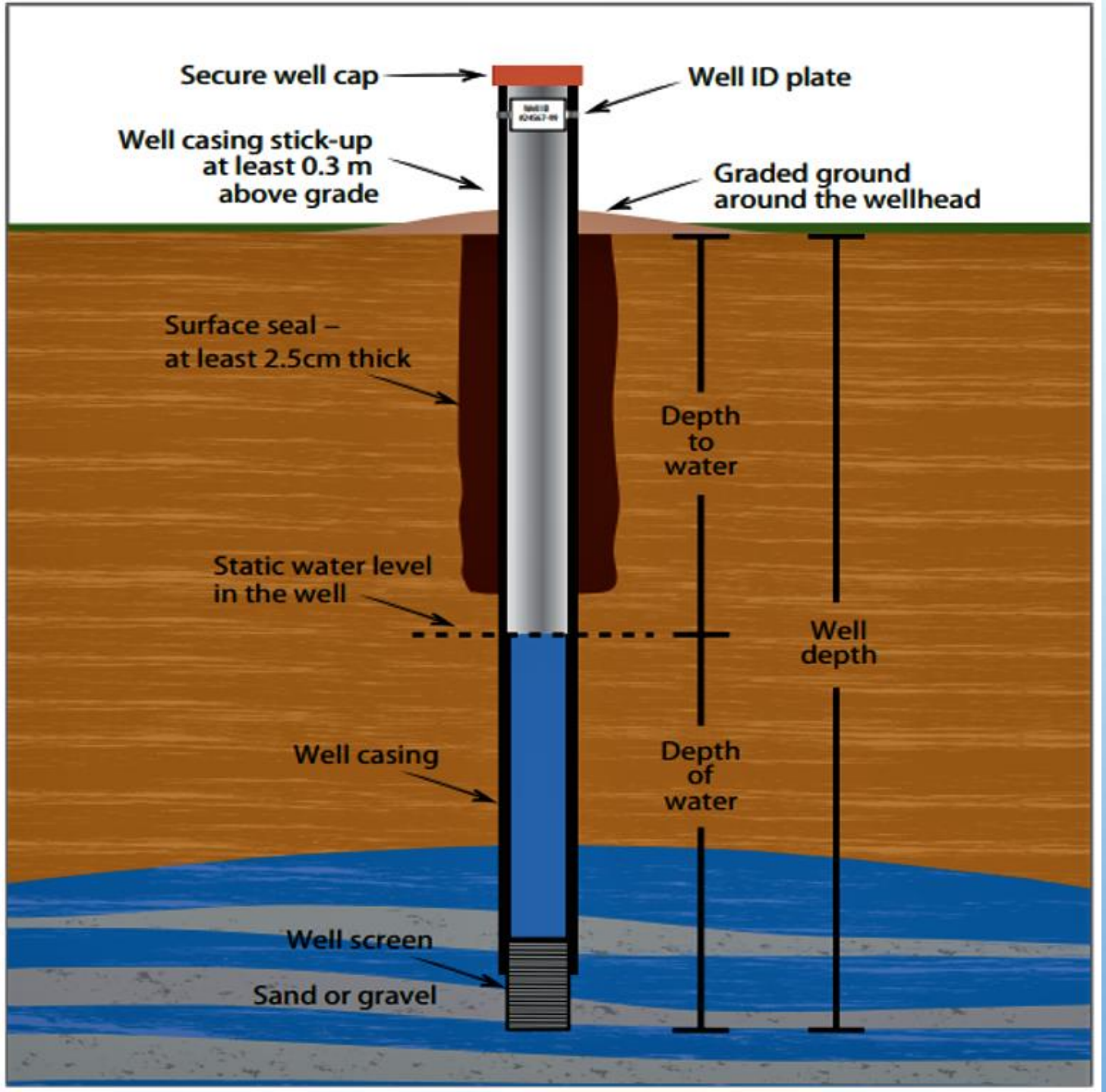
TYPES OF SUBSURFACE WATER



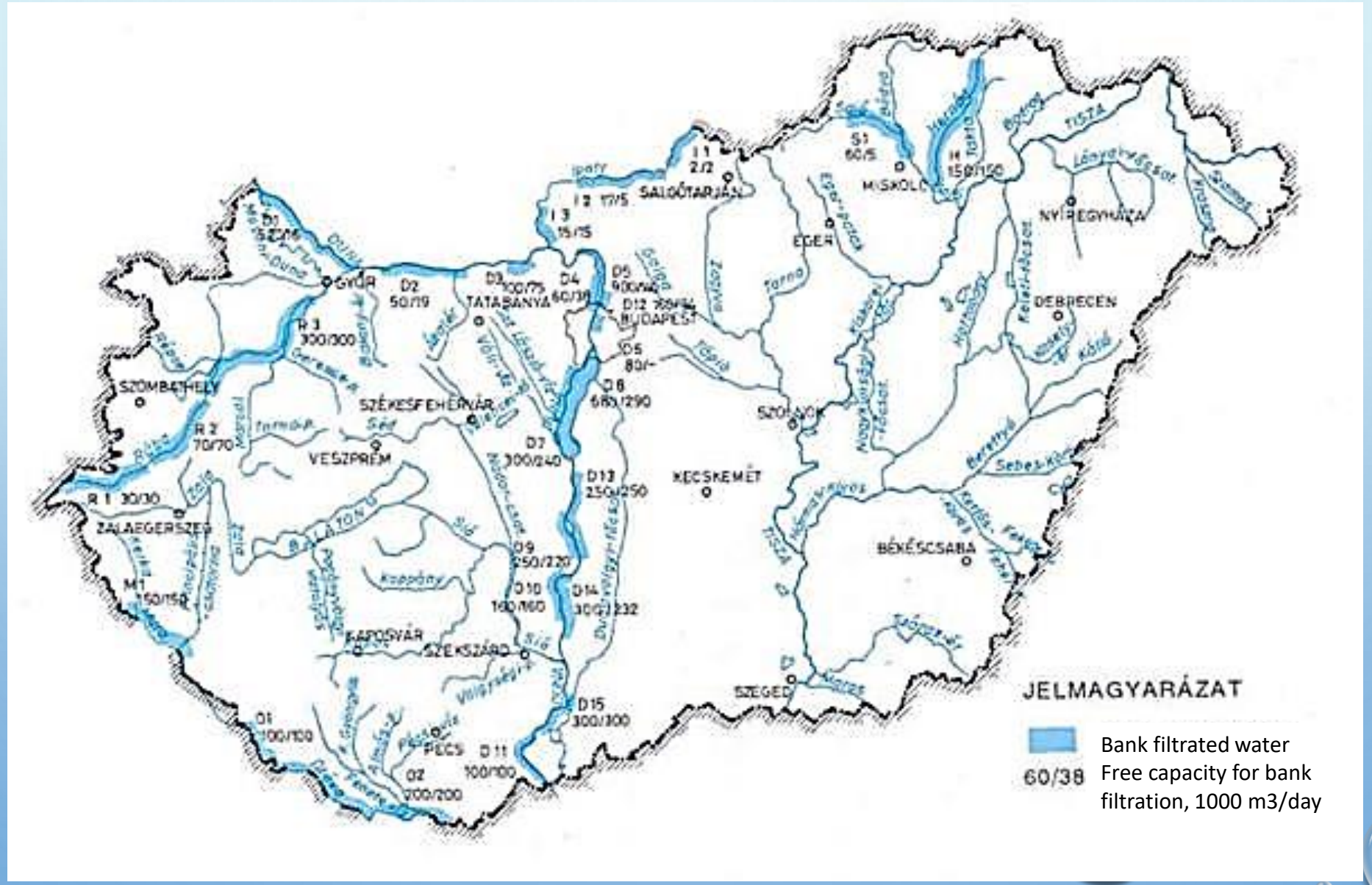
METHODS FOR WATER EXTRACTION

- SIMPLE DUG/BORED WELLS
- GRAVEL PACKED HORIZONTAL COLLECTOR WELL
- DRILLED WELL
- KARST WELLS/MINES

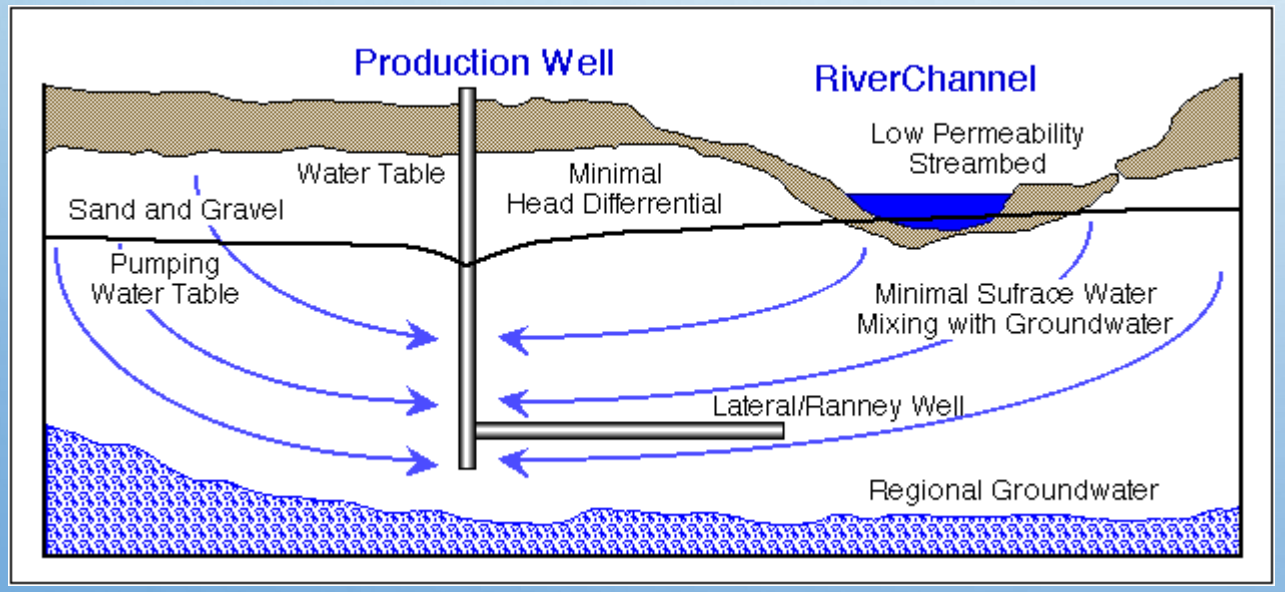


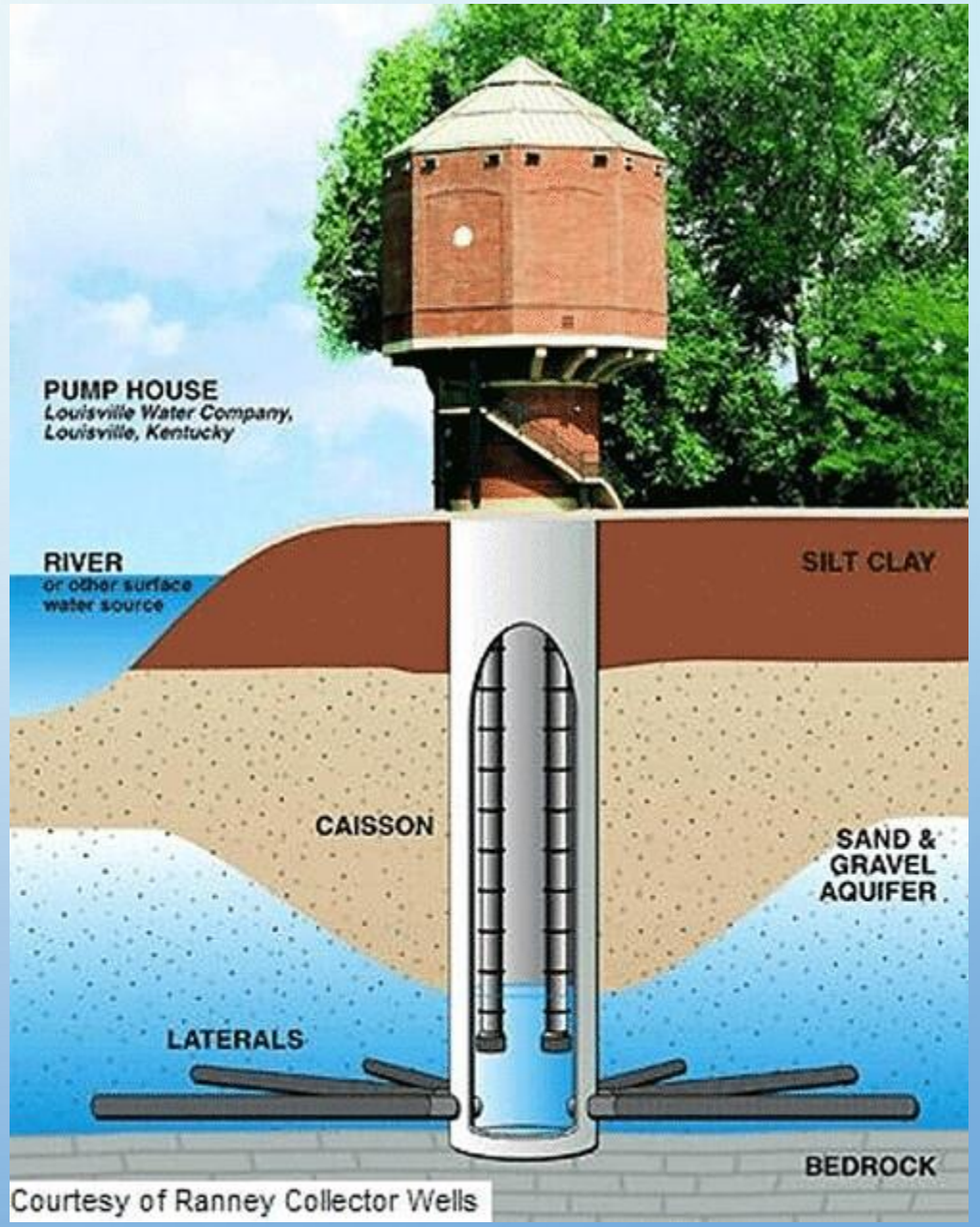

Secure well cap
Well ID plate
Well casing stick-up at least 0.3 m above grade
Graded ground around the wellhead
Surface seal – at least 2.5cm thick
Depth to water
Static water level in the well
Well depth
Well casing
Depth of water
Well screen
Sand or gravel

BANK FILTRATION IN HUNGARY



BANK FILTRATION





PROTECTION OF WATER BASES

- One of the most important tasks of environmental protection
- Purpose: To maintain water quality and fulfill the requirements of the intended water use
- Water protection areas of subsurface water bases (three zone):
  - **Internal protection area** (fenced in a circle of R = 10 m, facilities directly serving water production, e.g. wells; unauthorized access is also prohibited)
  - **External protection area** (area 100x100 meters, task: protection of the nearest part of the water supply area; facilities indirectly serving water production; limited agricultural cultivation (no fertilization), no industrial activity)
  - **Hydrogeological protection area** (R = 1 - 2 km; catchment area; here only activities with an increased risk of pollution are prohibited (e.g. large-scale livestock farm, chemical industrial activity working with toxic substances)

SURFACE WATER SUPPLIES

- ENDANGERING FACTORS:
  - INDUSTRIAL/AGRICULTURAL ACTIVITY
  - SEWAGE DISCHARGE (INDUSTRIAL AND MUNICIPAL SEWAGE)
- PRECAUTIONS:
  - PROHIBITION OF THE INTRODUCTION OF UNTREATED SEWAGE
  - RESTRICTION OF AGRICULTURAL ACTIVITY (E.G. ARTIFICIAL FERTILIZERS) IN THE CATCHMENT AREA

BASIC REQUIREMENTS FOR DRINKING WATER

- DOES NOT CONTAIN CHEMICALS, OR LIVING ORGANISMS HARMFUL TO THE HUMAN BODY
- CONTAINS THE ESSENTIAL CHEMICALS
- ORGANOLEPTICALLY PLEASENT, NO DISTURBING DISCOLORATION, TASTE OR ODOUR, NO FLOATING PARTICLES
- SOME CHOSEN INDICATOR MICROORGANISMS SHOULD BE BELOW TLV, EVEN IF THEY ARE HARMLESS

ARSENIC

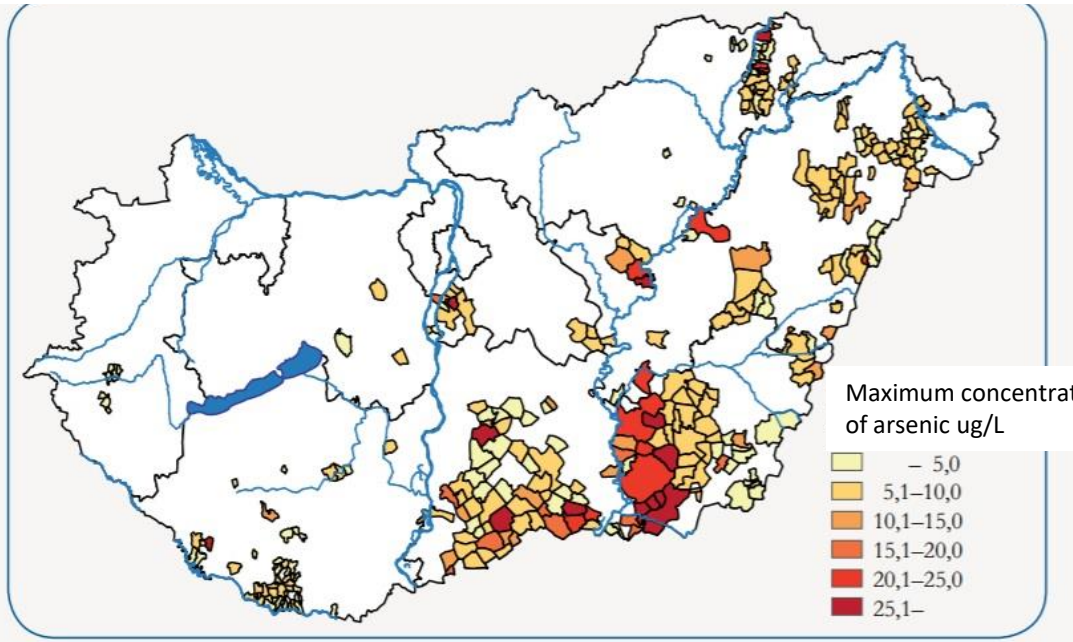
- DRINKING-WATER POSES THE GREATEST THREAT TO PUBLIC HEALTH FROM ARSENIC.
- INORGANIC ARSENIC IS NATURALLY PRESENT AT HIGH LEVELS IN THE GROUNDWATER OF A NUMBER OF COUNTRIES, SUCH AS ARGENTINA, CHILE, CHINA, INDIA (WEST BENGAL), MEXICO, THE UNITED STATES OF AMERICA, AND PARTICULARLY BANGLADESH WHERE APPROXIMATELY HALF OF THE TOTAL POPULATION IS AT RISK OF DRINKING ARSENIC-CONTAMINATED WATER FROM TUBE WELLS.
- IN ONE ESTIMATE, CONSUMPTION OF ARSENIC CONTAMINATED DRINKING-WATER IN BANGLADESH RESULTED IN ABOUT 9100 DEATHS AND 125 000 DISABILITY-ADJUSTED LIFE YEARS (DALYS*) IN 2001

https://www.nnk.gov.hu/attachments/article/213/arsenic_WHO[1].pdf

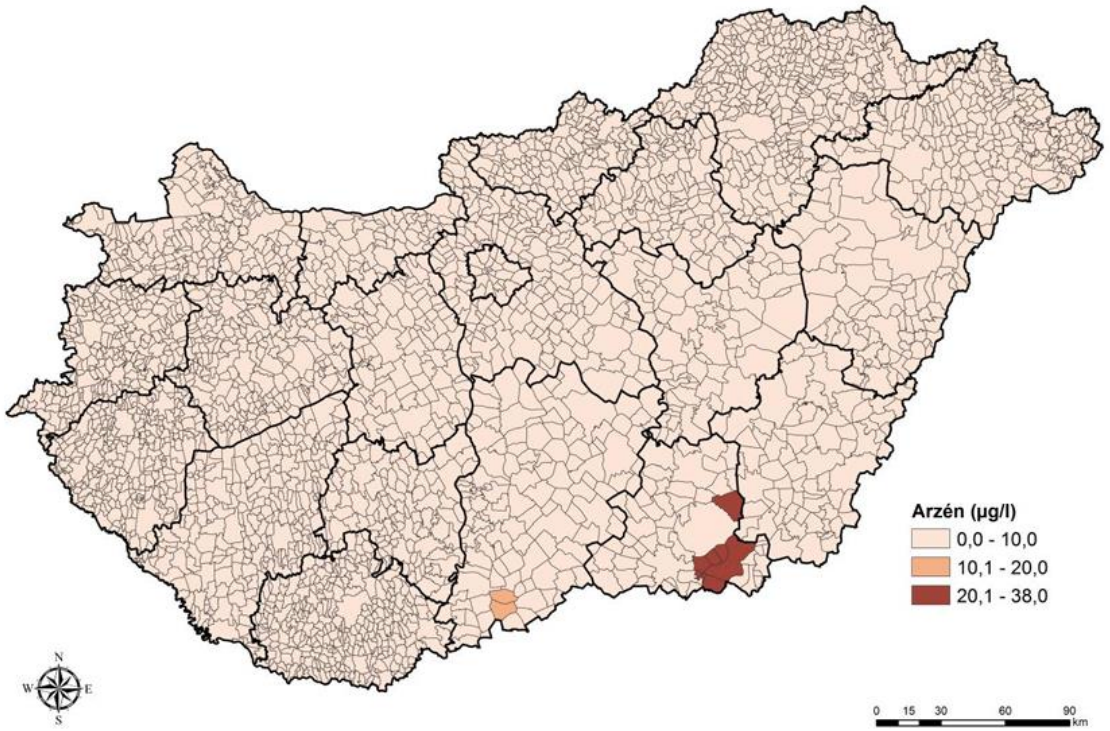
ARSENIC

- TLV: 10 µg/l
- Temporary measures: 50 µg/l (until 2009. dec.) and 20 µg/l until 2012. dec)
- Typical concentration in surface waters: 1-2 µg/l
- Natural (geological) origin South-East part of Hungary
- Antropogenic origin (mining, waste incineration, pesticides)
- Inorganic arsenic compounds: veryfied human carcinogens
- Long term exposition: epidemiological proof for increased risk of skin, lung, bladder cancer and for pregnancy and birth defects, e.g. miscarriages
- Removal: adsorption, precipitation methods

The arsenic-affected areas of Hungary with the relevant arsenic concentrations of drinking water, 2017



Forrás: Nemzeti Népegészségügyi Központ.



The arsenic-affected areas of Hungary with the relevant arsenic concentrations of drinking water, 2021

BORON

- Limit value: 1 mg / l
- geological origin
- Reproductive and developmental disorders
- Removal: by ion exchange or reverse osmosis only

FLUORIDE

- Limit value: 1 mg / l
- calcium metabolism, bone and tooth development
- Concentration too low: tooth decay
- Too many: <2 mg / l: enamel discolouration, <4 mg / l: skeletal system damage

NITROGEN FORMS

- Natural contaminants (originating from nitrogen cycle)
- Lack of sewerage and fertilizer use together increased its presence and concentration in groundwater
- **Nitrate**
  - It can be converted to nitrite in the gastric
- **Nitrite**
  - converts hemoglobin in the blood to methaemoglobin, which is unsuitable for transporting oxygen
  - endangers infants (especially in the first 3 months) (methaemoglobinaemia)
  - Mutagenic

HEAVY METALS

- Industrial origin: Cd, Hg, Cr (VI)
- From plumbing, faucets: Cr (III), Ni, Cu, Pb, Cd
- Cr (III), Se, Cu – essential
- Hg, Cd - damages the kidneys
- Cr (VI) - gastrointestinal cancer, eczema (in case of skin contact)
- Pb
  - reduce the utilization of trace elements, vitamins
  - causes kidney damage, fetal damage
  - adversely affects menthal development and intelligence (in childhood)
- Removal: by adsorption or precipitation

Parameter	TLV (drinking water)
Cadmium	5 µg/l
Chromium	50 µg/l
Copper	2 mg/l
Lead	10 µg/l
Mercury	1 µg/l
Nickel	20 µg/l
Selenium	10 µg/l

INDICATOR PARAMETERS

- ORGANIC MATTER CONTENT- can serve as a nutrient for microorganisms → proliferation in the drinking water network
- HARDNESS ideal: 100-150 mg / l CaO
- Soft: cardiovascular diseases
- (Hard: kidney stones)
- SODIUM
  - Role in the maintanance of biological membrane transport -> maintain nervous system, hormonal system
  - Too much: high blood pressure

ORGANOLEPTIC PARAMETERS

- Sensory characteristics - consumer acceptability
- Taste, smell
  - excessive chlorination,
  - metabolites of microorganisms(earthy, musty taste),
  - inadequate concentration of some ions (high Fe, Mn, Na or too low hardness)
- Color
  - E.g. high iron content
- Turbidity
- water base pollution,
- reduction in the efficiency of cleaning technology

METHODS FOR WATER CLEANING

- **Coagulation and Flocculation**
- Coagulation and flocculation are often the first steps in water treatment. Chemicals with a positive charge are added to the water. The positive charge of these chemicals neutralizes the negative charge of dirt and other dissolved particles in the water. When this occurs, the particles bind with the chemicals and form larger particles, called floc.
- **Sedimentation**
- During sedimentation, floc settles to the bottom of the water supply, due to its weight. This settling process is called sedimentation.
- **Filtration**
- Once the floc has settled to the bottom of the water supply, the clear water on top will pass through filters of varying compositions (sand, gravel, and charcoal) and pore sizes, in order to remove dissolved particles, such as dust, parasites, bacteria, viruses, and chemicals.

DISINFECTION

- After the water has been filtered, a disinfectant (for example, chlorine, chloramine) may be added in order to kill any remaining parasites, bacteria, and viruses, and to protect the water from germs when it is piped to homes and businesses.

Requirements:

- It should be able to kill microorganisms in small quantities, very effectively.
- The effect is long-lasting (until the water reaches the consumer's tap).
- Avoid the formation of by-products that adversely affect water quality.
- Do not chemically react with any substance other than microorganisms.

TYPES OF DISINFECTION

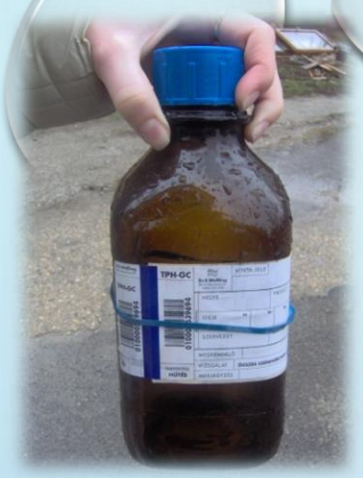
- PHYSICAL METHODS
  - BOILING
  - UV
- CHEMICAL METHODS
  - CHLORINATION (THE MOST COMMON METHOD FOR WATER DISINFECTION IN HUNGARY)
  - OZONE (POWERFUL AND FAST DISINFECTION, OZONE RESIDUE QUICKLY DISAPPEAR FROM THE SYSTEM

WATER QUALITY MEASUREMENTS

- Real time monitoring and operation control of drinking water systems
- The incorporation of recent advances in the information and communications technology (ICT).
  - best strategies for water and energy use,
  - to assess in real-time the efficiency of water networks,
  - to avoidwater losses because of leakage,
  - to minimize risk of inadequatewater quality,
  - to understand consumer demands by taking into account the behaviours and attitudes of the consumers and to improve the plans of asset predictive maintenance.

