



INTRODUCTION TO ENVIRONMENTAL HEALTH ILLNESS AND PREVENTION

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OBJECTIVES

1. To understand the definition of environmental health and components of the environment
2. To describe the interaction between humans and the environment
3. To understand common concepts in environmental health; exposome, environmental risk transition, sensitive populations
4. To understand the framework for disease prevention in environmental health
5. To identify global environmental health priorities
6. To describe environmental health situation globally
7. To identify air pollutants, their sources and effects
8. To describe water sources and the hydrological cycle
9. To identify water pollutants, their sources and effects
10. To describe methods for prevention of air and water pollution
11. To identify diseases attributed to environmental pollution



OVERVIEW OF ENVIRONMENTAL HEALTH



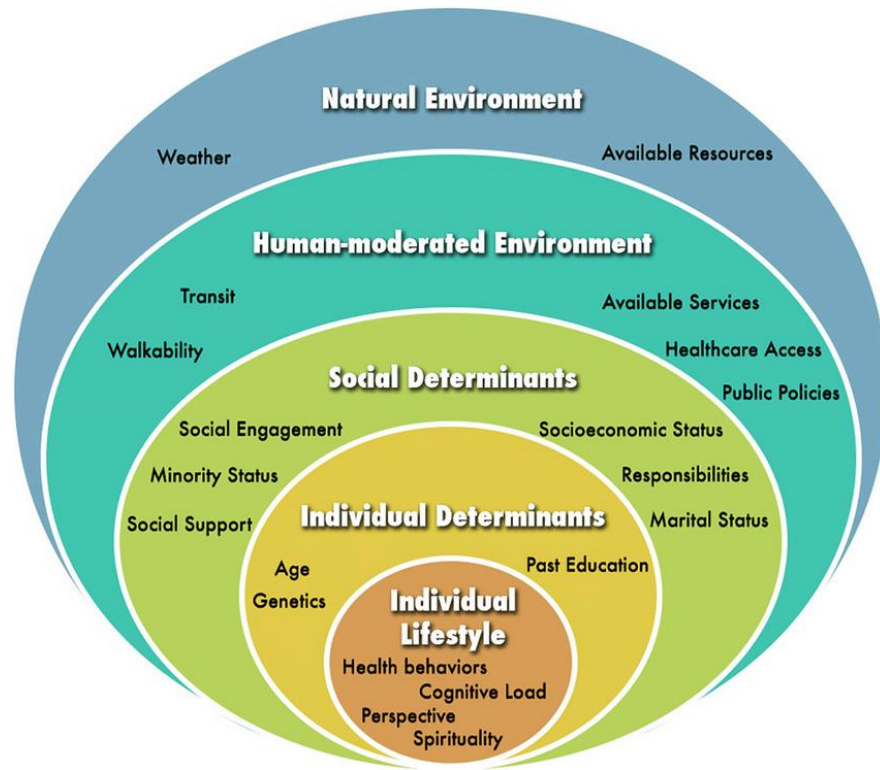
WHAT IS ENVIRONMENTAL HEALTH?

Environmental health is the branch of public health that focuses on preventing human injury and illness and promoting health and well-being by:

- identifying and evaluating environmental sources
- implementing policies and programs to reduce chemical and other environmental exposures in air, water, soil and food



COMMON TERMINOLOGY IN ENVIRONMENTAL HEALTH



Environment

- The complex of physical, chemical, and biotic factors that act upon an organism or an ecological community and ultimately determine its form and survival

Ecological system (ecosystem)

- Dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit.

Ecological model

- Proposes that the determinants of health interact and are interlinked over the life course of individuals

Exposome

- the measure of all the exposures of an individual in a lifetime and how those exposures relate to health.

COMPONENTS OF THE ENVIRONMENT

1. Physical environment
 - Noise, radiation
2. Chemical
 - Air, toxic waste, pesticides, water
3. Biological environment
 - Disease organisms, allergens, insects
4. Social environment
 - Culture, habits, access to healthcare

ENVIRONMENTAL EXPOSURES THAT IMPACT HUMAN HEALTH



- Air
- Water
- Food
- Soil
- Land cover
- Other living creatures
- Weather
- Waste
- The built environment
- Radiation

SENSITIVE POPULATIONS



Intrinsic Factors

- Age
- Sex
- Genetics
- Race/Ethnicity

Acquired Factors

- Chronic medical conditions
- Health care access
- Nutrition/Fitness
- Social Factors (poverty, employment status, language)

HUMAN FACTORS THAT IMPACT THE ENVIRONMENT

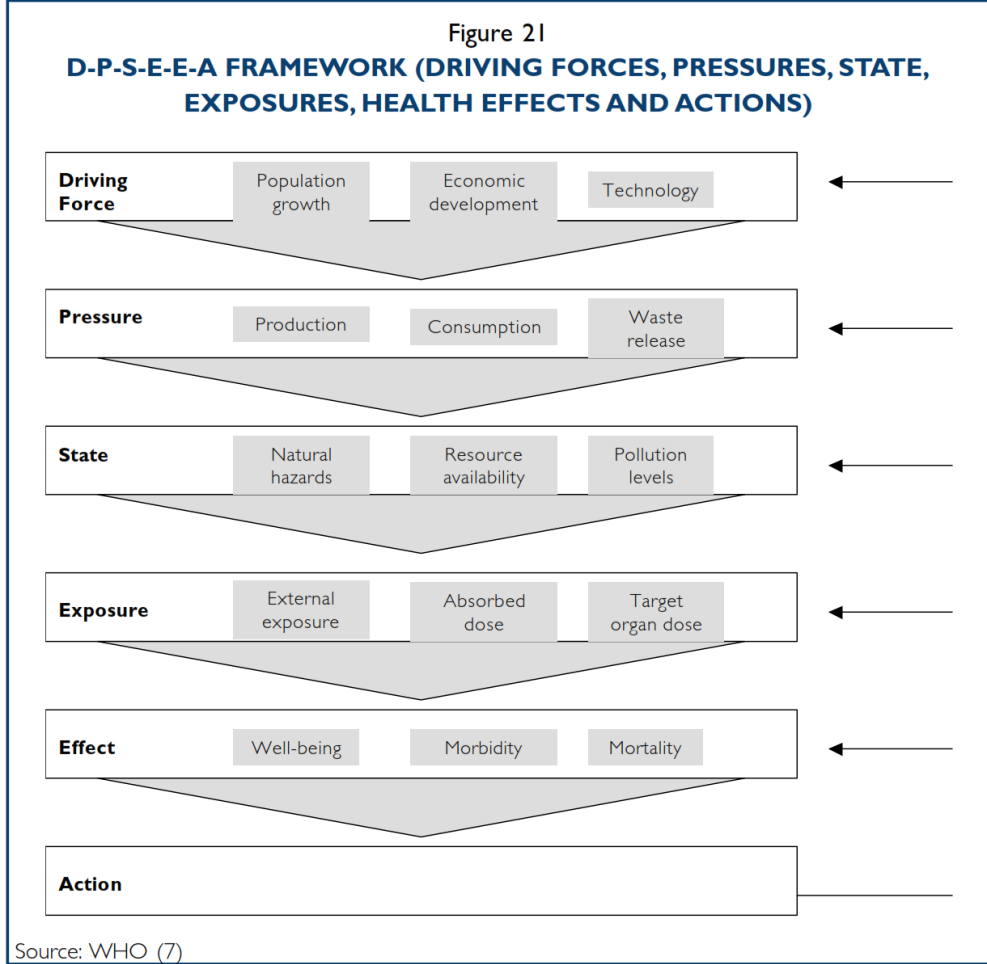


- Population
- Industry
- Mining
- Land use
- Waste
- Recreation
- Animal resource
- Agriculture
- Transportation
- Construction

HOW MANY EARTHS ARE
NEEDED IF EVERYONE
LIVED LIKE YOU?

<https://www.footprintcalculator.org/home/en>





D-P-S-E-E-A FRAMEWORK

GLOBAL ENVIRONMENTAL HEALTH PRIORITIES

Environmental health issues in developing countries resulting in significant mortality:

- Unsafe water, poor sanitation, and hygiene
- Indoor smoke (cookstoves)
- Vector-borne disease
- Urban air pollution
- Road traffic accidents
- Lead exposure
- Unintentional poisonings
- Climate change

