Northern Technical University

Engineering Technical College / Mosul

Power Mechanics Engineering Technology

Branch: Renewable Energy Engineering

Air Pollution Lectures

Fourth Year

Prepare by
Dr. Omar Mohammed Yousif

2025/2026

Lecture No (12)

Introduction to pollution

1. Class: third Year

2. Subject: Introduction to pollution

3. Number of weeks: one week

4. Central idea: Introduction to pollution

5. The Test:

Introduction

Ecological Systems and pollution:

pollutants and toxic compounds through the environment is very similar to the movement of energy and nutrients within the ecosystem and on a larger scale throw the biosphere. These chemicals may cause harm to living organisms and their environment.

A pollutant is defined as "a Substance that occurs in the environment at least in part, as a result of human activities, and which has a deleterious effect on the environment". One of the most useful classifications of pollutants divides them into two major the groups:

a-Those that affect the physical environment and

b-Those that are directly toxic to organisms including humanity.

Pollutants that change the physical environment:

Pollutant do not have any obvious direct effect on some living organisms but simply change the physical environment in such a way as to make conditions less suitable for life. There are two good examples of this phenomena.

e.g a global scale, the atmospheric increase in levels of carbon dioxide which can give rise to significant global changes and may lead to global warming.

Toxic pollutants-:

Some compounds directly affect an organisms health and these are called toxic pollutants.

Toxic pollutants include a range of compounds from heavy metals, poly chlorinated biphenyls and dioxines to radioactive ions. There toxicity depends on a number of factors such as concentration and chemical forms .

Environmental factors affecting toxicity:

A large Number of environmental factors influence the toxicity of chemical compounds. Chemical that are released into the atmosphere, water or soil are often transformed from one form to another. For example, consider Mercury (Hg), is virtually unavailable to biological systems and hence has no toxicity, when the Mercury is transformed into methylated Mercury by bacteria and fungi in soil and water it becomes extremely toxic to biological system.

There is a whole range of other environmental parameters that affect the toxicity of compounds

1-such as the level of organic compounds the present،

2- environmental temperature, etc.

Air pollution

Introduction

Air pollution was a problem and highly industrialized Urban areas where coal was burned as an industrial and domestic fuel. The pollutants from coal include particulates, carbon dioxide and unburnt hydrocarbons. The replacement of coal in industrial and household buy natural gas, oil, and unclear power leads to a significant improvement in local urban air quality and the smoke and particulates become under control, but a significant air pollutants still exist in the Urban air environment due to transpiration. Approximately 70 per cent of the total carbon monoxide pollution is due to transpiration as is 10 per cent of unburnt hydrocarbon and 10 percent of nitrous oxides.

Table 1 lists the trace species concentrations in clean and polluted air.

Table 2-A lists the sources of major air pollutants.

Air pollution concern on several scales: micro, meso and macro.

Indoor air pollution results from products used in construction materials, inadequacy of ventilation, and geophysical factors that may result in exposure to naturally occurring radioactive material.

Industrial and mobile sources contribute to to meso-scale air pollution that contaminates the ambient hair that surround us outdoors so that how our focus will predominately b be on them.

Table 2-B and 2-C lists some quality d&a properties of pollution.

1-1physical and chemical fundamentals:

Polluted air may treat as if it were ideal, we assume that at the same temperature and pressure , different kinds of gases have densities proportional to there molecular mass.

Then:

$$\rho = \frac{1}{R_O T} PM$$

ρ : density in ***kg/m³***

P: absolute pressure in ***kpa***

M : molecular mass in ***grams/ mole***

T : absolute temperature in ***K***

R_O: universal gas constant **8.314** ***KJ/Kmol.K***

Or:

$$PV = nR_O T$$

Because of combustion products have different composition than air, Dalton's law needed to farms the basic for the calculation of gas concentrations.

$$P_t = P_1 + P_2 + P_3 + \cdots.$$

$$P_t = \frac{n_1 R_O T}{V} + \frac{n_2 R_O T}{V} + \frac{n_3 R_O T}{V} + \cdots$$

$$P_t = (n_1 + n_2 + n_3 + \cdots)\frac{R_O T}{V}$$

Air pollution metrology is, in part, a consequence of the thermodynamic processes of the the atmosphere. One such process a diabetic expansion and and contraction.

There are three basic units of measure used in in reporting air pollution data: microgram per cubic meter (*M*g/m3), parts per million (ppm), and the micron (M).both Mg/m3 and ppm are used to indicate the the concentration of gaseous pollutant. The concentration of particulate matter may be reported only as Mg/m3 and the Mm used to report particle size. It must be noticed that ppm is is a volume to volume ratio. So that change in temperature and the preasure do not change the ratio of the volume of pollutant gas to the volume of air that contains it

Converting (*M*g/m3) to (ppm) :

1- Convert the mass mp in grams to Vps in L at STP

$$V_{ps} = \frac{m_p}{GMW} * 22.414 \qquad {}^{L}/_{Mole}$$

mp Concentration of specie in *M*g/m3 or mg/m3

Where ***GMW*** : is the g/mole

2-correction for reading other than STP .

$$V_p = \frac{m_p}{GMW} * 22.414 \ ^{L}/_{Mole} * \frac{T_2}{273\ K} * \frac{101.325\ Kpa}{P_2}$$

$$\text{PPm} = \frac{g}{g}$$

For example: a 1 cubic meter sample of hair was found to contain 80 *M*g/m3 of SO2 at a temprature Of 25C and pressure of 103.19 KPa. What was the SO2 concentration in ppm?

$$\text{PPm} = \frac{80 * 10^{-6}}{64} * 22.414 * 10^{-3} \ ^{L}/_{Mole} * \frac{298}{273} * \frac{101.325\ Kpa}{103.19}$$

$$= 0.03ppm$$

Example: according to rules convert the concentrations of CO =30mg/m^3 , NO2=400*M*g/m^3 , and SO2=350 *M*g/m^3 to ppm at STP and NSTP . (at 25 and 103 kpa) .

Sol: one mole of an ideal at standard temp (0C°) and press (101.324 Kpa) occupies 22.414 Liters .

