Freshwater and Groundwater Pollution

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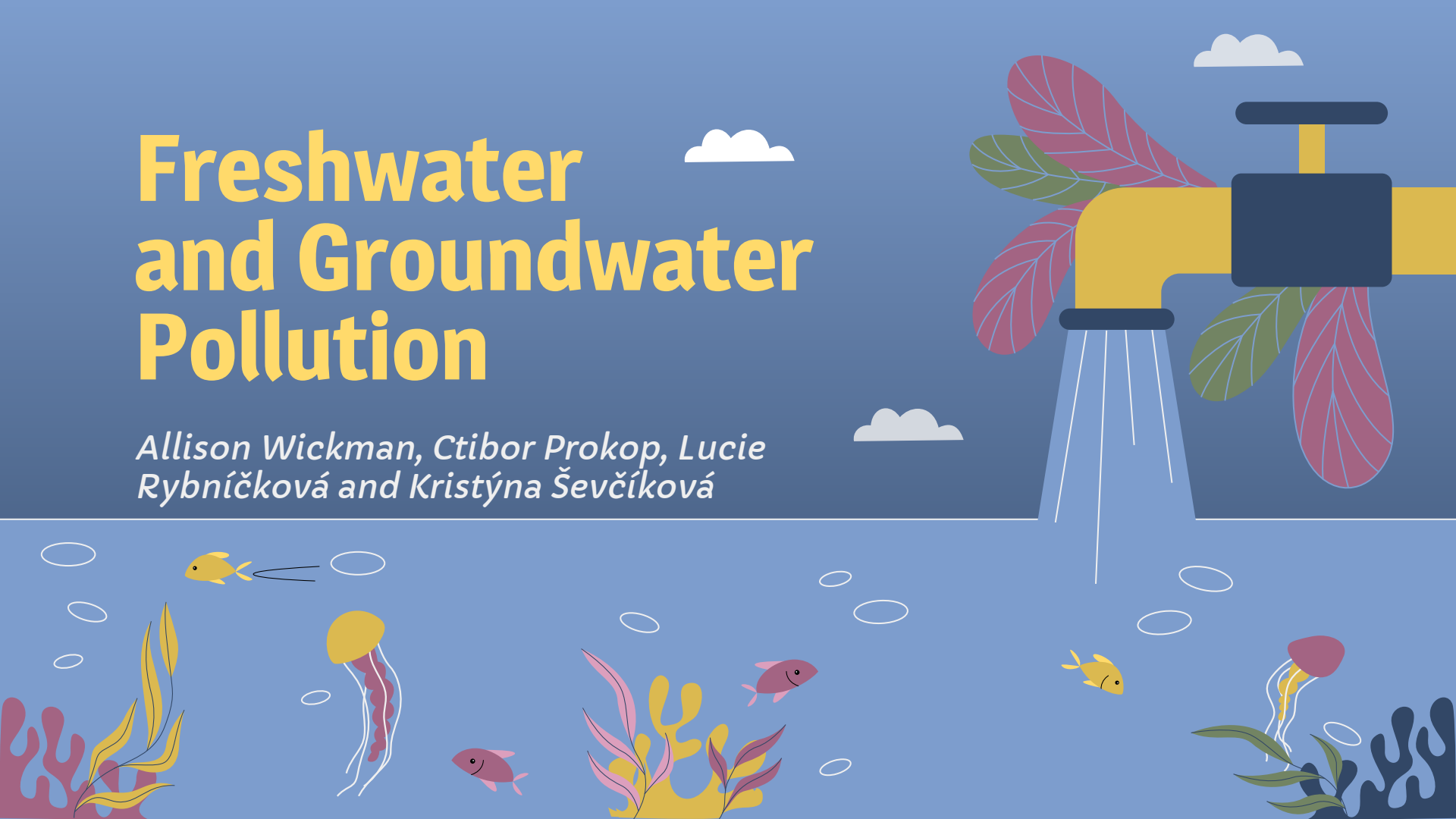

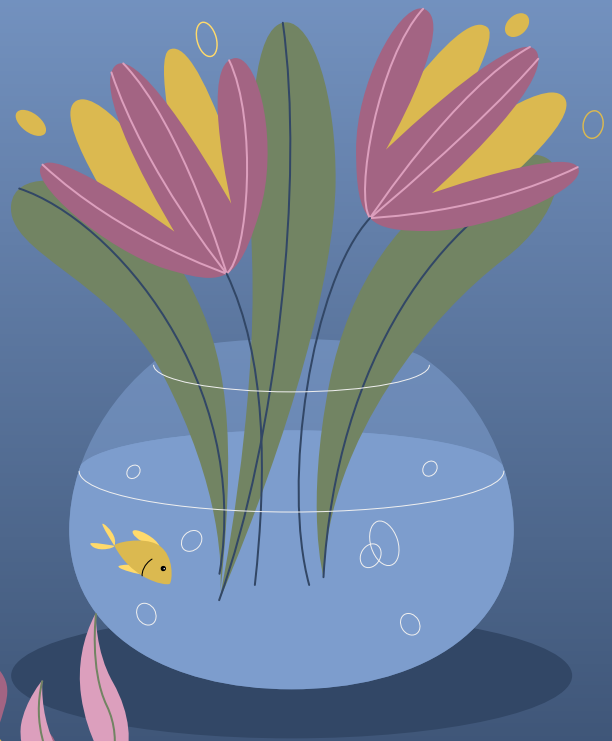

Brainstorm

1. Where do I notice water pollution?
2. What sources of water pollution do I know?
3. What solutions to water pollution do I know?

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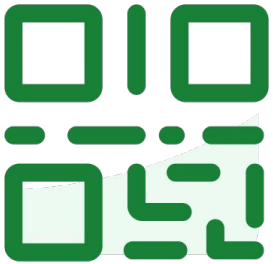

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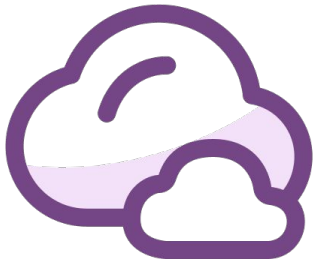

Where do I notice water pollution?

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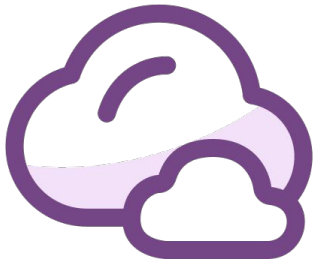

What sources of water pollution do I know?

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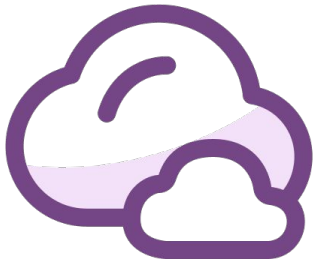

What solutions to water pollution do I know?

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Water pollution risks and major water pollution sources

Importance of Freshwater Systems (= Natural capital)

Ecological Services

- Climate moderation
- Nutrient cycling
- Waste treatment
- Flood control
- Groundwater recharge
- Habitats for many species
- Genetic resources and biodiversity
- Scientific information

Economic Services

- Food
- Drinking water
- Irrigation water
- Hydroelectricity
- Transportation corridors
- Recreation
- Employment

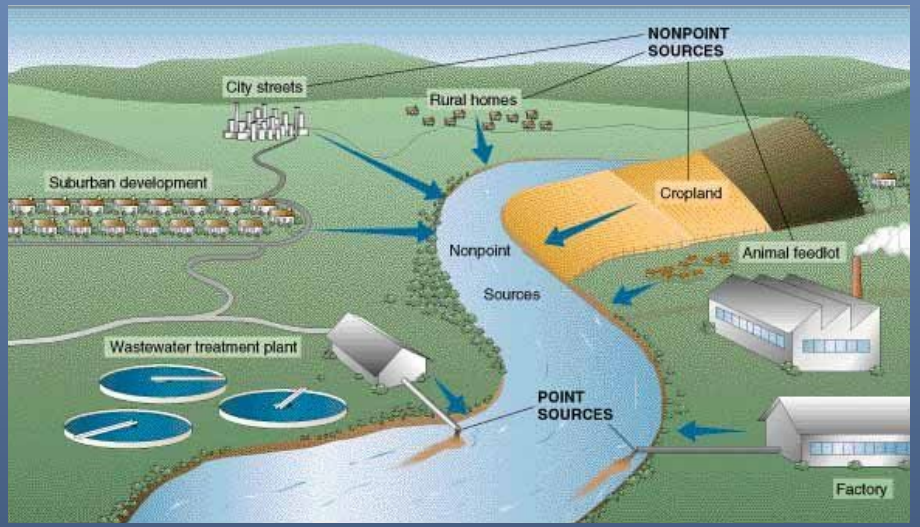
- Ethical concerns

Sources of water pollution

- Water pollution = any change in water quality that can harm living organisms or make the water unfit for human use

Types of water pollution

- Point - identifiable, at specific locations, easier to monitor and regulate
- Nonpoint - broad, diffuse areas



Main sources of water pollution - by activity

Agricultural

- eroded sediments
- fertilizers and pesticides
- livestock bacteria (...)