REGULAR MONITORING

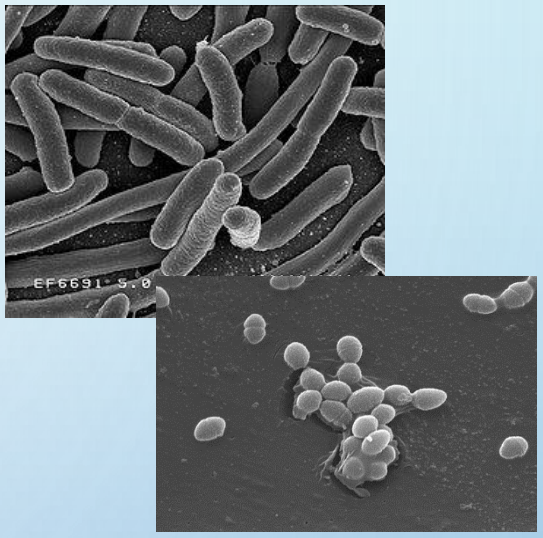
- SEVERAL TIMES/YEAR
- WATER PROTECTION AREAS – COMPLIANCE WITH STANDARD REQUIREMENTS
- VISUAL INSPECTION OF TECHNICAL EQUIPMENTS
- ACCORDING TO THE CONDITIONS, SAMPLING AND LABORATORY ANALYSIS TO IDENTIFY REGULAR AND SPECIAL COMPONENTS (ON-SITE INSPECTION STAFF DECIDE THE LIST OF PARAMETERS)



SAMPLING

- REPRESENTATIVE SAMPLE (E.G. TAPWATER - USUALLY RUN WATER FOR 5 MINUTES, USUALLY 1 LITER SAMPLE)
- SAMPLING OF WATER FED INTO THE CONSUMER NETWORK AND CONSUMED DRINKING WATER
- THE LABORATORY CAN ONLY DETERMINE THE PRESENCE AND CONCENTRATION OF THE SELECTED PARAMETERS
- FIELD TEST: ACTIVE CHLORINE CONTENT AND DISSOLVED GASES
- LABORATORY PROCESSING: UNREFRIGERATED SAMPLE - WITHIN 4-5 HOURS, REFRIGERATEDSAMPLE - WITHIN 24 HOURS
- STERILE BOTTLE FOR BACTERIOLOGICAL TESTS

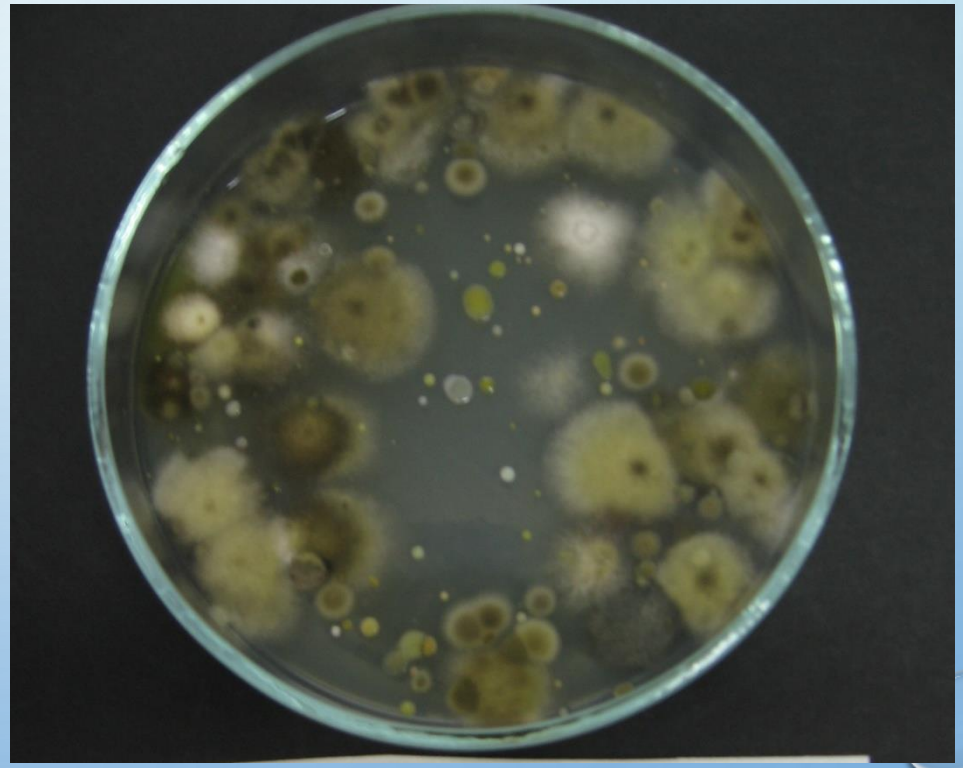
MICROBIAL PARAMETERS



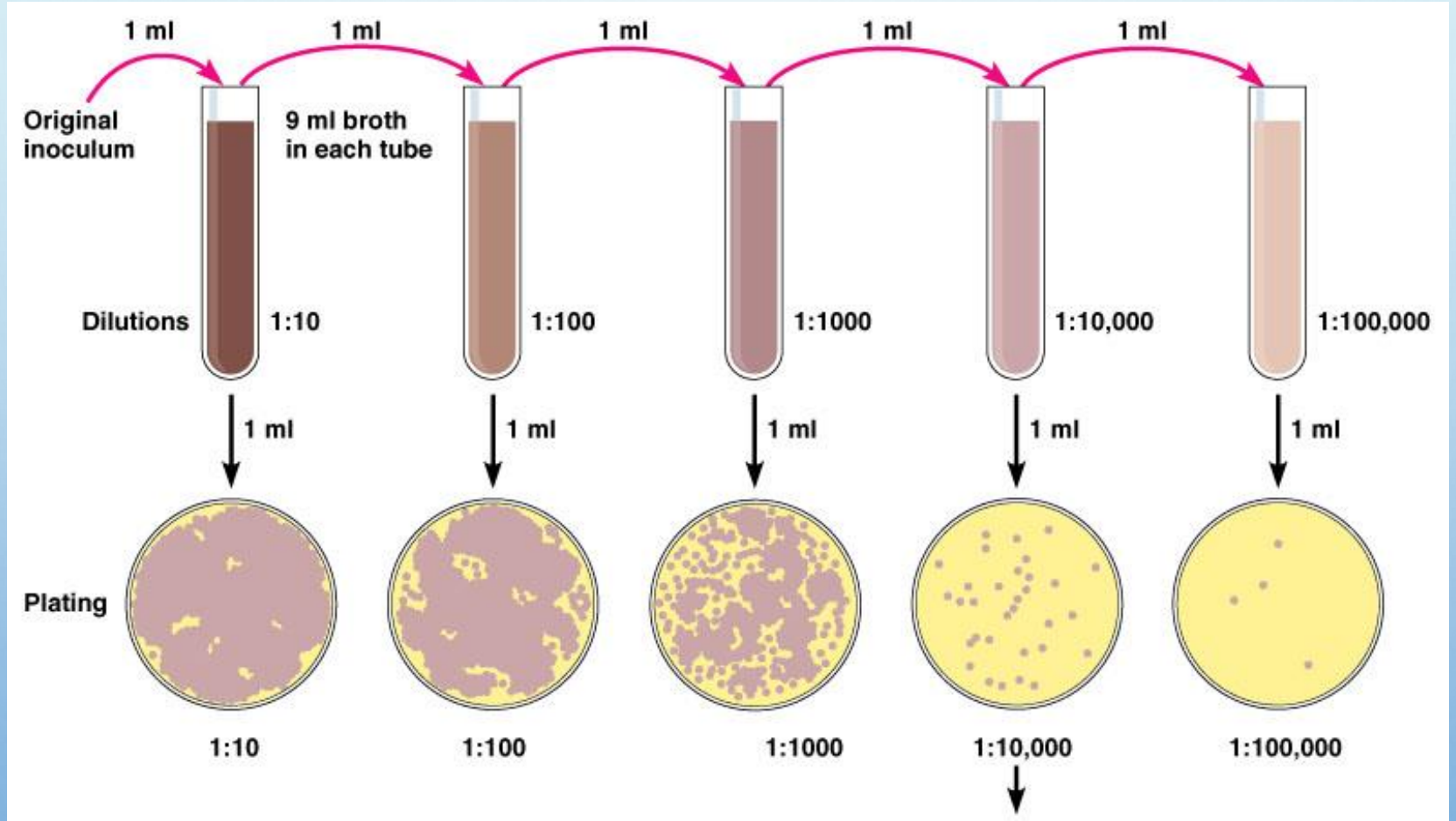
- FAECAL INDICATORS – SEWAGE DISCHARGE
  - *FAECAL COLIFORMS* → *E. COLI* (0/100 ML)
  - *ENTEROCOCCUS* (0/100 ML)
- *PSEUDOMONAS AERUGINOSA* (0/100 ML) – BIOFILMS (HOSPITAL WATER NETWORKS)
- *CLOSTRIDIUM PERFRINGENS*
  - 0/100 ML (INCLUDING SPORES)
  - INDICATOR OF WATER TREATMENT TECHNOLOGY

TOTAL VIABLE CELL COUNTS (COLONY FORMING UNITS)

- APPROX. NUMBER LIVING AND PROLIFERATING MICROORGANISMS
- MOST OF THEM ARE HARMLESS
- INDICATORS OF WATER TREATMENT EFFICIENCY

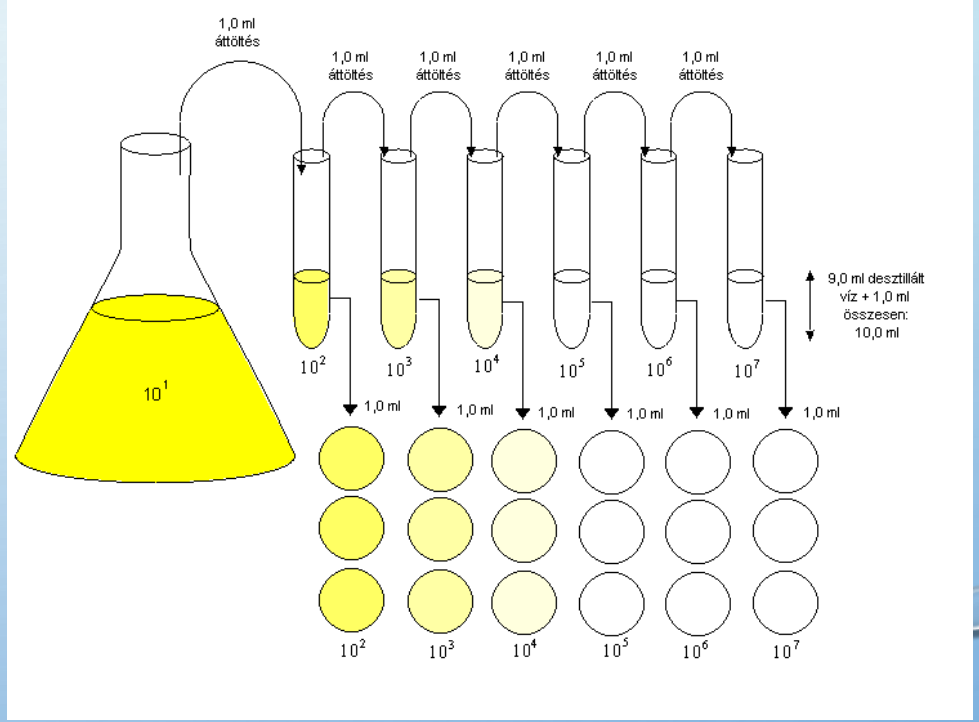


POUR PLATE TECHNIQUE



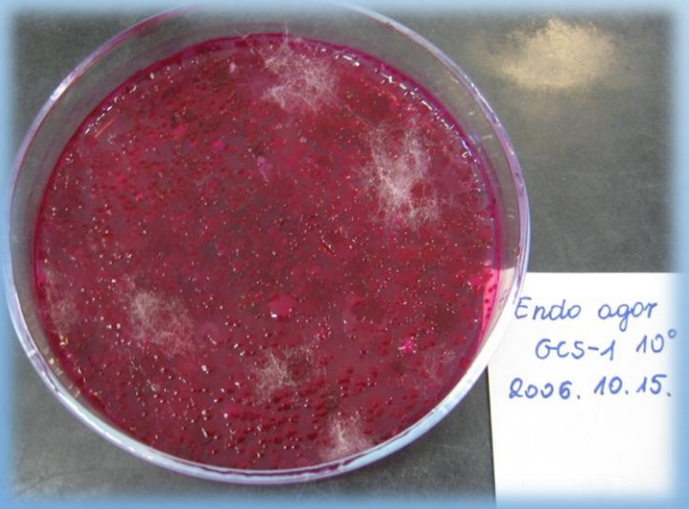
MOST PROBABLE NUMBER METHOD (MPN)

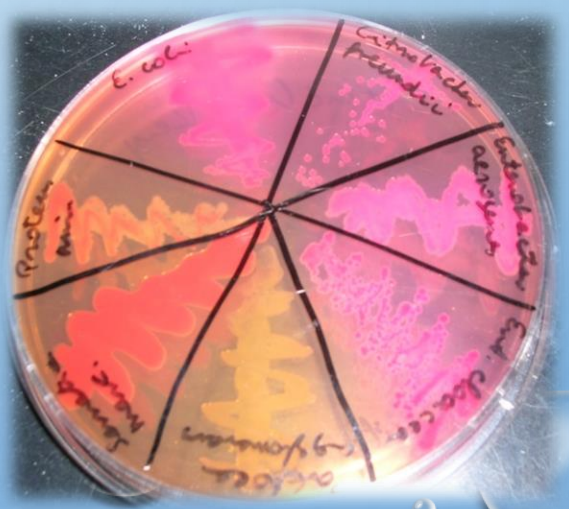
- CULTIVATION OF OBLIGATE AEROBIC MICROORGANISMS
- MIX THE DIFFERENT LEVELS OF DILUTION WITH LIQUID BROTH MEDIUM
- 3-5 REPLICATES
- READING: OPTICAL DENSITY, DISCOLORATION, ETC.
- STATISTICAL METHOD (HOSKINS TABLE) FOR MPN DETERMINATION



E. COLI AND COLIFORMS

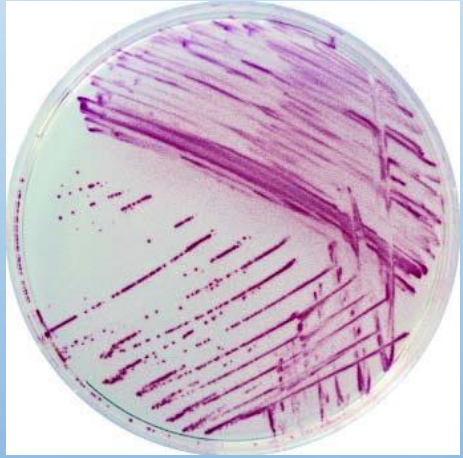
- E. COLI IS THE TYPICAL MEMBER OF HUMAN FECES
- LIVING IN THE COLON
- 150 T YPES → ONLY A FEW ARE RESPONSIBLE FOR DISEASES
- INDICATOR OF FAECAL CONTAMINATION OF DRINKING WATER SUPPLY
- COLIFORMS – COLI-LIKE MICROORGANISMS (NOT RELIABLE FAECAL INDICATORS)



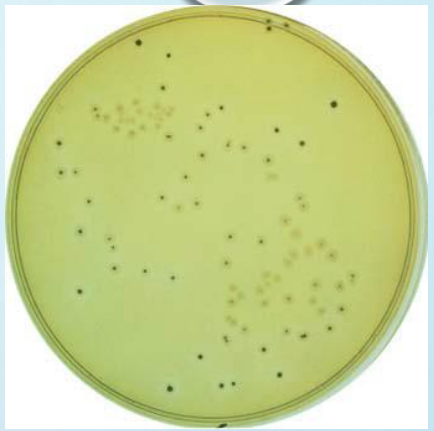


FAECAL ENTEROCOCCI

- RESISTANT TO ENVIRONMENTAL CONDITIONS – INDICATE AN OLDER FAECAL CONTAMINATION
- ENTEROCOCCUS FAECALIS
- COMMON MEMBER OF HUMAN COLON'S MICROBIAL COMMUNITY



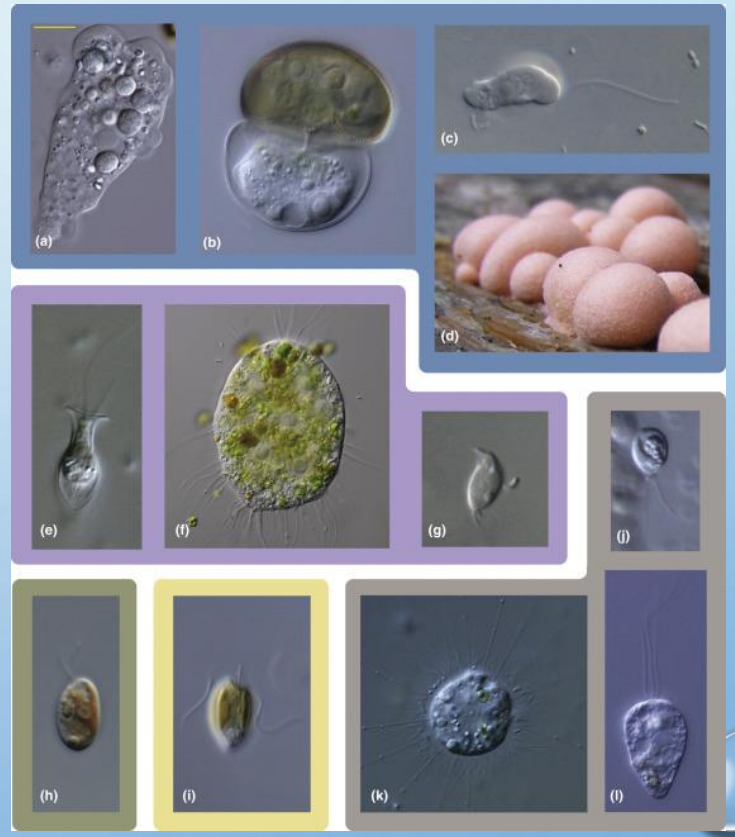
CLOSTRIDIUM



- SPORE FORMING ANAEROBIC BACTERIA
- COMMONLY DETECTABLE IN SOIL, HAVE A ROLE IN MINERALIZATION
- SOME SPECIES ARE MEMBERS OF HUMAN GASTROINTESTINAL MICROBIOME
- RARE OCCASION OF ILLNESS
- THEIR PRESENCE GIVE INFORMATION ABOUT THE FATE OF RESISTANT MICROORGANISMS IN THE WATER SYSTEM

MICROSCOPIC BIOLOGICAL PARAMETERS

- NATIONAL REGULATION
- 1 L CONCENTRATED SAMPLE
- WORMS, PROTISTS, FUNGI INHIBITOR BACTERIA CANNOT OCCUR
- THRESHOLD LIMIT VALUES:
  - IRON AND MANGANESE BACTERIA: 2 X 10^4 /ml
  - SULFUR BACTERIA: 2 X 10^4 /ml
  - ALGAE AND CYANOBACTERIA: 5 X 10^3 /ml
  - Amoebozoa: no unusual changes
  - Nematodes: no unusual changes



Amoebozoa, Obazoa, Cryptophyta, Haptophyta, and 'other taxa.'

WATERBORNE DISEASES

842,000 DIARRHEAL DEATHS IN LOW AND MIDDLE-INCOME COUNTRIES ARE CAUSED BY INADEQUATE DRINKING-WATER, SANITATION AND HANDWASHING PRACTICES (WHO, 2014)

USA:

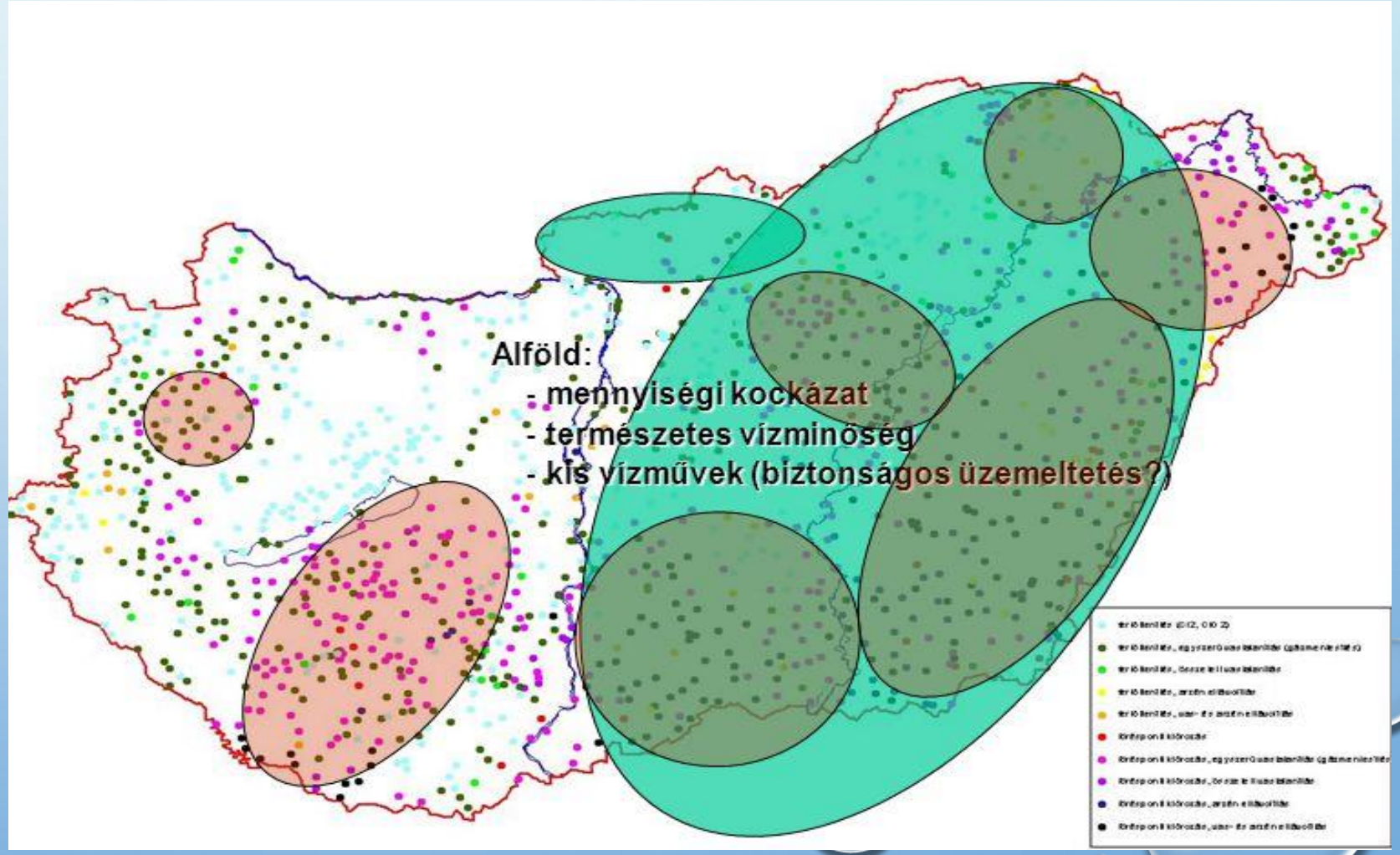
- 7.2 MILLION CASES/YEAR
- 120,000 HOSPITALIZATIONS
- 7000 DEATHS
- $3.2 BILLION HEALTHCARE COSTS

WATERBORNE INFECTIONS, WATER-RELATED EPIDEMICS

- Pathogen microorganisms can enter drinking water naturally and artificially
- Water-borne illness are associated with the following symptoms: diarrhea, nausea, fever
- Criteria for water-related epidemics:
  - Suddenly occuring symptoms among people living in the same water supply area
  - Contamination of the drinking water can be verified
  - After shuting down the water source, mass illness no longer occurs
- The role of the microbial laboratory is to help diagnose the infection and to identify the patogen germ, and to provide advice on choosing the best available treatment (ie. choose an antimicrobial therapy)

WATER SCARCITY

- WATER SCARCITY
- NATURAL WATER QUALITY
- SAFE OPERATION OF WATER SYSTEMS



PROVIDING CLEAN WATER IS THE BEST HUMANITARIAN INVESTMENT

- **WASH:** WATER, SANITATION ÉS HYGIENE
- UNICEF WORKS IN OVER 100 COUNTRIES TO HELP PROVIDE ACCESS TO CLEAN WATER AND RELIABLE SANITATION, AND TO PROMOTE BASIC HYGIENE PRACTICES IN RURAL AND URBAN AREAS, INCLUDING IN EMERGENCY SITUATIONS. WE ACHIEVE BETTER WASH RESULTS FOR CHILDREN BY:
- EMPOWERING COMMUNITIES
- SUPPORTING SCHOOLS
- HUMANITARIAN ACTION
- RESPONDING TO COVID-19
- INCREASING FOCUS ON SUSTAINIBILITY
- PARTNERSHIP

https://tools.waterpathogens.org/maps/

RECREATIONAL WATER

- WATER IS A GENERAL TRANSPORT MEDIUM, → SPREAD AND SURVIVAL OF MANY PATHOGENS.
- IN ADDITION TO DRINKING WATER, BATHING WATER POLLUTION IS A SERIOUS PUBLIC HEALTH PROBLEM NOT ONLY IN DEVELOPING COUNTRIES BUT ALSO IN DEVELOPED STATES.
- **BATHING IN A COMMON BODY OF WATER ALWAYS POSES A RISK TO PUBLIC HEALTH**.
- SIMILARLY TO DRINKING WATER, THE MAJOR PROBLEM IS THE PRESENCE OF PATHOGENIC BACTERIA, VIRUSES, PROTISTS, LARVAE OF WORMS
- THE POPULATION CAN BECOME INFECTED WHILE BATHING OR DURING OTHER WATER RECREATIONAL ACTIVITIES.

- **NATURAL BATHING WATERS**
- ANY ELEMENT OF SURFACE WATER WHERE THE COMPETENT AUTHORITY EXPECTS A LARGE NUMBER OF PEOPLE TO BATHE AND HAS NOT IMPOSED A PERMANENT BATHING PROHIBITION, OR ISSUED PERMANENT ADVICE AGAINST BATHING (HEREINAFTER BATHING WATER). IT APPLY TO:
  - RIVER WATER (RIVER, PERMANENT AND INTERMITTENT WATERCOURSE, BACKWATER)
  - STILL WATER (NATURAL AND ARTIFICIAL LAKE, RESERVOIR)
  - WATER FACILITY (CANAL)WATER, OR THEIR PARTS.
- **POOLS**
- PUBLIC BATHS (PUBLIC BATHING FACILITIES BUILT IN AN ENCLOSED AREA, INSIDE OR OUTSIDE THE BUILDING (POOL, BATH, SHOWER).
- SPA POOLS WITH SERVICES
- SWIMMING POOLS

NATURAL WATERS FOR RECREATION

- REGULATION: DIRECTIVE 2006/7/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL OF 15 FEBRUARY 2006 CONCERNING THE MANAGEMENT OF BATHING WATER QUALITY
- MEMBER STATES SHALL ANNUALLY IDENTIFY ALL BATHING WATERS AND DEFINE THE LENGTH OF THE BATHING SEASON
- ENSURE THAT MONITORING OF THE PARAMETERS SET OUT IN ANNEX I, COLUMN A, TAKES PLACE IN ACCORDANCE WITH ANNEX IV.
- THE MONITORING POINT SHALL BE THE LOCATION WITHIN THE BATHING WATER WHERE: (A) MOST BATHERS ARE EXPECTED; OR (B) THE GREATEST RISK OF POLLUTION IS EXPECTED, ACCORDING TO THE BATHING WATER PROFILE.
- THE DIRECTIVE DOES NOT APPLY TO SWIMMING POOLS OR SPA POOLS, OR TO ARTIFICIALLY CREATED CONFINED WATERS, SUBJECT TO TREATMENT OR USED FOR THERAPEUTIC PURPOSES.

ANNEX I

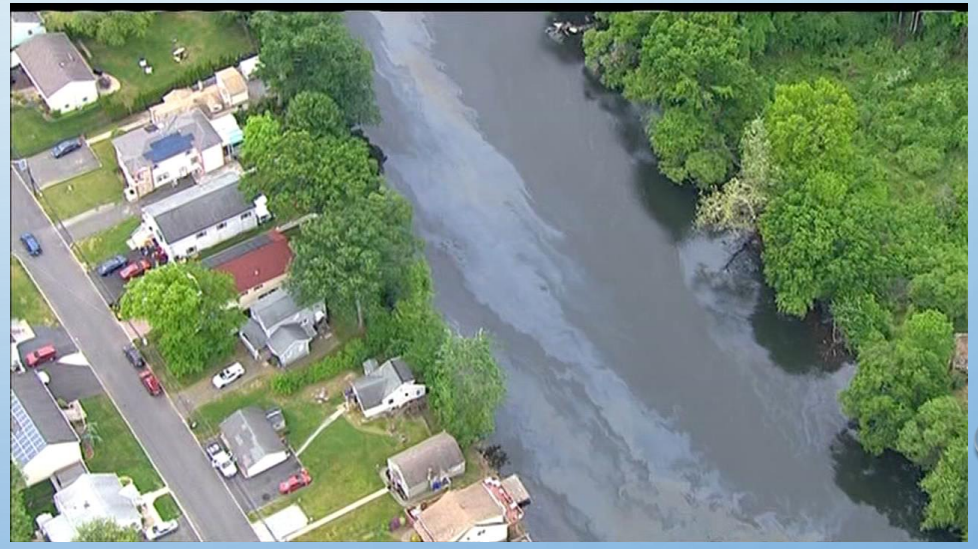
For inland waters

	A	B	C	D	E
	Parameter	Excellent quality	Good quality	Sufficient	Reference methods of analysis
1	Intestinal enterococci (cfu/100 ml)	200 (*)	400 (*)	330 (**)	ISO 7899-1 or ISO 7899-2
2	Escherichia coli (cfu/100 ml)	500 (*)	1 000 (*)	900 (**)	ISO 9308-3 or ISO 9308-1

(*) Based upon a 95-percentile evaluation. See Annex II.
(**) Based upon a 90-percentile evaluation. See Annex II.

SITE VISIT AND EVALUATION

- IT IS PERFORMED BY THE LOCAL OPERATOR, OR A LABORATORY COMMISSIONED BY THE AUTHORITIES
- ON-THE-SPOT MONITORING (OBSERVATION)
- FLOATING POLLUTION
- OIL SLICK
- ODOR
- HYDROPHITES
- CYANOBACTERIAL BLOOM



SAMPLING AND EXAMINATION

1. SAMPLING POINT: WHERE POSSIBLE, SAMPLES ARE TO BE TAKEN 30 CENTIMETRES BELOW THE WATER'S SURFACE AND IN WATER THAT IS AT LEAST ONE METRE DEEP.

2. STERILISATION OF SAMPLE BOTTLES

3. SAMPLING

- THE VOLUME OF THE SAMPLING BOTTLE/CONTAINER IS TO DEPEND ON THE QUANTITY OF WATER NEEDED FOR EACH PARAMETER TO BE TESTED. THE MINIMUM CONTENT IS GENERALLY 250 ML.
- EMPLOY AN ASEPTIC TECHNIQUE TO MAINTAIN THE STERILITY OF THE SAMPLE BOTTLES.
- CLEARLY IDENTIFIED IN INDELIBLE INK ON THE SAMPLE AND ON THE SAMPLING FORM.

4. STORAGE AND TRANSPORT

- PROTECTED FROM EXPOSURE TO LIGHT,
- TEMPERATURE OF AROUND 4°C,
- THE TIME BETWEEN SAMPLING AND ANALYSIS IS TO BE KEPT AS SHORT AS POSSIBLE (LONGER THAN 4 HOURS – COOLING)
- IT IS RECOMMENDED THAT SAMPLES BE ANALYSED ON THE SAME WORKING DAY. IF THIS IS NOT POSSIBLE FOR PRACTICAL REASONS, THEN THE SAMPLES SHALL BE PROCESSED WITHIN NO MORE THAN 24 HOURS. I
- IN THE MEANTIME, THEY SHALL BE STORED IN THE DARK AND AT A TEMPERATURE OF 4°C±3°C

SPAS AND POOLS

- NO CLEAR EUROPEAN REGULATION
- 212/1996 (VII.24) GOVERNMENT ORDER NO. ON THE ESTABLISHMENT AND OPERATION OF PUBLIC BATHS
- 37/1996 (X.18) MINISTRY OF WELFARE ORDER ON PUBLIC HEALTH CONDITIONS FOR THE ESTABLISHMENT AND OPERATION OF PUBLIC BATHS
- THE USE OF PUBLIC BATHS MUST BE DESIGNED IN SUCH A WAY THAT THE HEALTH OF BATHERS IS NOT ENDANGERED BEYOND A REASONABLE LEVEL!