ENVIRONMENTAL RISK TRANSITION

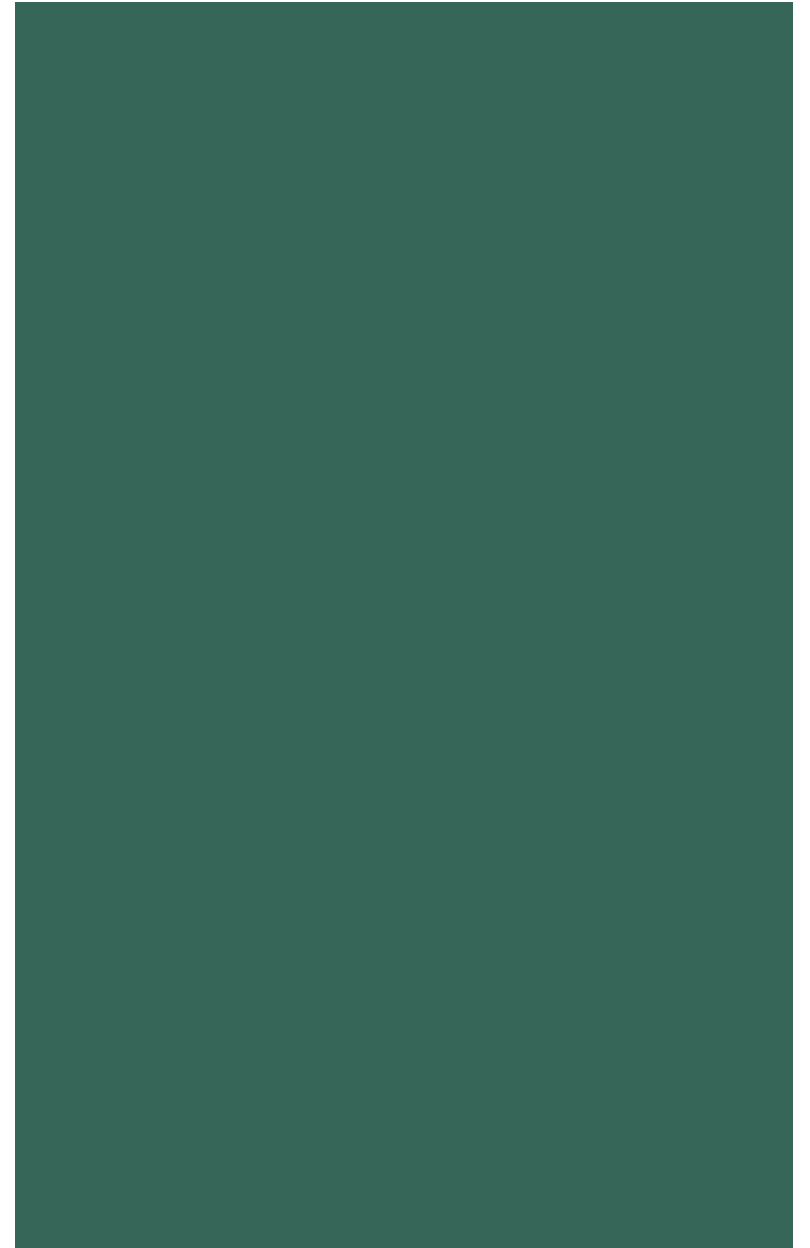
Less developed:

- poor water/ sanitation/hygiene >> diarrheal diseases
- indoor air pollution >> respiratory diseases
- poor housing quality >> infectious diseases

More developed (industrialized):

- long-term and long-range pollutant
- such as acid rain precursors
- ozone-depleting chemicals
- greenhouse gases >>>>> climate change

AIR POLLUTION DISEASES AND PREVENTION



CRITERIA AIR POLLUTANTS

TABLE 10.2 National Ambient Air Quality Standards for Criteria Air Pollutants

| Pollutant | | Primary/ Secondary | Averaging Time | Level | Form |
|-------------------------------------|-------------------|-----------------------|-------------------------|------------------------|---|
| Carbon monoxide (CO) | | Primary | 8 hours | 9 ppm | Not to be exceeded more than once per year |
| | | | 1 hour | 35 ppm | |
| Lead (Pb) | | Primary and secondary | Rolling 3-month average | 0.15 µg/m ³ | Not to be exceeded |
| Nitrogen dioxide (NO ₂) | | Primary | 1 hour | 100 ppb | 98 th percentile of 1-hour daily maximum concentrations, averaged over 3 years |
| | | Primary and secondary | 1 year | 53 ppb | Annual mean |
| Ozone (O ₃) | | Primary and secondary | 8 hours | 0.070 ppm | Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years |
| Particulate pollution (PM) | PM _{2.5} | Primary | 1 year | 12 µg/m ³ | Annual mean, averaged over 3 years |
| | | Secondary | 1 year | 15.0 µg/m ³ | Annual mean, averaged over 3 years |
| | | Primary and secondary | 24 hours | 35 µg/m ³ | 98 th percentile, averaged over 3 years |
| | PM ₁₀ | Primary and secondary | 24 hours | 150 µg/m ³ | Not to be exceeded more than once per year on average over 3 years |
| Sulfur dioxide (SO ₂) | | Primary | 1 hour | 75 ppb | 99 th percentile of 1-hour daily maximum concentrations, averaged over 3 years |
| | | Secondary | 3 hours | 0.5 ppm | Not to be exceeded more than once per year |

Modified and reproduced from US Environmental Protection Agency. Criteria air pollutants. National Ambient Air Quality Standards (NAAQS) table. Available at: <http://www.epa.gov/criteria-air-pollutants/naqs-table>. Accessed June 18, 2017.

CARBON MONOXIDE (CO)

- Odorless, tasteless, colorless gas
- By product of combustion
- Primary sources are motor vehicles and anything with a combustion engine.
- Other sources: gas-powered stoves, space heaters, water heaters, generators, fireplaces, tobacco smoke, volcanoes, and forest fires.
- Health effects
 - Absorbed in the blood and displaces oxygen from hemoglobin
 - Fatigue, headaches, nausea, dizziness, disorientation, and visual and coordination impairment, angina, cognitive impairment and death.

PARTICULATE MATTER (PM)

- Solid or liquid particles suspended in air
- Can be primary or secondary

Types

1. PM 10
2. PM 2.5
3. Nanoparticles (<0.1)

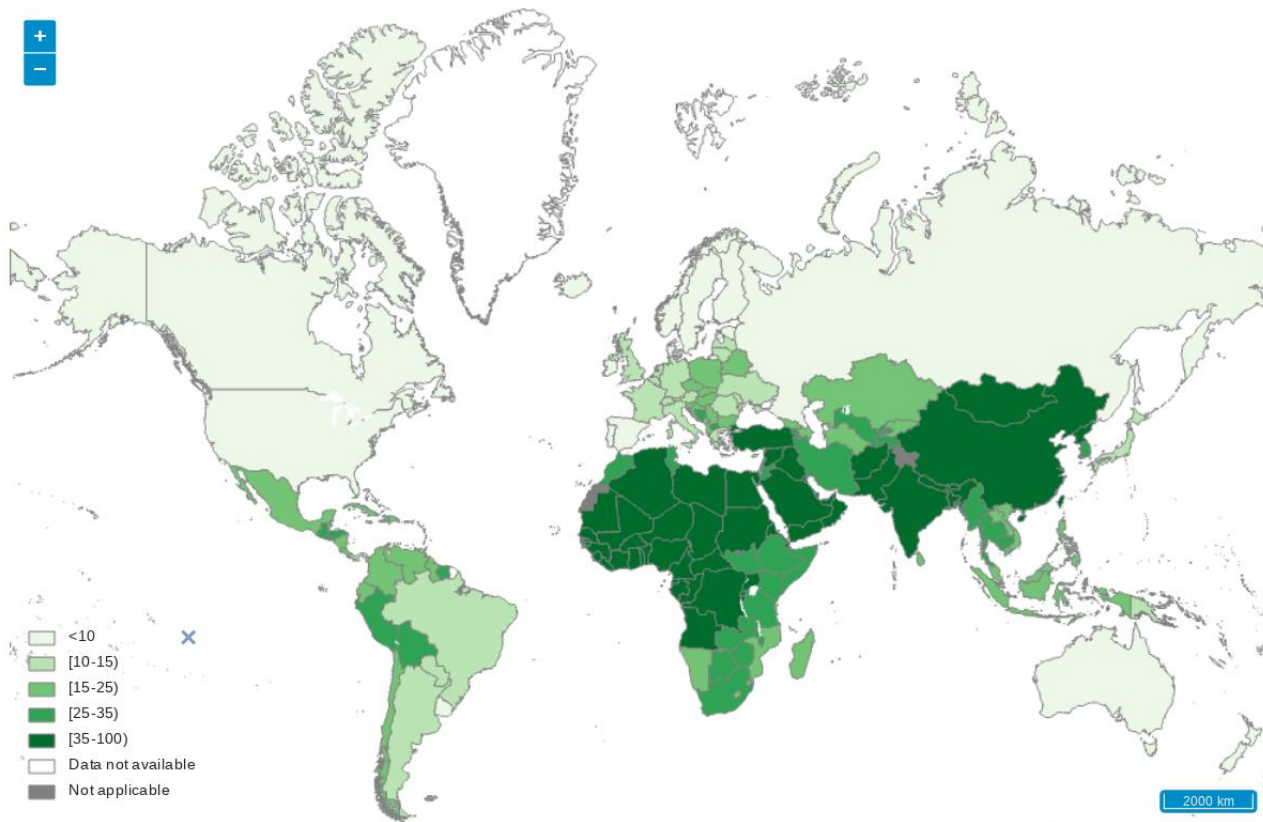
Sources

- a. Manmade: Burning of fuels, driving unpaved roads, industrial activity, combustion process
- b. Natural: dust, mold, pollen, salt spray

PARTICULATE MATTER (PM)

Health effects

- Larger particles deposit in mucous membranes
- Smaller particles can be inhaled and penetrate into the lung and even blood stream (e.g. diesel exhaust)
- Irritation of mucous membranes (eyes, throat, nose)
- Respiratory symptoms
- Exacerbation of chronic pulmonary and cardiac conditions
- Increased ER visits, hospitalizations, and mortality



The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of WHO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

GLOBAL CONCENTRATIONS OF FINE PARTICULATE MATTER PM2.5.