Industrial

- organic and inorganic chemicals
- heavy metals
- oils and greases
- leakage of coal ash from slurry ponds (...)

Mining

- land disturbance leading to erosion of sediments
- runoff of chemicals

\+ Factor of climate change - downpour intensity

Most common pollutants (1/2)

Infectious agents (bacteria, viruses, protozoa, parasites)

- Human and animal waste

Oxygen-demanding wastes (biodegradable animal wastes and plant debris)

- Sewage, animal feedlots, food-processing facilities, paper mills

Plant nutrients (nitrates, phosphates) -> excessive algae growth

- Sewage, animal waste, inorganic fertilizers

Toxic Organic chemicals (oil, gasoline, plastics, pesticides, fertilizers, cleaning solvents)

- Industry, agriculture, households, runoff from urban areas

Harmful algal blooms

Use of pesticides and inorganic fertilizers

Animal feedlots

Sewage water leak

Most common pollutants (2/2)

Sediments (soil, silt) -> photosynthesis disruption, food web disruption

- Land erosion - farms, construction sites, mining: heavy metals (lead, mercury, arsenic, cadmium, chromium etc.)
- Unlined landfill, household chemicals, mining waste, industrial discharges
- Thermal - Electric power and industrial plants

Landfill lining

Impact of population growth

= more people will lead to more pollution

Growth in population ->

growth in resource use ->

growth in waste / ecological footprint

Pollution problems in rivers and lakes

Pollution problems in rivers and lakes

- Waterways are connected - problem in one place may cause problems in other places too
- Concrete in cities causes polluted rainwater to quickly flow into rivers instead of soaking into the ground. This increases nutrient levels in the water and can lead to the growth of algae and harmful algae blooms.

Sources of pollution

- Point pollution
  - You can trace the contaminamination to a culprit
  - dumping of industrial waste, effluent from sewage treatment facilities, illegal dumping
  - other hazardous chemical deposition (e.g. nuclear waste).
  - Heat can also be a pollutant.
  - Plastics and other solid materials (sometimes they even melt toxins in the water)
  - Easier to control

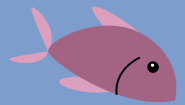
Sources of pollution

- Nonpoint pollution
  - Contamination, that gets into the water system (that cannot be traced to a person, source and a place)
  - Agricultural runoff (pesticides, fertilizers, manure), acid rain, nitrate deposition, and leaching from septic tank

Problems of a lake

- Eutrophication
- The clarity and quality of the water may decrease and that causes deaths of fish (especially bioindicators)
- Industrial heavy metals can be found in food chain - that causes death and diseases not only the fish, but also their predators (that consume them)
- Atmospheric pollutants can get in the water by acid rains

River’s self-cleaning capacity



Physical processes

- Dilution (ředění)
  - the mixing of discharged wastewater with the stream water
- sedimentation
  - the settling down of solid particles onto a river bottom and their removal from the watercourse (when floods come, they can reverse the effect and pollute the water again)
- Straining/filtering (Scezování/filtrace)
  - mainly the interception of floating particles by the movement of water through gravel and sand in a river bottom where small bits of organic matter or inorganic material may be filtered

Physical processes

- Aeration (provzdušňování)
  - the process of transferring gases, especially oxygen, from the air into the water and helps reduce pollutants (it supports bacteria that feed on organic matter and help decompose it)
- Grinding and dissolution (Mletí a rozpouštění)
- Adsorption
  - When pollution sticks to the surface of particles or solid materials, it reduces their toxicity

Chemical processes

- Oxidation and reduction
  - Contribution to decomposure of dead organic substances
- hydrolysis
  - Transformation and disintegration of organic pollutants with groups that are easily hydrolyzed (chemically broken down due to reaction with water) - Transformace a rozklad organických znečišťujících látek se skupinami, které se snadno hydrolyzují (chemicky rozkládají reakcí s vodou).

Chemical processes

- Photolysis
  - Decomposition under the influence of light
- Absorption/assimilation
  - Uptake or dissolution of atoms, molecules or ions (přijímání nebo rozpouštění atomů, molekul nebo iontů)

Biological processes

- Handled by organisms living in the water, mainly by decomposers

If we overload the river...

- It can lead to:
  - Dying of organisms
  - Destruction of the aquatic ecosystem
  - Reduced agricultural productivity
  - Degradation of the water's quality

Eutrophication in lakes due to excessive nitrogen and phosphorus

What is eutrophication?

A process that occurs when an environment becomes enriched by nutrients (lakes and rivers it's usually nitrogen and phosphorus). Excess plant growth leads to oxygen depletion.

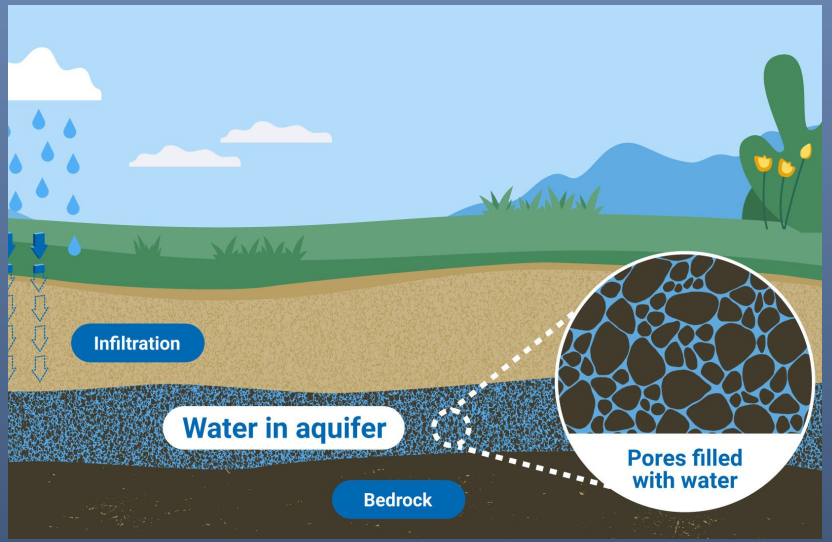
What are the consequences?

- So many nutrients cause the growth of algae and other plants
- Decrease of oxygen
- Death of fish and other aquatic organisms
- Disruption of the food chain
- Decrease of biodiversity
- The blooms of the algae can release toxins(like cyanotoxins) in the water
- Contaminated water is no longer drinkable
- Decrease of recreational activities (smell and appearance)
- Decrease of the availability of potable water (pitná voda)
- Contamination of underground water

Groundwater Pollution by Chemicals, and Purification Methods

Groundwater Pollution by Chemicals

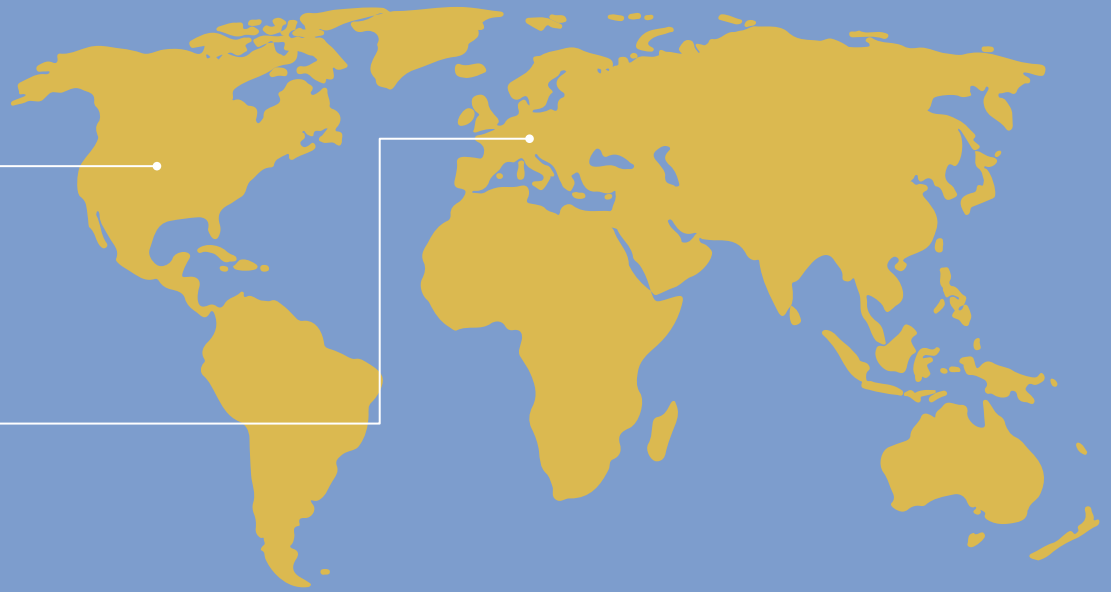
Groundwater is found beneath the Earth's surface, stored in soil and rock layers called aquifers. It is a crucial source of drinking water for billions of people worldwide, and contaminants can pose serious human health and environmental risks.