Sol : for CO 30 mg/m^3

a- at STP

$$V_{CO} = \frac{m_p}{GMW} * 22.414 \quad {}^{L}\!/_{Mole}$$

$$= \frac{30 * \frac{10^{-3} g}{m^3}}{28 \frac{g}{mole}} * 22.414 * 10^{-3} \quad {}^{m^3}\!/_{Mole} = 24 * \frac{10^{-6} g}{g}$$

$$= 24\, ppm$$

2- At NSTP

$$V_p = \frac{m_p}{GMW} * 22.414 \;\; {}^{L}\!/_{Mole} * \frac{T_2}{273\, K} * \frac{101.325\, Kpa}{P_2} =$$

$$= \frac{30 * \frac{10^{-3} g}{m^3}}{28 \frac{g}{mole}} * 22.414 * 10^{-3} \;\; {}^{m^3}\!/_{Mole} * \frac{298}{273\, K}$$

$$* \frac{101.325\, Kpa}{103} = 25.76 * 10^{-6} = 25.76\, PPm$$

b- for NO2 400 *M*g/m³

b- at STP

$$V_{NO2} = \frac{m_p}{GMW} * 22.414 \quad {}^{L}/_{Mole}$$

$$= \frac{400 * \frac{10^{-6} g}{m^3}}{46 \frac{g}{mole}} * 22.414 * 10^{-3} \quad {}^{m^3}/_{Mole}$$

$$= 1.9478 * \frac{10^{-7} g}{g} = 0.19478\, ppm$$

3- At NSTP

$$V_{NO2} = \frac{m_p}{GMW} * 22.414 \ {}^{L}/_{Mole} * \frac{T_2}{273\ K} * \frac{101.325\ Kpa}{P_2} =$$

$$= \frac{400 * \frac{10^{-6} g}{m^3}}{46 \frac{g}{mole}} {}^{m^3}/_{Mole} * \frac{298}{273\ K} * \frac{101.325\ Kpa}{103}$$

$$= 2.0916 * 10^{-6} = .20916\, PPm$$

c- for SO2 350 *M*g/m³

d- at STP

$$V_{SO2} = \frac{m_p}{GMW} * 22.414 \quad {}^{L}/_{Mole}$$

$$= \frac{350 * \frac{10^{-6} g}{m^3}}{64 \frac{g}{mole}} * 22.414 * 10^{-3} \quad {}^{m^3}/_{Mole}$$

$$= 1.225 * \frac{10^{-7} g}{g} = 0.1225\, ppm$$

4- At NSTP

$$V_{NO2} = \frac{m_p}{GMW} * 22.414 \ \ {}^{L}/_{Mole} * \frac{T_2}{273\ K} * \frac{101.325\ Kpa}{P_2} =$$

$$= \frac{350 * \frac{10^{-6} g}{m^3}}{64 \frac{g}{mole}} {}^{m^3}/_{Mole} * \frac{298}{273\ K} * \frac{101.325\ Kpa}{103}$$

$$= 1.315 * 10^{-7} = 0.1315\, PPm$$

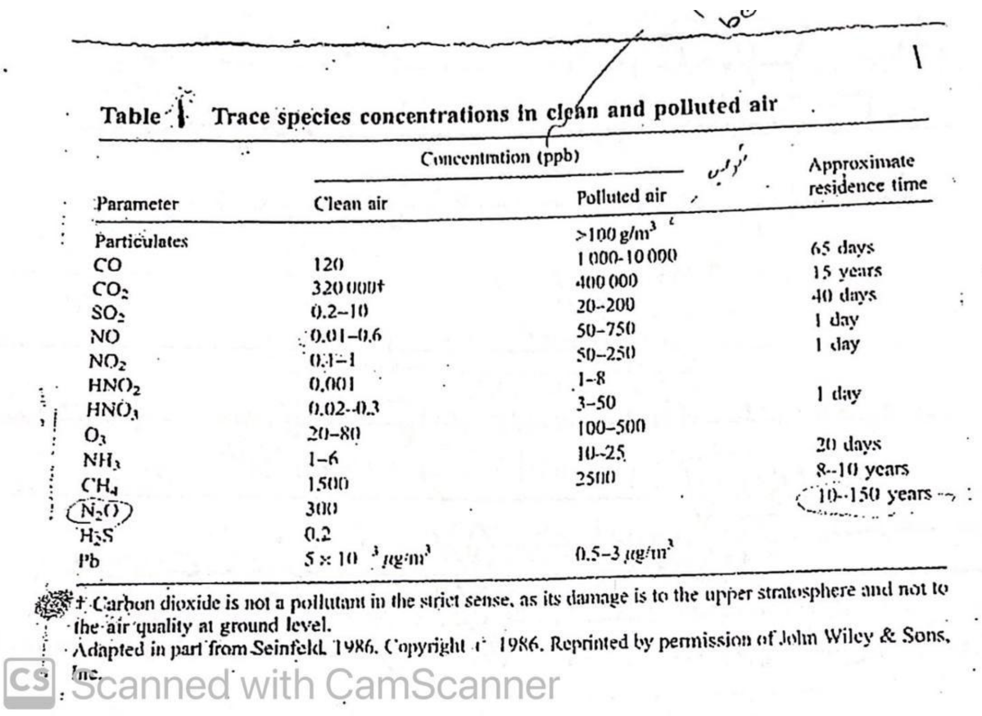


Table 1 Trace species concentrations in clean and polluted air

Parameter	Concentration (ppb)		Approximate residence time
	Clean air	Polluted air	
Particulates		>100 g/m^3	
CO	120	1 000-10 000	65 days
CO_2	320 000†	400 000	15 years
SO_2	0.2–10	20–200	40 days
NO	0.01–0.6	50–750	1 day
NO_2	0.1–1	50–250	1 day
HNO_2	0.001	1–8	
HNO_3	0.02–0.3	3–50	1 day
O_3	20–80	100–500	
NH_3	1–6	10–25	20 days
CH_4	1500	2500	8–10 years
N_2O	300		10–150 years
H_2S	0.2		
Pb	5×10^{-3} µg/m^3	0.5–3 µg/m^3	

† Carbon dioxide is not a pollutant in the strict sense, as its damage is to the upper stratosphere and not to the air quality at ground level.