MAJOR TYPES OF PUBLIC BATHS

TWO TYPES:

FILLING-DRAINING POOLS AND WATER CIRCULATING POOLS

FROM 1996, A PUBLIC BATH CAN ONLY BE ESTABLISHED BY CIRCULATION SYSTEM

EXCEPTIONS: SOME SPA POOLS WHERE BIOLOGICALLY ACTIVE COMPONENTS WOULD BE DAMAGED BY WATER CIRCULATION (MOST OF WHICH OPERATE WITHOUT DISINFECTION)

THE AMOUNT OF INDICATOR MICROORGANISMS SHOULD BE BELOW THE LIMIT

WATER MUST BE FROM A WELL THAT PROVIDES DRINKING WATER QUALITY

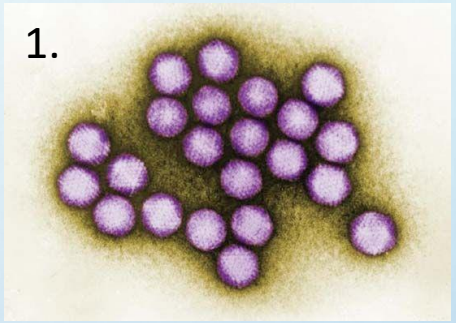
APPROPRIATE CHEMICAL COMPOSITION

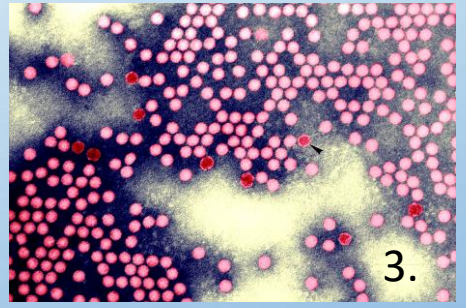
QUALITY OF POOL WATER

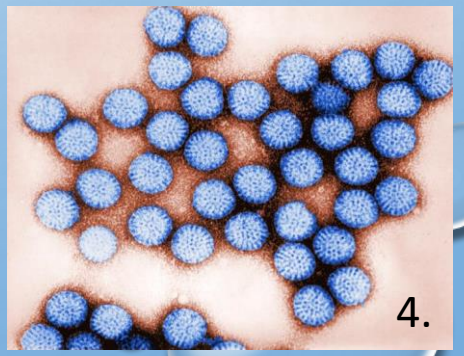
- CHEMICAL COMPOSITION:
- THE MOST COMMON PROBLEM IS DISINFECTANT RESIDUE - FREE ACTIVE CHLORINE - INDICATES DISINFECTION EFFICIENCY TLV: 1 MG / L -
- BOUNDED ACTIVE CHLORINE - INDICATES THE FORMATION OF DISINFECTION BY-PRODUCTS
- MICROBIOLOGICAL EXAMINATION
  - INDICATOR BACTERIA (E. *COLI, MICROCOCCUS, ENTEROCOCCUS* - FAECAL INDICATORS)
  - *STAPHYLOCOCCUS AUREUS* - A BACTERIUM OF SKIN ORIGIN - INDICATES THE OVERUSE OF THE POOL OR THE INSUFFICIENT AMOUNT OF FRESH WATER LOAD
  - *PSEUDOMONAS AERUGINOSA* - BIOFILM-FORMING BACTERIUM - WATER HEAVILY CONTAMINATED WITH MICROORGANISMS - OPPORTUNISTIC PATHOGEN - CAN CAUSE WOUND INFECTIONS, EAR INFECTIONS
- *LEGIONELLA* TESTING IS ALSO RECOMMENDED FOR CIRCULATING, AEROSOL GENERATING POOLS (E.G. HOT TUBS).

VIRUSES IN POOLS

- THE NUMBER OF VIRUSES IS NOT RELATED TO THE BACTERIOLOGICAL CONDITION!
- WATER-BORNE HUMAN PATHOGENIC VIRUSES, COLLECTIVELY KNOWN AS ENTERAL VIRUSES, INFECT IN THE FECAL-ORAL TRANSMISSION PATHWAY
- THESE ARE MAINLY REPRESENTATIVES OF THE FOLLOWING VIRUS FAMILIES:
    1. ADENOVIRIDAE (ADENOVIRUS TYPES 40 AND 41),
    2. CALICIVIRIDAE (GENERA NOROVIRUS AND SAPOVIRUS),
    3. PICORNAVIRIDAE (POLIOVIRUSES, COXSACKIEVIRUSES, ECHOVIRUSES, ENTEROVIRUSES, HEPATITIS A)
    4. REOVIRIDAE (ROTAVIRUSES)
- DISEASES CAUSED BY ENTERIC VIRUSES: GASTROENTERITIS, HEPATITIS, MYOCARDITIS, ASEPTIC MENINGITIS, OCULAR INFLAMMATION AND RESPIRATORY DISEASES







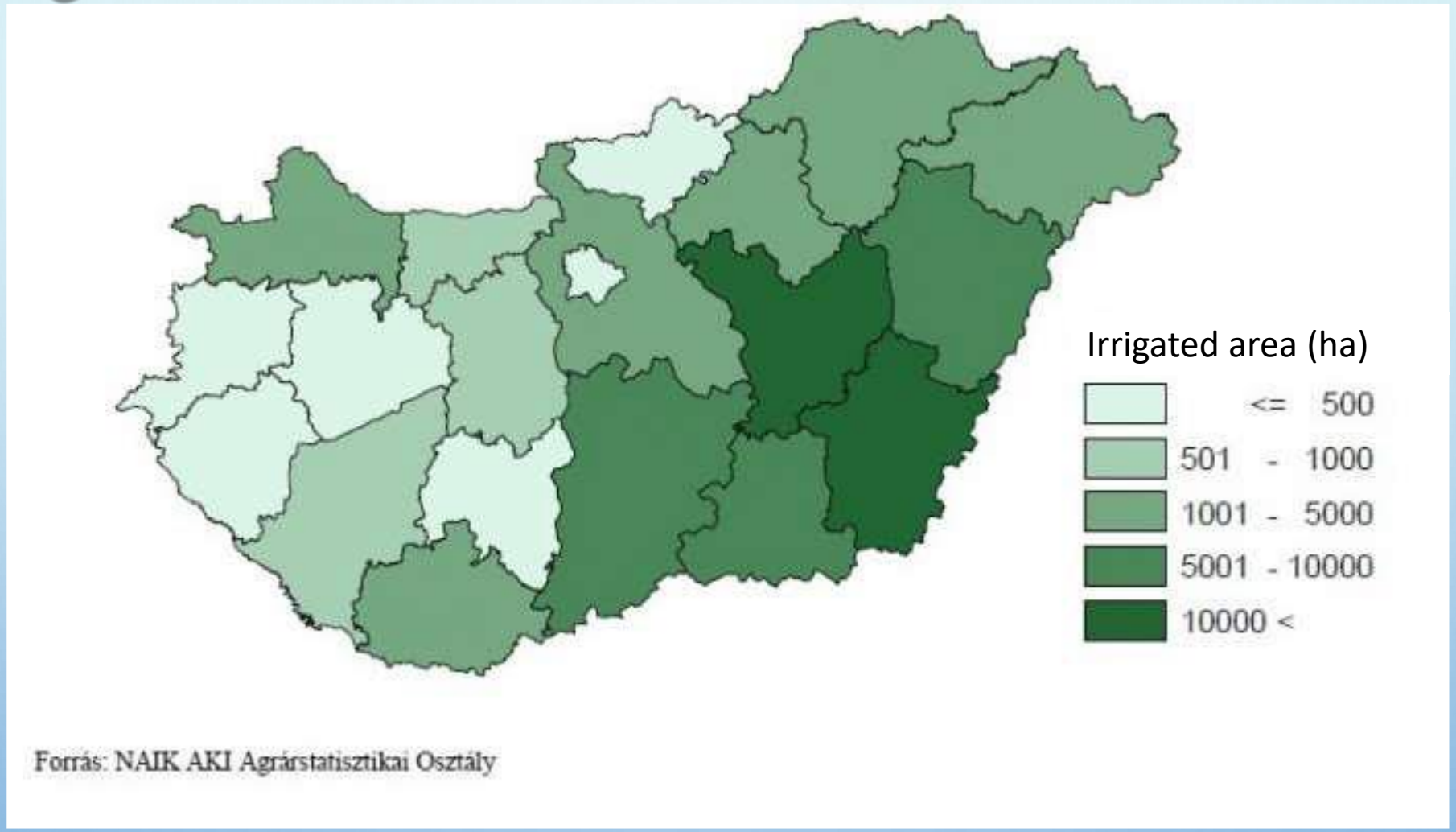
DETECTION OF VIRUSES IN WATER SAMPLES

- THEIR DIRECT DETECTION (IN CELL CULTURE) IS SLOW AND HAS A LOW SENSITIVITY.
- BACTERIAL AND BACTERIOPHAGE INDICATORS ARE INADEQUATE.
- MOLECULAR DIAGNOSTICS (PCR) IS MORE ACCURATE, BUT BECAUSE THE TITER OF VIRUSES IS EXTREMELY LOW, UP TO HUNDREDS OF LITERS OF SAMPLE WOULD BE REQUIRED TO PERFORM (FILTRATION, OR FLOCCULATION).
- IMPROVING EFFICIENCY: VIROBATHE PROJECT (METHOD BASED ON REVERSIBLE BINDING TO THE REACTIVE SURFACE DUE TO CHARGE CHANGES IN THE CAPSID PROTEINS OF VIRUSES INDUCED BY PH CHANGES - CELLULOSE ESTER MEMBRANE).
- BASED ON THE VIROBATHE RESULTS, THE MOST COMMON GROUP WAS ADENOVIRUSES (KERN ET AL., 2011).

IRRIGATION WATER

BACKGROUND:

- 2019 CXIII. ACT ON IRRIGATION FARMING IN HUNGARY
- SURFACE IRRIGATION HAS THE GREATEST TRADITION, INCLUDING SPRINKLER IRRIGATION.
- FROM THE EARLY 1980S, CENTER PIVOT AND LINEAR MACHINES WERE POPULAR, BUT TODAY 80% OF IRRIGATED FIELDS IN THE FIELD OPERATE WITH LATERAL MOVE (WHEELMOVE) MACHINES.
- ON THE AVERAGE OF THE LAST 10 YEARS, THE SIZE OF IRRIGATED AREAS IN HUNGARY DID NOT EXCEED 100 THOUSAND HECTARES. THE AREA WITH A WATER PERMIT IS ABOUT 200 THOUSAND HECTARES.
- IRRIGATION TAKES PLACE ON ALMOST 90% OF ARABLE LAND, WITH ONLY 4-5% DISTRIBUTED AMONG FRUIT, VINEYARDS AND GRASSLANDS.
- THE PROPORTION OF IRRIGATED AREA IN HUNGARY IS BARELY 1-2%.



- SOURCE OF IRRIGATION WATER: 92% SURFACE WATER, 7.5% SUBSURFACE WATER, 0.5% BANK FILTRATION.

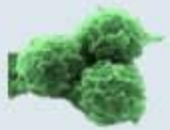
PROCESS OF IRRIGATION

- WATER ABSTRACTION (FROM NATURAL OR ARTIFICIAL WATERCOURSES, LAKES, RESERVOIRS, GROUNDWATER)
- WATER TRANSPORT (OPEN SEWER OR PIPELINE)
- WATER DISTRIBUTION
- WATER APPLICATION

- PROBLEMS WITH IRRIGATION WATER:
  - CHEMICAL
  - MECHANICAL
  - BIOLOGICAL (BACTERIA, VIRUSES, PROTOZOA)

MICROBIAL CONTAMINATION OF IRRIGATION WATER

TABLE 1 CHARACTERISTICS OF RELEVANT WATERBORNE PATHOGENS IN THE NETHERLANDS

Pathogen	Carrier	Characteristics	
Viruses *enterovirus*	Human	Very small (25 nm), persistent in environment and treatment, very infectious	
Bacteria *Campylobacter* *E. coli O157:H7*	*Human* *Animal*	Small (0.2x5 µm), not very persistent, also spread by birds and water fowl	
Protozoa *Cryptosporidium* *Giardia*	*Human* *Animal*	Larger (3-6 µm), extremely persistent in environment and chemical treatment	

HYGIENE OF SEWAGE

- MORE THAN HALF OF THE ORGANIC MATTER OF MUNICIPAL SEWAGE STOCK IS FAECES
- VERY HIGH CONTENT OF PROTEIN AND PROTEIN BREAKDOWN PRODUCTS, AS WELL AS FATS AND CARBOHYDRATES
- FATS ARE USUALLY EMULSIFIED
- LARGE AMOUNTS OF (FECAL) MICROBES
- THERE ARE ALSO MANY INORGANIC SUBSTANCES
- IT CONTAINS ALL THE MATERIALS THAT CAN GET THROUGH THE DRAIN OF THE FLUSH TOILET!
- THREE FORMS OF POLLUTANTS FROM A PHYSICO-CHEMICAL POINT OF VIEW: SUSPENDED SOLIDS, COLLOIDAL STATE, SOLUTION

EVALUATION OF WASTEWATER

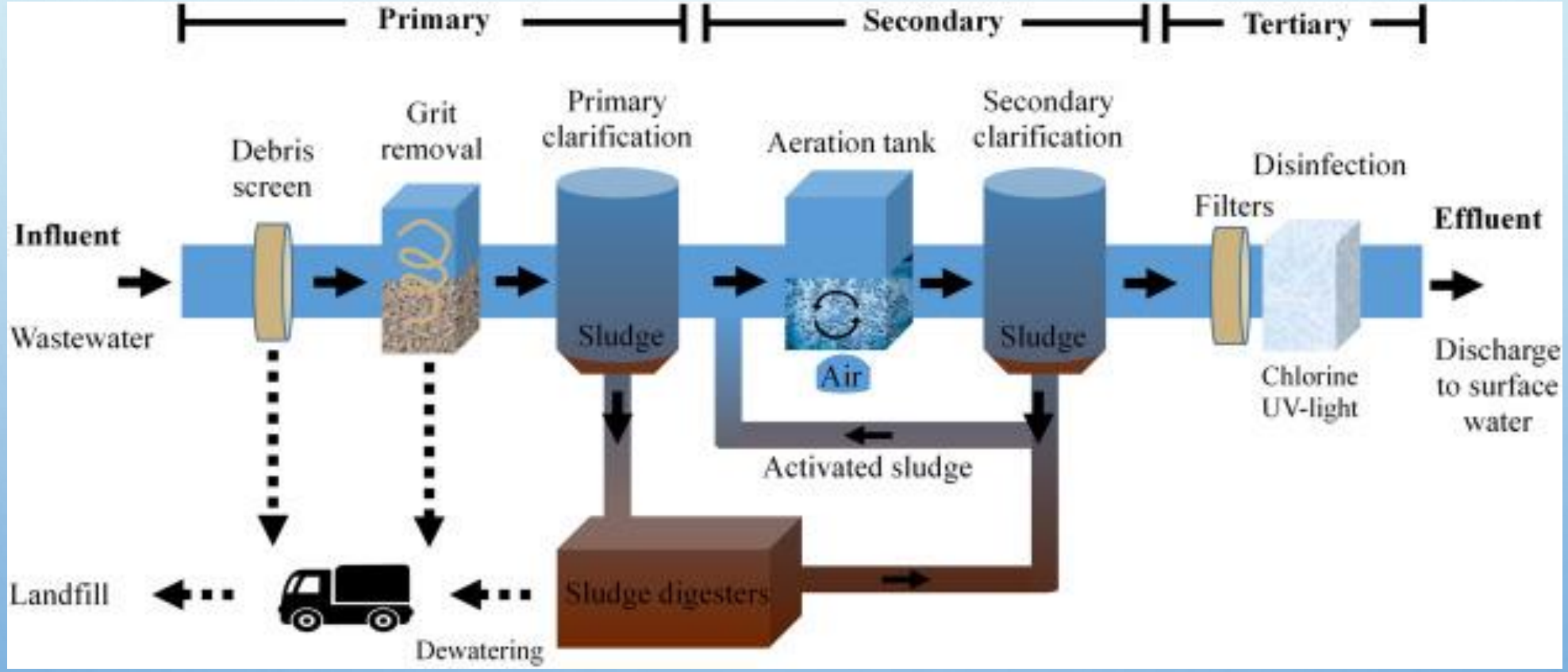
- INFORMATIVE, CONTROL, DETAILED OR TARGETED INSPECTION
- SEWAGE SAMPLING: IT IS IMPORTANT TO CHOOSE THE SAMPLING SITE CAREFULLY (BASED ON A SITE VISIT)
- ITS QUALITY VARIES IN SPATIALLY AND OVER TIME → AVERAGE SAMPLES (SPATIAL OR TEMPORAL AVERAGES)
- SAMPLES SHOULD BE REFRIGERATED (0- + 4 ° C) AND PROCESSED WITHIN 24 HOURS
- OCCASIONALLY CHEMICAL PRESERVATION

GENERAL PARAMETERS

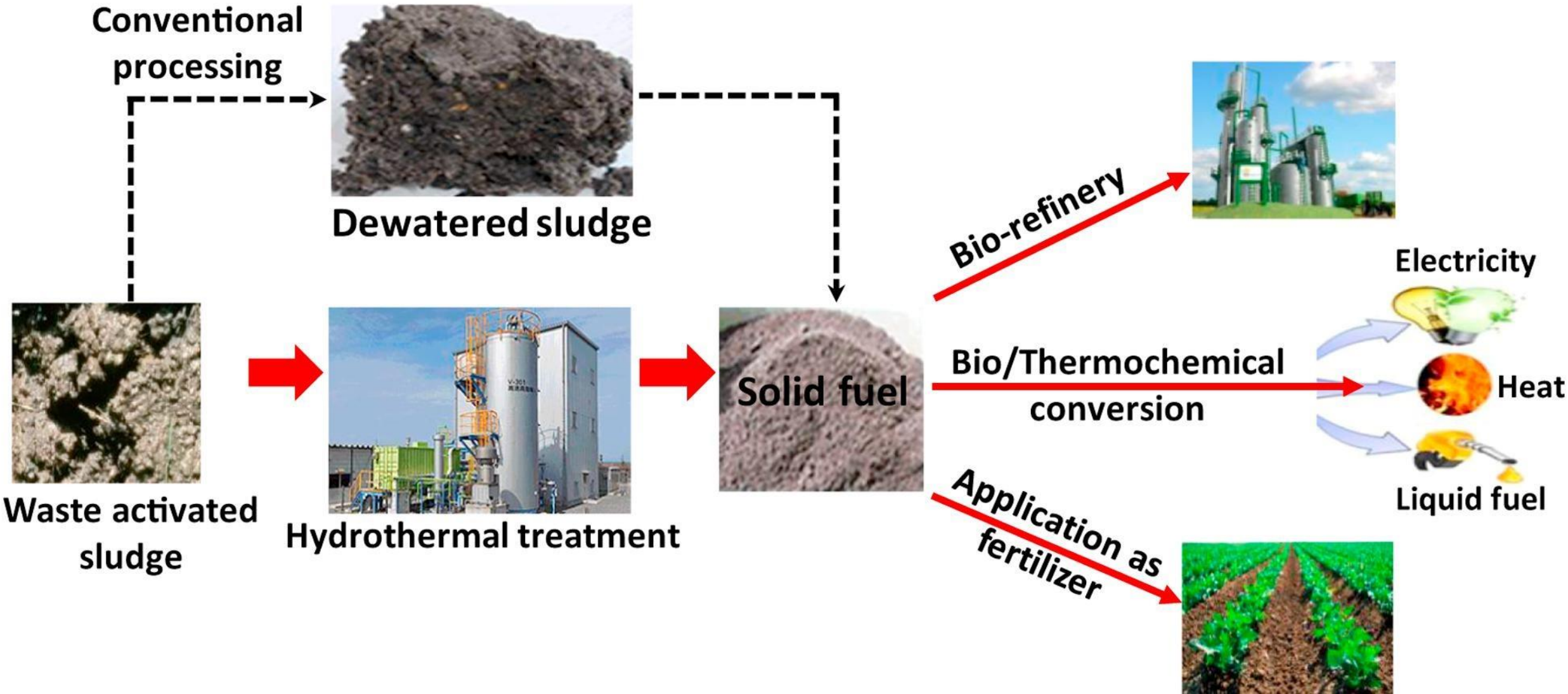
- COLOR, SMELL, TRANSPARENCY
- IT CAN PROVIDE SUBJECTIVE, YET IMPORTANT INFORMATION ON THE GENERAL CONDITION AND THE DEGREE OF CONTAMINATION
- COLOR: FRESH DOMESTIC EFFLUENT: GRAYISH YELLOWISH GREENISH GREY
- ODOR: FROM MUSTY TO URINE, FAECAL ODOR (ROTTEN EGG ODOR INDICATES ANAEROBIC DECOMPOSITION)
- TRANSPARENCY: PROVIDES INFORMATION ON ITS QUALITY
- SUSPENDED SOLIDS CONTENT, LOSS ON IGNITION UNIT MG / LITER (BY FILTRATION, DRYING) - ORGANIC POLLUTION

- ORGANIC MATTER CONTENT - THE MOST IMPORTANT MEASURE OF POLLUTION
- MEASUREMENT: COD (PERMANGANATE), BOD (FIVE DAYS)
- OXYGEN BALANCE INDICATORS:
- DISSOLVED OXYGEN CONTENT
- ANAEROBIC DEGRADABILITY IT IS MEASURED WITH A REDOX INDICATOR
- PH
- CHLORIDE
- NITROGEN AND PHOSPHORUS FORMS
- SULFATE
- CONDUCTIVITY

WASTEWATER TREATMENT



SEWAGE SLUDGE TREATMENT



WASTE MANAGEMENT AND WASTE HYGIENE

Dr. Edit Kaszab

Associate professor

kaszab.edit@uni-mate.hu

A LITTLE HISTORY

- One of the oldest landfill contained bones, tiles and ash and was found in a Stone Age settlement
- Size: 320 x65 m, height 8.5 m.
- It was set on fire time after time - probably to eliminate unpleasant odors.
- In ancient times, waste was collected in amphorae in European and Asian cities and was collected regularly from households.
- A usual method was to dig pits for faeces and other waste that was occasionally cleaned.
- Waste was usually deposited in the outskirts of the city (landfills), sometimes in a large amount - It reached a height of 13 meters in Carthage and 50 meters near Rome.

ANCIENT HYGIENE AND SANITATION

- Wars and pandemics
- In Herodotus' book entitled Historia, Vol. 8, Greece was saved by the Loimos (plague and / or dysenteria?) that struck Xerxes' troops invading Thessaly to such an extent that the Persian army, which numbered 800,000, was forced to retreat with nearly 300,000 dead.
- The successful conquests of Alexander the Great were also stopped by an epidemic. In North India, the rebellion over the mass enteral disease of soldiers (cholera?) forced a retreat, and this triggered the collapse of the empire, which was also accelerated by the early death of the genius young warlord (323 BC).
- The "Antonius plague" almost completely flooded the Roman Empire around 165 AD; according to the information provided by Galenos, symthoms (vesicular rash) raise suspicions of variola. Marcus Aurelius, the philosopher, died in variola, too (180 AD).
- The Huns couldn't occupy Constantinople because an epidemic devastated humans, horses, and cattle alike (presumably anthrax).

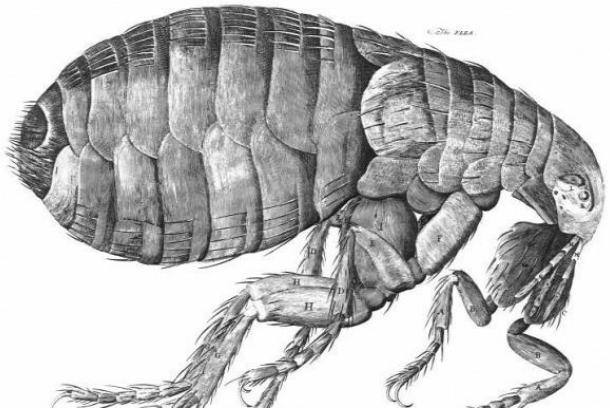
- Plague - *Yersinia pestis* ; dysenteria - *Shigella* sp. e.g. *Shigella dysenteriae;* cholera – *Vibrio cholerae;* variola – black pox - *Poxvirus variolae*; anthrax - *Bacillus anthracis*

WASTE MANAGEMENT IN THE MIDDLE AGES

- From the medieval castles, food waste and rubbish were simply dumped on the hillside. In the cities, the contents of the potty and other liquid waste were poured from the window onto the street. There, pigs rumbled in the knee-deep, stinky swamp. Many streets could only be used on stilts. The streets were crowded with rats.
- Epidemics: plague, cholera. In 1348, Paris, the connection between hygiene, sanitation and the spread of epidemics was recognized.
- As a result of the recognition, private service providers started to remove the garbage from the city. Other methods: in London, all ravens and falcons have been declared to be protected because they have eaten up the waste.

HIGIENE AND HISTORY IN HUNGARY

- The epidemic that ended the siege of Nándorfehérvár in 1456, (plague?) brought success to the Hungarians, but at a high price - the János Hunyadi and Giovanni di Capistrano, the main leaders of the Hungarian army died.
- 1566 – Miksa I. launched a campaign to liberate Buda from the Turkish army, but a typhoid epidemic broke out in the camps (Győr and Komárom) – no. of deaths – 30 000. The army disintegrated → spread the disease all around Europe (morbus hungaricus).
- Plague – first data since 1095. Adversely affected the military events during Rákóczi's War of Independence (1703-1711). 300 000 of the country's 3 million inhabitants died of the disease (both covilians nad soldiers).



INDUSTRIAL REVOLUTION

- Waste disposal was not common until the New Ages. In the 19th century, another cholera epidemic sweeped across Europe → urgent need for interventions. Robert Koch → found the link between illness and hygiene.
- At end of the 19th century, the first waste incinerator was established, and selective waste sorting – manual sorting (1898 in the USA).
- After the Industrial Revolution, the composition of waste changed drastically. It is no longer just organic waste (risk of infection → plague and cholera epidemics). Nowadays, waste is a chemical mixture of xenobiotics and partly highly toxic substances that will not degrade for centuries (persistant organic substances).

HISTORICAL OVERVIEW

500 BC	Athens, Greece	First landfill of the European society. Regulations on waste disposal (not closer to the settlements than 1.5 km)
New Testament in the Bible	Jerusalem	The Gehenna Valley is the city's ever-burning smoky landfill. Over time, it becomes one of the synonyms for hell.
200 AD	Rome	There were no house-to-house garbage collection, but waste was regularly collected from streets.
1348	Florence, Italy	Plague → regulation to clean up streets and to supervise the removal of waste
1357	London, England	Local authorities banned the disposal of solid waste such as garbage, manure into the Thames or any other waterways
1372	London, England	Penalty for throwing/pouring out liquid waste from windows
1388	England	National authorities banned the disposal of solid waste such as garbage, manure into the waterways of England
1392	London, England	Regulation of slaughterhouse waste management. Trustees have been appointed to ensure the cleanliness of the city.

DEFINITION OF WASTE IN OUR TIME

- In general: the substance (worn-out product, residue, separated pollutant) that is generated in the course of human producer-, consumer, or daily life activities, and then, under the given technical, economic and social conditions, its owner cannot use or sell, or does not want to. Therefore, the owner wants to remove it from the place of origin, or the piling up would pose a health risk and / or environmental pollution.
- In short: waste is any substance or object which the holder discards or intends or is required to discard.