Groundwater as a Source of Drinking Water

35%
USA

49%
Czech Republic



Agricultural Contaminants

Modern agricultural practices utilize several innovations to increase crop production, such as:

- Fertilizers
- Pesticides (herbicides, insecticides, and fungicides)
- Extensive irrigation

Agricultural Contaminants

Fertilizers and pesticides contain many chemicals that, when ingested by humans, cause a variety of detrimental health effects. Modern agriculture overuses these chemicals, and they leech into our aquifers.

Fertilizers	Pesticides
Nitrate	Glyphosate
Nitrite	Metribuzin
Ammonia	DDT
Nitrogen Oxides	Dieldrin
Organic Nitrogen	Benomyl
Phosphorus	Metiram

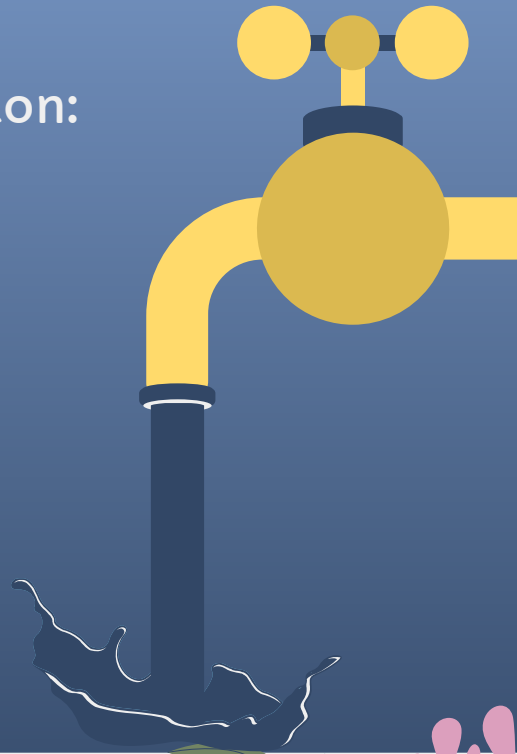
Agricultural Contaminants

Modern irrigation practices promote nutrient leaching and increases infiltration into the soil, which increases the concentration of contaminants in aquifers.

Industrial Contaminants

Common sources of industrial groundwater pollution:

- Industrial liquid effluent
- Underground and surface storage tanks
- Industrial sewers
- Bulk chemical storage areas
- Accidental/ catastrophic discharge



Industrial Contaminants

Industrial effluent:

the wastewater generated by industrial facilities, containing various contaminants including heavy metals, nitrates, pharmaceuticals, POPs, etc.

Transportation-related Pollution

Rainwater and snowmelt from roads carry contaminants into the soil:

- Oils, lubricants, tars
- Exhaust gas components (heavy metals, carbon & nitrogen oxides)
- Particles from worn out tires or brake discs
- Worn road surfaces
- Winter road maintenance substances

Transportation-related Pollution

Road salts are used in the winter, and they are easily carried by snowmelt into the soil. This increases the salinity of the groundwater, making it:

- Unfit to drink
- Unfit to be used for irrigation
- Detrimental to plant and animal life

Domestic Contaminants

Domestic contaminants include:

- Landfill waste leaching
- Domestic wastewater (sewage network)
- Household fuel pollution

Impacts on Human Health

Heavy Metals

Can be carcinogenic, and cause liver, kidney, and intestinal damage

Nitrates/ Nitrites

Enter the bloodstream and cause oxygen deprivation - “Blue Baby Syndrome” in infants

Fluoride

Excess fluoride can cause skeletal fluorosis and dental problems

Radionuclides

An industrial contaminant that can be carcinogenic and damage the kidneys

Environmental Impacts

Ecosystem disruption:

- Polluted groundwater can seep into rivers, lakes, and wetlands, harming aquatic life
- Excess nutrients can cause algae blooms
- Accumulation of chemicals in groundwater decreases soil quality

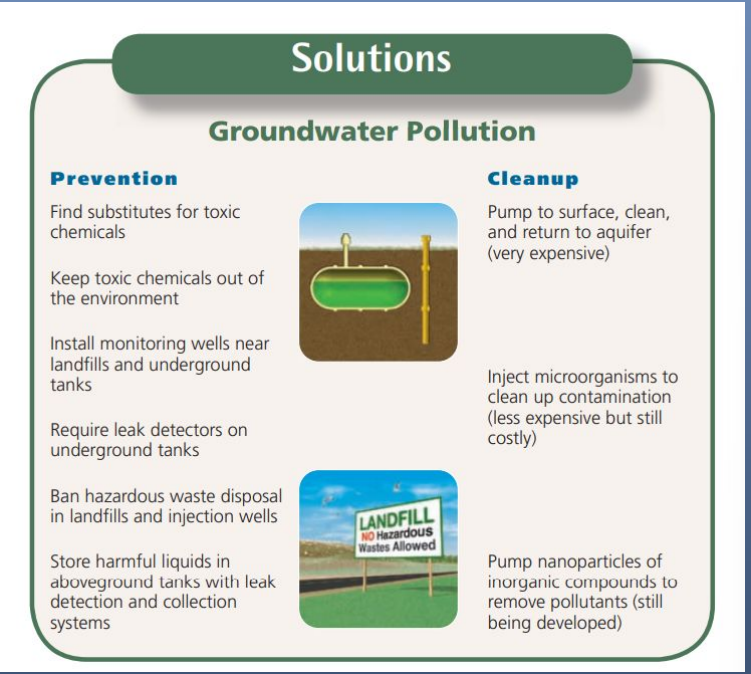
Methods of Groundwater Purification

	Biological	Chemical	Physical
Method	This method uses microorganisms and organic matter to break down chemicals	This method uses chemical precipitation, oxidation, ion exchange, and carbon absorption to remove chemicals	This method, called pump and treat, physically removes the water to treat it before reinjecting the water.
Benefits	Water doesn't have to be removed from the ground; convenient	Can be used in a wide variety of situations and locations	Controls contaminant migration, and reduces plume concentration

The Case for Pollution Prevention

Unlike other sources of freshwater, groundwater cannot cleanse itself very well due to the very slow movement of water through the earth.

Cleanup solutions are costly and often too difficult to implement - many cities have turned to investing in prevention efforts instead.



Case Study

New York City, USA - faced spending $6 billion to build water purification facilities to provide drinking water for its residents. Instead, the city invested in the restoration and protection of the forests and wetlands in the area within their watershed. This method cost only $1.5 billion, and allows the groundwater to be naturally filtered.

Solutions

Solutions

- Structure:
  - General information
  - Different categories
  - Selected types of solutions

Categories of solutions

- preventive X subsequent
- human made X natural
- in urban areas X in nature
- small scale X big scale
    - point X non-point pollution
    - average person X big organizations (companies, government etc.)
- different technologies
- sustainable

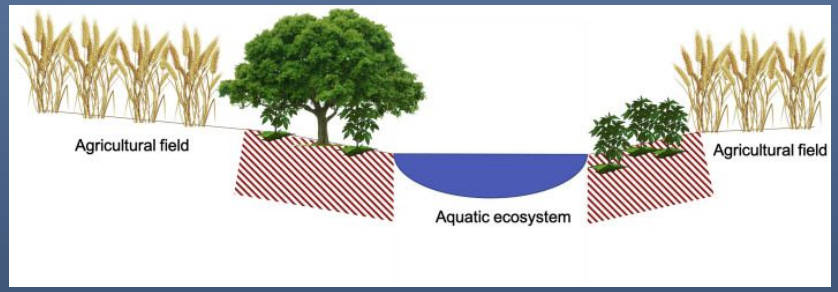
Laws

- Major part in fighting water pollution
- Czech republic:
  - Water pollution fee (§ 88, § 89 of the Water law - 254/2001)
  - Efficiency?