SULPHUR DIOXIDE SO₂

- Water soluble gas
- Primarily produced by power plants
- Produced from burning sulfur containing fuels; e.g. coal
- Natural sources are volcanoes
- Can be converted to sulfuric acid and contributes to acid rain formation
- Health effects: respiratory symptoms, hospitalizations from cardiovascular and respiratory causes, eye irritation, adverse pregnancy outcomes, and mortality

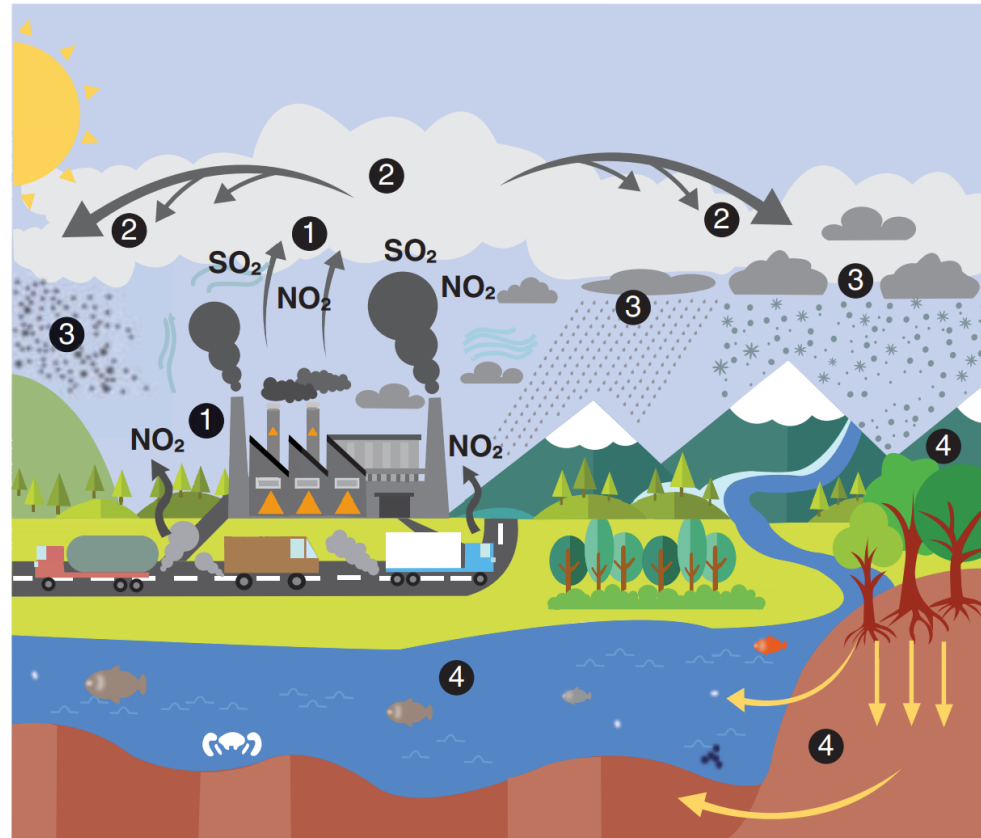


FIGURE 10.11 Acid rain pathway.

* Numbers shown in figure refer to the pathway for acid rain in our environment.

¹ Emissions of SO₂ and NO_x are released into the air.

² The pollutants are transformed into acid particles that may be transported long distances.

³ These acid particles then fall on earth as dust, rain, snow, and other materials.

⁴ The acid rain particles may cause harmful effects on soil, forests, streams, and lakes.

Reproduced from US Environmental Protection Agency. What is acid rain? Available at: <https://www.epa.gov/acidrain/what-acid-rain>. Accessed June 6, 2017.

NITROGEN OXIDES (NOX)

- Category of gases containing nitrogen and oxygen
- Produced through combustion when nitrogen in air is oxidized
- Precursors of tropospheric ozone and particulate matter
- NO is a greenhouse gas
- NO₂ is a criteria pollutant
- Sources:
 - Motor vehicles, and power plants
 - Indoor kerosene heaters, nonvented gas stoves and heaters, and tobacco smoke.
 - Processes in soil, forest fires, and lightning

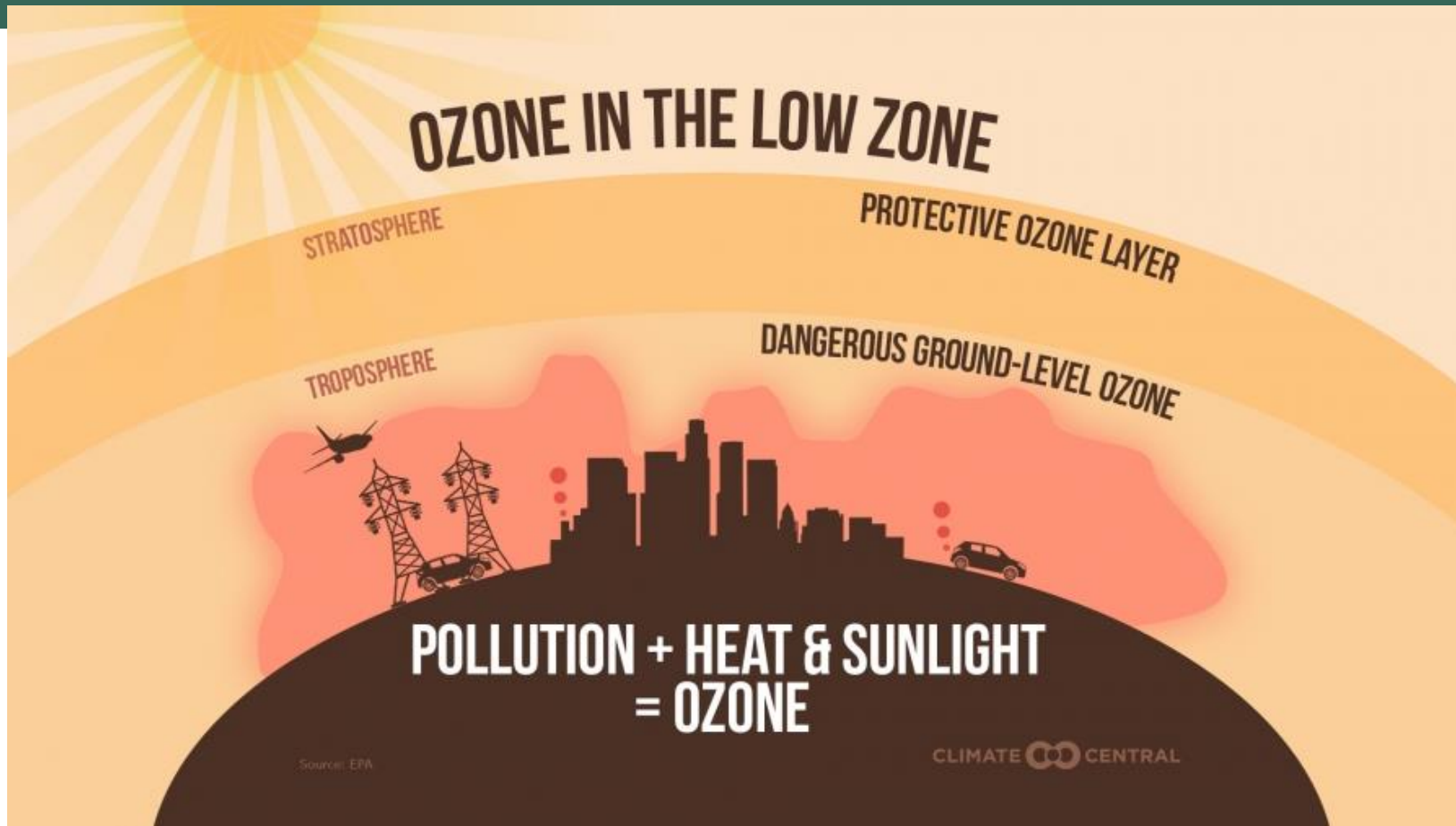
VOLATILE ORGANIC COMPOUNDS (VOCs)

- Group of chemicals that readily evaporate at normal temperature and pressure
- Include benzene, chloroform, formaldehyde
- Produced from transportation, industrial processes, and naturally from vegetation
- Half of VOCs are from transportation, particularly old poorly maintained vehicles
- Precursors of ozone
- Health effects: Irritation of respiratory tract, headaches, and cancer.