Adapted in part from Seinfeld, 1986. Copyright © 1986. Reprinted by permission of John Wiley & Sons, Inc.

Table2A Mager [illegible]

Pollutant	Power stations	Traffic	Domestic heating	Oil refining	Quarrying, mining مناجم الحجر	Chemical, pharmaceutical	Manufacturing metals, etc.	Waste incineration	Agriculture
	Sources or activity								
Particulates	✓	✓	✓		✓		✓	✓	✓
CO	✓	✓	✓					✓	
CO_2	✓	✓	✓					✓	
SO_x	✓	✓	✓	✓				✓	
NO_x	✓	✓	✓	✓				✓	
VOCs	✓	✓	✓	✓				✓	
O_3		✓							
HC	✓	✓	✓	✓		✓		✓	
Heavy metals									
Pb		✓			✓		✓	✓	
Hg	✓		✓		✓	✓	✓	✓	
Cu					✓		✓	✓	
Cd			✓		✓	✓	✓	✓	✓
Zn					✓		✓	✓	
Radionuclides†								✓	
CFCs							✓	✓	

2B

Table2B -International Ambient Air Quality Standards for criteria pollutants

النسب المقبولة حسب مقاييس الدول العالمية

Pollutant	Averge time	USA Federal USEPA ($\mu g/m^3$)	California ($\mu g/m^3$)	EC Directives ($\mu g/m^3$)	WHO Air quality guidelines ($\mu g/m^3$)	TA Luft, Germany ($\mu g/m^3$)
CO (carbon monoxide)	15 min				100 000	
	30 min				60 000	
	1 h	40 000	23 000		30 000	30 000
	8 h	10 000	10 000		10 000	10 000
NO_2 (nitrogen dioxide)	1 h		470	200	400	200
	24 h				150	80
	Annual	100				
O_3 (ozone)	1 h	235	180		200	
	8 h					
	24 h				65	
	100 day				60	
SO_2 (sulphur dioxide)	10 min				500	
	1 h		655		350	
	3 h	1300				400
	24 h	365	105	250–350	125	140
	Annual	80		80–120	40–60	60
Particulates (PM-10)	24 h	150	50	250	125	150–300
	Annual	50	30	80	50	
SO_2 + PM-10	24 h			100–150		
	Annual			40–60	60–90	
Pb (lead)	1 month		1.5			
	3 month	1.5				
	Annual			2	0.5–1	2
Total suspended particulates (TSP)	24 h	260				
	Annual	75				
HC	3 h	160 (non-CH_4)				

2C

تركيز عليه

Table2C Properties and pollution significance of criteria pollutants

Pollutant	Properties	Pollution significance
Carbon monoxide	Colourless, odourless gas	Formed during incomplete combustion of hydrocarbons. Causes greenhouse effects and climatic changes
Nitrogen dioxide	Brown-orange gas	Significant component of photochemical smog and acid deposition
Ozone	Highly reactive	A secondary pollutant, produced during formation of photochemical smog. Damages flora and materials
Sulphur dioxide	Colourless, choking gas, soluble in H_2O to produce sulphurous acid, H_2SO_3	Principal component of acid deposition. Damages humans, flora, fauna and materials
PM-10	Particulate matter < 10 μm in diameter—black smoke	Coal burning power station, traffic, domestic coals, quarrying, incineration. Can cause respiratory problems
Lead	Heavy metal, bioaccumulative	Principal source leaded petrol. Also from lead pipes, quarrying, incineration. Damages humans and fauna

Size

Lecture No (13)

Ambient air quality standards for criteria pollutants

1. Class: third Year

2. Subject: Introduction to pollution

3. Number of weeks: one week

4. Central idea: Ambient air quality standards for criteria pollutants

5. The Test:

Ambient air quality standards for criteria pollutants:

The criteria pollutants may be considered as likely to exist in all urban area. Their concentrations will vary depending on the level of industrial and traffic activity and the degree of sophistication of control. Besides the six criteria pollutants, hundreds of other pollutants may also be emitted to the atmosphere. This later tend to be industry-specific and not as ubiquitous as the criteria pollutants.

Air pollution standards

Studies on the environmental effects of any air pollutant emitted by stationary or mobile sources that adversely affect human health or the environment are used by the U.S. Environmental Protection Agency (EPA) to establish the National Ambient Air Quality Standards.(NAAQS) These standards are for ambient air that is, the outdoor air that normally surrounds us. EPA calls the pollutants listed in Table 3 criteria pollutants. The Primary Standards was established to protect human health with an "adequate margin of safety" the secondary standards are intended to prevent environmental and property damage.