LEGAL BACKGROUND

- EWC is **a hierarchical list of waste descriptions established by Commission decision** 2000/532/EC2.
- It is divided into **twenty main chapters**, most of which are industry-based but some of which are based on materials and processes.
- Each of these has a two digit code between 01 and 20.
- Chapters do not have equal priority
- Chapters 1-12 and 17-20 are source activity related
- Chapters 13-15 are waste type related
- Chapter 16 – wastes not otherwise specified

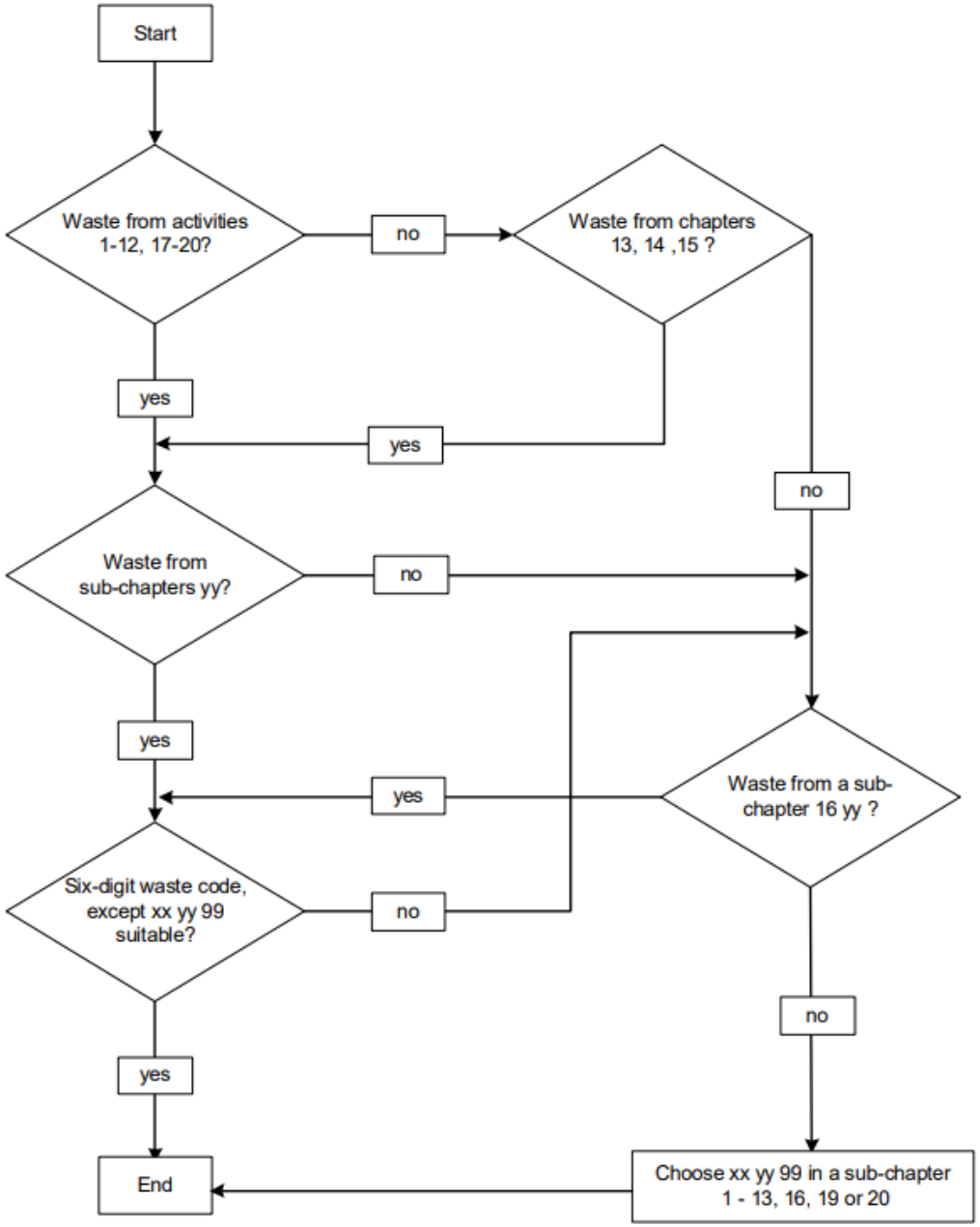
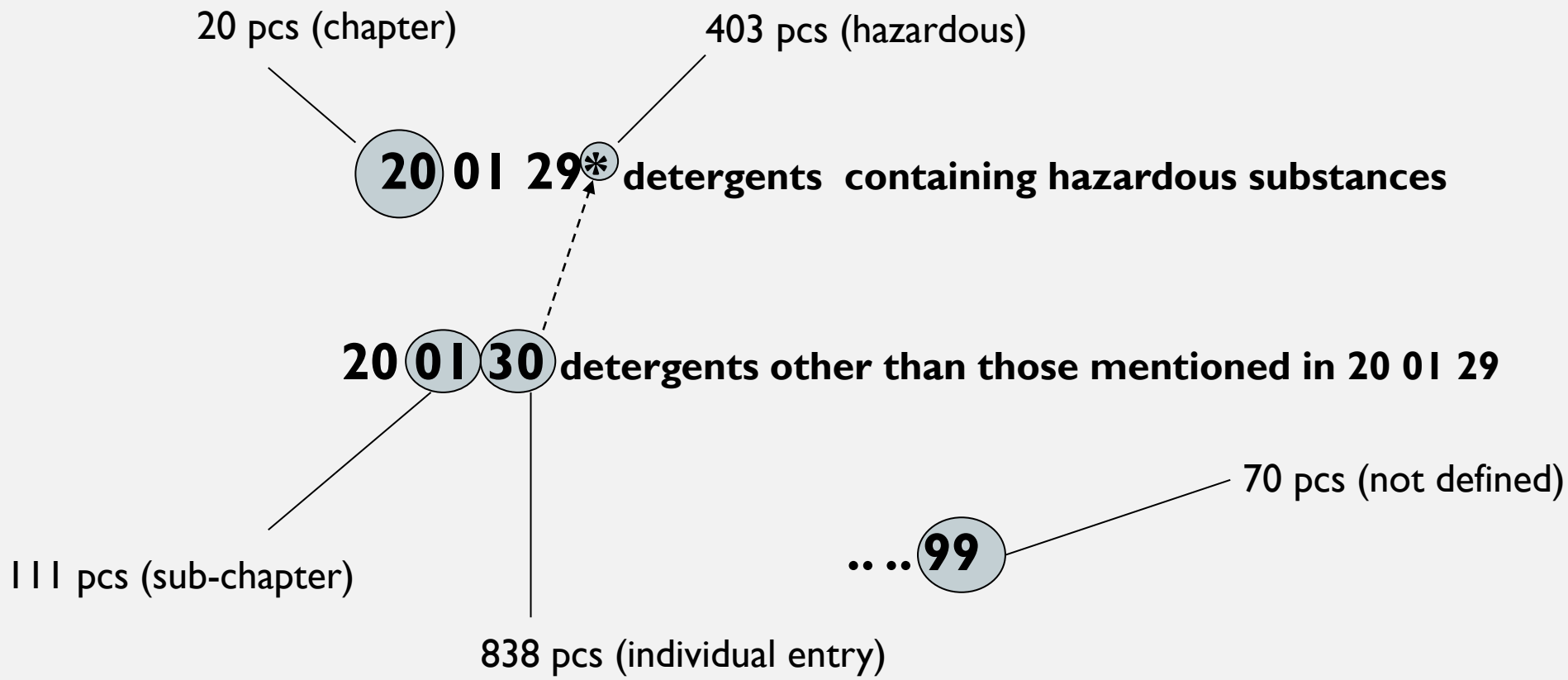


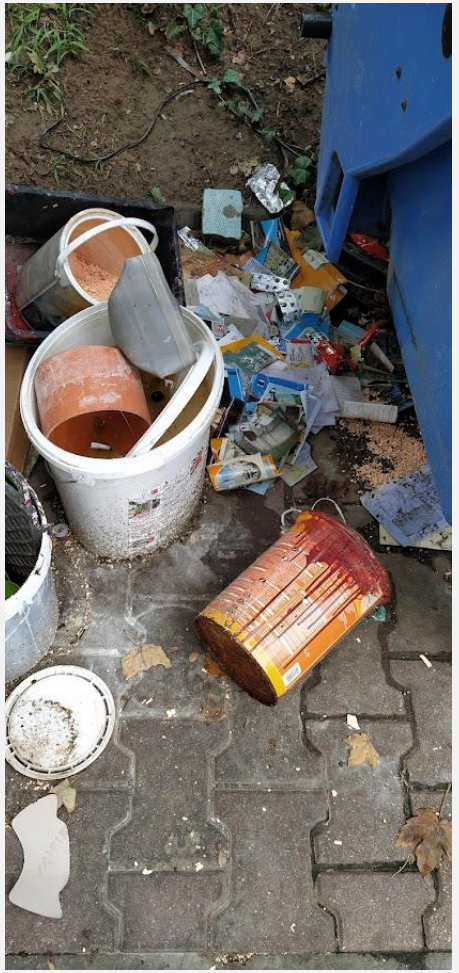
Fig. 1: Schematic flow chart on the correct assignment of wastes to LoW codes

EWC codes


20 pcs (chapter)
403 pcs (hazardous)
20 01 29* detergents containing hazardous substances
20 01 30 detergents other than those mentioned in 20 01 29
111 pcs (sub-chapter)
838 pcs (individual entry)
.. .. 99
70 pcs (not defined)

CATEGORIZATION OF WASTES

- Source (municipal, production)
- State of matter (solid, liquid, sludge)
- Environmental effect (hazardous, non-hazardous, inert)
- Hazardous waste:
  - Developed administration for management
  - Increased health risk during treatment
- Municipal waste:
  - It is usually less hazardous, but the ignorance, negligence and intentionality leads to the random appearance of hazardous materials
  - Municipal solid waste = ‚garbage'
  - Municipal liquid waste = sewage



THE COMPOSITION OF MUNICIPAL WASTE

Municipal	Organic (natural)	Compostable e.g. apple, orange peel, cellulose, paper
	Organic (synthetic)	Plastic E.g. bags, lego, rubber duck…
Hazardous	Organic (natural)	Infectious organic matters (animal or plant origin) e.g. poisoned mouse
	Organic (synthetic)	Household chemicals e.g. disinfectants, medicines (bottles), paints
	Inorganic	Metals, heavy metals E.g. E-waste, batteries, lead soldier, paints

TOXIC

MUTAGENIC

CARCINOGEN

BIOACCUMULATIVE

Fire and explosion

TERATOGEN

INFECTIOUS

ENDOCRINE DISRUPTING

CORROSIVE

RADIOACTIVE

PERSISTANT

HAZARDOUS WASTE (REQUIRING SPECIAL HANDLING)

- Waste that poses a risk to health and the environment due to its origin, composition and concentration
- Hazardous waste can be generated during production, processing, distribution and consumption (Hungary: listed in Annex 1 in Act CLXXXV of 2012)

explosive• oxidizing• flammable• irritating• toxicity•
carcinogenic• corrosive• infectious• harmful to reproduction•
mutagenic• generating acute toxic gases• sensitizing• ecotoxic

- E.g. metallurgical and metal processing slags and sludges, Wastes petroleum refining and utilization• incineration residues from power plants and waste incinerators

THE BIOLOGICAL PROPERTIES OF WASTE

- Infectiveness
  - Typhoid fever (Salmonella typhi), cholera (Vibrio cholerae), Escherichia coli, etc.
  - Opportunistic pathogens: Pseudomonas aeruginosa, Bacillus cereus
  - Various intestinal worms (Ascaris, Trichinella spiralis)
- Insects, rodents
- Biodegradability

Name	Disease	In humid environment the required parameters to destroy		
		temperature, °C	Time (min.)	Viability (days)
Salmonella typhi	Typhoid fever	55-60	5-30	4-115
Salmonella paratyphi B.	Paratyphoid fever	60	15-20	24-136
Shigella dysenteriae	Bacillary dysentery	55	60	10-40
Vibrio colerae	cholera	50	30-60	1
Ascaris (egg)	Ascariasis	50-55	5-7	120
Trichinella spiralis (larvae)	Trichinosis	66,5	1	100-180
Entamoeba hystolytica	Amoebic dysentery	45-50	30 5	40-50

The Lifecycle of Plastics

Plastic bag

20 years

Coffee cup

30 years

Plastic straw

200 years

6-pack plastic rings

400 years

Plastic water bottle

450 years

Coffee pod

500 years

Plastic cup

450 years

Disposable diaper

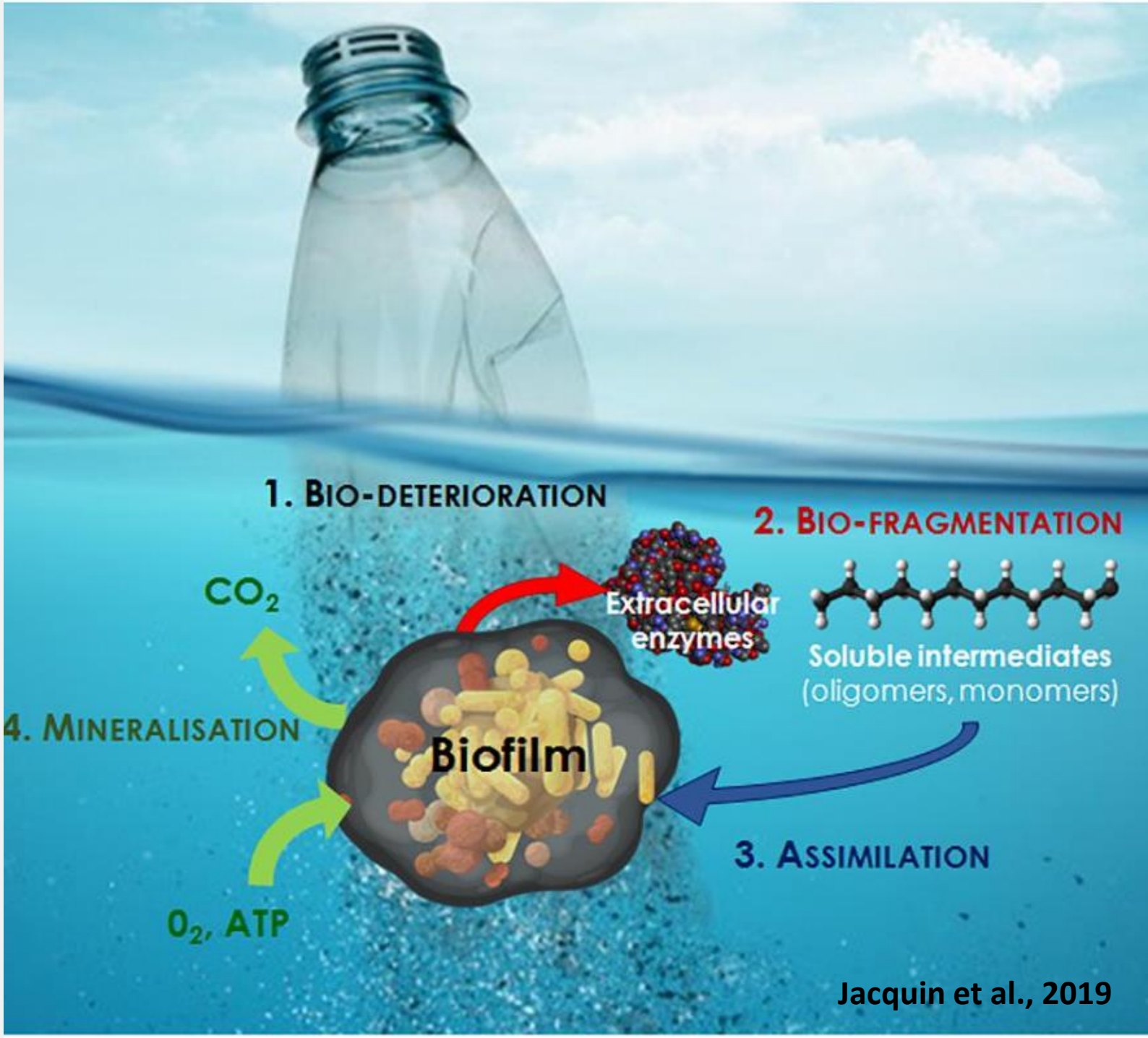
500 years

Plastic toothbrush

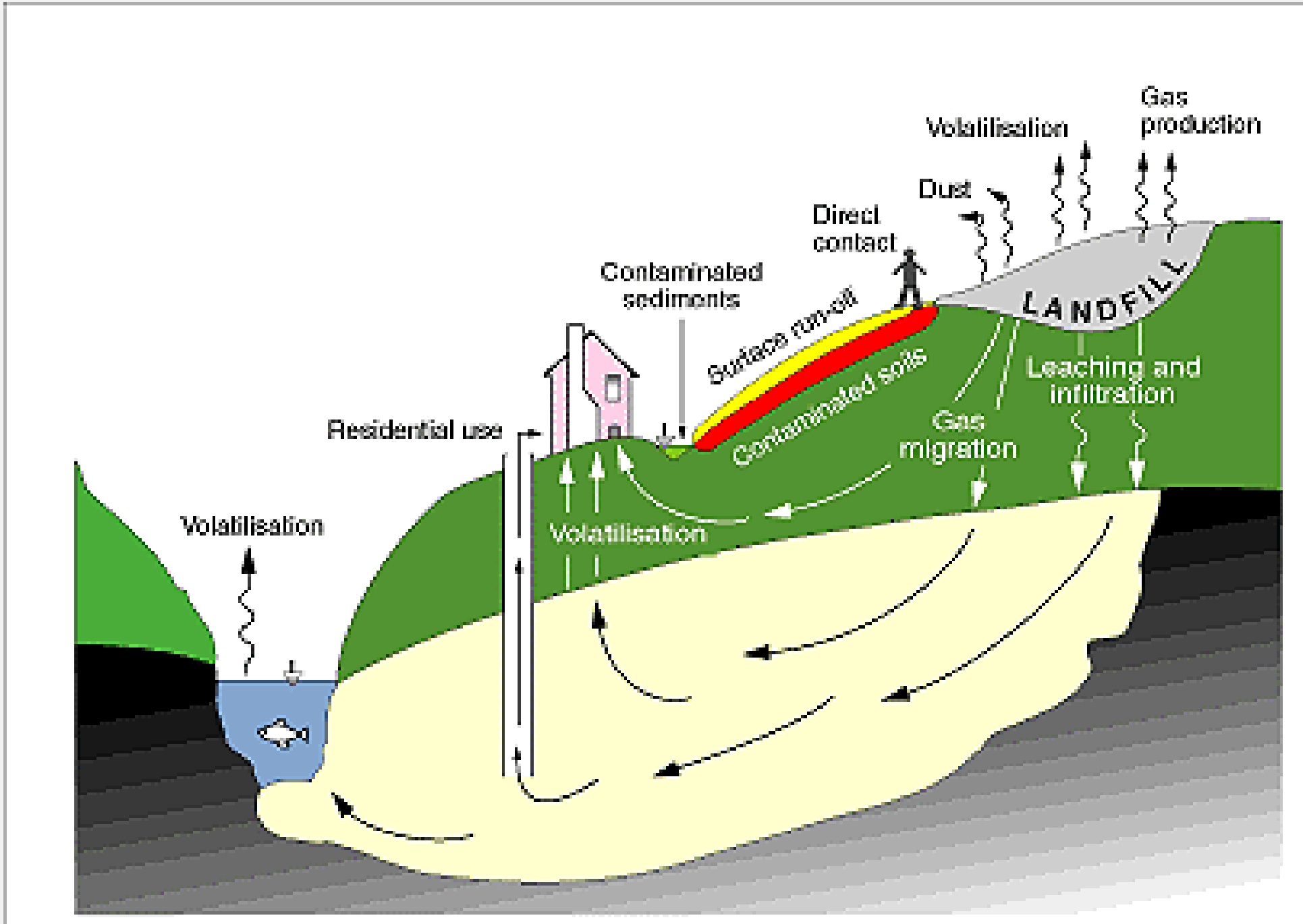
500 years

PLASTIC BIODEGRADATION

- The different steps of plastic biodegradation at sea



Jacquin et al., 2019


Volatilisation
Gas production
Dust
Direct contact
Contaminated sediments
Surface run-off
LANDFILL
Contaminated soils
Leaching and infiltration
Residential use
Gas migration
Volatilisation
Volatilisation

THE ENVIRONMENTAL EFFECTS OF WASTE

Soil, groundwater (groundwater) and surface water pollution (endangering water bodies)

• Air pollution (odorous gases, dusts, CH_4, CO_2, spontaneous combustion, combustion products of prohibited open burning)

• Risk of infection

• Distribution of insects and rodents

• Landscape degradation

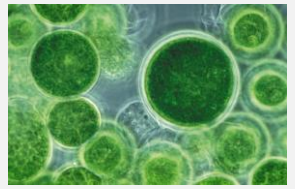
TRANSFORMATION OF WASTES IN THE ENVIRONMENT

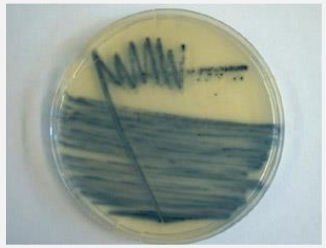
- Photochemical processes (UV radiation)
- Redox processes (burning)
- Hydrolysis (pH)
- Metabolic processes (microorganisms)

- → various types of chemicals and their metabolites – need effect-based tools to evaluate the toxicity of waste

ECOTOXICITY TESTS (EFFECT-BASED METHODS)

- Evaluation of hazardous wastes:
  - Algae growth test
  - White mustard (*Sinapis alba*) growth inhibition test
  - *Daphnia* test
  - Fish test
  - *Azotobacter agile*
- Sewage sludge application:
  - Soil toxicity tests with soil bacteria:
    - *Pseudomonas fluorescens*
    - *Azotobacter chroococcum*
    - *Pseudomonas putida*
- Bacterial biotests:
  - *Aliivibrio fischeri* lumineszcencia gátlás





STANDARDS FOR BIOTESTS

OECD = Organization for Economic Cooperation Develpment
ISO = International Standardization Organization
US EPA = US Environmental Protection Agency
SETAC = Society for Environmental Toxicology and Chemistry
IOBC = International Organisation for Biological and Integrated Control of Noxious Animals and Plants
EPPO = European and Mediterranean Plant Protection Organization
ASTM = American Society of Testing and Materials
ANSI = American National Standards Institute
CEN = European Commitee for Standardization
AFNOR = Association Francaise de Normalisation
EEC = European Economic Community
WHO = World Health Organisation
BBA = Biologische Bundesanstalt für Land-und Forstwirtschaft
OPPTS = The Office of Prevention, Pesticides and Toxic Substances(EPA)
DIN = German Deutsches Institut für Normung

ENVIRONMENTAL POLLUTION CAUSED BY WASTES

- In many cases they are well absorbed (water soluble ----- fat soluble)
- Mobility → transmission
- Metabolic processes → toxic metabolites
- Long degradation (especially if environmental conditions are not optimal) - persistance
- Retain in natural cycles – persistance

THE MOST COMMON PROBLEMS WITH WASTE

- Public health problems: waste is a possible source of infections and a triggering effect in epidemics
- Environmental health problems: inappropriate technology in waste management → the pollution of environmental elements (soil, water, air)
- Quantity: continuously increasing amount of waste produced – the available technologies cannot keep up with the increasing volume
- Economic problems: the remediation of the contaminated environment caused by waste and the implementation of new waste management technologies to minimize pollution cause a significant economic loss and cost.
- Social problems: dissatisfaction in certain groups caused by the presence and negative effects of waste and waste management

WASTE MANAGEMENT STRATEGY

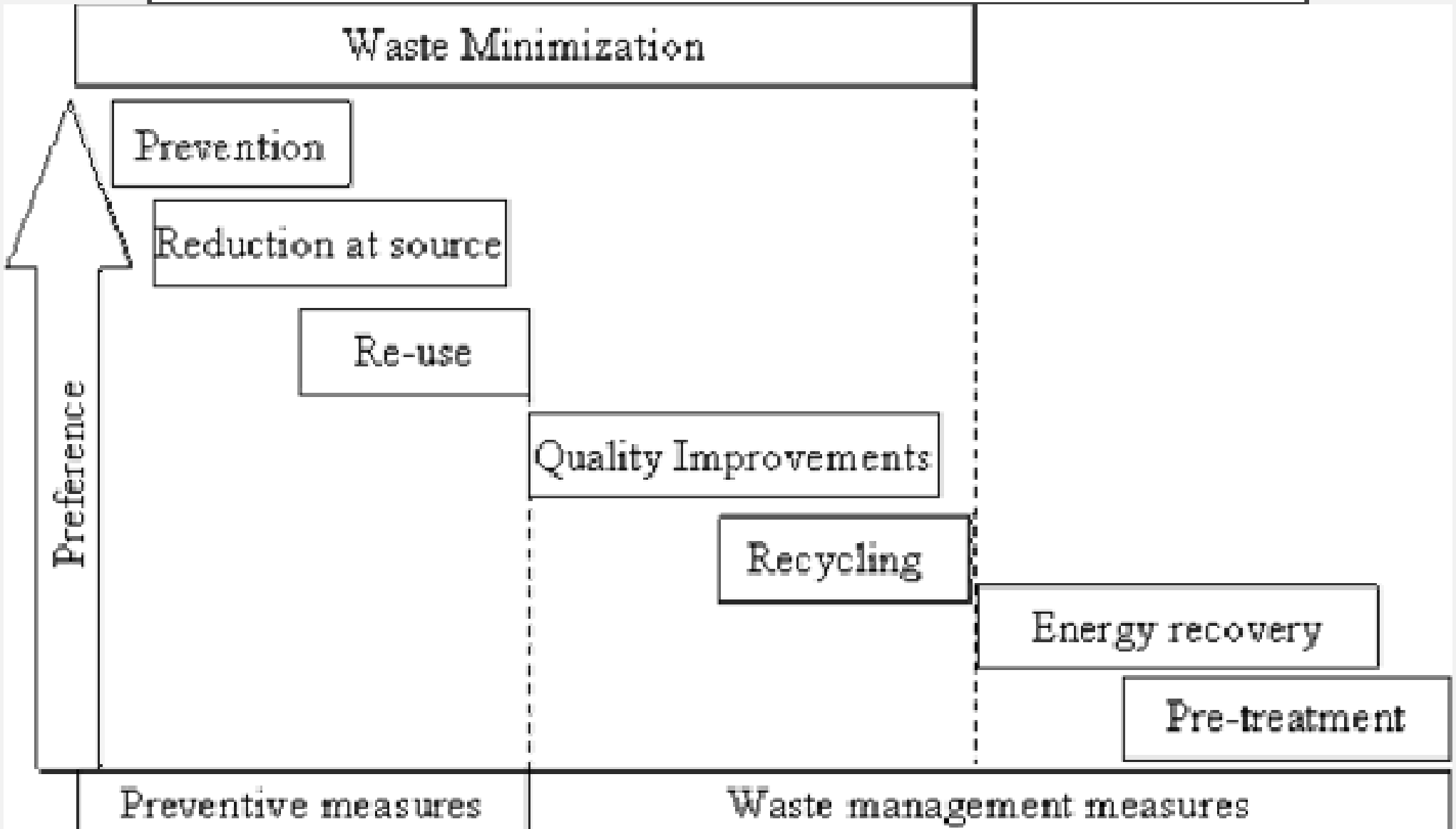
- One of the most effective tools for solving waste problems is integrated waste management.
- Integrated waste management is the set of activities that result in an environmentally efficient, cost-effective solution to waste-related problems.
- In order to implement integrated waste management, the so-called waste hierarchy must be established, because during waste management it is very important in what order the generated waste must and can be treated and disposed of.