OZONE

- Gas in the troposphere (ground-level ozone) and in the stratosphere (ozone layer)
- Groundlevel ozone is harmful, the ozone layer is protective
- Tropospheric ozone is formed from VOCs and Nox with sunlight
- Concentrations are seasonal increasing during hotter months
- Health effects:
 - Respiratory symptoms
 - Decreased lung function
 - Increased ER visits and hospitalizations
 - Children and asthmatics are particularly sensitive

GOOD UP HIGH...BAD NEARBY



URBAN AIR POLLUTION

4.2 million
deaths every year

occur as a result of exposure to ambient
(outdoor) air pollution

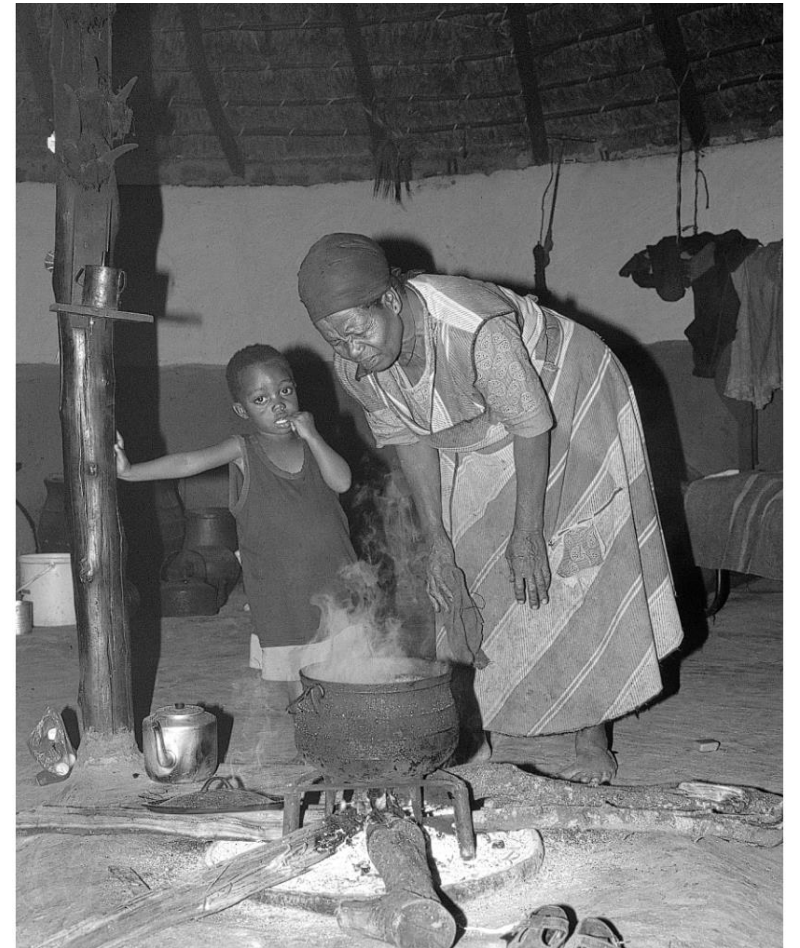
9 out of 10 people

worldwide live in places where air quality
exceeds WHO guideline limits

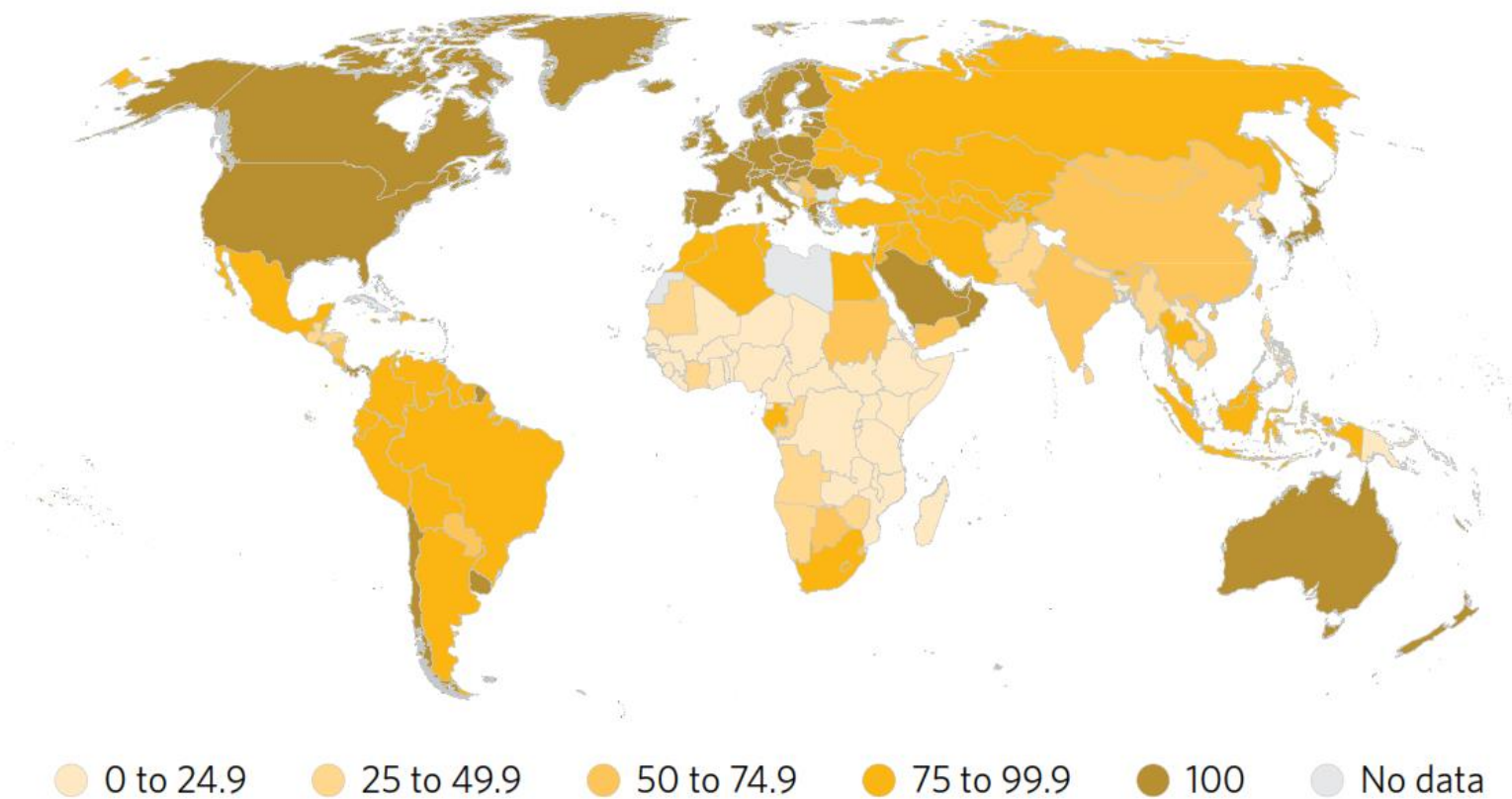
- Composed of PM10 and PM2.5 include pollutants such as sulfate, nitrates and black carbon
- 91% of premature deaths occurred in low and middle-income countries
- Contributes to the burden of disease from stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma.
- Pollution sources include residential energy for cooking and heating, vehicles, power generation, agriculture/waste incineration, and industry.

INDOOR AIR POLLUTION

- 2.6 billion people use open fires and simple stoves fueled by kerosene, biomass, or coal for cooking
- Disproportionately effects poor in low- and middle-income countries
- Rate of access to clean cooking fuels and technologies is 0.1% per year



Share of the population with access to clean cooking systems, 2019 (percentage)



Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

27% from
pneumonia

18% from
stroke

27% from
ischaemic
heart disease

20% from
COPD

8% from lung
cancer

3.8 million

deaths every year as a result of household
exposure to smoke from dirty cookstoves and
fuels



DUST AND SANDSTORMS



- Common weather events in arid and semi-arid regions
- Winds lift large amounts of sand and dust from bare, dry soils
- Transport 1000s of km
- Dust particles can contain various hazardous materials
- Health effects include:
 - respiratory conditions
 - CVD
 - increased ER visits
 - increased mortality

AIR POLLUTION PREVENTION

Standards and regulations

- National Ambient Air Quality Standards (NAAQS)
- Removal of lead from gasoline
- Regulating Co2 emissions from vehicles
- Cap and trade approach
- Regulations targeting environmental change (e.g. desertification)

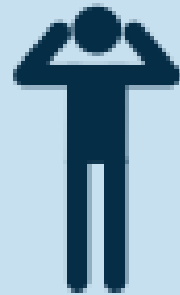
Education and awareness

- Ozone action days
- Carbon monoxide awareness month

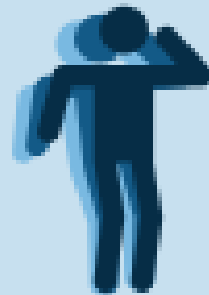
| Air Quality Index (AQI) Values | Levels of Health Concern | Colors |
|---------------------------------------|---------------------------------------|--|
| <i>When the AQI is in this range:</i> | <i>...Air quality conditions are:</i> | <i>...As symbolized by this color:</i> |
| 0 to 50 | Good | Green |
| 51 to 100 | Moderate | Yellow |
| 101 to 150 | Unhealthy for sensitive groups | Orange |
| 151 to 200 | Unhealthy | Red |
| 201 to 300 | Very unhealthy | Purple |
| 301 to 500 | Hazardous | Maroon |

Reproduced from US Environmental Protection Agency. Air Quality Index (AQI) basics.
 Available at: <https://airnow.gov/index.cfm?action=aqibasics.aqi>. Accessed June 7, 2017.

WHAT ARE THE SYMPTOMS OF CARBON MONOXIDE POISONING?