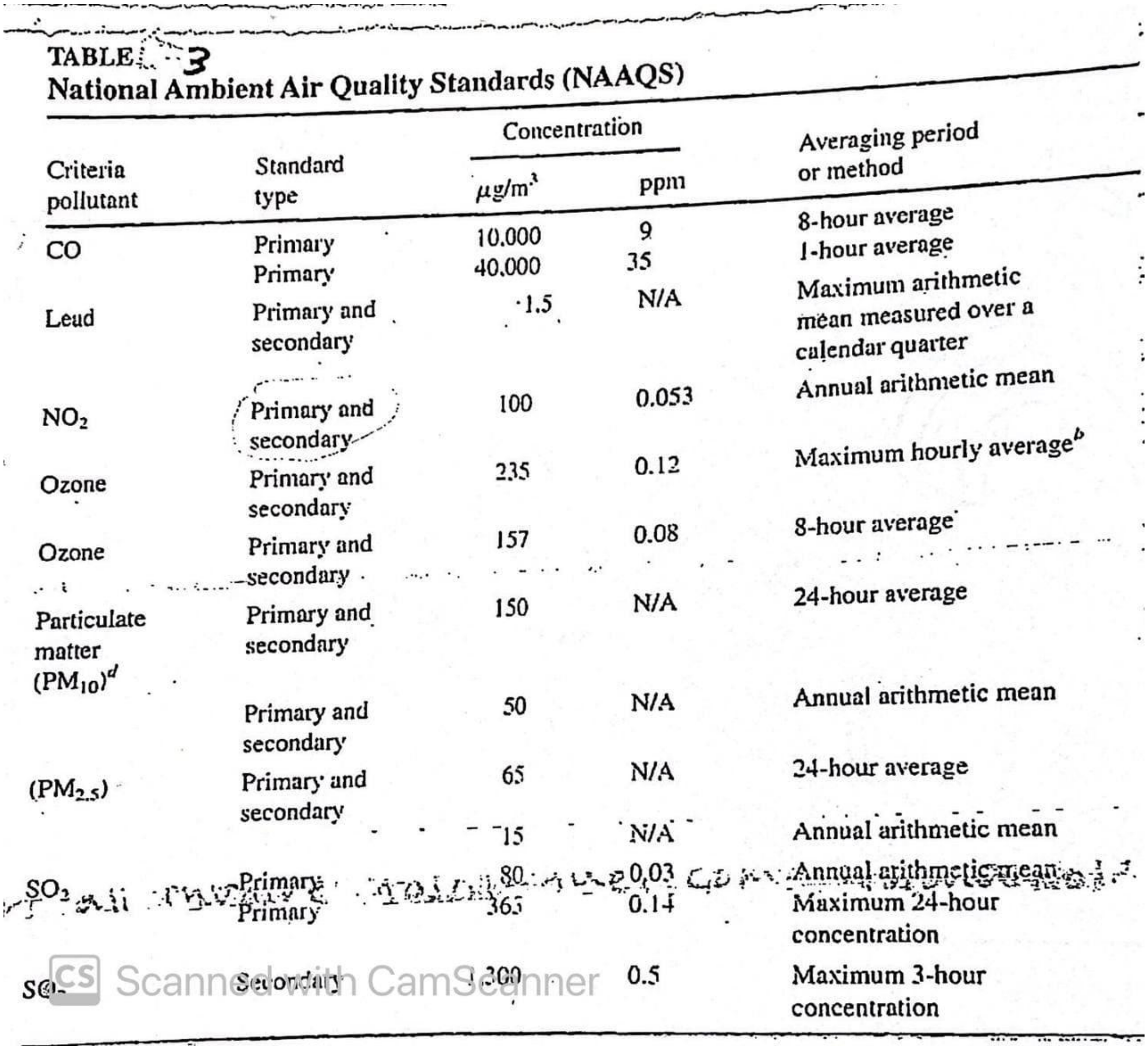


TABLE 3

National Ambient Air Quality Standards (NAAQS)

Criteria pollutant	Standard type	Concentration		Averaging period or method
		$\mu g/m^3$	ppm	
CO	Primary	10,000	9	8-hour average
	Primary	40,000	35	1-hour average
Lead	Primary and secondary	1.5	N/A	Maximum arithmetic mean measured over a calendar quarter
NO_2	Primary and secondary	100	0.053	Annual arithmetic mean
Ozone	Primary and secondary	235	0.12	Maximum hourly average[b]
Ozone	Primary and secondary	157	0.08	8-hour average
Particulate matter (PM_{10})[d]	Primary and secondary	150	N/A	24-hour average
	Primary and secondary	50	N/A	Annual arithmetic mean
$(PM_{2.5})$	Primary and secondary	65	N/A	24-hour average
		15	N/A	Annual arithmetic mean
SO_2	Primary	80	0.03	Annual arithmetic mean
	Primary	365	0.14	Maximum 24-hour concentration
SO	Secondary	1300	0.5	Maximum 3-hour concentration

Air pollution regulation:

In the last few decades especially after the milestone 1970 clean air act in the US, air pollution has been regulated all over the world through a serious of laws and regulations.

The European commission has developed a series of framework detectives for controlling ambient air pollution and monitoring concentrations which give thresholds and specify the monitoring methods and number of observations for SO_2, NO_2, particulate matter (PM), lead, and tropospheric ozan (O_3).

The United Nations economic commission for Europe (UN-ECE) has created protocols to reduce long range transboundary air pollution. New developments of Air pollution modelling and regulations in Europe can be found at the EUROTRAC project.

In the United States the environmental protection agency (US-EPA) has established air quality standards to protect public health, including the health of sensitive populations such as children or older adults ,and people with asthma.

The US-EPA has set national air quality standards (NAAQS) for six principle air pollutants: nitrogen oxides (expressed as NO_2), Ozone, Sulphur dioxide, PM, Carbon monoxide (CO), and lead(Pb). 4 of these pollutants (Co,Pb,NO_2 and SO_2) are emitted directly from A variety of services. Ozone is not directly emitted but is formed when nitrogen oxides(NO_x)and volatile organic compounds (VOCs) react in the presence of sunlight. P.m. is mostly directly emitted, butPM2.5 particles can also be added as secondary pollutants (sulfates, nitrates, and organic particles).

The United States clean air act provides the principal for national, state, tribal, and local efforts to protect air quality. Improvements in air quality are the result of effective implementation of clean air laws and regulations as well as efficient industrial technologies.

Under the clean air act, the US-EPA has a number of responsibilities, including the following:

1. conducting periodic reviews of NAAQS for the six principal pollutants.
2. Ensuring that season quality standards are met (in cooperation with the state, tribal, and local governments) through national standards and strategies to control air pollutants emissions from vehicles, factories, and other sources.
3. Reducing emissions of SO_2 and NO_x that cause (acid rain).
4. Reducing air pollutants such as PM Sox, and NO_x which can reduce visibility across large regional areas, including many of Nation's parks and wilderness areas.
5. insuring that sources of toxic air pollutants that may cause cancer and other adverse human health and environmental effects are well controlled and the risks to public health and environment are substantially reduced.

6. limiting the use of chemicals that damage the stratospheric ozone layer in order to prevent increased levels of harmful UV radiation.