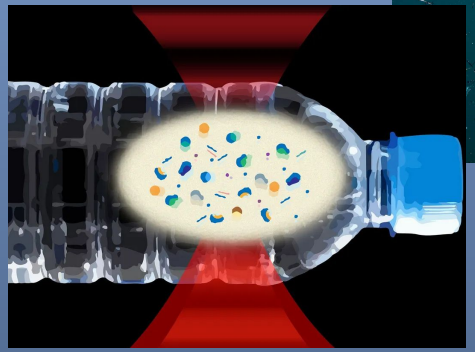
- Depends on how the definitions are set
- Exceptions
- How low the cap on pollution levels is set
- Discharge trading

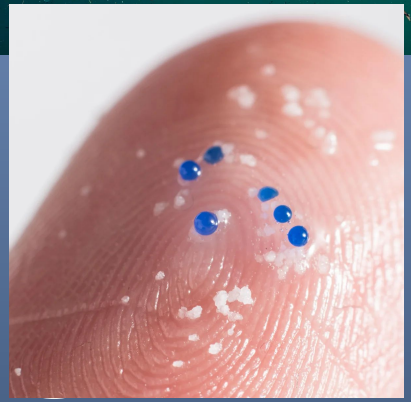
Agriculture solutions

- Less fertilizers and pesticides
- Slow-release substances
- Think about area of use (no slope land)
- Buffer vegetation
- Organic farming
- ... etc.



Limiting plastic pollution

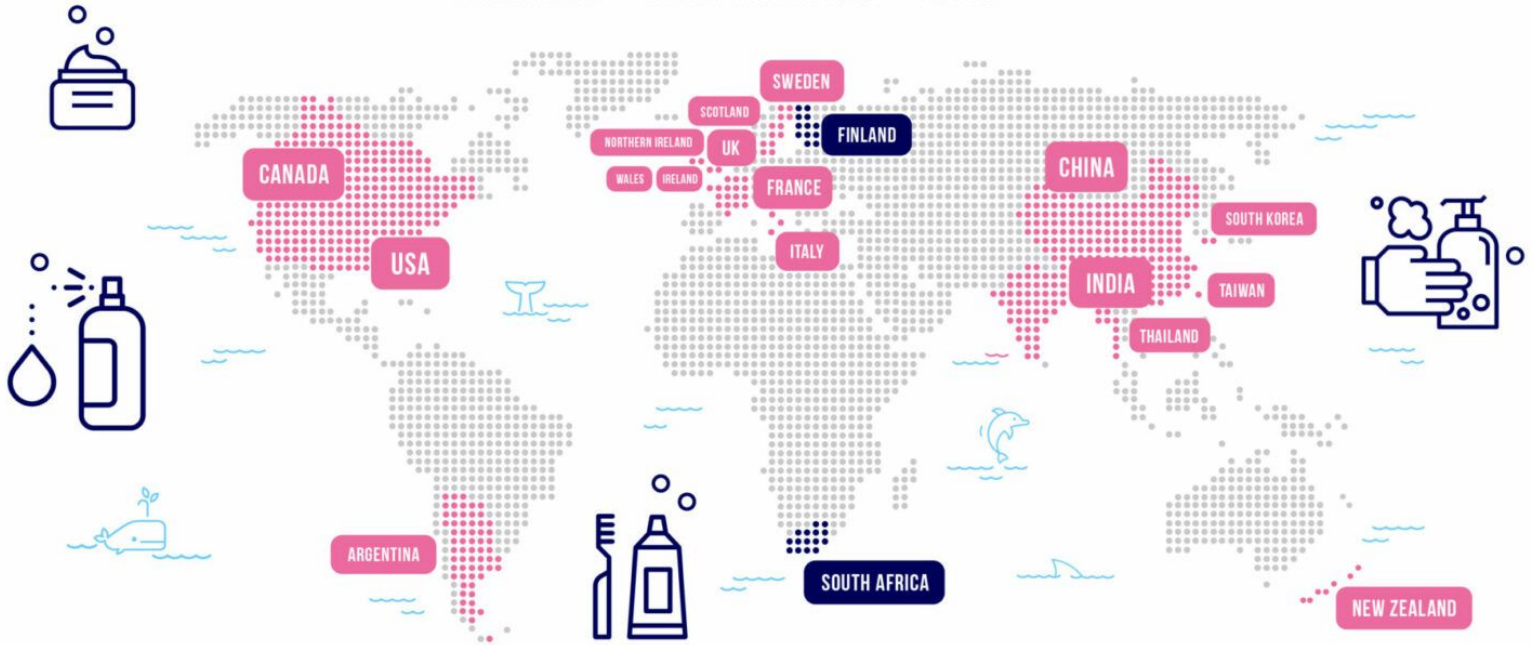




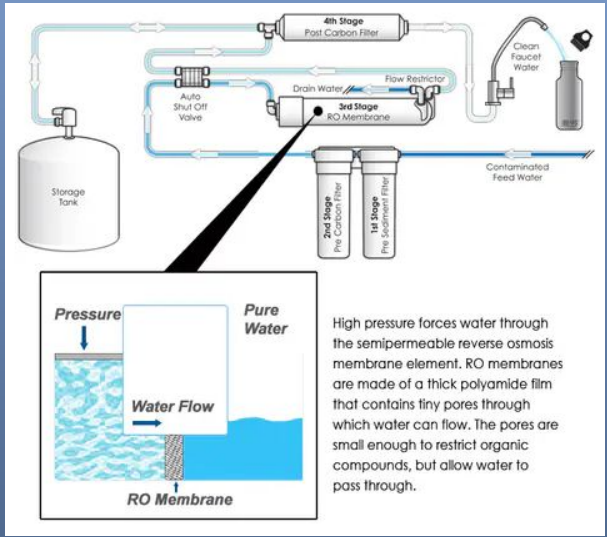
- General plastic waste
  - Doesn’t decompose
  - Causes clogging
  - Toxic chemicals
- Microplastics
  - Harmful in general
- Microbeads
  - Cosmetics and cleaning products

- Simple solution: Use alternatives
- Not so simple solutions: reverse osmosis, distillation, ultrafiltration

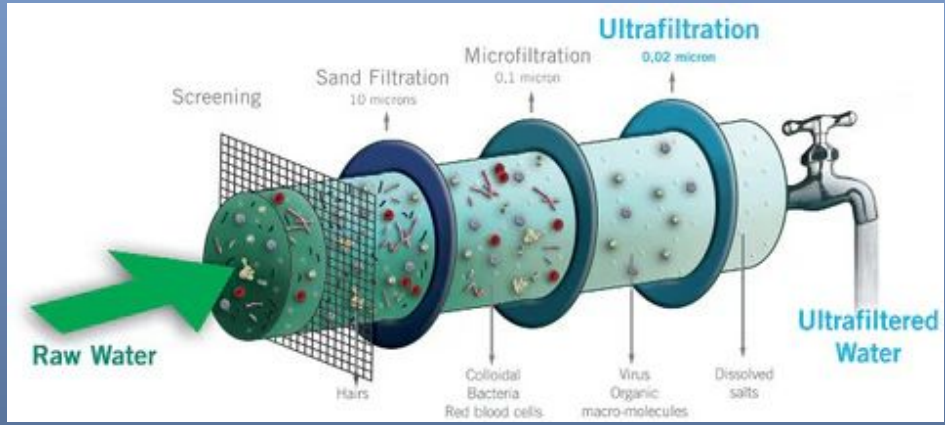
MICROBEADS BAN IN RINSE-OFF COSMETICS



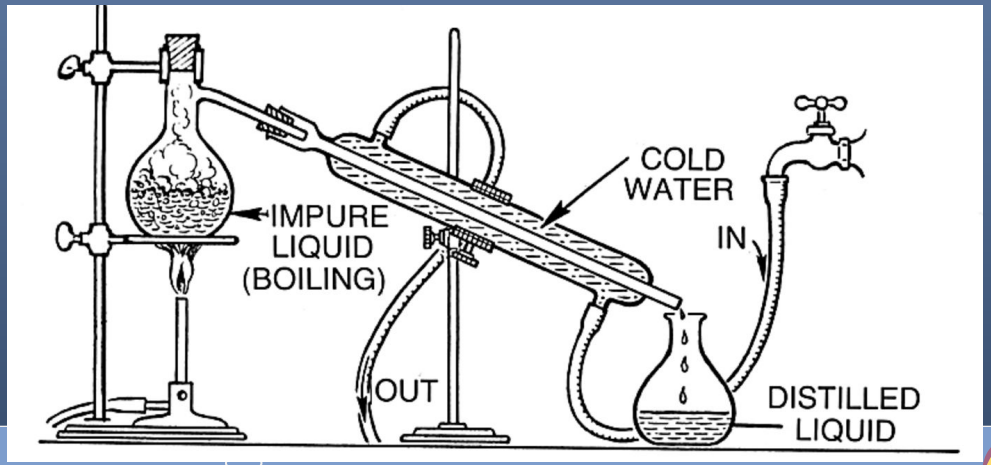
Reverse osmosis



Ultrafiltration



Distillation



Sewage treatment

- Septic tanks in rural areas
- Sewage treatment in urban areas
  - Primary, secondary, tertiary
- Separate networks of pipes in cities
  - Better but expensive
  - Paris