HEADACHE



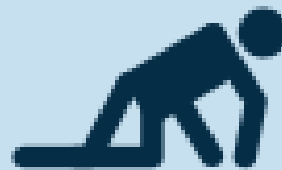
DIZZINESS



NAUSEA



BREATHLESSNESS



COLLAPSE



LOSS OF CONSCIOUSNESS


AIR QUALITY IN SAUDI ARABIA

| Parameter | Time-weighted average $\mu\text{g}/\text{Nm}^3$ (ppm) | Averaging time | Number of allowable exceedances ² |
|---|---|----------------|--|
| Carbon Monoxide | 10,000 (8.1) | 8 hours | None |
| | 40,000 (32) | 1 hour | |
| Lead | 0.5 (0.00005) | Annual | N/A |
| Nitrogen Dioxide | 660 (0.35) | 1 hour | 2 times per 30 days |
| | 100 (0.05) | Annual | N/A |
| Sulphur Dioxide | 730 (0.28) | 1 hour | 2 times per annum |
| | 365 (0.14) | 24 hour | 1 time per annum |
| | 80 (0.03) | Annual | N/A |
| Benzene | 5 (0.0015) | Annual | N/A |
| Particulate Matter (PM ₁₀) | 340 (variable) | 24 hour | 24 times per annum ³ |
| | 80 (variable) | Annual | N/A |
| Particulate Matter (PM _{2.5}) | 35 | 24 hour | 24 times per annum ⁴ |
| | 15 | Annual | N/A |
| Ozone | 235 (0.12) | 1 hour | 2 times per 30 days |
| Ozone | 157 (0.08) | 8 hour | 2 times per 7 days |
| Hydrogen Sulphide | 150 (0.01) | 24 hour | 10 times per annum |
| | 40 (0.03) | Annual | N/A |

In 2012 the Kingdom of Saudi Arabia's Presidency of Meteorology and Environment produced a new national Environmental Standards for 3 different air quality standards:

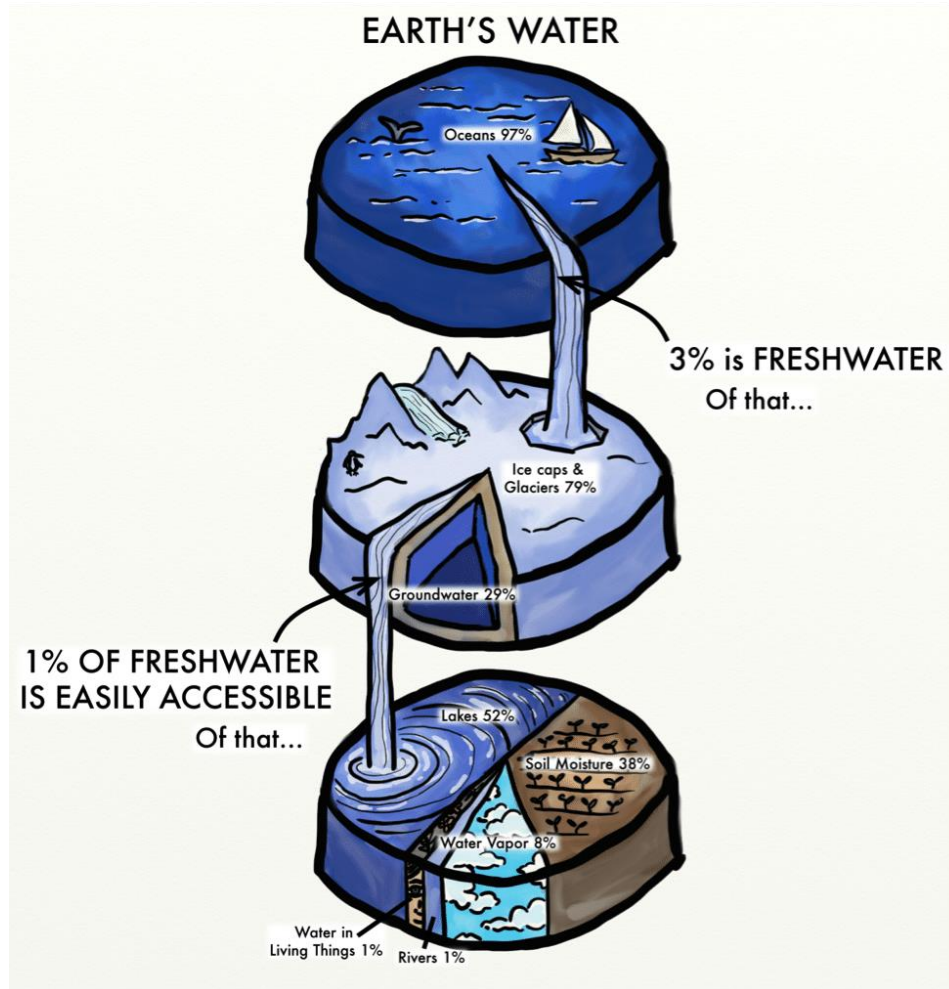
- I. Ambient Air Quality
- II. Mobile Source Emissions
- III. Emissions from Stationary Sources

What's the air quality in Riyadh now?