In Japan, the "basic Law for environmental pollution control" was enacted in in 1967. This Law supplies definitions of environmental pollution, describes the basic features of strategies for preventing environmental pollution and provides and overall structure for environmental pollution legislation and strategies. The main features of the basic law for environmental pollution control are:

1. Numerical standards for environmental pollution.
2. Regulation of emissions of polluting substances.
3. Regulation of the manufacturing sector.
4. Land use regulations.
5. Monitoring and measurement regimes.
6. Pollution prevention programs.
7. Pollution prevention facilities and systems.
8. Subsidy schemes for businesses to reduce pollution levels.
9. Compensation for pollution victims.
10. Dispute resolution mechanisms.

Air pollutants classification:

Air pollutant can be defined as any substance emitted into the air from an anthropogenic, biogenic or geogenic source, that is either not part of the natural atmosphere or is present in higher concentration than the natural atmosphere, and me cause a short-term or long-term adverse effect.

Pollutants can be classified as primary or secondary.

Primary pollutants are substances that are directly emitted into the atmosphere from sources. The main primary pollutants known to cause harm and high enough concentrations are the following:

1. carbon compounds, such as CO, CO_2,CH_4, and VOCs.
2. nitrogen compounds, such as NO, N_2O, and NH_3.
3. sulfur compounds, such as H_2S, and SO_2.
4. halogen compounds, such as chlorides, fluorides and bromides.
5. particulate matter (PM or "aerosols"), either in solid or liquid form, which is usually categorized into groups based on the aerodynamic diameter of the particles.

Secondary pollutants are not directly emitted from sources, but instead form in the atmosphere from primary pollutants (also called "precursors"). The main secondary pollutants known to cause harm in high concentrations are the following:

1. NO_2 and HNO_3 formed from NO.
2. Ozone (O_3) formed from photochemical reactions of nitrogen oxides and VOCs.
3. Sulfuric acid the droplets formed from SO_2 and nitric acid droplet from NO_2.
4. Sulfates and nitrates aerosols (e.g ammonium (bi) sulfate and ammonium nitrate) formed from reactions of sulfuric acid droplets and nitric acid droplets with NH_3, respectively.
5. Organic aerosols formed from VOCs in gas to particle reactions.

It was recognized that petroleum products are responsible for a new type of (smog), a photochemical summertime smog composed of secondary pollutants such as ozone that is quite different from the winter sulfur smog. The first has been labelled "Los Angeles" smog, to differentiate from the "London" smog.

Some secondary pollutants- sulfates, nitrates, and organic particles- can be transported over large distances, such as hundreds and even thousands of mile wet and deposition of these pollutants contributes to the "acid deposition" problem (often called "acid rain"), with possible damage to soils, vegetation, and susceptible lakes.

Transport and air pollution:

Almost all motorized transpiration today involves the combustion us fossil fuels which produces, in addition to energy, water vapor (H_2O) and carbon dioxide (CO_2). Neither of these products is damaging to human health. But CO_2 is the principle gas responsible for the greenhouse effect, an increase in the average temperature of the plant resulting from the trapping of solar energy, with which the increased presents of this gas in the atmosphere is associated.

The combustion of hydrocarbons produces a number of other by-products more directly damaging to human health than water vapour and carbon dioxide. These other pollutants have three possible origins:

a. The carbon present in the fuel does not adequately react with oxygen during combustion, for a variety of complex reasons, producing either carbon monoxide (CO) or condensing to form solid carbonaceous (soot), a basic component of particulate matter.
b. the hydrocarbon do not combust completely (or evaporate prior to combustion), being released as gaseous hydrocarbons called volatile organic compound (VOCs) adsorbing onto carbonaceous particles, thereby increasing the particulate.
c. other elements present in the fuel and air (including, sulphur, lead, nitrogen, zink, and magnesium) also become involved in the combustion process, producing various oxides of sulphur (SO_x), oxides of nitrogen (NO_2), sulphate(SO_3) aerosols and Ash also important components of particulate matter and lead aerosols.

These by- products can also react in the atmosphere producing secondary transport pollutants such as sulphuric acid, Salphates, and Ozone, which also damage human health. The type and extent of secondary pollutant production is heavily dependent on local atmospheric and climate conditions.

Atmosphere and climate, together with urban form population densities and Street densities, also influence the extent to which populations are exposed to primary and secondary pollutants.

Beside transport, manufacturing, power generation, and household sectors all involve fossil fuel combustion and share strongly in increasing the pollutants mentioned above.

Causes of air pollution from Transportation:

There are five principle causes of air pollution from motor vehicle that are responsible for the range of problems. These include:

a. Excessive vehicle use (especially in urban areas).
b. The persistence of all and outdated technology in the vehicle fleet.
c. Poor maintenance of the vehicle in use.
d. Unavailability or improper use of appropriate fuels.
e. The atmospheric, topographic, and climatological aspects of metropolitan areas where pollution is concentrated.

Lecture No (14)

Calculation of concentrations of air pollutants in atmosphere

1. Class: third Year

2. Subject: Introduction to pollution

3. Number of weeks: one week

4. Central idea: Calculation of concentrations of air pollutants in atmosphere

5. The Test:

Example : consider a thermoelectric power plant of 915 MW total capacity with a load factor (or annual capacity of 72.5%) and an efficiency 40 % , determine the amount produced of particulates , CO_2 and SO_2 if coal is used . the ultimate analysis and calorific value of coal is as follows :

Moisture	Ash	carbon	hydrogen	nitrogen	Sulphur	oxygen
8%	7.7%	77%	3 %	1.25%	1%	2.05%

calorific value =29.7MJ/Kg

sol :

(for total capacity) power =915*3600= $3294*10^3$ MJ/hr

(for annual capacity) power =$3294*10^3$ * 0.725 =$2388.15*10^3$ MJ/hr

$$\eta_{th} = \frac{power}{\dot{m}_f * L.V.C} \quad \Rightarrow \quad \dot{m}_f = \frac{power}{\eta_{th} * L.V.C}$$

$$\dot{m}_f = \frac{2388.15 * 10^3}{0.4 * 29.7} = 201\ t\ /hr$$

Assume 80% of Ash is as fly ash or particulates :