Septic tank systems

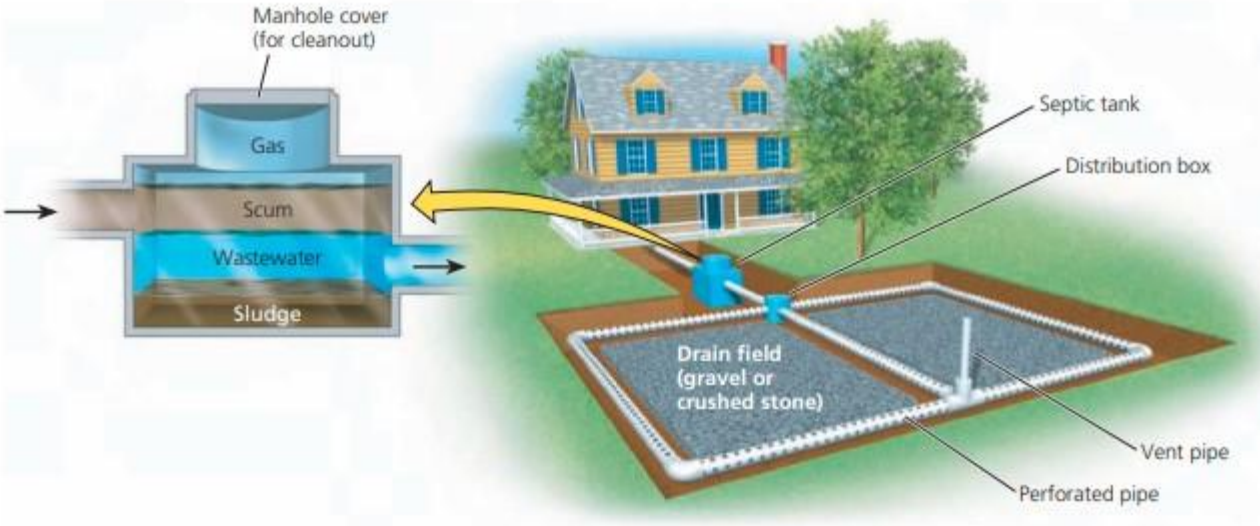


Figure 20-19 **Solutions:** *Septic tank systems* are often used for disposal of domestic sewage and wastewater in rural and suburban areas.

Sewage treatment systems

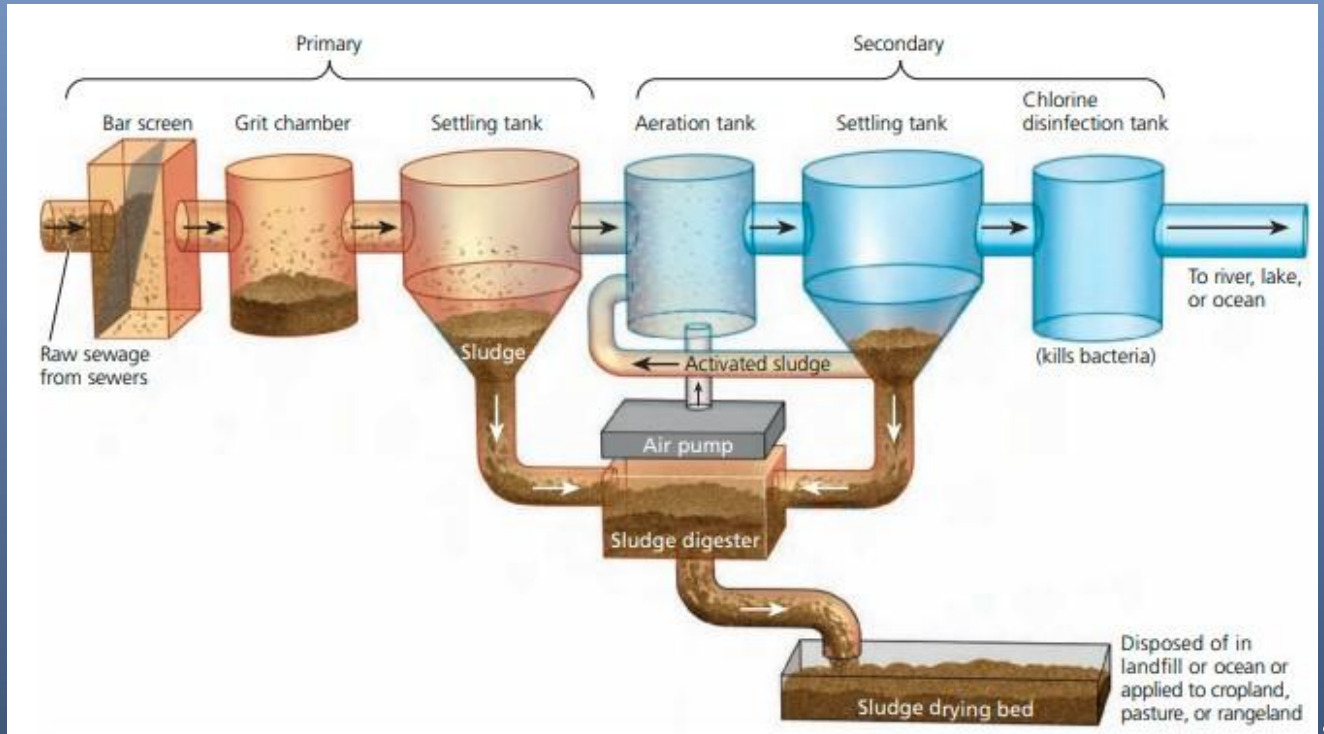
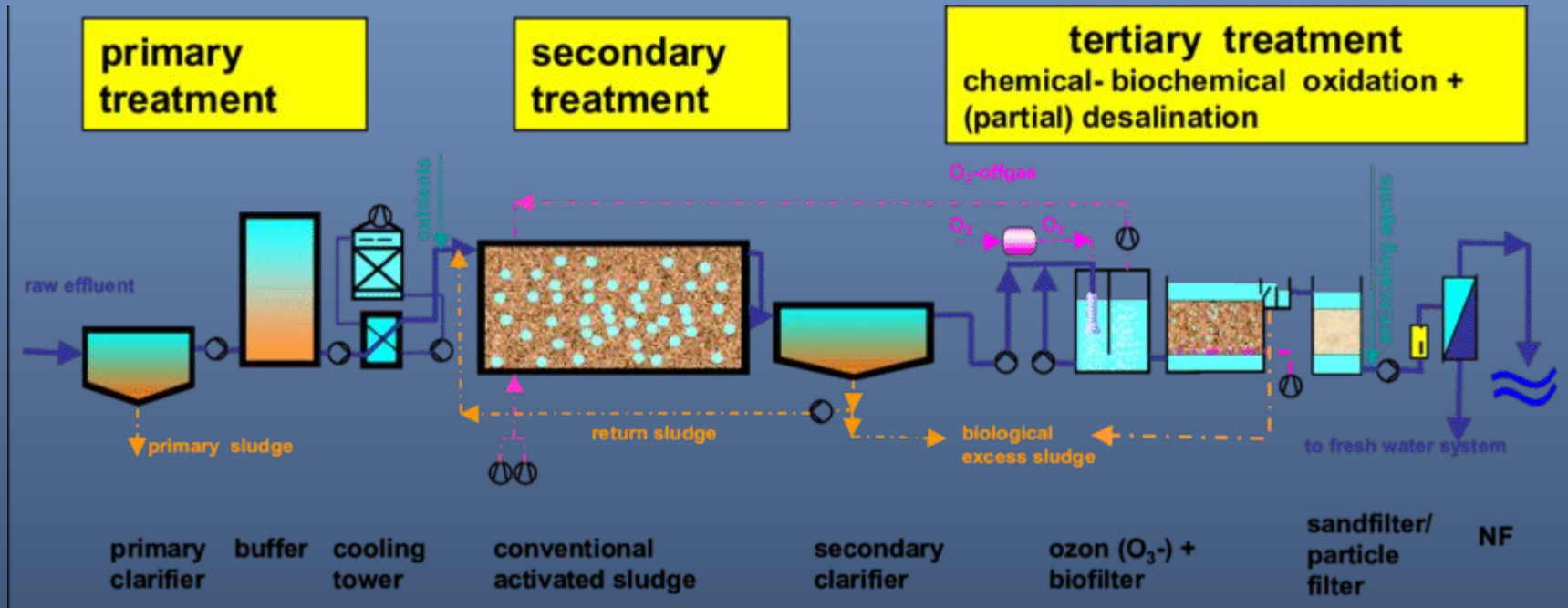