WASTE MANAGEMENT HIERARCHY

TARGETS

- by 2020, the preparing for re-use and the recycling of waste materials (such as paper, metal, plastic and glass) from households shall be increased to a minimum of overall 50 % by weight
- by 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste shall be increased to a minimum of 70 % by weight
- by 2025, the preparing for re-use and the recycling of municipal waste shall be increased to a minimum of 55 %, 60% and 65% by weight by 2025, 2030 and 2035 respectively

THE WASTE MANAGEMENT HIERARCHY ACCORDING TO THE OECD



URBANIZATION AND WASTE

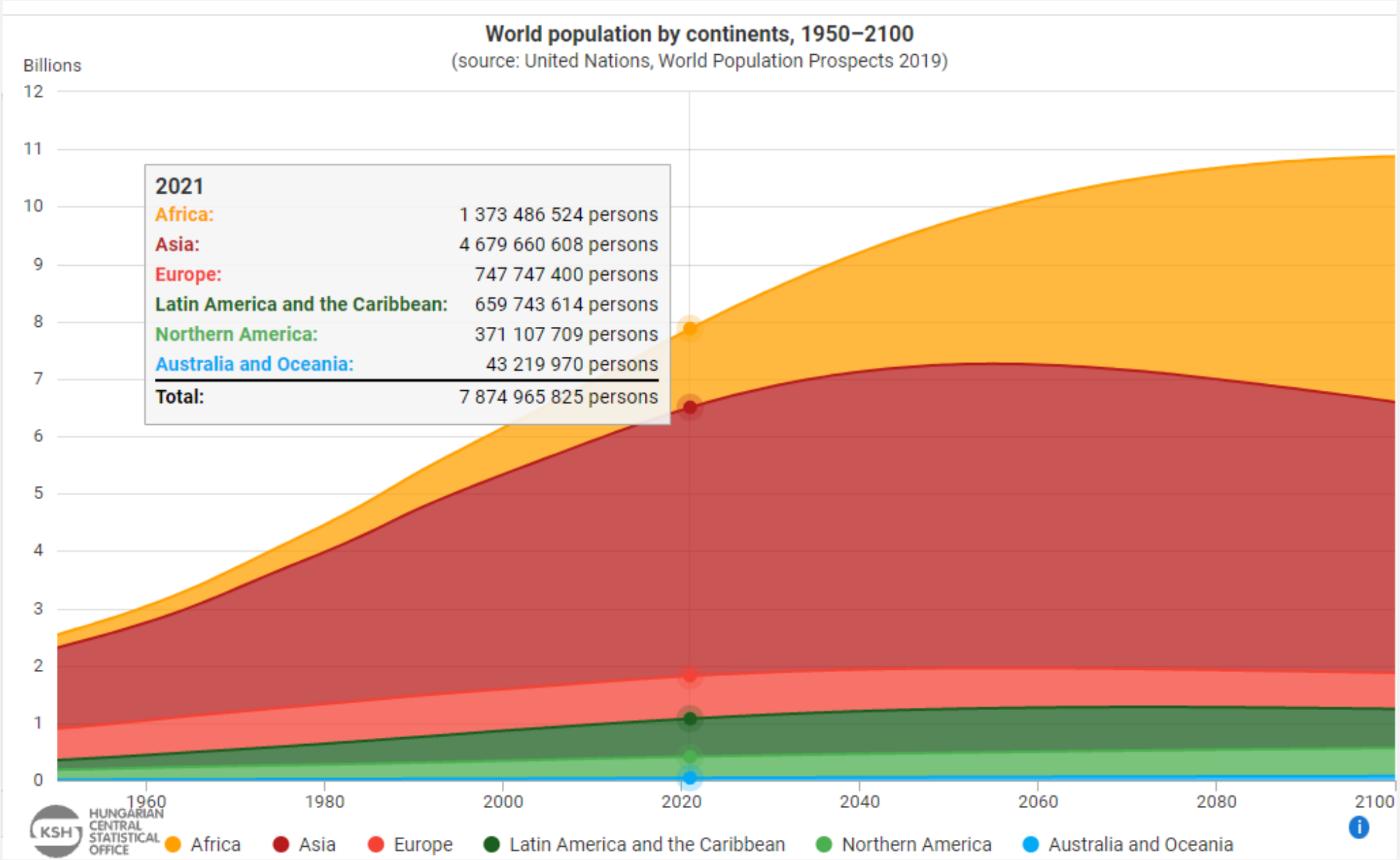


Figure 4.1 The urban world in 1890

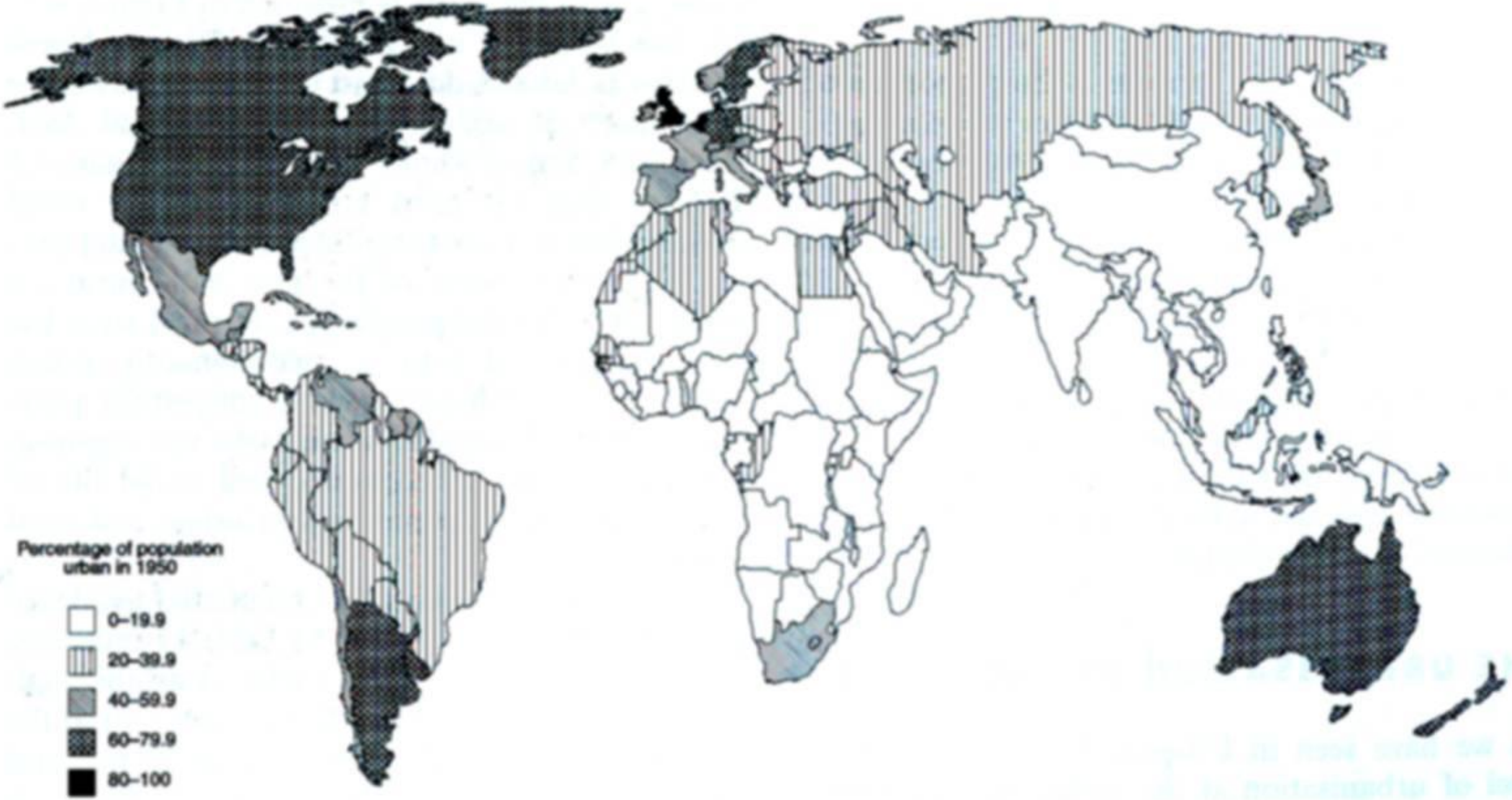


Figure 4.2 The urban world in 1950

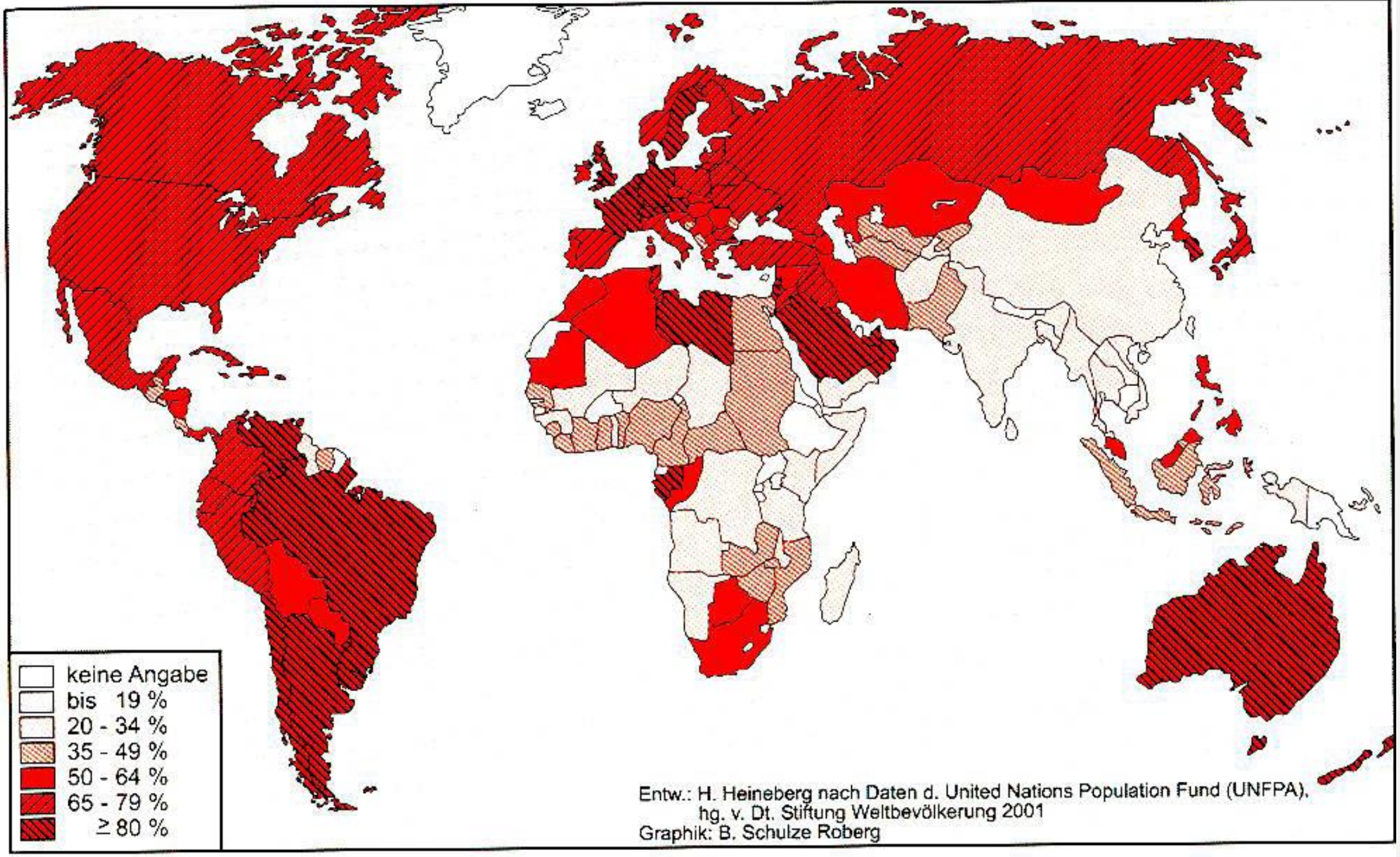


Abb. 6.5 Verstädterungsgrad in den Staaten der Erde um 2000

WASTE PRODUCTION IN EUROPE

Tweet 502 kg of municipal waste per capita were generated in the EU in 2019.

Tweet 48 % of municipal waste in the EU was recycled (material recycling and composting) in 2019.

Municipal waste generated, 2005 and 2019

Note: Countries are ranked in increasing order by municipal waste generation in 2019.

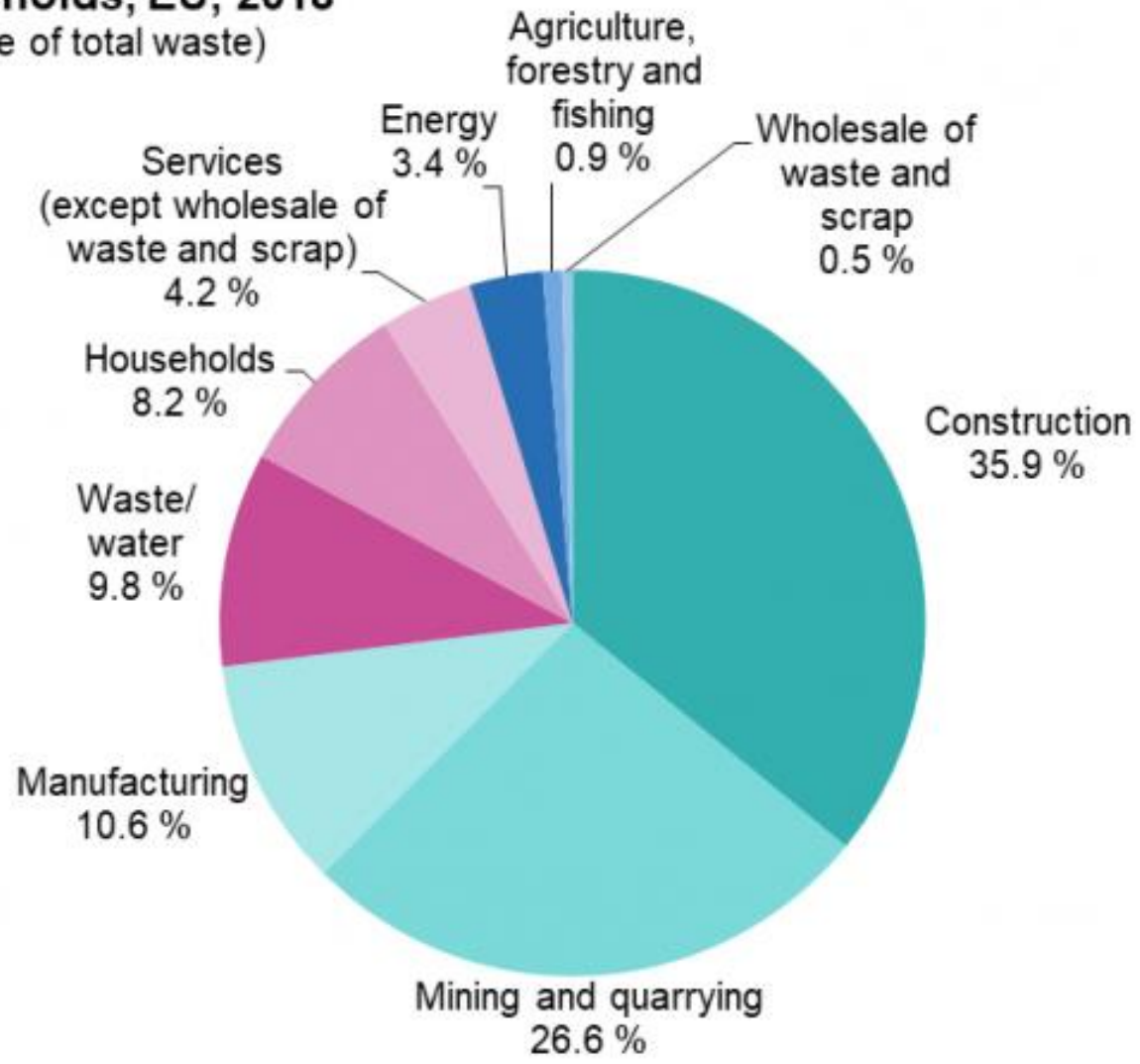
EU-27 estimated.

Bulgaria, Ireland, United Kingdom - 2018 data; Iceland - 2017 data.

Source: Eurostat (online data code: env_wasmun)

eurostat

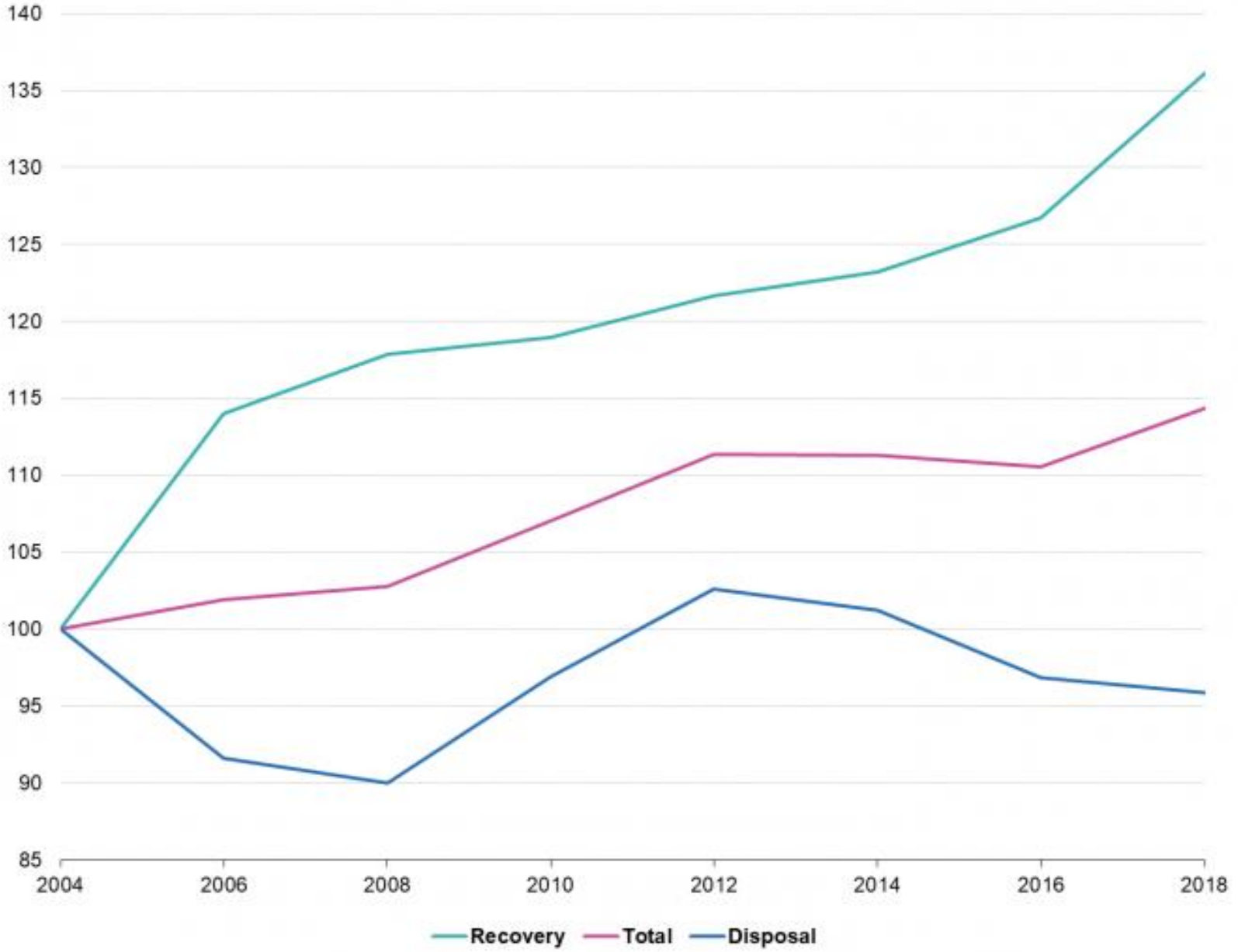
Waste generation by economic activities and households, EU, 2018
(% share of total waste)



Source: Eurostat (online data code: env_wasgen)

eurostat

Waste treatment, EU, 2004-2018
(Index 2004 = 100)

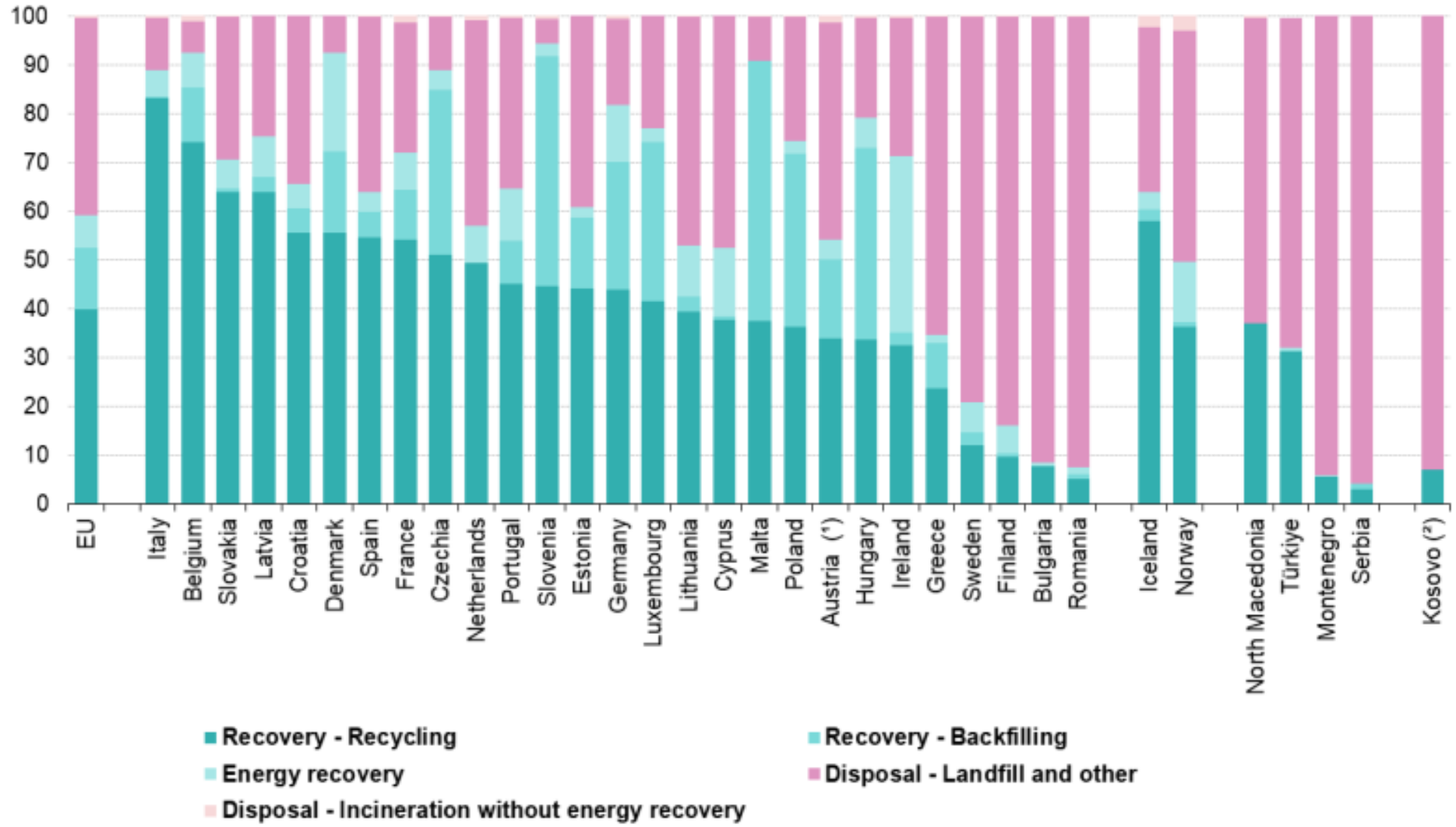


Source: Eurostat (online data code: env_wastrt)

eurostat

Waste treatment by type of recovery and disposal, 2020

(% of total treatment)



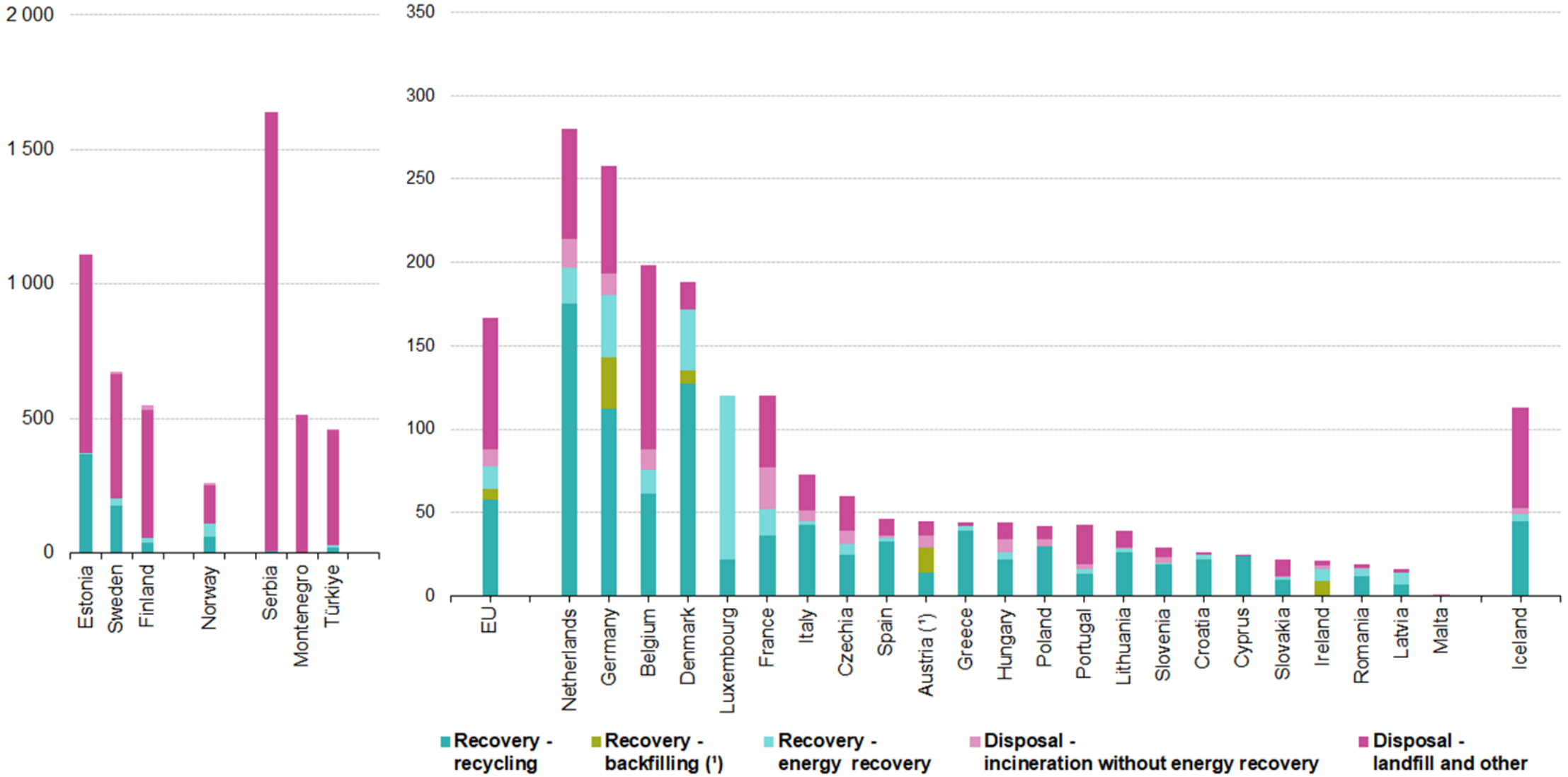
(1) Value of incineration for Austria estimated by Eurostat.

(2) This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo Declaration of Independence.

Source: Eurostat (online data code: env_wastrt)

eurostat

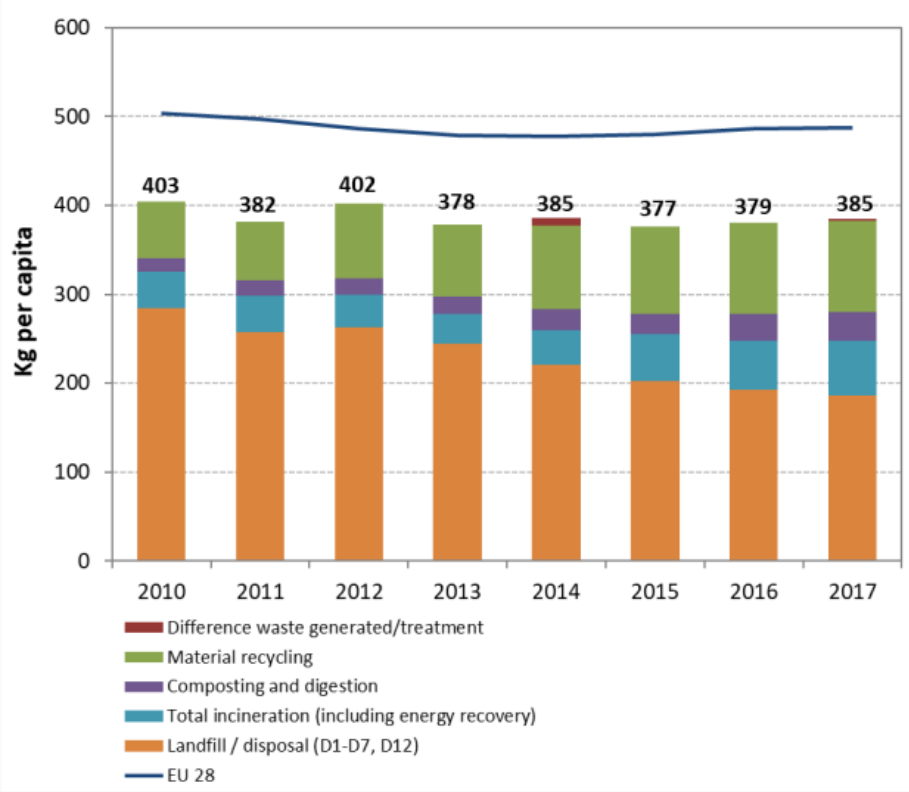
Hazardous waste treatment, 2020
(kg per capita)



(1) value of incineration for Austria estimated by Eurostat.
Note: the two parts of the figure have different scales for the y-axis.
Source: Eurostat (online data code: env_wastrt)

Hungary

municipal waste generation in 2017 has slightly increased compared to 2013 (from 378 kg/y/inhabitant to 385 kg/y/inhabitant). However, Hungary remains below the EU-28 average of 487 kg/y/inhabitant24. In addition, recycling rates have increased and landfilling has decreased.



Organic = 115 kg

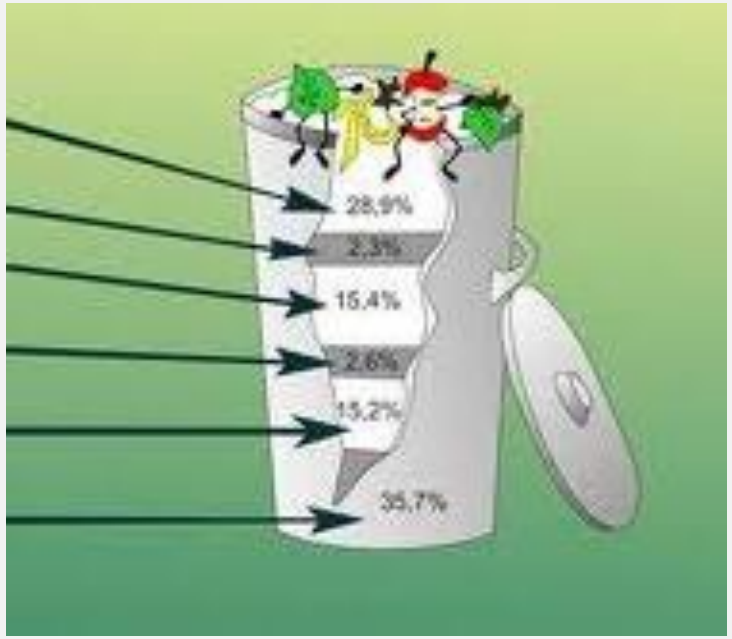
Metal = 9,49 kg

Plastic = 63,6 kg

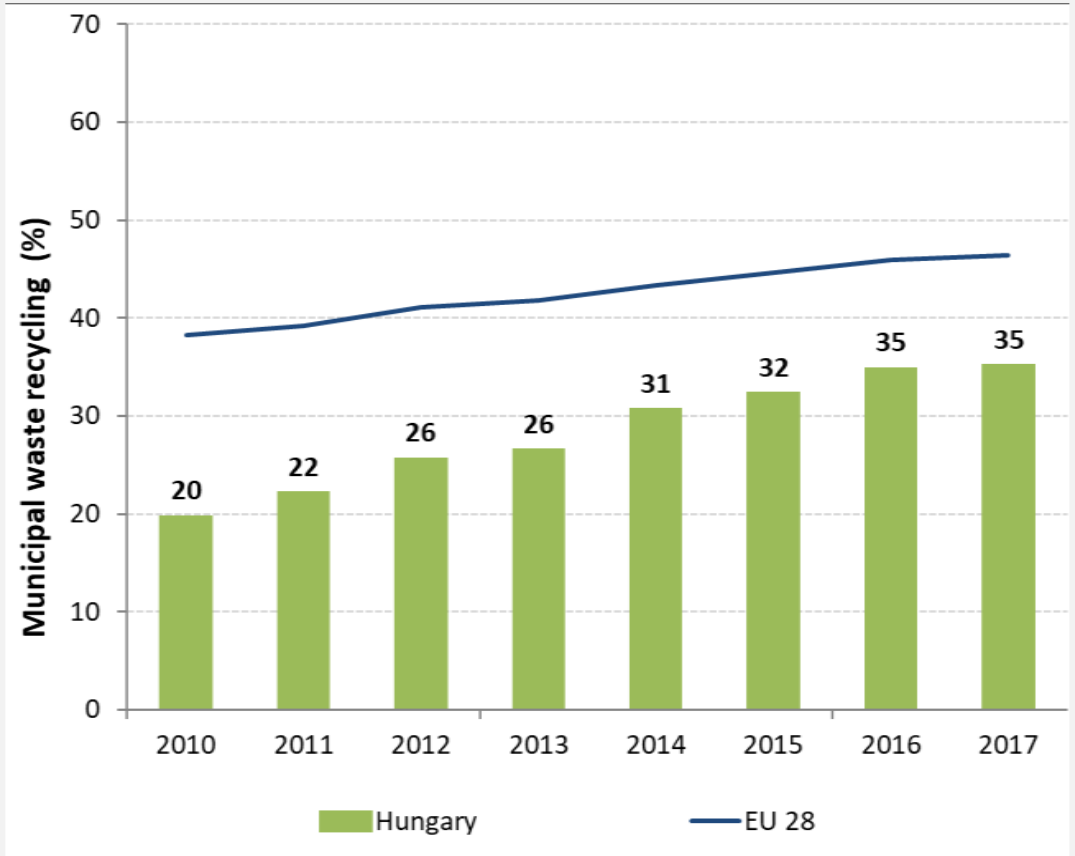
Glass = 10,7 kg

Paper = 62,7 kg

Other = 144 kg



- The 2019 EIR shows that for waste management, Hungary has made some progress in implementing measures to reach the 2020 targets.
- There has been a slight increase in the municipal waste recycling rate and a slight decrease in the landfilling rate.
- In 2012-2015, Hungary did not meet the packaging waste recycling targets, although it adopted measures to improve the recycling rate of glass packaging from 2018 onwards.
- Hungary has recently introduced some major reforms in the waste sector. However, the results of the structural changes in overall service management and delivery are yet to be examined after the data on performance have been submitted to Eurostat.
- The minimum service standards do not require that door-to-door separate collection be rolled out and the recycling targets for service operators are unlikely to act as an incentive.
- According to the Commission's 2018 'early warning report', Hungary is considered at risk of not meeting the 2020 municipal waste recycling target of 50 %.
- Meeting the post-2020 targets will require even greater efforts. In particular, Hungary should consider using effective economic instruments.