Particulates =0.8 *0.077 *201 = 12.38 t/hr

Carbon content in fuel (coal) =0.77*201= 154.77 t/hr

$C + O_2 \longrightarrow CO_2$

نحول قيم العناصر في المعادله من المول n الى الكتله بالKg

m=n*M

$12kg\ C + 32\ kgO_2 \longrightarrow 44\ kg\ CO_2$

$1\ kg\ C + \frac{32}{12}\ kgO_2 \longrightarrow \frac{44}{12}\ kg\ CO_2$

$154.77\ \ C + \frac{32}{12} * 154.77\ \ O_2 \longrightarrow \frac{44}{12} * 154.77\ \ CO_2$

Amount of CO2 = 576.5 t/hr

Sulphur content in fuel (coal) =0.01*201= 2.01 t/hr

$S + O_2 \longrightarrow SO_2$

نحول قيم العناصر في المعادله من المول n الى الكتله بالKg

m=n*M

$32kg\ s + 32\ kgO_2 \longrightarrow 64\ kg\ SO_2$

$1\ kg\ S + \frac{32}{32}\ kgO_2 \longrightarrow \frac{64}{32}\ kg\ SO_2$

$2.01\ kg\ S + 2.01\ kgO_2 \longrightarrow 2 * 2.01\ kg\ SO_2$

Amount of SO2 = 4.02 t/hr

The annual production is as follows :

Particulates =12.38 *365 *24 = 10.844 *10^3 t /year

CO2= 567.5 *365*24 = 4970 *10^3 t /year

SO2 =4.02* 365 *24 = 35.21 *10^3 t/ year

While SO2 and CO2 are emitted into the atmosphere the particulates are captured by flue gas cleaning devices generally by electrostatic precipitators (ESP) . if an (ESP) removes 99.5 % of particulates , compute the amount of particulates emissions :

Particulates= 0.5/100 * 10.844 *10^3 = 540 t /year

Not : other emissions of VOCs , HC , NOx , and others may be released in lesser quantities , but their magnitude depend on power plant technology

Example2: compute the HC discharged from a population center of 1 million if :

300000 vehicles travel 12000 km per annual emitting 1 g/ km each .

The per capita consumption of oil-based point is 2 liters per annual with a HC content of 1 kg per liter

The per capita HC from dry cleaning solvent is 1kg per annum

Sol:

Vehicles : 300000*12000*1*10^{-6}=3600 ton

Paints : 2 lit * 1 kg/lit * 1000000 person =2000 ton

HC solvent : 1000000 person * 1 kg = 1000 ton

Total =6600 ton

10^{*3} *6600/ 1000000 person = 6.6 kg per capita per year

Example 3 : compute the weekly concentrations of CO2 , CO ,C that discharge from a population center of 1 million if there is 250000 cars using gasoline fuel has a chemical formal (C_8H_{18}) and the products of combustion of carbon in fuel contains 80% CO2, 18% CO , and 2% C . The products also contain H2O , N2 and O2 and burning achieved through stoichiometric mixture . Assume that each car consume 5 liter per day and work 75% through a week . Take the density of gasoline as 780 :

Sol:

$$C_8H_{18} + A(O_2 + 3.76N_2) \longrightarrow aCO_2 + bH_2O + A * 3.76N_2$$

$$A = n + \frac{m}{4} = 8 + \frac{18}{4} = 5$$

$$C_8H_{18} + 12.5(O_2 + 3.76N_2) \longrightarrow 8CO_2 + 9H_2O + 12.5 * 3.76N_2$$

80% CO2, 18% CO , and 2% C from C

1 mole of C_8H_{18} contains (8*12+18*1)=114 kg

$$V = \frac{m}{\rho} = \frac{114}{780} = 0.1461\, m^3 = 146.1\, liter$$

$$\frac{114}{146.1} = \frac{m_{5lit}}{5\ liter} \rightarrow mass\ \ of\ 5\ liter = 3.9\ kg$$

$$n = \frac{m}{M} = \frac{3.9}{114} = 0.03421\ Kmol$$

$$0.03421C_8H_{18} + 12.5(O_2 + 3.76N_2) \longrightarrow aCO_2 + b\ CO + x\ C + fH_2O + dO_2 + 43.25N_2$$

$$m_{CO_2} = (M * N * 0.8) = 44(8 * 0.03421) * 0.8 = 9.633\ kg/day$$

$$m_{CO_2} = m * no\ of\ day\ * \%\ of\ work\ in\ week * no\ of\ cars\ = m\frac{t}{week}$$

$$m_{CO_2} = 9.633 * 7 * 0.75 * 250000 = 12.64\frac{t}{week}$$

$$m_{CO_2} for\ 1\ person = 12.64 * 10^3\ k\,g/1000000\ person = 0.01264\ kg\ /week$$

$$m_{CO} = (M * N * 0.18) = 28(8 * 0.03421) * 0.18 = 0.001379\ kg/day$$

$$m_{CO} = 1.379 * 7 * 0.75 * 250000 = 1.81\frac{t}{week}$$

$$m_{CO} for\ 1\ person = 1.81 * 10^6\ k\,g/1000000\ person = 1.81\ kg\ /week$$

$$m_C = (M * N * 0.02) = 12(8 * 0.03421) * 0.02 = 6.568 * 10^{-3}\ kg/day$$

$$m_C = 6.568 * 10^{-3} * 7 * 0.75 * 250000 = 0.08620\frac{t}{week}$$

$$m_{CO} for\ 1\ person = 0.08620 * 10^6\ k\,g/1000000\ person$$
$$= 0.00008620\ kg\ /week$$

Lecture No (15)

Description of air pollutants

1. Class: third Year

2.Subject: Description of air pollutants

3. Number of weeks: one week

4. Central idea: Description of air pollutants

5. The Test:

Description of air pollutants

A-Criteria Pollutants

A-1-Carbon Monoxide (CO):

Carbon monoxide is a colorless, odorless, tasteless Gas that is the most abundant of the criteria pollutants. It is a product of incomplete combustion of carbonaceous fuels, giving CO instead of CO_2. About 70 percent of all CR comes from mobile sources (see table 4,5). It has adverse effects on human health, replacing oxygen in the bloodstream and forming carboxyhemoglobin, (COHb).