Figure 20-20 **Solutions:** Primary and secondary sewage treatment systems help to reduce water pollution.
Question: What do you think should be done with the sludge produced by sewage treatment plants?


primary treatment
secondary treatment
tertiary treatment
chemical- biochemical oxidation + (partial) desalination
raw effluent
nutrients
O_2-offgas
O_2
O_3
scaling agents
primary sludge
return sludge
biological excess sludge
to fresh water system
primary clarifier
buffer
cooling tower
conventional activated sludge
secondary clarifier
ozon (O_3-) + biofilter
sandfilter/ particle filter
NF

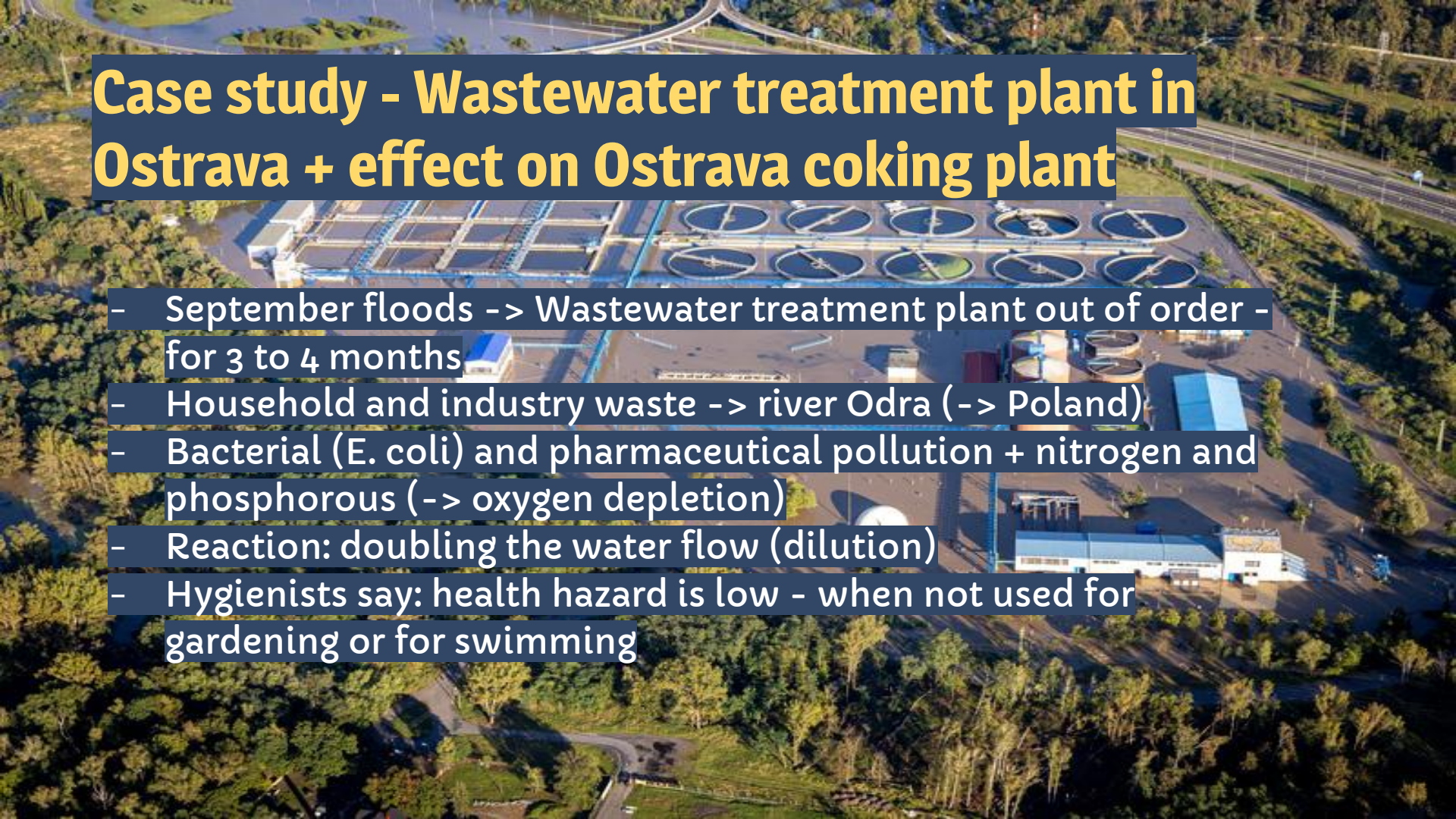
Average person solutions

- Use of technologies (filters)
- Agriculture solutions in small scale
- General use of water resources
- Education
  - Informing and educating
  - STOP to:
    - Water fresheners in toilets
    - Flushing medicine down the toilet
    - Pouring harmful chemicals (paints, solvents, pesticides etc.) down the drain

Case Study

Flooding throughout the Czech Republic in September impacted wastewater treatment facilities in Ostrava

Case study - Wastewater treatment plant in Ostrava + effect on Ostrava coking plant



- September floods -> Wastewater treatment plant out of order - for 3 to 4 months
- Household and industry waste -> river Odra (-> Poland)
- Bacterial (E. coli) and pharmaceutical pollution + nitrogen and phosphorous (-> oxygen depletion)
- Reaction: doubling the water flow (dilution)
- Hygienists say: health hazard is low - when not used for gardening or for swimming

Case study - Wastewater treatment plant in Ostrava + effect on Ostrava coking plant

- Ostrava coking plant: storing phenol-ammonia wastewater
- Transport to Deza in Krásná nad Bečvou
- In total, 10 wastewater treatment plants out of order after the floods in CZE


QUIZ TIME!

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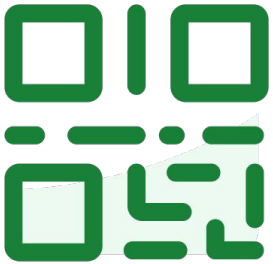

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What is one major impact of nitrate contamination in groundwater?

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What is NOT a categorical method of groundwater purification?

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What is eutrophication?

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Aeration is what type of process?

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Which category of solutions doesn't exist?

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Is water pollution fee an effective solution?

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Heavy metals like lead, mercury, and arsenic in water sources are primarily dangerous because:

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Freshwater ecosystems are important for which of the following reasons?

