

## **Event week on Heatwaves and Droughts EUMETrain**

## **Session 4 - 1 June 2023**

## Impacts on air quality

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I. Air pollutants types and sources
II. History
III. Major pollutants
IV. Heatwaves and Air Pollution



#### **AIR POLLUTANTS**

<u>Air Pollutants - g</u>ases, solid particles, or liquid droplets.

#### **Air Pollutants :**

- **Primary** - pollutants that are emitted directly by natural or anthropogenic (manmade) processes

<u>- Secondary - pollutants that result from</u> chemical reactions of atmospheric gases with gases emitted by natural or anthropogenic processes



## **MAJOR AIR POLLUTANTS (WHO)**

- Particle matter, ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead.
- <u>Air pollution</u> can have disastrous environmental effects, on water, soil, and air. Posing a serious threat to living organisms, with high impact in human health and natural ecosystems







## Since when air pollution started to be a environmental issue?



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## HISTORY OF AIR POLLUTION (1) THE MEDIEVAL POLLUTION

 In medieval London, pollution from coal burning was seen as such a serious matter that a commission was established in 1285 to investigate the problem. It was reconvened three years later with firm instructions to find a solution.

 In 1307, during the reign of Edward the First, legislation was introduced to prevent the use of sea coal by blacksmiths. It proved to be largely ineffective.



### HISTORY OF AIR POLLUTION (2) THE $16^{TH} - 19^{TH}$ CENTURY

- Wood for burning became scarce and expensive, and an increasing number of domestic chimneys encouraged an wider use of fossil fuel.
- 1661, the diarist and proto-environmentalist John Evelyn published a diatribe against air pollution in London: "Fumifugium, or The Inconvenience of the Aer and the Smoak of London Dissipated".
- 1813, December, reports of thick smog, smelling of coal tar, that blanketed London. Lasting for several days, people claimed you could not see from one side of the street to the other.
- 1873, December a similar fog occurred , with the death rate across London rise 40% above normal.



Claude Monet. Houses of Parliament, Effect of Sunlight, 1903



## HISTORY OF AIR POLLUTION (3) THE 20<sup>TH</sup> CENTURY

- 1948, Donora-Pennsylvania (EUA) Smog event:
  - 20 dead, 4,000 hospitalized

(https://www.smithsonianmag.com/history/deadly-donora-smog-1948spurred-environmental-protection-have-we-forgotten-lesson-180970533/)

- 1952, "Great Smog" in London, England
  - 4,000+ excess deaths during 5 day event (Dec 5 – 9, 1952)
  - 12,000+ excess deaths estimated due to persisting effects between Dec 1952 – Feb 1953

(https://www.metoffice.gov.uk/weather/learn-about/weather/case-

studies/great-smog)



London, Dec 5-9, 1952

#### HISTORY OF AIR POLLUTION (4) THE 21<sup>ST</sup> CENTURY

# Exposure to particulate matter with an aerodynamic diameter of 10 µm or less (PM10) in 1600 urban areas\*, 2008–2013

The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization 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.

Data Source: World Health Organization Map Production: Health Statistics and Information Systems (HSI) World Health Organization

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China and India are two of the world's countries where various forms of pollution have increased, causing widespread environmental and health problems





### HISTORY OF AIR POLLUTION (5) THE 21<sup>ST</sup> CENTURY - COVID-19 LOCKDOWN



The India Gate war memorial in New Delhi, India, on 17 October 2019 and on 8 April 2020, after a 21-day nationwide lockdown.

Source: Anushree Fadnavis/Adnan Abidi/Reuters. https://www.insider.com/before-after-photos-show-less-air-pollution-during-pandemic-lockdown#before-in-2019-cnn-cited-dangerous-levels-of-pollution-in-new-delhi-describing-indias-capital-as-shrouded-in-a-toxic-throat-searing-cloud-of-brown-smog-7.



#### GLOBAL POLLUTION LEVELS

Less	More	No
Pollution	Pollution	Data

**Notes:** All levels are based on average of the top 10 most polluted cities in each country. India is by far the worst with 134 fine particle matter 2.5[ug/m] and Sweden had the lowest levels at 7.2. Most of the data was collected in 2013 and 2014 with a few countries only having data available from 2009. Other countries, especially in Africa, did not have any data.

Reference: http://www.who.int/phe/health\_topics/outdoorair/databases/cities/en/



CC-BY-SA: http://asherfergusson.com

Data source: World Health Organization

#### PARTICULATE MATTER

- Natural sources -- fires, volcanic eruptions, salt spray from the oceans, pollen, dust storms
- Anthropogenic sources -- Dust and other small particles from construction, mining, agriculture; or fine particles from burning fossil fuels in factories, power plants, and dieseland gasoline-powered motor vehicles



#### **Potential health effects**

#### Respiratory

Cardiovascular

Allergic disease and asthma

Cardiopulmonary

Cancer

#### **PARTICULATE MATTER**

Image from NASA Global distribution of PM2.5 (2001-2006) Credit: Dalhousie University, Aaron van Donkelaar



#### NITROGEN OXIDES

- <u>Nitric oxide (NO)</u> is a nontoxic, colorless, and odorless gas.
- Nitrogen dioxide (NO<sub>2</sub>) is a toxic, yellow to reddishbrown gas that is pungent and corrosive. Provides polluted air with the yellow to reddish brown color.
- Respiratory irritant (NO2)

(but AQ standard seldom violated)

- Leads to ozone formation
- Leads to acidic deposition of HNO3

 $NO_x + VOCs + sunlight -> NO_x + O_3$ 



 $NOx = NO + NO_2$ 

#### **GROUND-LEVEL OZONE**

#### **Potential health effects**



#### Respiratory

#### Cardiopulmonary

Allergic disease and asthma

Pequim, Estádio Olimpico



Claude Monet. Houses of Parliament, Effect of Sunlight, 1903







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## HEAT WAVES | AIR POLLUTION





July 2022 heatwave brought very high O<sub>3</sub> pollution levels - some locations exceeded 200  $\mu$ g/m<sup>3</sup>.



#### 2018 HEATWAVE | PORTUGAL



Early August 2018 presented a short-lived but record-breaking extreme heat event in Portugal. Result from the advection of an anomalous warm air mass, originated over the Sahara, and transported under the influence of a strong subtropical ridge pattern.

#### **HEAT WAVES | AIR POLLUTION – TAKEWAY MESSAGES**

Sunlight and high temperature trigger chemical reactions between primary air pollutants such as  $NO_x$  (emitted by engines) and oxygen, causing a chemical reaction that forms  $O_3$ .

The hotter the day and the more intense the sun, the more ozone is formed!

Heat and radiation transform primary particles into secondary, smaller particles that can be more toxic(<PM2.5µg).

**Secondary particles** photochemically produced, are of crucial importance: they are ubiquitous and can make up to 90 percent (in number) of the total particulate matter.

Secondary particles are smaller than one thousandth of a millimeter (very fine particles) and even smaller (ultra fine particles).



#### Thank you for your attention!



Event Week on Heatwaves and Droughts, EUMETrain , 29 May to 1 June 2023 - ONLINE