Natural CO production is about 25 times that of the anthropogenic sources. The major source of natural co is the oxidation of methane in the troposphere. Thus The cycles of CO & CH_4 are interdependent.

CO is formed anywhere that a carbon containing material in burned, so CO exposure can happen anywhere that combustion occurs. Drivers stalled in traffic or driving in highly congested area, can have high exposure cigarette smoke contains CO too. Individuals with CO exposure at work, and who also smoke, increase their risk of adverse effect.

$$CH_4 + 1.5O_2 \rightarrow CO + 2H_2O$$

A-2 Nitrogen Oxides (NO2)

Nitrogen include:

- NO - nitric oxide
- NO_2 - nitrogen dioxide.
- NO_3 - nitrogen trioxide
- N_2O - nitrous oxide
- N_2O_5 - nitrogen pentoxide

The acids of nitrogen include:

- HNO_2 - nitros acid
- HNO_3 - nitric acid

NO_x are produced during the combustion of fossil fuels such as oil, coal, and gas. Fuel NO_x are produced in the oxidation of nitrogen containing compounds in the fuel. Negligible amount of fuel nitrogen exist in natural gas but up to 3 percent by weight of nitrogen compounds may exist in coal and oils. "Thermal NO_x" are produced bins outside station of atmospheric molecular N_2 at high temperature of combustion in the presence of oxygen. Most of the NO_x emissions are in the form of NO which rapidly oxides to NO_2 in the presence of O_2 or O_3 according to:

$$2NO + O_2 \leftrightarrow 2NO_2$$

$$NO + O_3 \rightarrow NO_2 + O_2$$

NO_2 is heavier then there and is soluble in may be in turn dissociate to NO or further oxidized to HNO_3 or HNO_2 according to:

$$2NO_2 + H_2O \rightarrow HNO_3 + HNO_2$$

$$3NO_2 + H_2O \rightarrow 2HNO_2 + NO + O_2$$

Furthermore, NO_2 may reacts with organic compounds to produce peroxyacetyl nitrates (PAN) or with hydrocarbons in the presence of sunlight to produce smog:

$$HC + NO_x + sunlight \rightarrow photochemical\ smog$$

NO_2 can cause respiratory problems NO and NO_2 can cause smog, which can cause pulmonary and bronchial diseases. Table 6 shows the NO_2 emissions per capita per annum. Table 7 shows that the no2 emission are related to mobile and stationary sources. In Table 7 it is seen that about 4 to 70 percent comes from mobile sources.

NO_2 is reddish brown in concentrated farm and gives a brownish yellow tint at lower concentration. At 5 PPM it has pungent sweetish odor. The average NO_2 concentration in tobacco smoke is approximately 5 PPM.

Example: compute the annual production of NO_x from the 50000 vehicles in a city, if the NO_x emissions rate is is 22.0 g/km per vehicle.

Solution:

assume the annual travel is 20000 km per vehicle. Then each vehicle produces 20000 tonnes NO_x

50000 * 40 = 2000 tonnes NO_x

A-3-Sulphur Oxides (SO_x):

The sulphur oxides include sulphur dioxide (SO_2), sulphur trioxide (SO_3), thier acids, and the salts of their acids. Sulphur oxides are the product of fossil fuel combustion, usually oil and coal. Fuels contain significant quantities of sulphur (less than 1 per cent) as inorganic sulphides or organic sulphur and, on burning, SO_2 and SO_3 are released. The following reactions show how sulfanic acid is produced or release of SO2:

$$SO_2 + OH^- \rightarrow HOSO_2^-$$

$$HOSO_2^- + O_2 \rightarrow SO_3^- + HO_2^-$$

$$SO_3^- + H_2O \rightarrow H_2SO_4^-$$

Sulfate particles (SO_4^{-2}) are found either as dry deposition or wet deposition. In wet deposition water vapor combines with H2SO4 to produce acid rain droplets.

SO_2 is a colorless, but has a suffocating, pungent, odor. The negative impact of SO_2 levels is on humans and plants. Impaired bronchial functioning is noted at ambient levels of approximately 25 mg/m3 for 10-minutes exposures. Forest growth is inhibited at levels as low as 50 mg/m3. Table 8 shows the annual levels in kg of SO_2 per capita per year. Table 9 shows this O_2 emissions for mobile and stationery sources.

Clearly SO_2 is a stationary source problem with 66 per cent of total SO2 coming from the power generation using coal and oil, while 25 percent comes from other industries producing their own power using fossil fuels. A further 7 percent comes from oil refineries and only 3 percent from transport source.

A-4-Particulate Matter (PM-10)-:

Particulate matter represents a complex mixture of organic and inorganic substances typically divided into two groups as shown in Table 10.

Terms used to describe particulate matter are include-:

Suspended particulate matter, total suspended particulate matter, black smoke, inhalable thoracic particles (which deposits on the lower respiratory tract, below larynx), PM-10 (the term indicates particulate matter of aerodynamic diameter 10 mm).

Particulate matter is imitated in urban areas from power plants, industrial processes, vehiculars traffic domestic coal burning, and industrial incinerators.

Table 11 shows values for rural and urban areas. Table 12 shows that p.m. has decreased substantially since 1970 and is now about 5 kg per capita per year European Union. Table 13 shows that stationary sources about three times that of mobile source. This is due to the presence of coal, peat and oil-fired power plants.

Secondary sources of particulates include the conversion of H_2S, SO_2, NO_x, and hydrocarbons. H_2S and SO_2 are converted to sulfate. NO_x and NH3 converted to nitrate. The hydrocarbons react to form products that condense to form particles at atmospheric temperatures.

Particles formed as a result of photochemical reactions to have very small diameters (<0.4 Mm). Smoke and fly Ash particles cover a wide range of sizes from 0.05 to 200Mm or more.

Small particles are removed from the atmosphere by accretion to water droplets, which grow in size until they are large enough to precipitate. Larger particles removed by direct to washout by falling raindrops.