- Despite a 16 % drop since 2013, landfilling is still a predominant form of municipal waste treatment in Hungary (48 % vs the EU average of around 28 %).
- In 2012-2015, Hungary did not meet the packaging waste recycling target of 55 %.
- The rate hovered around 50 % during this period, while the packaging recovery rate dropped slightly below the mandatory level of 60 %.

GENERAL REQUIREMENTS FOR WASTE MANAGEMENT

- 1. Separated collection at the place of origin;
- 2. Removal as soon as it is possible – avoid spread or exposition
- 3. Waste disposal – avoid environmental contamination, or the hazard of infection

BASIC REQUIREMENTS FOR WASTE CONTAINERS

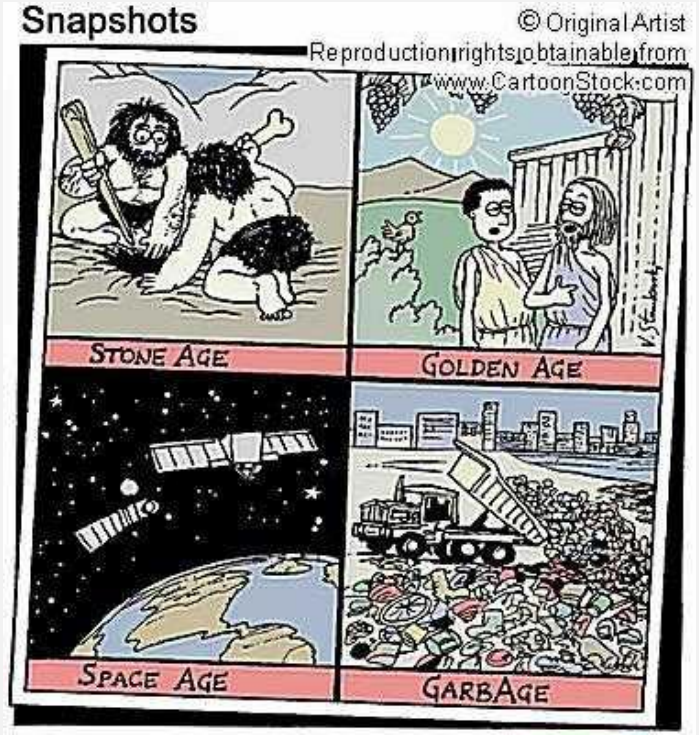
- Be designed in accordance with the type of waste
- Volume of the containers meets the requirements,
- Container is resistant to weathering and physical damage and unauthorized access, but it is easy to empty.

BASIC TECHNICAL REQUIREMENTS

- in accordance with the environmental and technical regulations in force
- it does not disturb the daily life of the inhabitants of the settlement more than necessary,
- fast and hygienic, minimal dust, odor and noise,
- Economical,
- Fits the image of the settlement, aesthetic.

Waste management

- transportation
- reuse
- composting
- incineration
- landfilling



Affected environmental elements

- air
- water
- soil
- landscape
- ecosystem
- Urban area

Transportation – Regional landfills – longer transportation

Air	***NO_X, SO_2, dust emission, accidents (emission of harmful substances)***
Water	***Surface, subsurface water contamination (accidents)***
Soil	***Soil contamination (accidents)***
Landscape	***Traffic***
Ecosystem	***Hazard on ecosystem (accidents)***
Urban area	***Exposition (accidents)***


RotoPress

Re-use

Air	***Dust emission***
Water	***Sewage***
Soil	***Landfilling of the residual materials***
Landscape	***Not fit the landscape***
Ecosystem	
Urban area	***Noise***


GREENPEACE


GREENPEACE


GREENPEACE


GREENPEACE

Composting

Air	***CO_2, CH_4 emission, odour***
Water	***leachate***
Soil	***leachate***
Landscape	***Land use, land use restrictions***
Ecosystem	
Urban area	

Incineration

Air	***Emission: SO_2, NO_X, HCl, HF, , CO, CO_2, N_2O, dioxins, furans, heavy metals (Zn, Pb, Cu, As)***
Water	***Deposition of hazardous materials and their***
Soil	***Disposal of slag, fly ash or metal residues***
Landscape	***Land use, land use restrictions***
Ecosystem	***Adverse effects of environmental pollution on food chain (bioaccumulation, biomagnification)***
Urban area	***Working with hazardous materials – health risk***

Waste incinerators in Hungary

In 2015:

1 municipal waste-to-energy plant

Non-municipal incineration plants - 28:

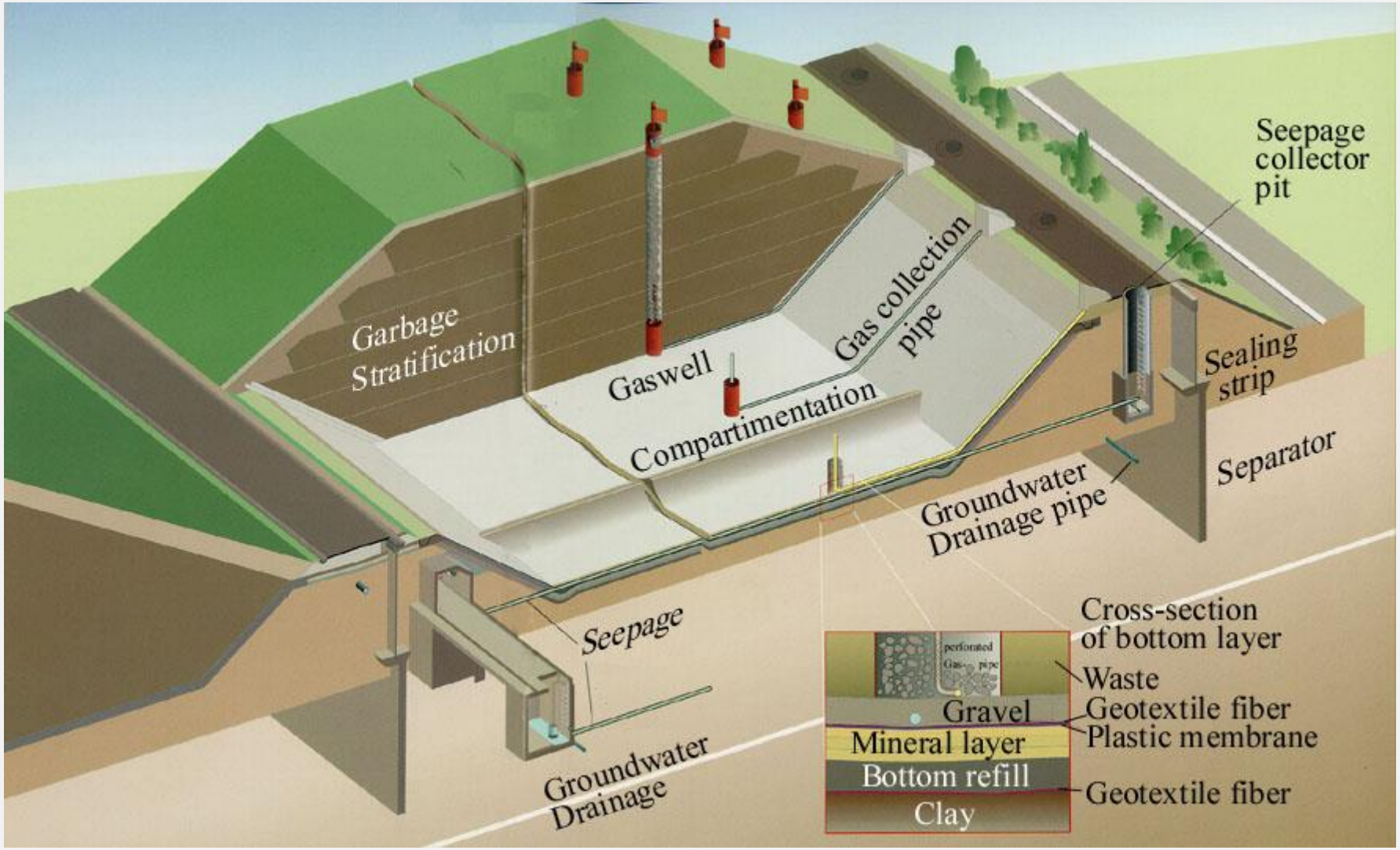
- 8 pcs non-hazardous waste incinerators 370 thousand tons/év capacity
- 16 pcs hazardous waste incinerator 350 thousand ton/year capacity
- 4 pcs dual - 210 thousand ton/year capacity

Settlement	Operator	Capacity
Balatonfűzfő	Fűzfői hulladékégető Szolgáltató Kft	7200 t/year
Beremend	Duna-Dráva Cement Kft. (Cementmű)	30 000 t/year
Budapest	FKF Rt., HUHA	420 000 t/year
Budapest XIV. ker.	SEPTOX Kft.	30 25 t/year
Budapest XIX. ker.	HT-Speciál 2000 Kft.	7000 t/year
Budapest XV. ker.	Palota Környezetvédelmi Kft.	6400 t/year
Debrecen	HAJDÚKOMM Kft.	1400 t/year
Dorog	SARPI Dorog Kft.	35 000 t/year
Győr	Győri Hulladékégető Kft.	8000 t/year
Kistarcsa	Progress B90 Kft.	751 t/year
Lábatlan	HOLCIM Rt. (Cementmű)	8000 t/year
Miskolc	Holcim Hungária Cementipari Zrt.	12 000 t/year
Oroszlány	Orviron Kft.	700 t/year
Pétfürdő	Huntsman Corporation Hungary Vegyipari Termelő-Fejlesztő Zrt.	3200 t/year
Sajóbábony	Észak-magyarországi Környezetvédelmi Kft.	17 600 t/year működő
Sajóbábony	Piro-Energia Kft.	pirolízis tervezett 40 000 t/year
Százhalombatta	MOL Rt. Dunai Finomító	26 000 t/year
Szeged	SZOTE Szolgáltató Kht.	750 t/year pirolízis
Szombathely	Megoldás Környezetvédelmi és Kereskedelmi Kft.	1480 t/year
Tiszaújváros	MOL Rt. Tiszai Finomító	7200 t/year
Tiszavasvári	ECOMISSZIÓ Kft.	5080 t/year
Vác	Duna-Dráva Cement- és Mészművek Rt.	13 000 t/year

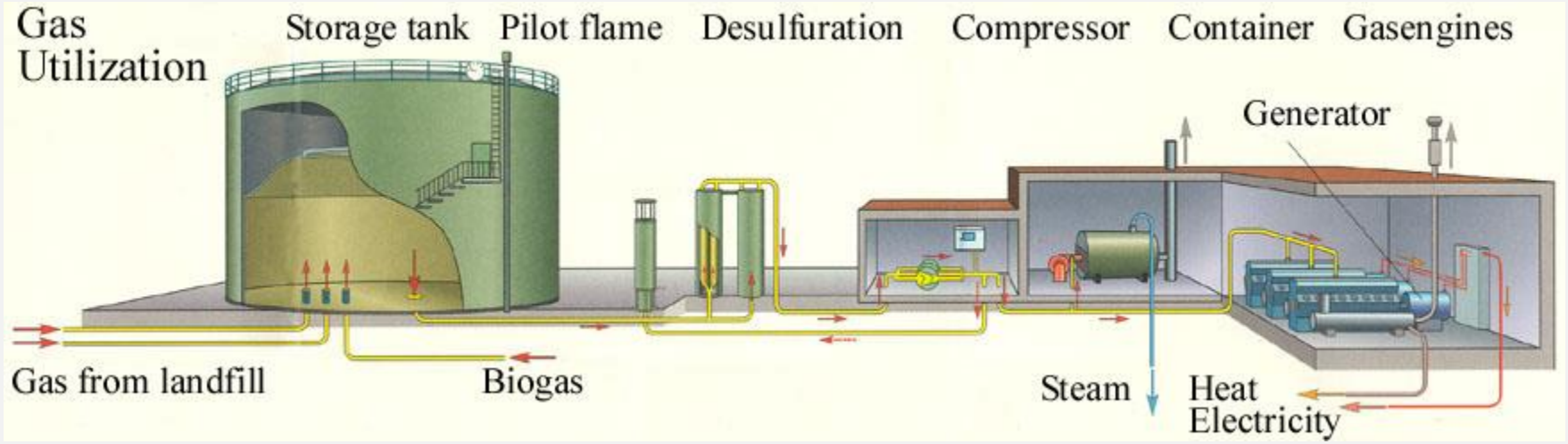
DEPOSITION

Air	***CH_4, CO_2 emission, odour***
Water	***Salts heavy metals, biodegradable, persistant contaminants – leakage***
Soil	***Accumulation of hazardous materials in soil***
Landscape	***Land use and restrictions in land use***
Ecosystem	***Adverse effects of environmental pollution on food chain (bioaccumulation, biomagnification)***
Urban area	***Working with hazardous materials – health risk***

Schematic diagram of landfill design



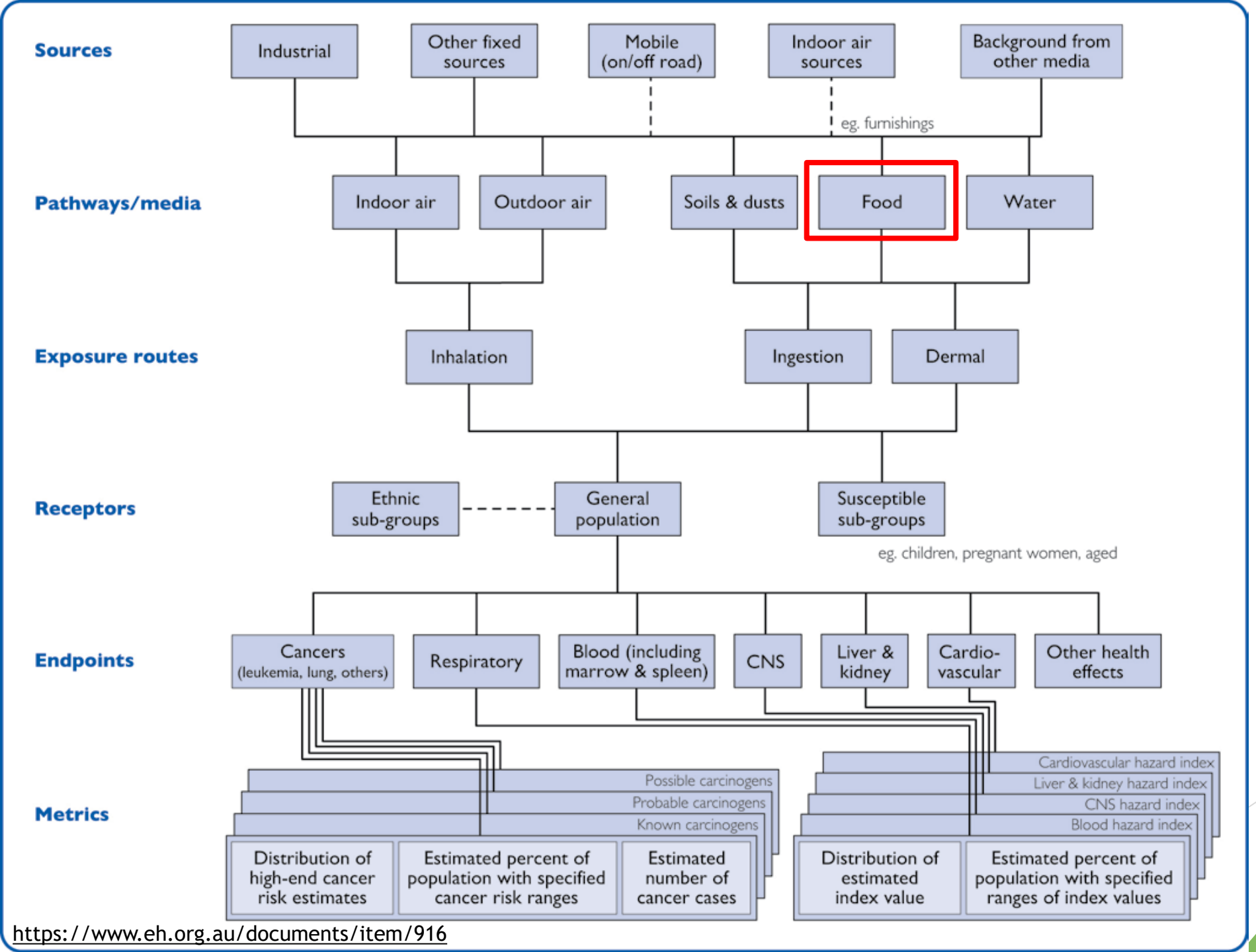
Schematic flowchart of biogas utilization originating from landfills



Food hygiene and food safety

Dr. Edit Kaszab

associate professor



https://www.eh.org.au/documents/item/916

Key facts (WHO) – the burden of foodborne diseases

- **Access to sufficient amounts of safe and nutritious food is key to sustaining life and promoting good health.**
- **Unsafe food containing harmful bacteria, viruses, parasites or chemical substances, causes more than 200 diseases – ranging from diarrhoea to cancers.**
- **An estimated 600 million – almost 1 in 10 people in the world – fall ill after eating contaminated food and 420 000 die every year, resulting in the loss of 33 million healthy life years (DALYs).**
- **US$110 billion is lost each year in productivity and medical expenses resulting from unsafe food in low- and middle-income countries.**
- **Children under 5 years of age carry 40% of the foodborne disease burden, with 125 000 deaths every year.**
- **Diarrhoeal diseases are the most common illnesses resulting from the consumption of contaminated food, causing 550 million people to fall ill and 230 000 deaths every year.**
- **Food safety, nutrition and food security are inextricably linked. Unsafe food creates a vicious cycle of disease and malnutrition, particularly affecting infants, young children, elderly and the sick.**
- **Foodborne diseases impede socioeconomic development by straining health care systems, and harming national economies, tourism and trade.**
- **Food supply chains now cross multiple national borders. Good collaboration between governments, producers and consumers helps ensure food safety.**

https://apps.who.int/iris/bitstream/handle/10665/199350/9789241565165_eng.pdf?sequence=1

Food hygiene (reminder)

Food hygiene: ‘the measures and conditions necessary to control hazards and to ensure fitness for human consumption of a foodstuff taking into account its intended use’ (EU food law)

- Applied for food originating from animal, plant, or mineral
- Applied for food production, marketing and processing to ensure the safety and consumability of food
- Food hygiene is the tool of food safety
- The main aim of food hygiene: to prevent and treat foodborne infections and intoxications

The history of food hygiene

- The oldest rules on meat consumption were religious prohibitions.
- There was already an extensive meat and butcher industry in the ancient Greek and Roman cities, under the supervision of the market police.
- In order to supply the armies, meat preservation methods are widespread: drying, salting, pickling
- Early medieval papal decree: pork and bacon were allowed to be consumed only after cooking, the consumption of meat from sick and dead animals was forbidden.
- The foundations of today's meat inspection assessment have been laid
- XIII. century - formation of butcher and butcher guilds*, the first slaughterhouses (1242, Trachenberg)
- 1276, Augsburg - provides for the examination of the meat of sick animals, but authorizes their sale with indication of the disease

* Guild, also spelled gild, **an association of craftsmen or merchants formed for mutual aid and protection** and for the furtherance of their professional interests. Guilds flourished in Europe between the 11th and 16th centuries and formed an important part of the economic and social fabric in that era.

Bíró, 2014

Food hygiene in Hungary

- XIII-XIV. century guild certificates: the butcher's industry was controlled by guild masters and meat viewers, the sale of spoiled meat was severely punished.
- Only fresh meat can be sold, meat with cysticercosis, goods left over from the previous week were not allowed to be sold on the market.
- Slaughter rules: only in the designated butcher's shop or next to surface water (cattle), animals intended for slaughter have also been examined since the 1700s (inspector).
- 1859- Decree of the Ministry of the Interior on cattle and meat inspections (animals suspected of rabies, anthrax may not be slaughtered)
- From 1888 a legal regulation has been issued on the slaughter and examination of animals intended for public consumption in order to avoid contagious diseases.

Bíró, 2014

Food hygiene in Hungary

- In 1908, a national regulation issued uniform rules for the performance of meat testing including the operation of slaughterhouses, the conditions of slaughter, meat inspection, meat processing, market hall and market meat distribution.
- The next regulation if from 1928 about animal health which, in accordance with the state of the art, set meat hygiene standards. The legislation clarified, expanded and made scientific the meat hygiene regulations, above all by creating the rules for bacteriological meat testing.
- Since the 1950s, a unified system of legislation has been created, which includes the highest level of legal sources, as well as the professional aspects of the areas related to food hygiene.

Current food hygiene regulations in Hungary

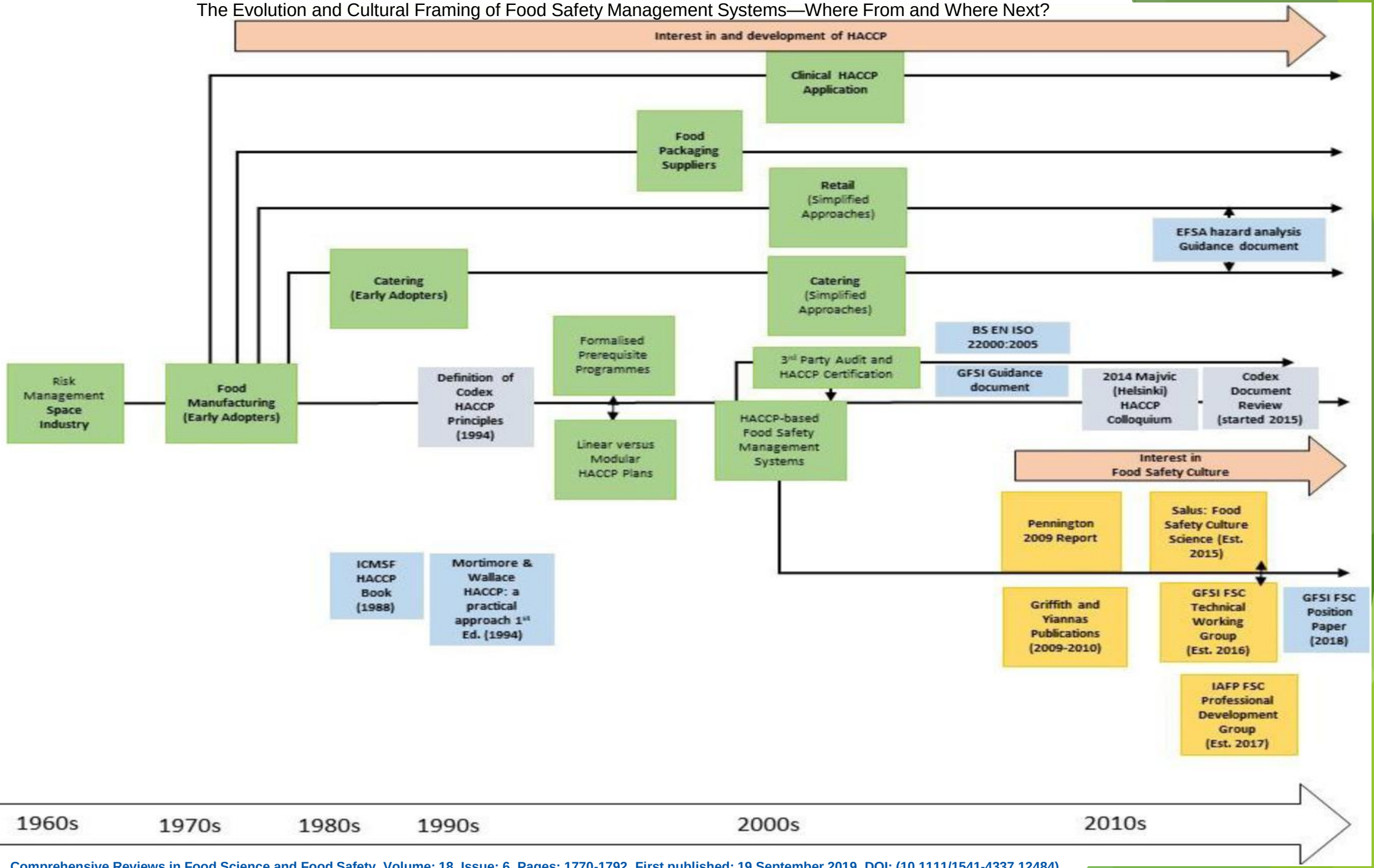
- Act LXXXII of 2003 on foodstuffs.
- Act XLVI of 2008 Act on the Food Chain and Official Supervision
- The Government Decision 1703/2013. (X. 8.) on the adoption of the Food Chain Safety Strategy (2013–2022)
- 68/2007. (VII. 26.) FVM-EüM-SZMM joint decree on certain food hygiene conditions for the production and placing on the market of food and on the official control of food
- The Hungarian Food Book (Codex Alimentarius Hungaricus) was issued in 2013 by the Ministry of Rural Development. The codex contains quality, marking and food safety requirements for food products.
- 220/2008. (VIII. 30.) on the procedure for issuing collections of mandatory regulations and recommended professional guidelines in the field of the food chain
- 152/2009. (XI.12.) Decree of the Ministry of Agriculture on the mandatory regulations of the Hungarian Food Book

Food safety in Europe

- Significant changes in the last few decades in the field of food hygiene
- Integrated approach through the whole food-chain to ensure food safety – involve agricultural production as a part of the food hygiene (declared by Codex Alimentarius).
- **Integrated approach**: ensure food safety from the place of primary production up to and including placing on the market or export. Every food business operator along the food chain should ensure that food safety is not compromised.
- Regulation 852/2004/EC of the European Parliament and of the council on the hygiene of foodstuffs → integrated approach
  - Reform of the food hygiene regulation
  - More efficient control by the authorities
  - Uniform control methodology
  - Establishment of a new control and supervision structure

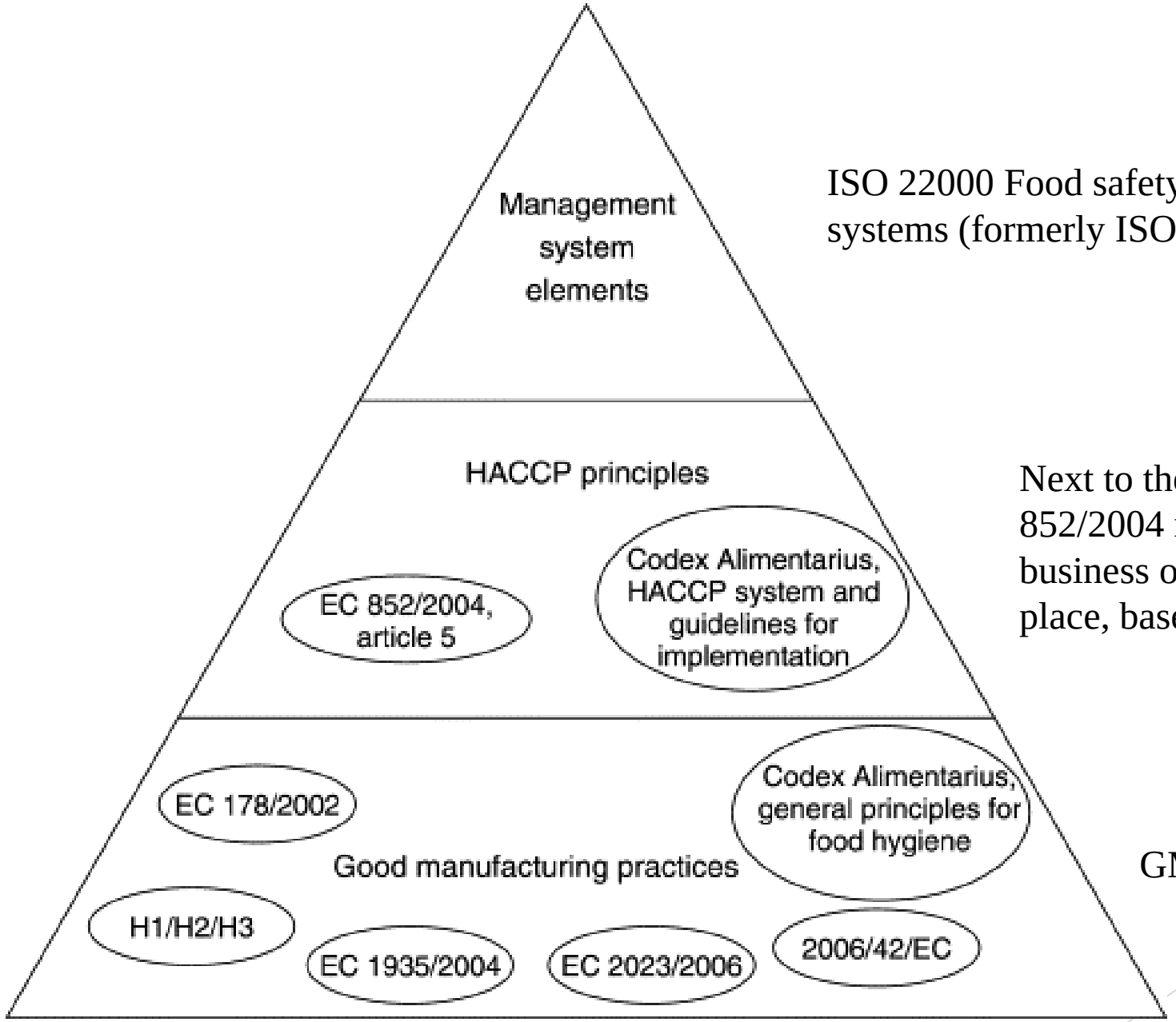
Laczay P., 2012

The Evolution and Cultural Framing of Food Safety Management Systems—Where From and Where Next?