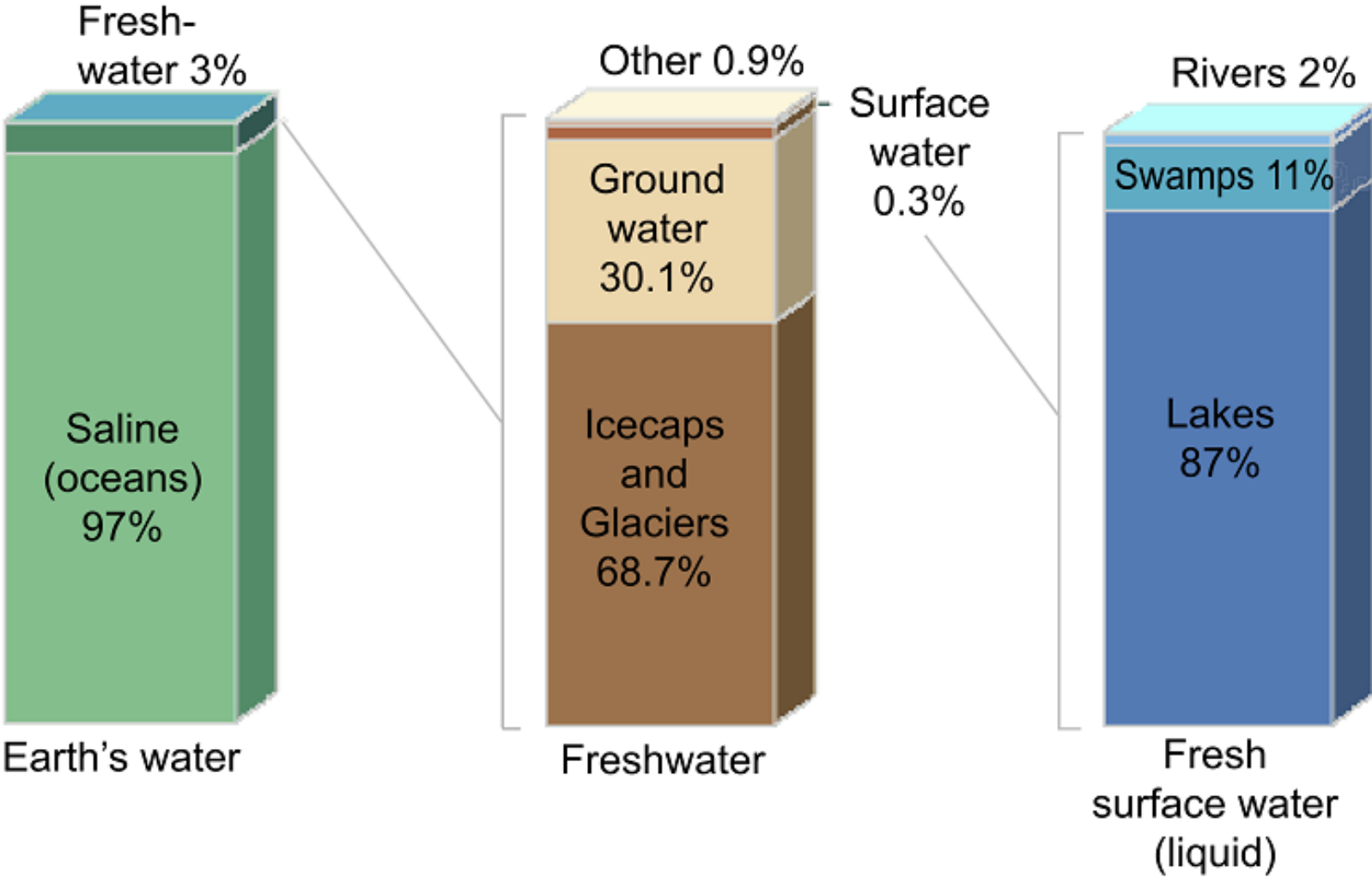
WATER POLLUTION DISEASES AND PREVENTION

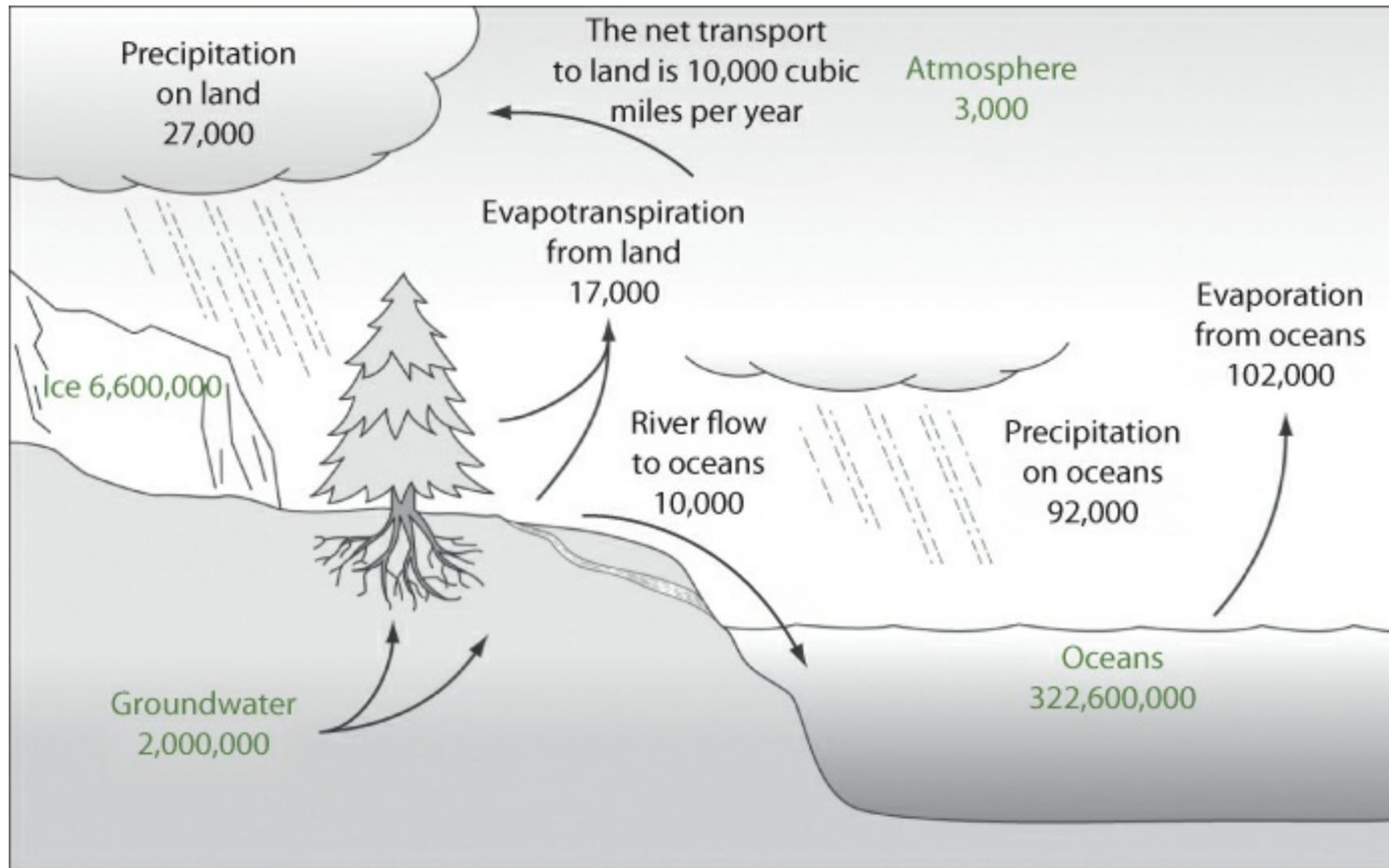




WHERE DO
HUMANS GET
WATER?

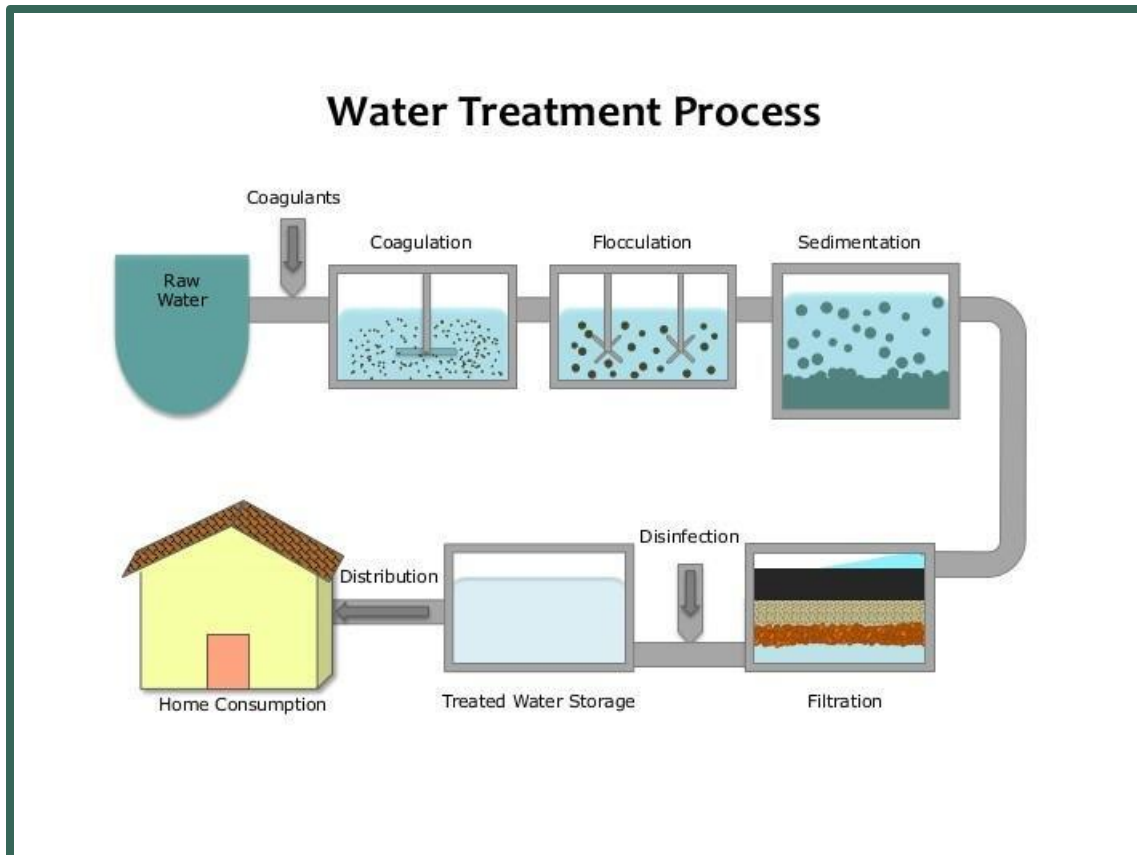
Distribution of Earth's Water





The Hydrological Cycle

WATER TREATMENT



- Processing of water takes place in water treatment plants
- There are four stages of water treatment : coagulation, sedimentation, filtration, and disinfection.

MICROBIAL WATER POLLUTION



- Water can be contaminated with various organisms including bacteria, viruses, helminths, protozoa
- Surface and groundwater contamination due to poor sanitation primarily
- Human health effects occur due to ingestion or other contact with polluted water
- Examples: Cholera, schistosomiasis (bilharzia), cryptosporidiosis, cercariasis (swimmers itch), legionellosis

Table 16.7 The Indicator Approach to Monitoring Water Quality

| Indicator | What does it indicate | Limitations |
|---|---|--|
| Coliforms | Presence of the coliform group of bacteria, many of which are present in human or animal fecal material. | Certain coliforms grow naturally in drinking-water biofilms, particularly at warmer temperatures. Not indicative of protozoa or viruses. |
| <i>E. coli</i> | Presence of <i>E. coli</i> ; strong indication of fecal contamination. | Inactivated more rapidly than other pathogens. Not indicative of protozoa or viruses. |
| Coliphages | Indicative of the presence of viruses specific to <i>E. coli</i> . | May or may not be indicative of viral pathogens. Not indicative of protozoa or bacteria. |
| Enterococci | May be indicative of presence of animal wastes as well as human waste. | Not indicative of protozoa or viruses. |
| <i>Clostridium</i> | Spore-forming bacteria; anaerobes; protozoa. | Not indicative of viruses. |
| <i>Pseudomonas</i> | Survives in drinking-water biofilms; may indicate presence of bacterial pathogens that are more persistent than coliforms. | Not indicative of protozoa or viruses. |
| Aeromonads | Survive in drinking-water biofilms; may indicate presence of bacterial pathogens that are more persistent than the coliforms. | Not indicative of protozoa or viruses. |
| Human-specific <i>Bacteroides fragilis</i> bacteriophages | Indicative of the presence of viruses specific to <i>B. fragilis</i> ; may be present when coliphages are absent. | May or may not be indicative of viral pathogens. Not indicative of protozoa or bacteria. |
| Turbidity | May indicate that the water exceeds turbidity regulations. Some studies show increased risk for waterborne disease at high turbidity (pathogens adhere to particles). | Measures only turbidity; cannot be directly correlated to pathogen loading. |
| Residual chlorine | Measures the disinfectant residual at the tap. Absence of residual chlorine has been shown in some studies to be consistent with waterborne disease. | Measures only residual chlorine; cannot be directly correlated to pathogen loading. |

CHEMICAL WATER POLLUTION

Anthropogenic

- Point source: a stationary location or fixed facility from which pollutants are discharged. E.g. a pipe, industrial plant, ship
- Nonpoint sources are diffuse pollution sources without a single point of origin. E.g. runoff
- Other examples: leaching of wastes into groundwater, lead leaching from old drinking-water pipes, and pharmaceuticals and personal care products (PPCPs) that are released into water from human sewage.