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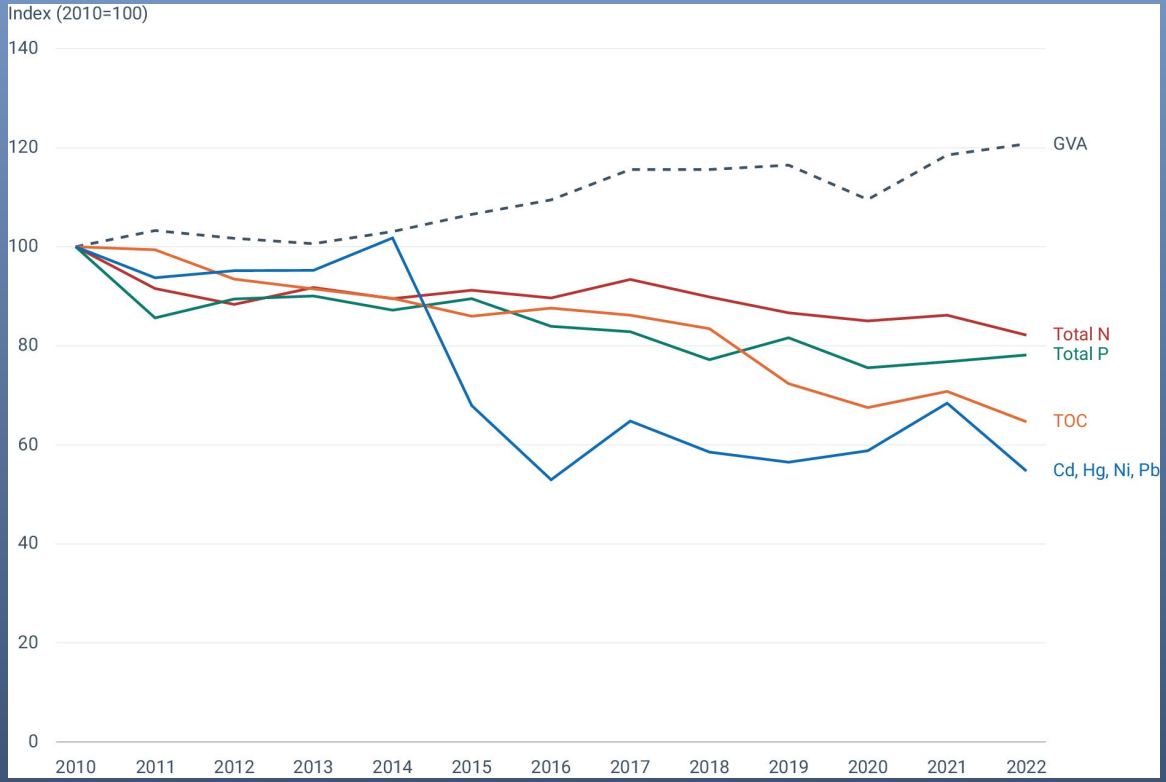
Industrial releases of pollutants to water and economic activity in the EU-27



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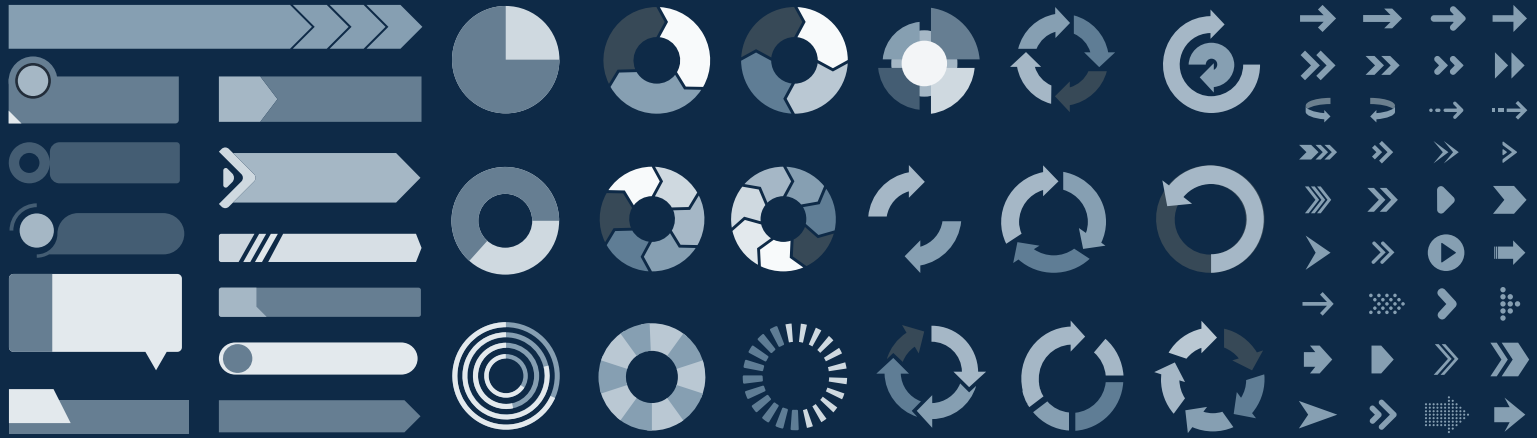






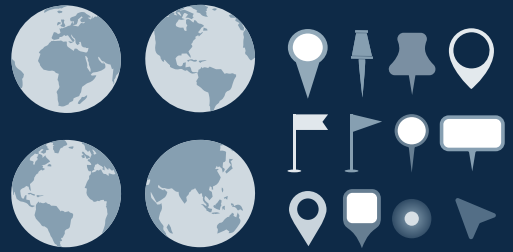

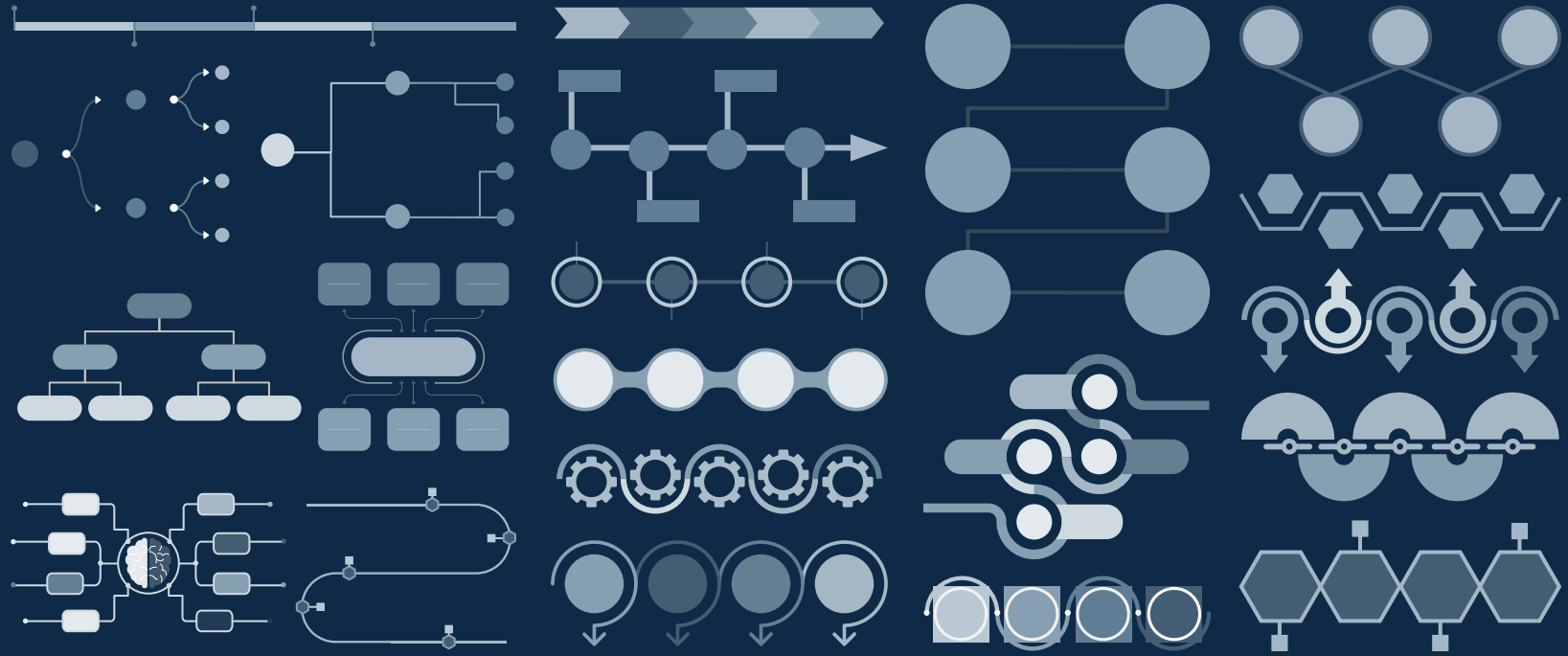

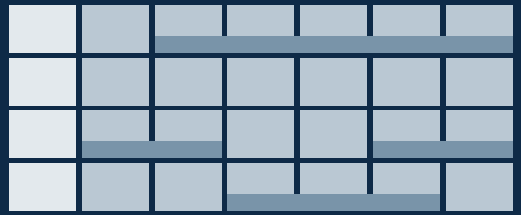

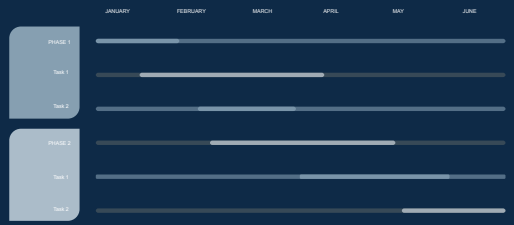
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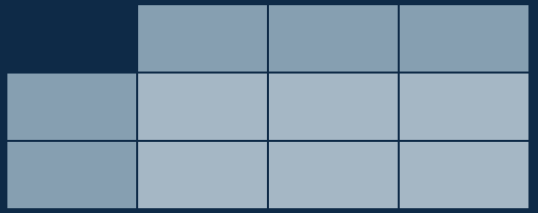