Comprehensive Reviews in Food Science and Food Safety, Volume: 18, Issue: 6, Pages: 1770-1792, First published: 19 September 2019, DOI: (10.1111/1541-4337.12484)

Structure of a food safety management system (FSMS)

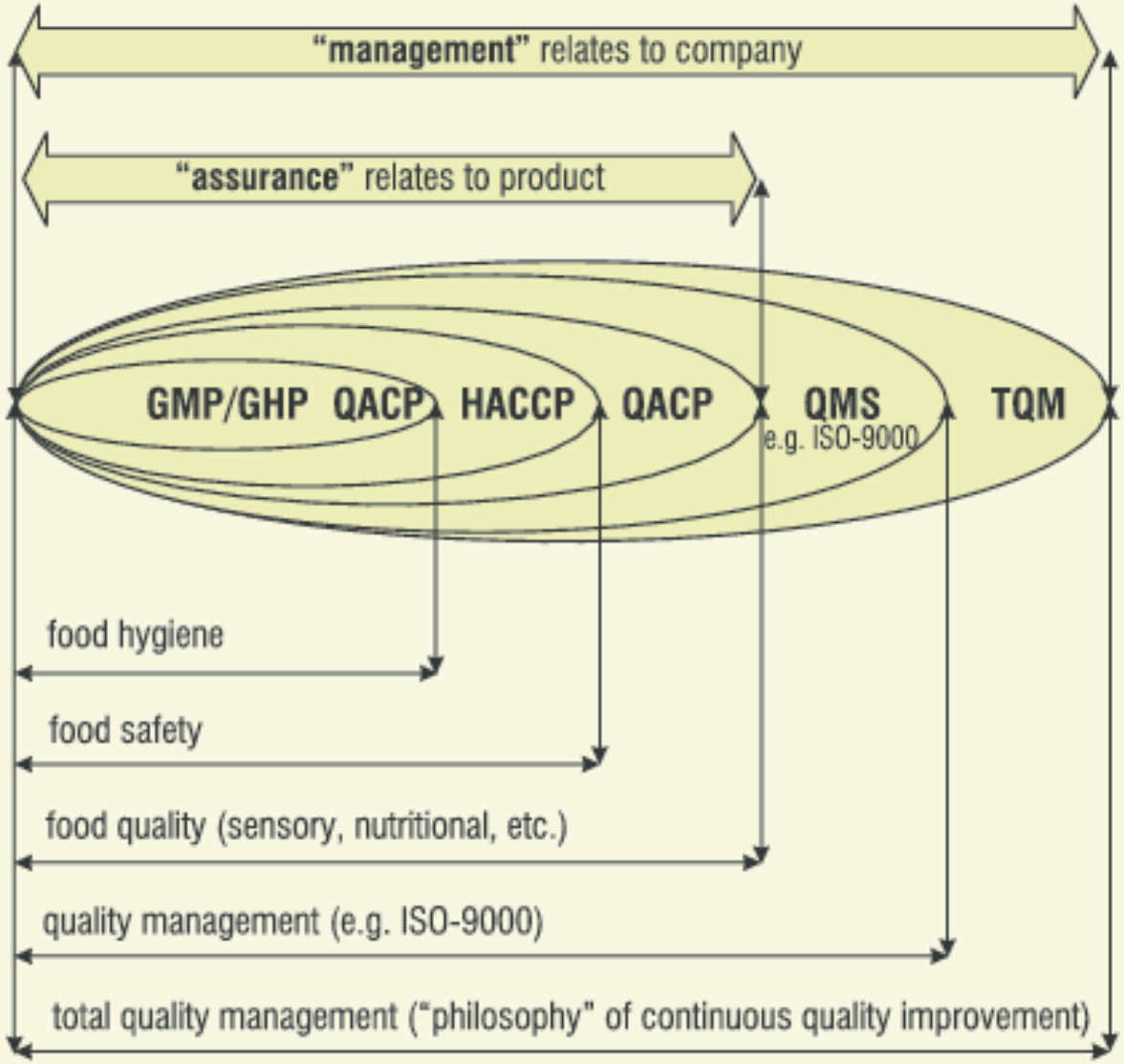


ISO 22000 Food safety management systems (formerly ISO 9001)

HACCP is a short name for 'Hazard Analysis and Critical Control Points'. HACCP is a higher standard and includes all requirements of the GMP standards.

Next to the GMPs, Regulation (EC) 852/2004 requires FBOs (food business operators) to put a system in place, based on the HACCP principles

GMPs are the base of the triangle.



Good Hygiene Practices (GHP), Good Manufacturing Practices (GMP) and Hazard Analysis and Critical Control Point (HACCP), Quality Assurance Control Points (QACP), Quality Management Systems (QMS, ISO-9000 (quality management) and ISO-14000 (environmental management)), Total Quality Management TQM

Good manufacturing practice (GMP)

Any practice regarding the conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain.

Good Manufacturing Practices (GMPs) are the **basic operational and environmental conditions** required to produce safe foods. They ensure that ingredients, products and packaging materials are handled safely and that food products are processed in a suitable environment.

Following Current Good Manufacturing Practices (CGMPs) help to ensure the safety of food. CGMP regulations generally address matters including

- appropriate personal hygienic practices,
- design and construction of a food plant and maintenance of plant grounds,
- plant equipment,
- sanitary operations,
- facility sanitation, and
- production and process controls during the production of food.

Codex Alimentarius

CODEX ALIMENTARIUS

World Health Organization

Food and Agriculture Organization of the United Nations

The C O D E X A L I M E N T A R I U S international food standards, guidelines and codes of practice contribute to the safety, quality and fairness of this international food trade. Consumers can trust the safety and quality of the food products they buy and importers can trust that the food they ordered will be in accordance with their specifications.

Aims:

Protecting consumer health

Removing barriers to trade

Scope:

The Codex Alimentarius includes standards for all the principal foods, whether processed, semi-processed or raw, for distribution to the consumer. Materials for further processing into foods should be included to the extent necessary to achieve the purposes of the Codex Alimentarius as defined. The Codex Alimentarius includes provisions in respect of food hygiene, food additives, residues of pesticides and veterinary drugs, contaminants, labelling and presentation, methods of analysis and sampling, and import and export inspection and certification.

Nature of Codex Standards

Codex standards and related texts are not a substitute for, or alternative to national legislation. Every country's laws and administrative procedures contain provisions with which it is essential to comply.

Codex standards and related texts contain requirements for food aimed at ensuring for the consumer a safe, wholesome food product free from adulteration, correctly labelled and presented. A Codex standard for any food or foods should be drawn up in accordance with the Format for Codex Commodity Standards and contain, as appropriate, the sections listed therein.

Codex standards and related texts are **voluntary** in nature.

Codex standards can be general or specific.

HACCP

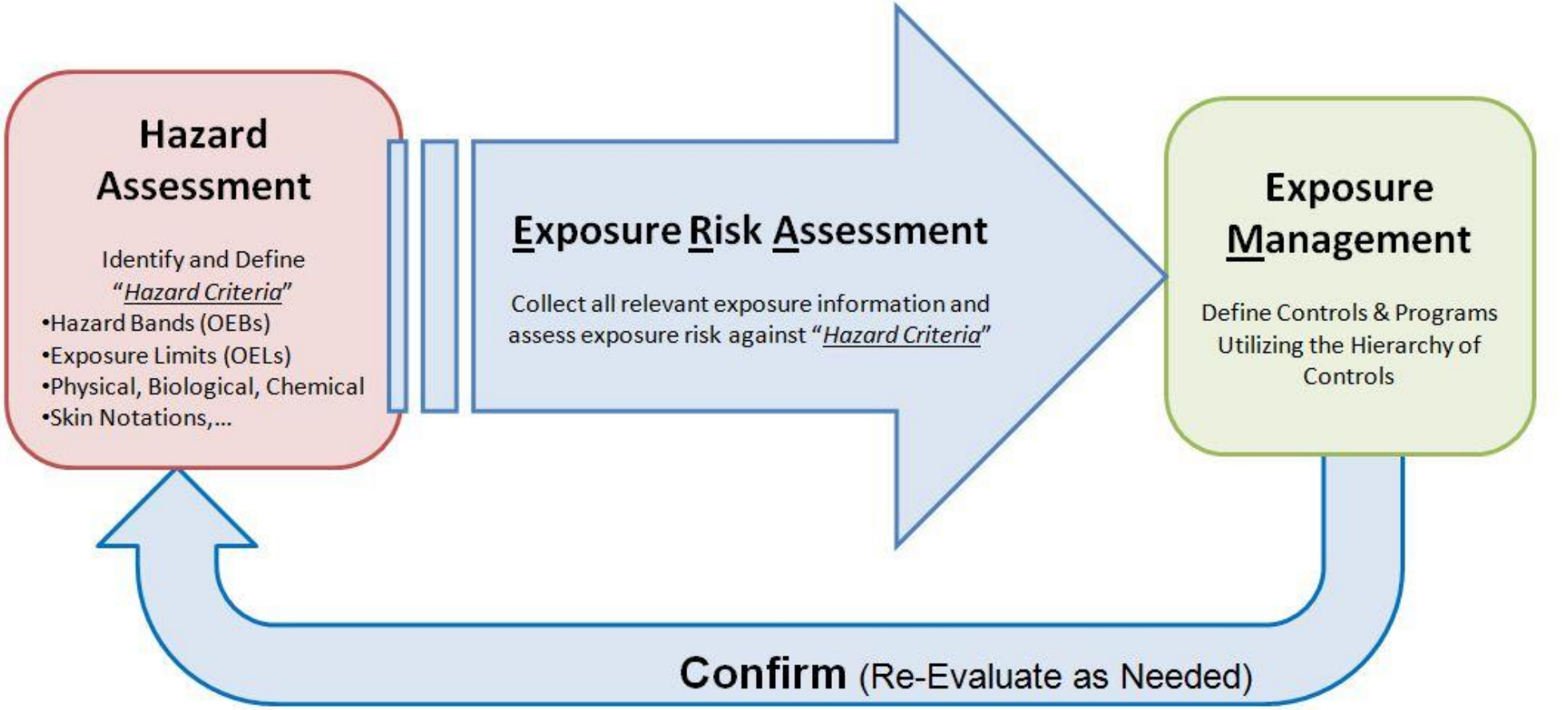
- HACCP is a **management system** in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product.
- HACCP is designed for use in all segments of the food industry from growing, harvesting, processing, manufacturing, distributing, and merchandising to preparing food for consumption.
- Prerequisite programs such as current Good Manufacturing Practices (cGMPs) are an essential foundation for the development and implementation of successful HACCP plans.
- Food safety systems based on the HACCP principles have been successfully applied in food processing plants, retail food stores, and food service operations.

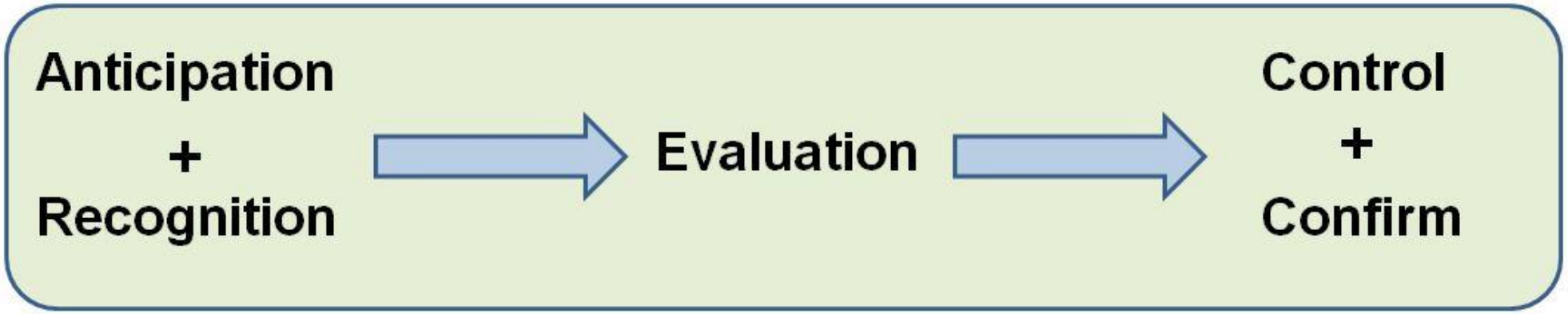
Definitions

- HACCP: A systematic approach to the identification, evaluation, and control of food safety hazards.
- HACCP Plan: The written document which is based upon the principles of HACCP, and which delineates the procedures to be followed.
- HACCP System: The result of the implementation of the HACCP Plan.
- HACCP Team: The group of people who are responsible for developing, implementing and maintaining the HACCP system.

HACCP Principles

- Principle 1: Conduct a hazard analysis.
- Principle 2: Determine the critical control points (CCPs).
- Principle 3: Establish critical limits.
- Principle 4: Establish monitoring procedures.
- Principle 5: Establish corrective actions.
- Principle 6: Establish verification procedures.
- Principle 7: Establish record-keeping and documentation procedures.





Fundamental Elements of Industrial Hygiene (ERAM Model)

Table 1.1 Overview of the structure of EU legislation

H1/H2/H3 (EC 852/2004 – EC 853/2004 – EC 854/2004) (EC 2004a–c)						
Microbiologal hazards	Chemical hazards	Physical hazards	Allergens	Additives	Contact materials	Equipment
EC 2073/2005 Water quality (regional)	EC 1881/2006 (EC 2006b) EC 396/2005 (EC 2005) EC 37/2010 (EC 2010)	FDA	EC 1169/2011 (EC 2011b)	2008/128/EC (EC 2008b) 2008/60/EC (EC 2008a) EC 1331/2008 (EC 2008c) EC 1332/2008 (EC 2008d) EC 1333/2008 (EC 2008e) EC 1334/2008 (EC 2008f) 95/2/EC (EC 1995)	EC 1935/2004 (EC 2004d) EC 450/2009 EC 2023/2006 (EC 2006b) EC 10/2011 (EC 2011a)	2006/42/EC (EC 2006a)

Food production chain

- It takes several steps to get food from the farm or fishery to the dining table. We call these steps the food production chain
- Contamination can occur at any point along the chain—during production, processing, distribution, or preparation.

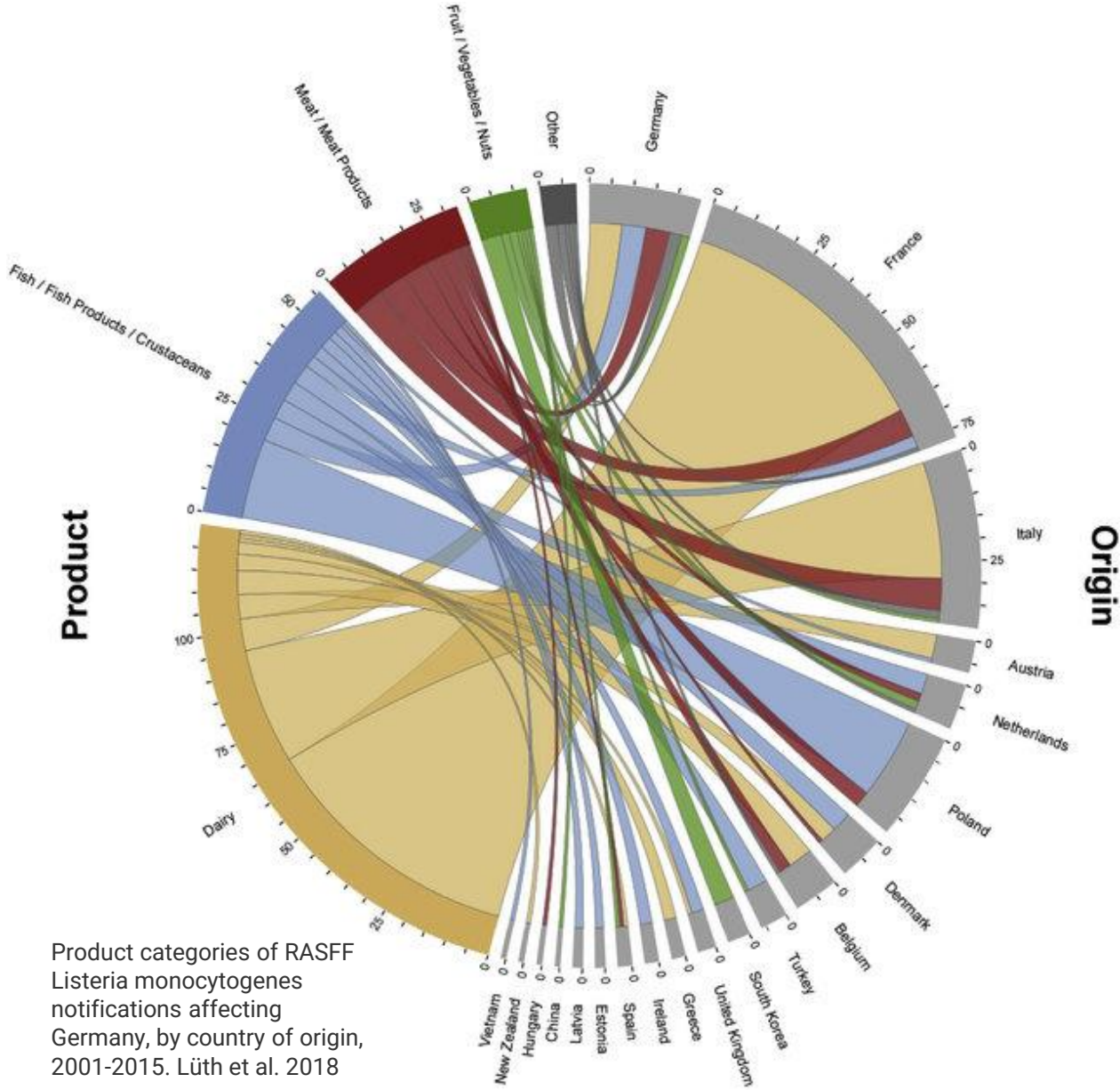
- The European Food Safety Authority (EFSA) provides **independent scientific advice** on **food-related risks**.
- EFSA issues advice on existing and emerging food risks. This advice informs European laws, rules and policymaking – and so helps **protect consumers from risks in the food chain**. Its remit covers:
  - food and feed safety
  - nutrition
  - animal health and welfare
  - plant protection
  - plant health.
- EFSA's work involves:
  - gathering **scientific data** and **expertise**
  - providing **independent**, **up-to-date scientific advice** on food safety issues
  - **communicating** its scientific work to the public
  - cooperating with **EU countries**, **international bodies**, and other **stakeholders**
  - **boosting trust** in the EU's **food safety** system by providing **dependable advice**.

NÉBiH - NFCSO (Hungary) – National Food Chain Safety Office

- The integrated food safety authority of Hungary, established on 15 March 2012.
- he activities of NFCSO are supervised by the Ministry of Agriculture and personally the chief veterinary officer of Hungary.
- The basic principle of organizing the activities of NFCSO is food safety risk analysis as defined by the Codex Alimentarius Commission.
- Besides food risk assessment and risk management, the Office also deals with food safety risk communication (both preventive and crisis communication) and also consumer related programmes, such as campaigns for conscious shopping, education programmes, responsible animal keeping, reducing antimicrobial resistance, prevention of food waste, prevention of forest fires

Rapid Alert System for Food and Feed

- The EU has one of the highest food safety standards in the world – largely thanks to the solid set of EU legislation in place, which ensures that food is safe for consumers. A key tool to ensure the flow of information to enabling swift reaction when risks to public health are detected in the food chain is **RASFF – the Rapid Alert System for Food and Feed**.
- Created in 1979, RASFF enables information to be shared efficiently between its members (EU Member State national food safety authorities, Commission, EFSA, ESA, Norway, Liechtenstein, Iceland and Switzerland) and provides a round-the-clock service to ensure that urgent notifications are sent, received and responded to collectively and efficiently.
- Thanks to RASFF, many food safety risks had been averted before they could have been harmful to European consumers.



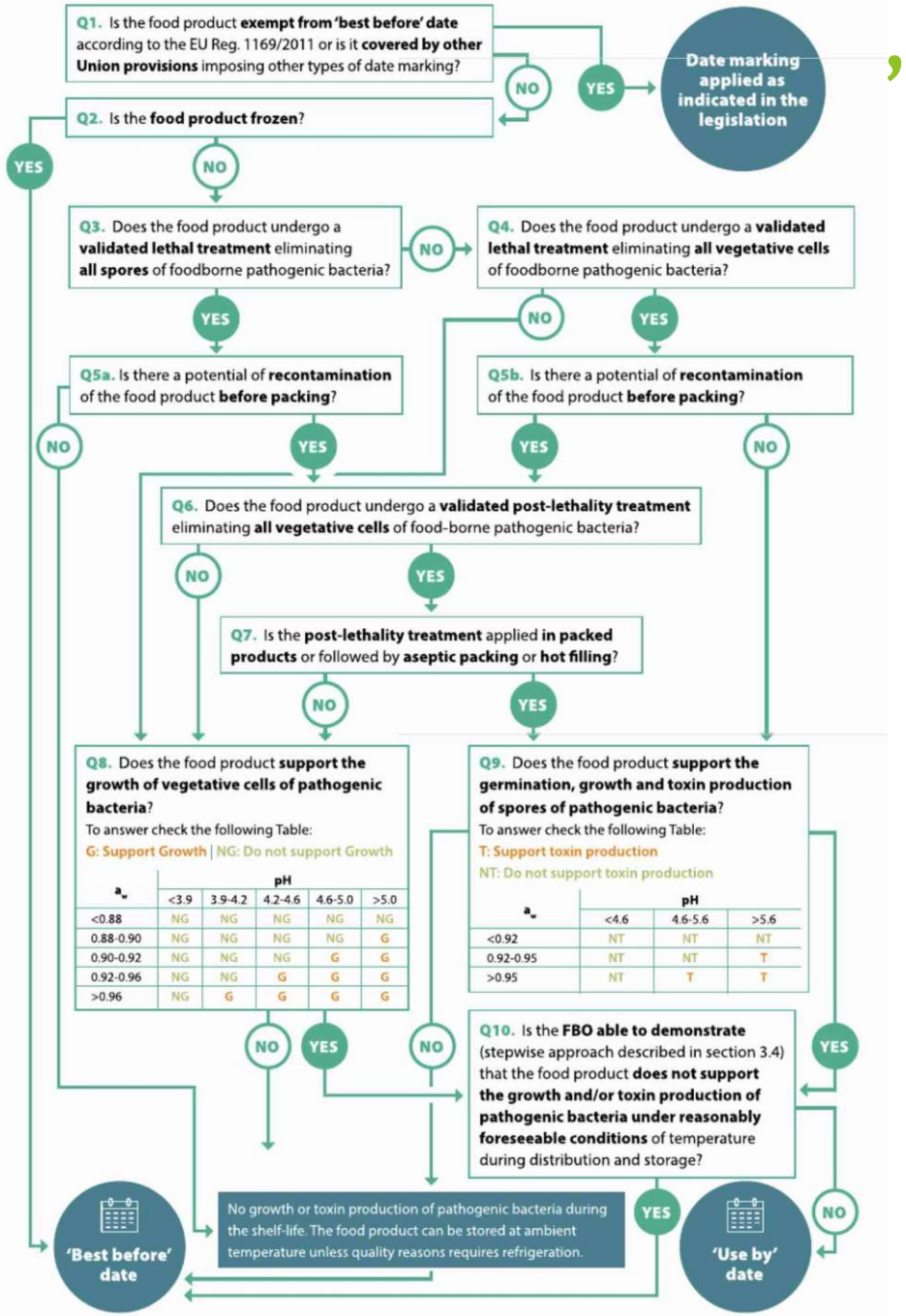
Product categories of RASFF Listeria monocytogenes notifications affecting Germany, by country of origin, 2001-2015. Lüth et al. 2018

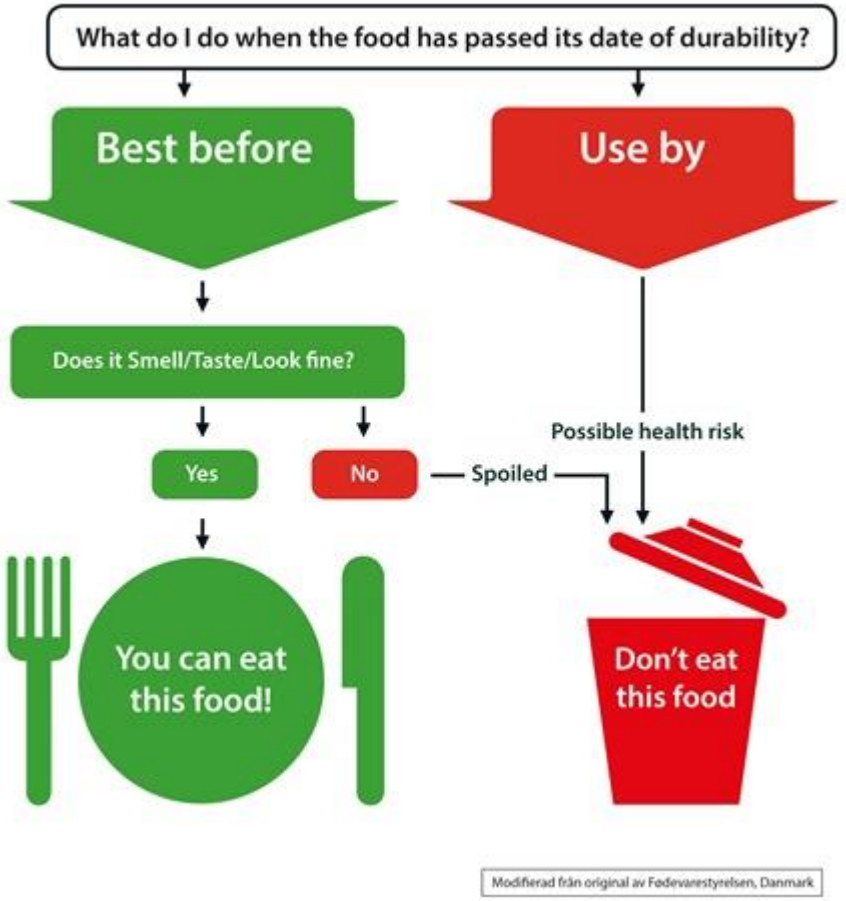
How to ensure food safety

- Protect food from contamination, including microorganisms that pose a health risk, toxic and non-required substances
- Prevent any microorganisms present in the food from propagation, which would lead to food poisoning and early spoilage of the food.
- Destroy all microorganisms that pose a health risk (by heat or other treatment).
- Guarantee that the food will not cause harm to the consumer if it is prepared and / or consumed in accordance with the intended use (consumer's responsibility).

Bíró, 2014

‚Best before' vs. ‚use by'





Sources: foodtimes.eu; National Food Agency, Sweden

Requirements for food

Food testing

Characteristic features required to satisfy the perceived or real needs of consumers.

Requirements for food's environment

- Production
- Processing
- Treatment
- Preservation
- Storage
- Package
- Marketing

Food quality for the consumers and for the authorities – different requirements

Consumer demand	Public health requirements
Organoleptic characteristics	Hygiene (safety)
Functional characteristics	Nutritional value
Freshness	Meet the standard requirements
Shelf life	
Nutritional value	
Safety	
Price	

Microbial hazard in foodstuffs

- Microbiological agents and chemical contaminants are the most important substances harmful to the human body through the consumption of food.
- Among the microbiological agents, zoonotic (animal-to-human) pathogens deserve special attention: bacteria, viruses, parasites and prions

Among them, **bacteria** are of the greatest importance related to food consumption:

- *Salmonella* (meat, mainly poultry, eggs, egg powder, egg juice, egg-based foods, spices)
- *Campylobacter* (poultry, raw milk, water)
- *Listeria* (raw milk, cheeses made from raw milk, soft cheeses, so-called RTE (ready-to-eat)* foods)
- Haemorrhagic *E. coli* (beef, raw milk, manure-contaminated vegetables (mainly salads), drinking water, sprouts)
- *Clostridium botulinum* (home-made meat products, ham, sausage, canned)

Parasites

- Toxoplasma (not well heat-treated meat, any post-contaminated food).