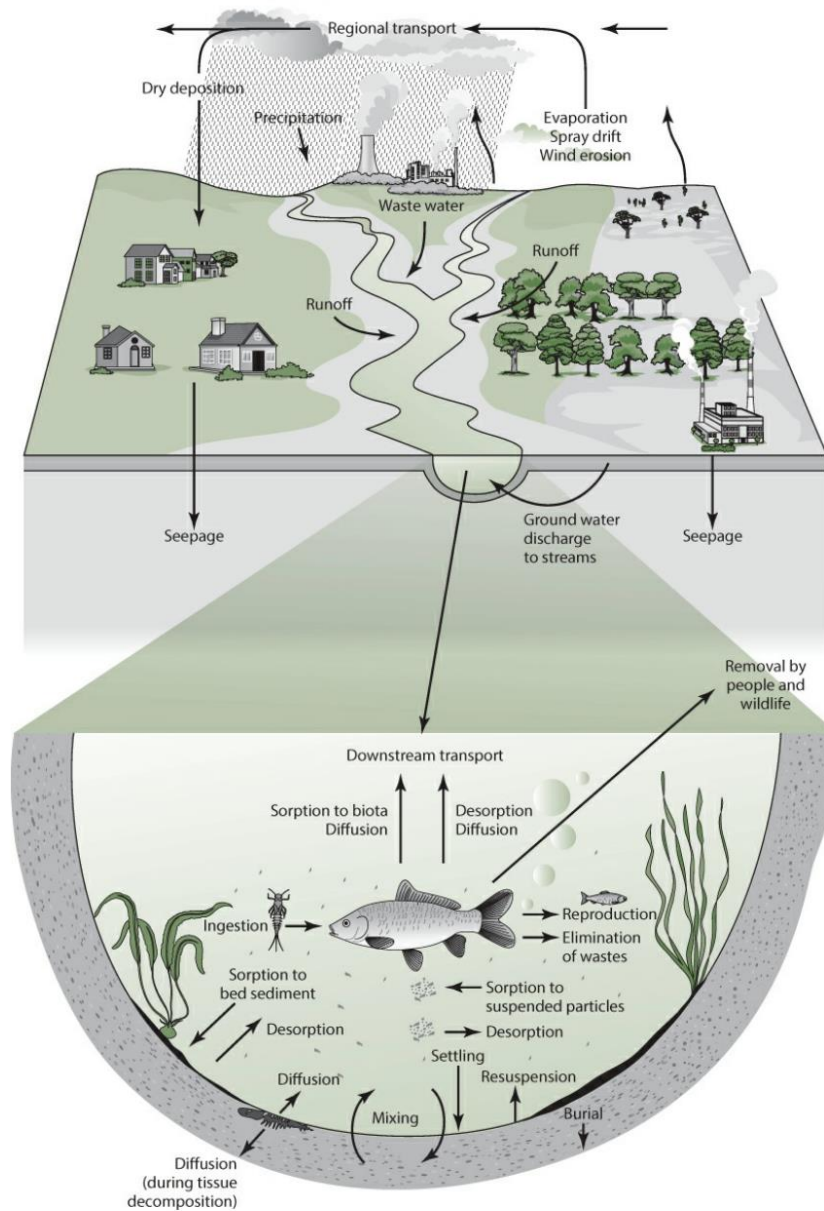


Figure 16.3 Pesticide Movement in the Hydrological Cycle, Including Movement to and from Sediment and Aquatic Biota in a Stream



WATER, SANITATION, AND HYGIENE (WASH)

WHAT IS CLEAN WATER?

Water that is free from:

- disease-causing microbes including bacteria, viruses, protozoa, and worms
- High concentrations of anthropogenic chemical contaminants (e.g. pesticides, nitrates, microplastics, other industrial pollutants)
- High concentrations of naturally occurring contaminants such as arsenic and flouride

WHAT IS BASIC SANITATION?

Sanitation facilities that are effective in separation of excreta from human contact and prevention of human fecal pollution of the environment.

Examples:

- Flush or pour-flush toilets
- Latrine connected to a pipe sewer
- Septic tank
- Pit latrine
- Composting toilet

GLOBAL WASH SITUATION

BILLIONS OF PEOPLE STILL LACK ACCESS TO SAFE DRINKING WATER, SANITATION AND HYGIENE

IN 2020



2 BILLION PEOPLE

26%

LACK
SAFELY MANAGED
DRINKING WATER



3.6 BILLION PEOPLE

46%

LACK
SAFELY MANAGED
SANITATION



2.3 BILLION PEOPLE

29%

LACK
BASIC
HYGIENE

- 771 million people lack even basic drinking water
- 1.7 billion people without basic sanitation
- 494 million practice open defecation
- 1 in 3 people lacked basic handwashing at home and 670 million had no handwashing facility at all



TWO IN FIVE

**HEALTH CARE FACILITIES
WORLDWIDE HAVE**

NO

**SOAP AND WATER OR
ALCOHOL-BASED
HAND RUB**

[2016]

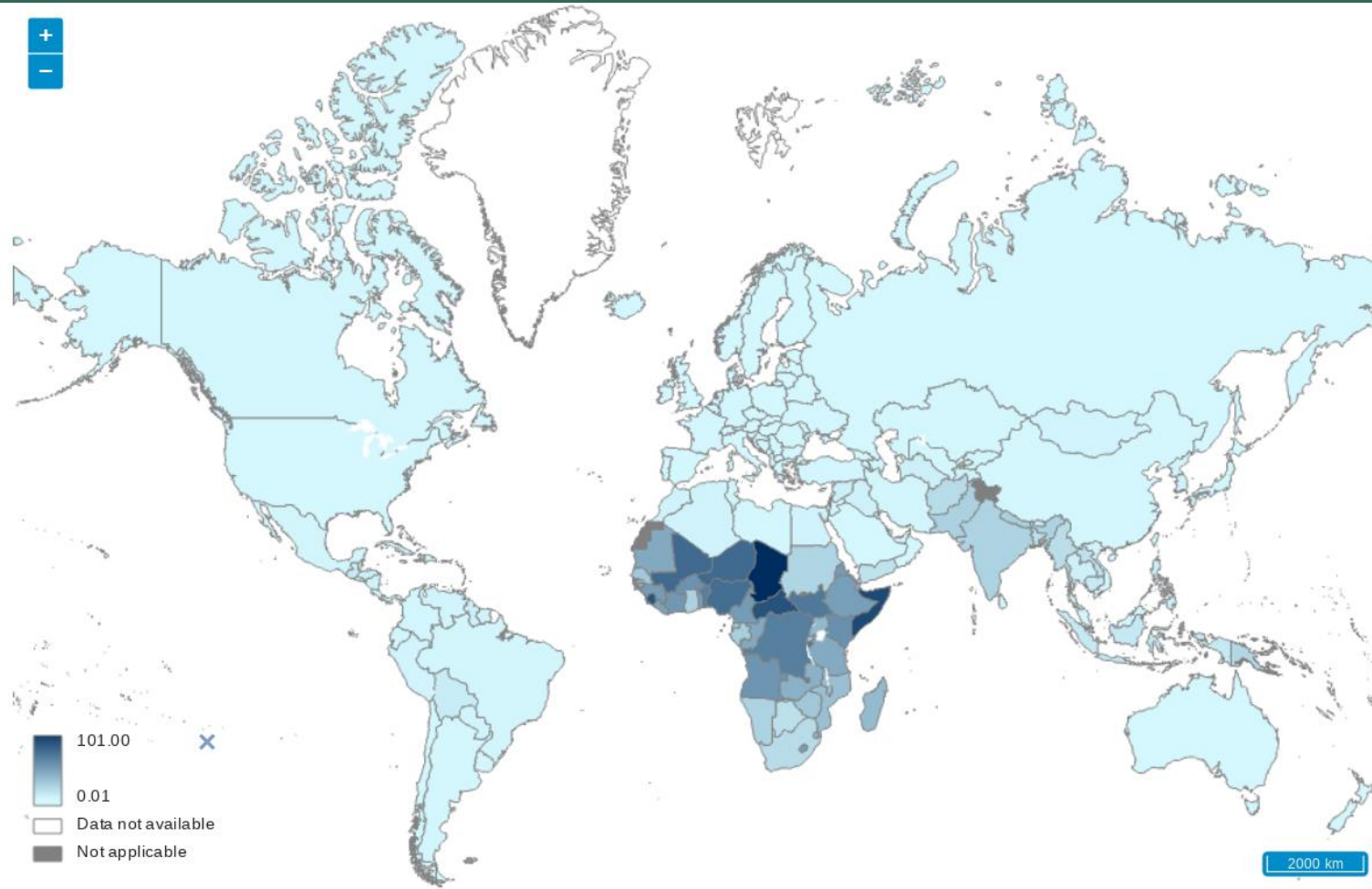


WASH- ASSOCIATED HEALTH EFFECTS

- Diarrheal diseases
- Schistosomiasis
- Soil transmitted helminth and trachoma infections
- Respiratory tract infections
- Malnutrition
- Vector-borne diseases (e.g. Malaria)