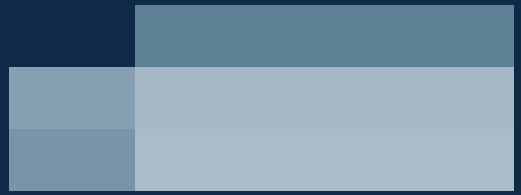

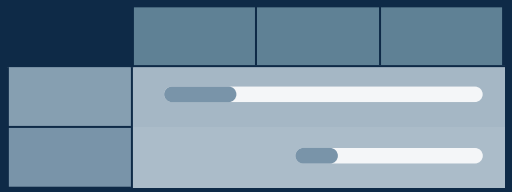

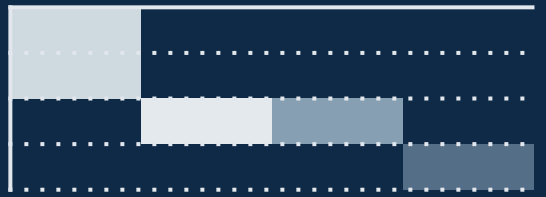

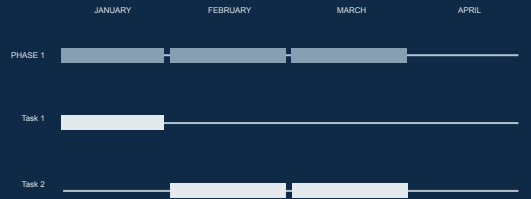
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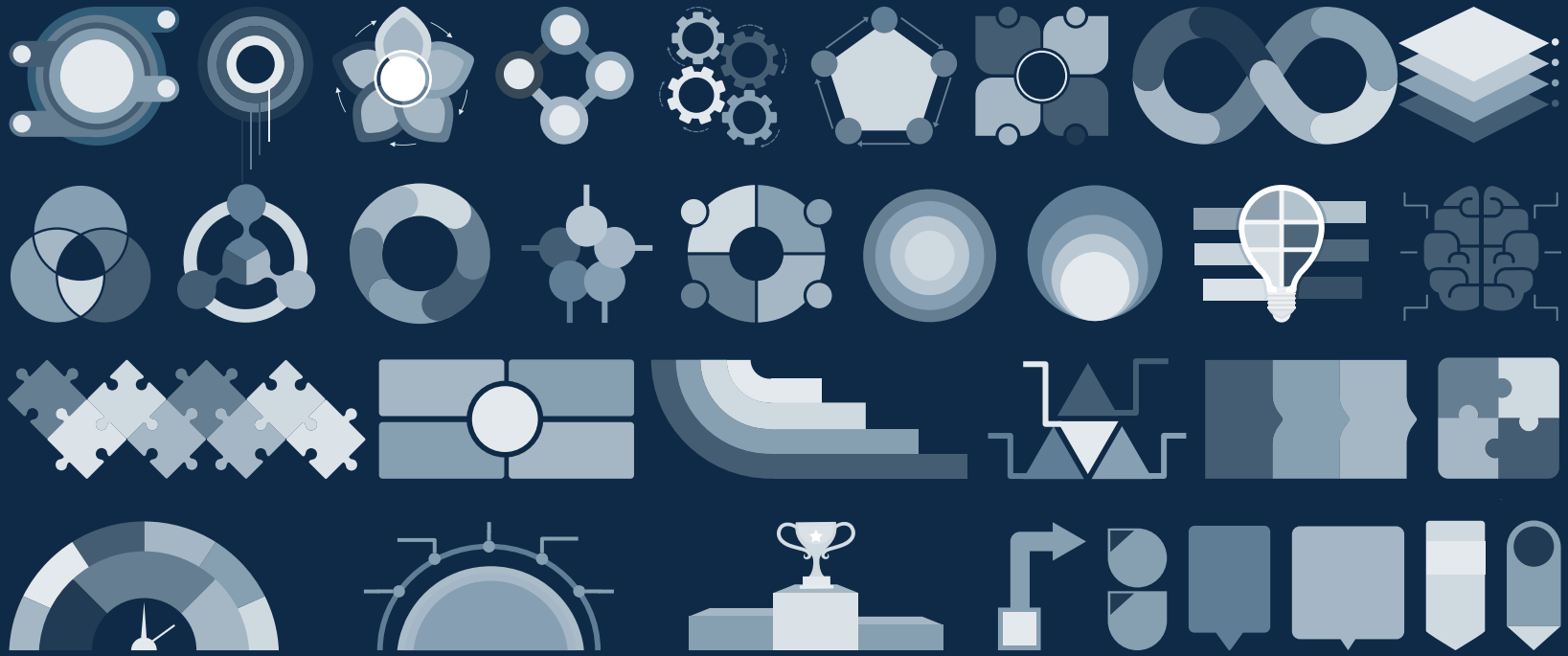

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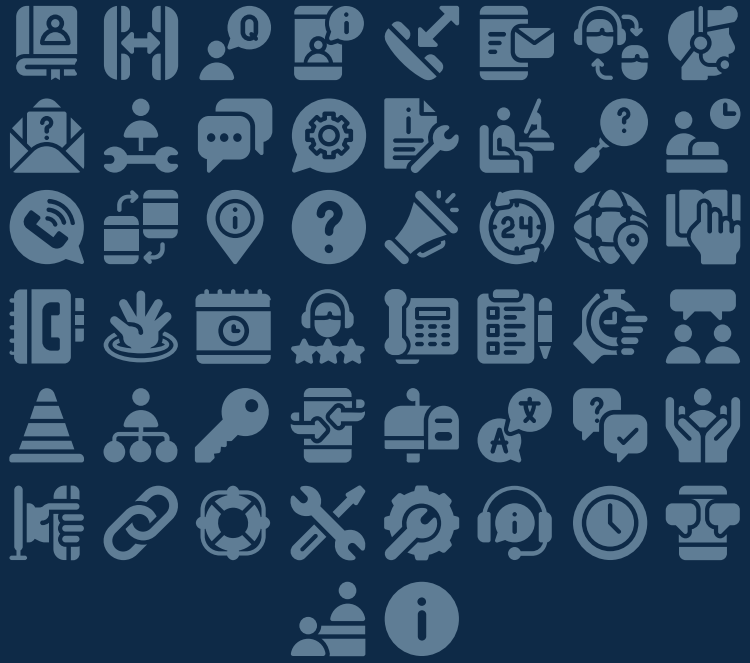

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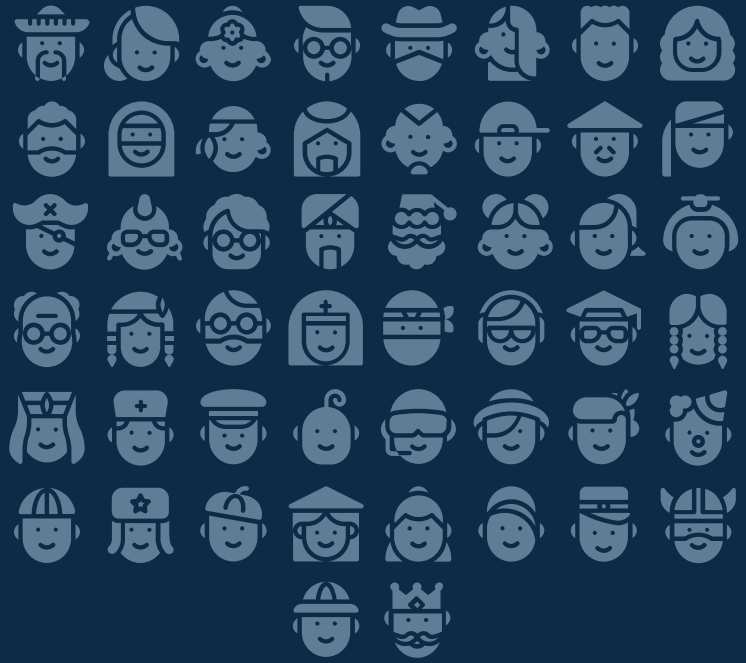

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