Viruses

- Caliciviruses (berries, salads, but can be any food)

***pre-cleaned, precooked, mostly packaged and ready for consumption without prior preparation or cooking**

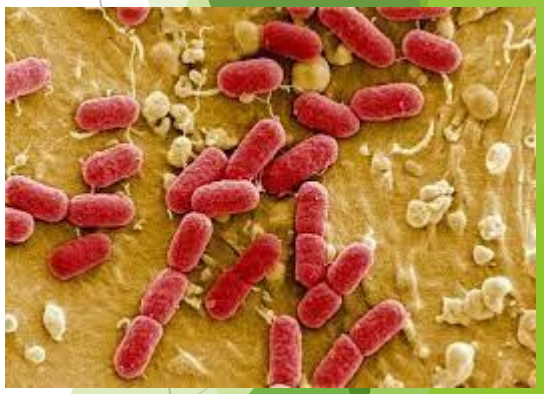
Reported human diseases caused by zoonotic agents in the European Union (2008)

	Incidence/100 thousand inhabitants					
	EU average	D	A	NL	GB	H
Campylobacteriosis	40,7	78,7	51,4	39,2	90,9	54,9
Salmonellosis	26,4	52,2	27,7	15,5	18,8	66,1
Yersiniosis	1,8	5,3	1,1	— **	0,1	0,4
Listeriosis	0,3	0,4	0,4	0,3	0,3	0,2
VTEC*	0,7	1,1	0,8	0,6	1,9	0
Q-fever	0,5	0,5	—	6,2	<0,1	0

*: Disease caused by verotoxin-producing *E. coli*; **: no data available <

Laczay P., 2012

	Incidence/100 thousand inhabitants					
EU average	D	A	NL	GB	H	
Campylobacteriosis	40,7	78,7	51,4	39,2	90,9	54,9
Salmonellosis	26,4	52,2	27,7	15,5	18,8	66,1
Yersiniosis	1,8	5,3	1,1	— **	0,1	0,4
Listeriosis	0,3	0,4	0,4	0,3	0,3	0,2
VTEC*	0,7	1,1	0,8	0,6	1,9	0
Q-fever	0,5	0,5	—	6,2	<0,1	0



- In *Yersinia enterocolitica* infection the pathogen can be cultured from gastroenteric patients, but the vector (food) can rarely by identified. Therefore, according to European laboratory studies, the prevalence of *Yersinia enterocolitica* poisoning in food is below 1%.
- *EHEC - One *E. coli* strain that causes a severe intestinal infection in humans is known as enterohemorrhagic *E. coli* (EHEC). It's the most common strain to cause illness in people. It's different from other *E. coli* because it produces a potent toxin called Shiga toxin. The *E. coli* version of the toxin was named "verotoxin" because of its ability to kill Vero cells. This toxin damages the lining of the intestinal wall, causing bloody diarrhea.
- 10% of EHEC infections lead to Hemolytic uremic syndrome (HUS) is a condition that can occur when the small blood vessels in your kidneys become damaged and inflamed. This damage can cause clots to form in the vessels. The clots clog the filtering system in the kidneys and lead to kidney failure, which could be life-threatening.
- Q fever is **a disease caused by the bacteria *Coxiella burnetii***. This bacteria naturally infects some animals, such as goats, sheep, and cattle. It is a zoonosis, a disease of animals that can infect humans. Q fever can be spread by ticks which pass the bacteria from an infected to susceptible animal, or contracted by drinking unpasteurised infected milk. First identified in Australia in 1935, Q fever has since been found worldwide, with the exception of New Zealand.

Listeriosis

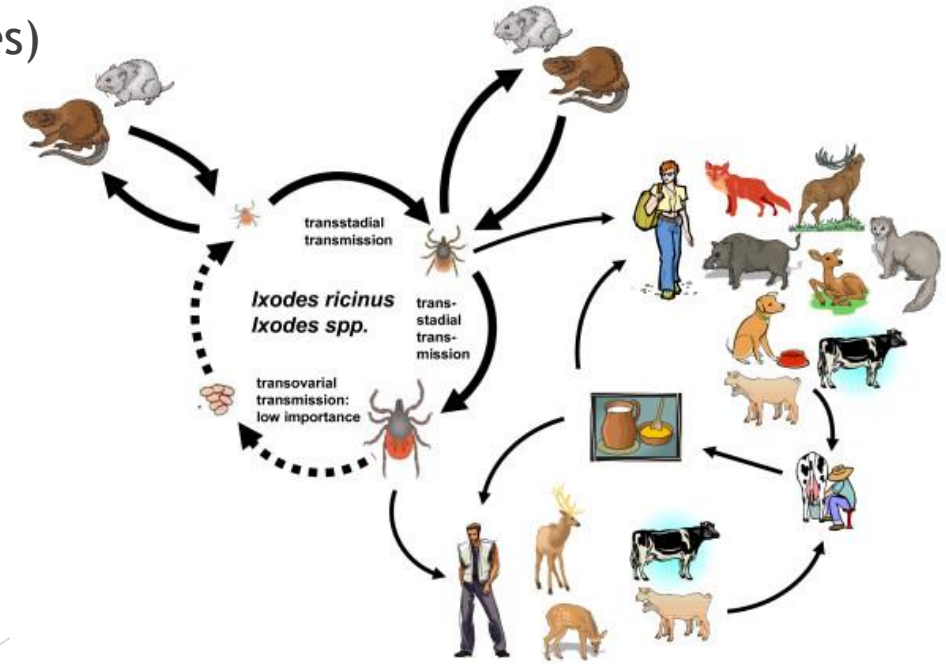
- Foodborne listeriosis is one of the most serious and severe foodborne diseases. It is caused by the bacteria *Listeria monocytogenes*. It is a relatively rare disease with 0.1 to 10 cases per 1 million people per year depending on the countries and regions of the world. Although the number of cases of listeriosis is small, the high rate of death associated with this infection makes it a significant public health concern.
- Unlike many other common foodborne diseases causing bacteria, *L. monocytogenes* can survive and multiply at low temperatures usually found in refrigerators. Eating contaminated food with high numbers of *L. monocytogenes* is the main route of infection. Infection can also be transmitted between humans, notably from pregnant women to unborn babies.
- *L. monocytogenes* are ubiquitous in nature and found in soil, water and animal digestive tracts. Vegetables may be contaminated through soil or the use of manure as fertilizer. Ready-to-eat food can also become contaminated during processing and the bacteria can multiply to dangerous levels during distribution and storage.
- Food most often associated with listeriosis include:
  - foods with a long shelf-life under refrigeration (*L. monocytogenes* can grow to significant numbers in food at refrigeration temperatures when given sufficient time); and
  - foods that are consumed without further treatment, such as cooking, which would otherwise kill *L. monocytogenes*.
- Two types of Listeriosis: non-invasive, invasive form

Listeriosis

- **At-Risk Groups**
- The severity of listeriosis varies and in some cases can be fatal, especially among the elderly, people with weakened immune systems or chronic diseases.
- Listeriosis can be particularly dangerous for pregnant women and their newborn babies, leading to serious complications with their pregnancy, including miscarriage and stillbirth. Babies born with a listeriosis infection may develop severe health complications that require immediate medical attention, lead to lifelong health problems, or result in death. Women who suspect they have symptoms of listeriosis (muscles aches, nausea, stiffness in neck, headaches, etc.) should seek medical care immediately and tell their health provider what they ate.
- **Prevention**
- In general, guidance on the prevention of listeriosis is similar to guidance used to help prevent other foodborne illnesses. This includes practicing safe food handling and following the WHO Five Keys to Safer Food (1. Keep clean. 2. Separate raw and cooked. 3. Cook thoroughly. 4 Keep food at safe temperatures. 5. Use safe water and raw materials.)

Foodstuff with the highest health risk (according to NéBIH)

- Poultry meat (*Salmonella, Campylobacter*), mainly through cross-contamination
- Raw milk, dairy product (*Campylobacter, Listeria*, raw milk is a possible vector in the transmission of tick-borne encephalitis virus!!)
- Eggs, egg products (Salmonella)
- Cold cuisine, confectionery (*Salmonella, Staphylococcus*, viruses)
- Shells (viruses)
- Salads, edible sprouts (*E. coli, Salmonella*, viruses)



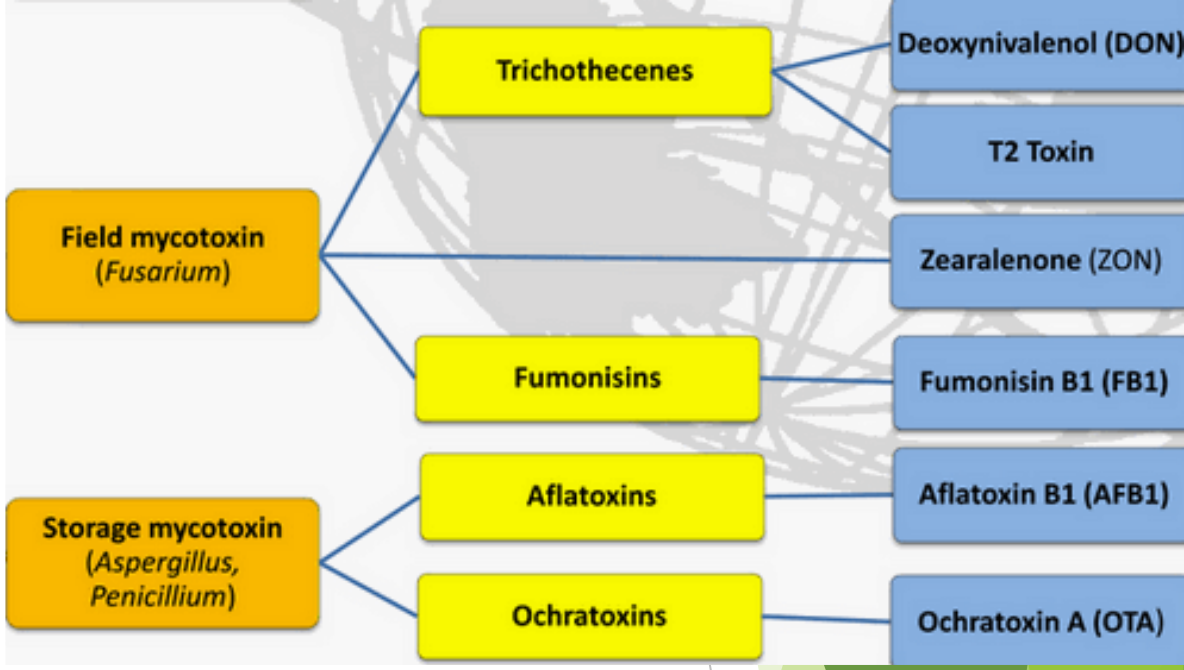
Chemical contamination of foodstuffs

- Chemical contamination usually remain hidden from the consumer as they slowly exert their harmful effects on health (chronic effects).
- Most of them effect and contaminate food-producing animals and plants during the primary production on the farm,
- A small fraction is generated during food processing.
- Major types:
  - residues of veterinary medicines and plant protection products (herbicides, insecticides, fungicides…)
  - various pollutants of environmental origin (for example: toxic metals, dioxins, polychlorinated biphenyls)
  - biological contaminants (mycotoxins, marine and freshwater biotoxins, histamine)
  - naturally occurring toxic substances (cyanoglycosides, nitrites, nitrates, alkaloids, etc.)

Note: cyano glycosides are degraded by enzymes, the conditions of the released hydrogen cyanide in the toxic human body (LD50 = 0.5-2.5 mg / kg orally) are not optimal for HCN cleavage (gastric pH too acidic, small intestine: too alkaline) . The body's defense mechanism (rhodanide formation) renders the cleaved hydrogen cyanide harmless.

Mycotoxins

- Mycotoxins are **toxic compounds that are naturally produced by certain types of moulds (fungi)**. Moulds that can produce mycotoxins grow on numerous foodstuffs such as cereals, dried fruits, nuts and spices. ... Mycotoxins appear in the food chain as a result of mould infection of crops both before and after harvest.

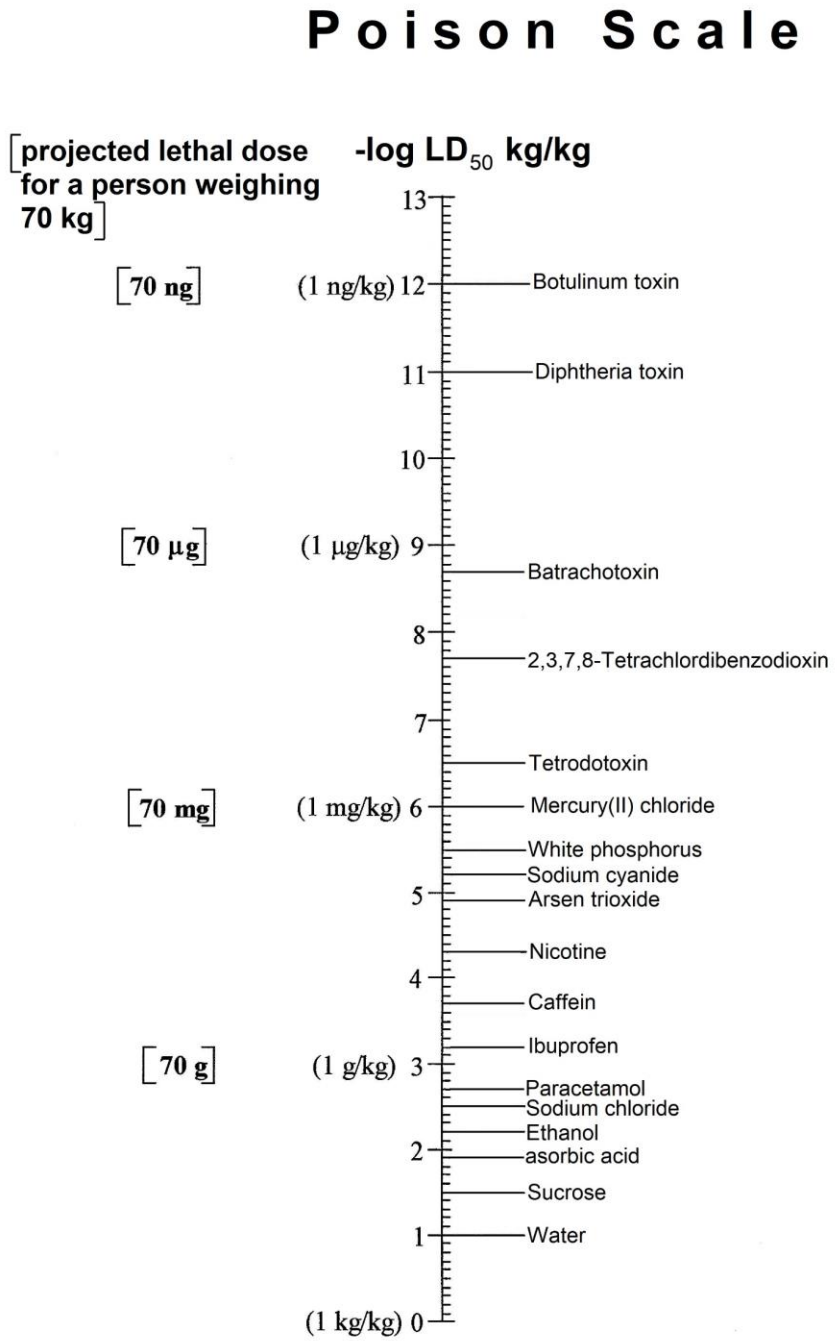


- Major mycotoxin producers: *Fusarium*, *Aspergilus*, *Penicillium* species
- Health effects: acute toxicity immunesupression, mutagenic, carcinogenic, teratogenic
- Affected organs: gastrointestinal, respiratory, endocrine, reproductive, nervous and immune systems

Naturally occuring food toxins

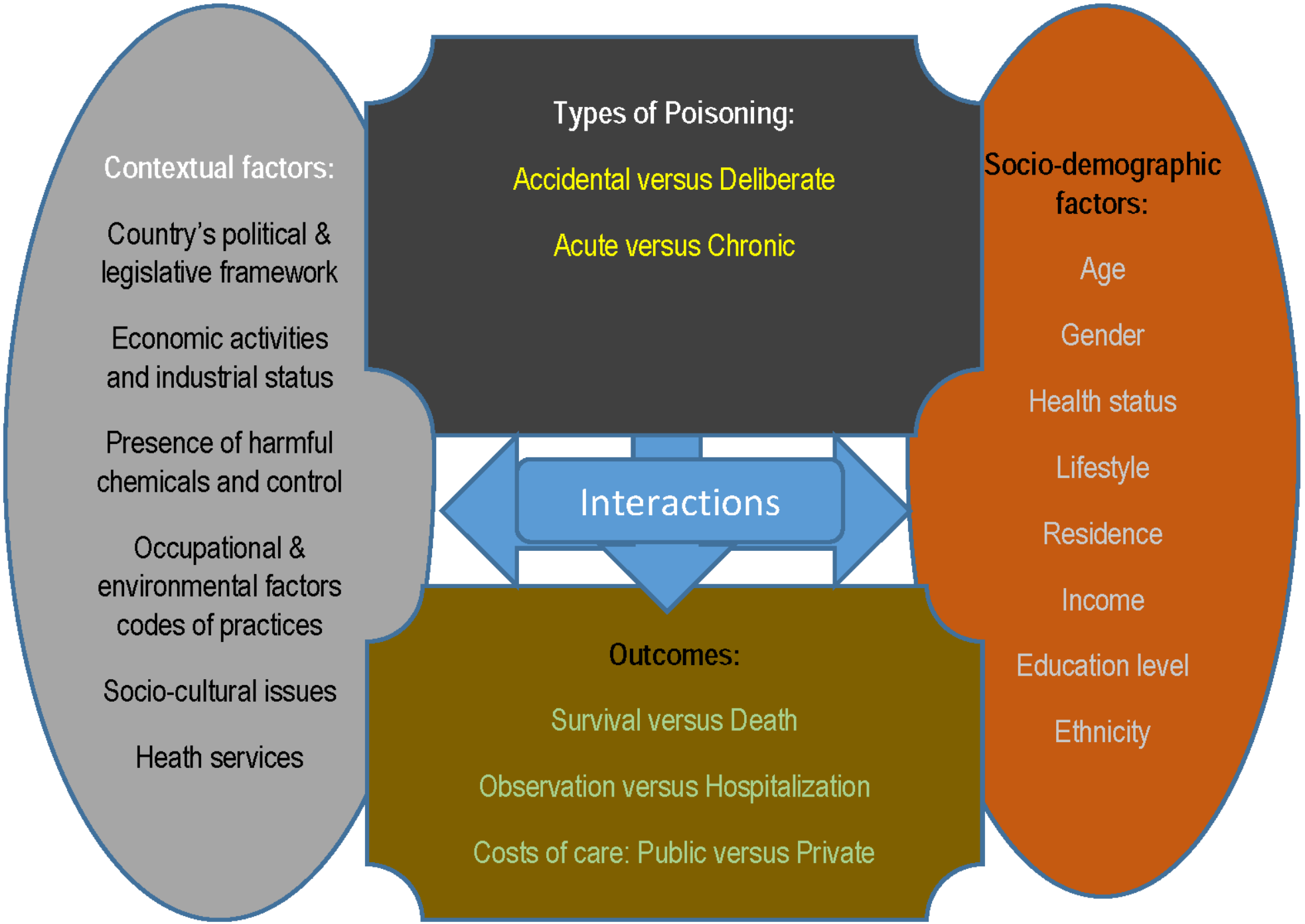
Anyagmegnevezés	Az élelmiszer fajtája	Határérték (mg/kg)
SZOLANIN	Nyers, hámozott burgonya	180
CIÁN	Csonthéjas magvakkal készült édesipari termékek	5,0
(CHN)	Természetes gyümölcspálinkák, pálinkakészítmények és egyéb tömény szeszes italok	40,0 (valódi kisüsti minőség) 20,0 (kereskedelmi minőség)
	Borok, gyümölcsborok és különleges borkészítmények	1,0
METANOL (CH_3OH)	Természetes gyümölcspálinkák, pálinkakészítmények és egyéb tömény szeszes italok	2,0 térf% + (valódi kisüsti minőség) 0,2 térf% + (kereskedelmi minőség)
NITRÁT (NO_3^-)	Csecsemők és kisgyermekek számára készülő főzelékkonzervek (pl.: paraj)	400
NITRIT (NO_2^-)	Csecsemők és kisgyermekek számára készülő főzelékkonzervek (pl.: paraj)	10

Jelzés: + = a készítmény abszolút etanol tartalmára számítva



Chemical contamination of foodstuffs

- Chemicals that harm the health of the consumer can also be produced during food processing and food preparation
- Chemical contaminants (e.g. polycyclic aromatic hydrocarbons, nitrosamines) can also enter food from production equipment and packaging materials.
- Contamination can be a result of the improper use of additives (dyes, preservatives, artificial sweeteners, antioxidants).

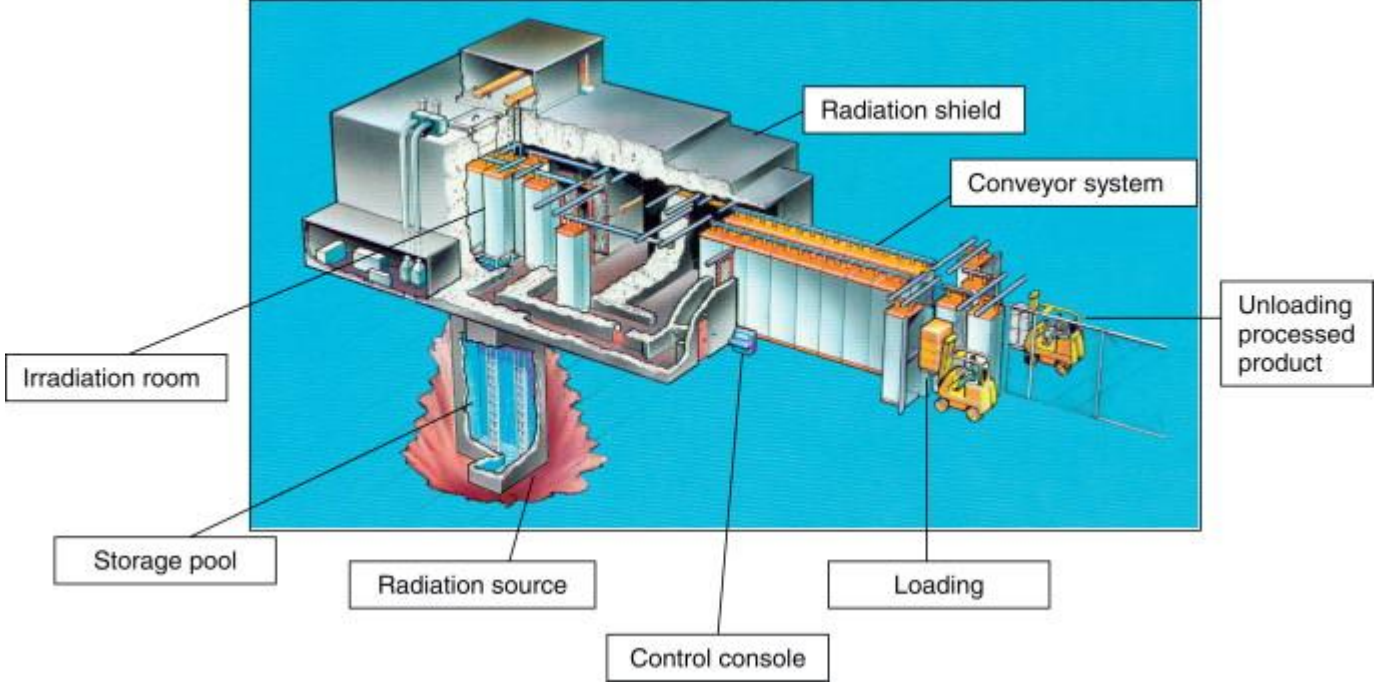

Contextual factors:
Country's political & legislative framework
Economic activities and industrial status
Presence of harmful chemicals and control
Occupational & environmental factors codes of practices
Socio-cultural issues
Heath services
Types of Poisoning:
Accidental versus Deliberate
Acute versus Chronic
Interactions
Outcomes:
Survival versus Death
Observation versus Hospitalization
Costs of care: Public versus Private
Socio-demographic factors:
Age
Gender
Health status
Lifestyle
Residence
Income
Education level
Ethnicity

Radiocontamination in food

- Food and drinking water may contain both naturally-occurring and man-made radionuclides. When consumed, this may expose people to radiation. For this reason, it is important to know the amounts of radionuclides in food and drinking water and, if necessary, control their distribution.
- Artificial radioactivity can also get into food. This can happen when radioactive materials are discharged into the environment from civil or military nuclear operations. Artificial radioactivity then passes through the food chain in the same way as natural radioactivity.
- The Chernobyl accident in 1986 was the main source of radioactive contamination in European food. The radioactive substance caesium-137 has been the most problematic in the long term, as it has a half-life of 30 years and is readily absorbed into the food chains. E.g. in Norway, the vast majority of foods now contain low levels of caesium-137.

Food irradiation

- Irradiation is physical treatment of food with high-energy ionising radiation to:
- Destroy microorganisms, viruses, bacteria or insects
- Prevent germination and sprouting of potatoes, onions and garlic
- Slow down ripening and ageing of fruit and vegetables
- Prolong the shelf life and prevent food-borne diseases in meat, poultry and seafood
- Its use is limited but authorised in many European countries.
- A **total of 7,832 tons of products** were treated with ionizing irradiation in EU nations in 2018 and 2019, which was down by 23.3 percent compared to 2016 and 2017. Treatment was mainly in Belgium with 81.4 percent, or 6,377 tons, of the irradiated food in the EU followed by Spain, France, Germany and Hungary.



- **There are three sources of radiation approved for use on foods.**
- Gamma rays are emitted from radioactive forms of the element cobalt (Cobalt 60) or of the element cesium (Cesium 137). Gamma radiation is used routinely to sterilize medical, dental, and household products and is also used for the radiation treatment of cancer.
- X-rays are produced by reflecting a high-energy stream of electrons off a target substance (usually one of the heavy metals) into food. X-rays are also widely used in medicine and industry to produce images of internal structures.
- Electron beam (or e-beam) is similar to X-rays and is a stream of high-energy electrons propelled from an electron accelerator into food.

The WHO Golden Rules for Safe food preparation

1. **Choose foods processed for safety.**

While many foods such as fruits and vegetables. are best in their natural state. others simply are not safe unless they have been processed. For example, always buy pasteurised as opposed to raw milk and if you have the choice, select fresh or frozen poultry treated with ionizing radiation. When shopping, keep in mind that food processing was invented to improve safety as well as to prolong shelf-life. Certain foods eaten raw, such as lettuce, need thorough washing.

The WHO Golden Rules for Safe food preparation

2 Cook food thoroughly.

Many raw foods. most notably poultry meats and unpasteurised milk are very often contaminated with disease-causing pathogens. Thorough cooking will kill the pathogens, but remember that the temperature of all parts of the food must reach at least 70°C, If cooked chicken is still raw near the bone, put it back in the oven until it's done - all the way through. Frozen meat fish and poultry must be thoroughly thawed before cooking.

The WHO Golden Rules for Safe food preparation

3. Eat cooked foods immediately.

When cooked foods cool to room temperature. microbes begin to proliferate. The longer the wait the greater the risk. To be on the safe side, eat cooked foods just as soon as they come off the heat.

The WHO Golden Rules for Safe food preparation

4. Store cooked foods carefully.

If you must prepare foods in advance or want to keep leftovers, be sure to store them either hot - (near or above 60°C) or cool (near or below 1°C) conditions. This rule is of vital importance if you plan to store foods for more than four or five hours. Foods for infants should preferably not be stored at all A common error. responsible for countless cases of foodborne disease. is putting too large a quantity of warm food in the refrigerator In an overburdened refrigerator, cooked foods cannot cool to the core as quickly as they must. When the centre of food remains warm (above 10°C) too long, microbes thrive, quickly proliferating to disease-producing levels.

The WHO Golden Rules for Safe food preparation

5. Reheat cooked foods thoroughly.

This is your best protection against microbes that may have developed during storage (proper storage slows down microbial growth but does not kill the organisms). Once again, thorough reheating means that all parts of the food must reach at least 70°C.

The WHO Golden Rules for Safe food preparation

6. Avoid contact between raw foods and cooked foods.

Safely cooked food can become contaminated through even the slightest contact with raw food. This cross-contamination can be direct as when raw poultry meat comes into contact with cooked foods. It can also be more subtle. For example, don't prepare a raw chicken and then use the same unwashed cutting board and knife to carve the cooked bird. Doing so can reintroduce all the potential risks for microbial growth and subsequent illness that were present prior to cooking.

The WHO Golden Rules for Safe food preparation

7. Wash hands repeatedly. Wash hands thoroughly before you start preparing food and after every interruption - especially if you have to change the baby's nappy or have been to the toilet. After preparing raw foods such as fish, meat or poultry, wash again before you start handling other foods And if you have an infection on your hand, be sure to bandage or cover it before preparing food. Remember too, that household pets – dogs, birds, and especially turtles - often harbour dangerous pathogens that can pass from your hands into food.

The WHO Golden Rules for Safe food preparation

8. Keep all kitchen surfaces meticulously clean.

Since foods are so easily contaminated. any surface used for food preparation must be kept absolutely clean. Think of every food scrap, crumb or spot as a potential reservoir of germs. Cloths that come into contact with dishes and utensil s should be changed every day and boiled before re -use. Separate cloths for cleaning the floors also require frequent washing.

The WHO Golden Rules for Safe food preparation

9. Protect foods from insects, rodents, and other animals.

Animals frequently carry pathogenic microorganisms which cause foodborne disease. Storing foods in tightly sea led containers is your best protection.

The WHO Golden Rules for Safe food preparation

10. Use pure water.

Pure water is just as important for food preparation as for drinking. If you have any doubts about the water supply, boil water before adding it to food or making ice for drinks. Be especially careful with any water used to prepare an infant's meal.