Table 1. | Disease burden from inadequate WASH, 2016^a

| DISEASE | DEATHS | DALYS (THOUSANDS) | POPULATION- ATTRIBUTABLE FRACTION |
|--|-------------------------|----------------------|---|
| Diarrhoeal diseases | 828 651 | 49 774 | 0.60 |
| Soil-transmitted helminth infections | 6 248 | 3 431 | 1 |
| Acute respiratory infections | 370 370 | 17 308 | 0.13 |
| Malnutrition ^b | 28 194 | 2 995 | 0.16 |
| Trachoma | <10 | 244 | 1 |
| Schistosomiasis | 10 405 | 1 096 | 0.43 |
| Lymphatic filariasis | <10 | 782 | 0.67 |
| <i>SUBTOTAL: drinking-water, sanitation and hygiene</i> | <i>1 243 869</i> | <i>75 630</i> | <i>NA</i> |
| Malaria | 354 924 | 29 708 | 0.80 |
| Dengue | 38 315 | 2 936 | 0.95 |
| Onchocerciasis | <10 | 96 | 0.10 |
| <i>SUBTOTAL: water resource management</i> | <i>393 239</i> | <i>32 740</i> | <i>NA</i> |
| Drownings | 233 890 | 14 723 | 0.73 ^c |
| <i>SUBTOTAL: safety of water environments</i> | <i>233 890</i> | <i>14 723</i> | <i>NA</i> |
| TOTAL: inadequate water, sanitation and hygiene | 1 870 998 | 123 093 | NA |



Mortality rate attributed to poor WASH services.

OTHER WASH-ASSOCIATED EFFECTS



HARMFUL CHEMICALS FROM HUMAN
ACTIVITIES AND INDUSTRIAL WASTES SUCH
AS PESTICIDES AND FERTILISERS.



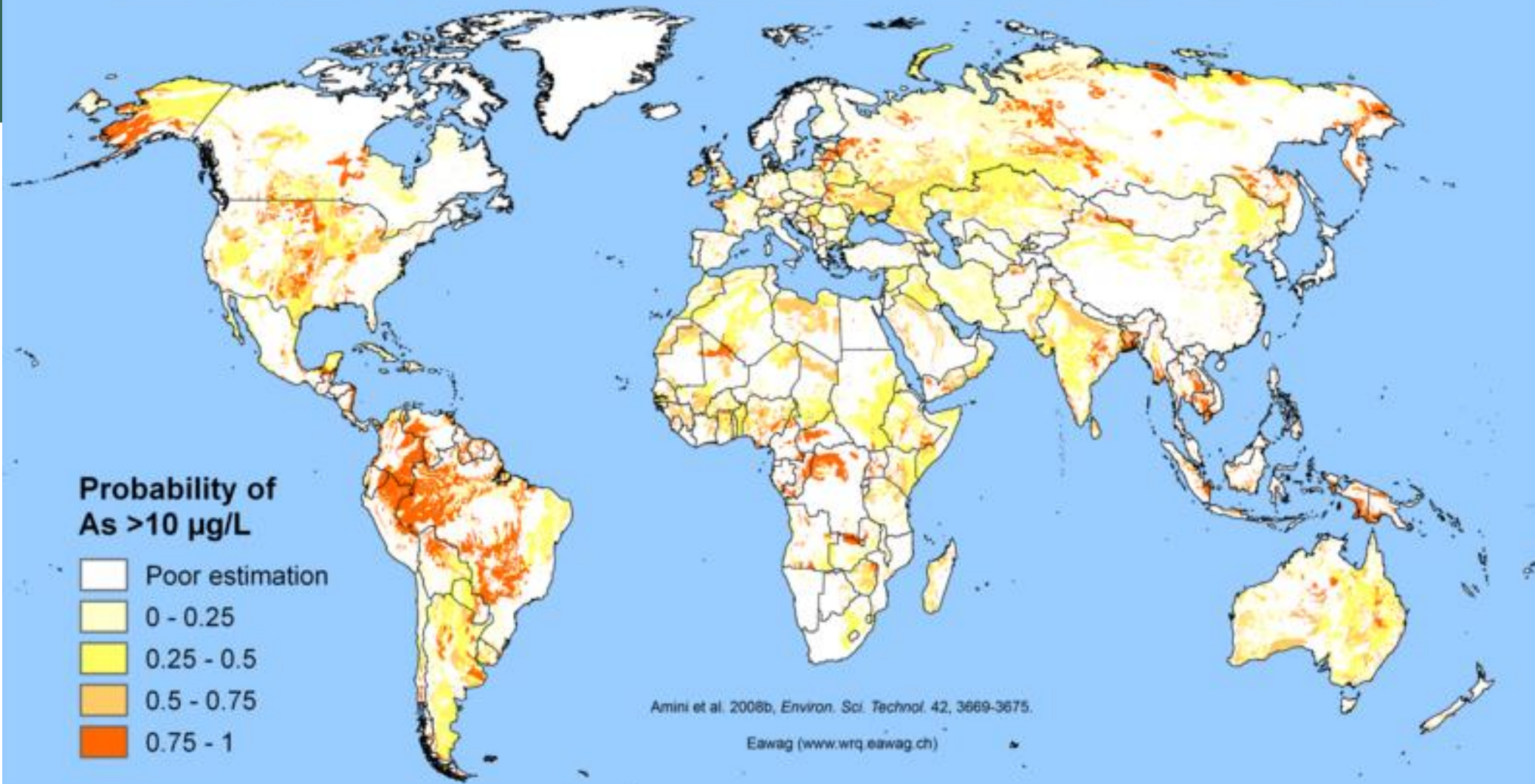
CHEMICALS AND MINERALS FROM THE
NATURAL ENVIRONMENT, SUCH AS ARSENIC,
COMMON SALTS AND FLUORIDES.

ARSENIC CONTAMINATION IN WATER

- Arsenic is naturally-occurring contaminant in groundwater affecting 140 million people in 50 countries.
- Long term exposure can cause skin lesions (arsenicosis) and cancer.
- Exposure has also been associated with cardiovascular disease and diabetes
- In utero and early childhood exposure is linked to negative cognitive development
- In Bangladesh 1.4 million tube wells have high levels of naturally occurring arsenic



Modeled global probability of geogenic arsenic contamination in groundwater for reducing and for high-pH/oxidizing aquifer conditions

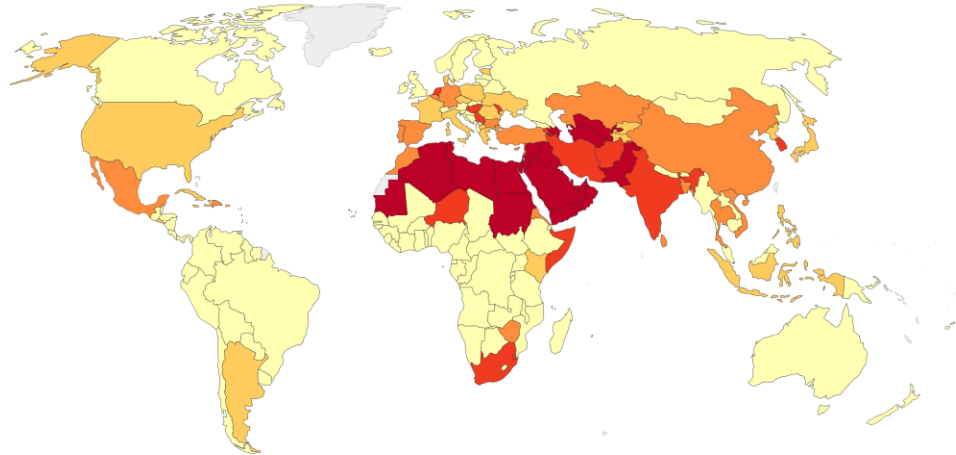


WATER SCARCITY

Freshwater withdrawals as a share of internal resources, 2017

Annual freshwater withdrawals refer to total water withdrawals from agriculture, industry and municipal/domestic uses. Withdrawals can exceed 100% of total renewable resources where extraction from nonrenewable aquifers or desalination plants is considerable.

Our World
in Data



Source: UN Food and Agriculture Organization (FAO)

OurWorldInData.org/water-access-resources-sanitation/ • CC

- When a resource is extracted faster than it is renewed.
- More developed countries consume more water.
- Less developed consume a larger proportion for agriculture.
- Temporary disruptions of water affect those is less developed countries.

WATER AND HEALTH IN SAUDI ARABIA



- Extremely water scarce area
- Consume 4 times the renewal rate
- Ranked third in consumption after the US and Canada
- Relies heavily on water desalination
- The majority of wastewater is not reused
- Water conservation is one of the goals of Vision 2030
- *Qatrah* is a program by the National Water Company that aims to decrease Saudi Arabia's consumption of water

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