Inhalation of enough pm overtime increase the risk chronic respiratory disease.

A-5- Volatile OrganicC (VOCs):

Organic air pollutants comprise hydrocarbons and other substances (about 50 per cent hydrocarbons). Many are reactive (including CH_4) in the air environment and have considerable environmental and health implications. The most abundant HC is methane with ambient concentration off 1 to 6 ppm. The less abundant but more reactive organic compounds include:

Ethylene oxide, formaldehyde, $CLFC_5$ and PCBs. These are almost all manufactured and are known or suspected carcinogens. Many are precursors for photochemical oxidants and react with NO_x and O_2 with the presence of sunlight to produce smog and aerosol pollution.

They may irritate the eye, throat and lungs and inhibit plant growth.

VOCs emissions come from a wide range of sources as shown in table 14. Typically VOCs are sourced, 27 percent from transport, 17 percent from solvents industry, 15 percent from coal mining, 17 percent from landfilling (CH_4), 10 percent from gas distribution, 12 percent from natural sources (forcets) and 2 per cent others.

Ambient air quality standards do not impose limits to VOCs. This is so because there is no safe limit for most of these compounds.

A-6-Hydrocarbons (HC):

Hydrocarbons one species of VOCs emissions. The organic compounds containing only carbon and hydrogen. Diaper calories are petroleum products and are classified as shown in Table 15.

The most common hydrocarbon is methane, it is one of the greenhouse gases and produced by animals, forestry, bog lands, landfill sites, and vehicles. It's damaging influence to the ozone layer is only now being recognized. The alkenes(or olfins) are highly reactive, when combined with NOx ethylene produces peroxyacetyl nitrate (PAN) and ozone.

The major sources of man-made hydrocarbons included traffic, organic chemical production, transport and processing of crude oil and distribution of natural gas. Table 16 shows that the HC production varies from 30 to 90 kg per capita per year. Table 17 shows the HC production percent from mobile and stationary sources.

A-7-Ozone (O3):

Ozone is considered a "criteria pollutant "because of its association with urban smog. It is a secondary pollutant formed when sunlight causes photochemical reaction, involving NO_x and VOC. The most abundant oxidant is Ozone . The formation of smog is simplified as:

$$Hydrocarbons + NO_x + sunlight \rightarrow photochemical\, smog$$

It must be noticed that without Ozone, every living things on the earth's surface would-be incinerate on the other hand, as we have already noted, Ozone can be lethal. The presence of Ozone in the upper atmosphere (20 to 40Km up) provides a barrier to ultraviolet (UV) radiation. The small amounts that do seep through provide us with our summer tan.

Too much UV will cause skin cancer. Although Oxygen also serve as a barrier to UV radiation, it absorb only over a narrow band centered at a wavelength of 0.2Mm. in 1974 sound test hypothesized that chlorofluorocarbons (CF_2CL_2 and $CFCL_3$ - often abbreviated as CFC),which are used as aerosol propellants and refrigerants, react with Ozone Through retires of reactions which may lead to remove ozone from the system, and that the chlorine atom is continually recycled to convert more Ozone to oxygen.

The source of HC and NO_x in urban area is primarily from vehicles. The irradiation of air containing hydrocarbons and oxides of nitrogen leads to:

- Oxidation of NO to NO_2.
- Oxidation of HCs.
- Formation of O_3.

Clean tropospheric background levels of O_3 are 20 to 80ppb, while urban polluted area may reach concentration of up to 500 ppb. High levels of Ozone are associated with health effects of chest constriction and irritation of the mucous membrane. Ozone concentrations tend to peak in the afternoon, and can cause eye irritation, aggravation of respiratory diseases and damage to plants and animals.

A-8- Lead(Pb)-:

The heavy metals of cadmium, lead, and Mercury are significant air pollutants. Lead is a blush grey soft metal with a melting point of 327.5c and boiling point of 1740 c . Organic lead compounds such tetraethyl and tetra-methyl lead are the distance extensive fuel additives. They are colorless liquids and are less volatile than most petrol components and they tend to become concentrated when petrol evaporates. The largest source of Pb in the atmosphere has been from Loaded gasoline combustion, but with the gradual elimination worldwide of lead in gasoline, air Pb levels have been decreased considerably. Other airborne sources include combustion of solid waste, coal, and oil. Emissions from iron and steel production and lead smelters and tobacco smoke.

Exposure to Pb can affect the blood, kidney, and Nervous, immune, cardiovascular, and reproductive systems.

Background levels of lead in air are about $5*10^{-5}$ Mg/m3. Environments with high traffic densities have polluted concentrations of 0.5 to 3 Mg/m^3. The annual ambient air quality standards are set internationally at 2 Mg/m^3. Table 18 shows the Pb emissions reduced during several years. Table 19 shows the percentage of using unleaded gasoline of some countries at 1990.

H.W: Report about Strategies for control of emissions from internal combustion engines

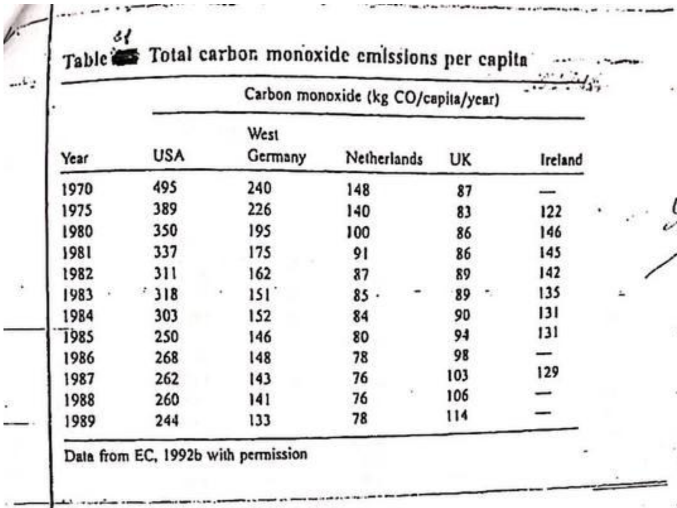
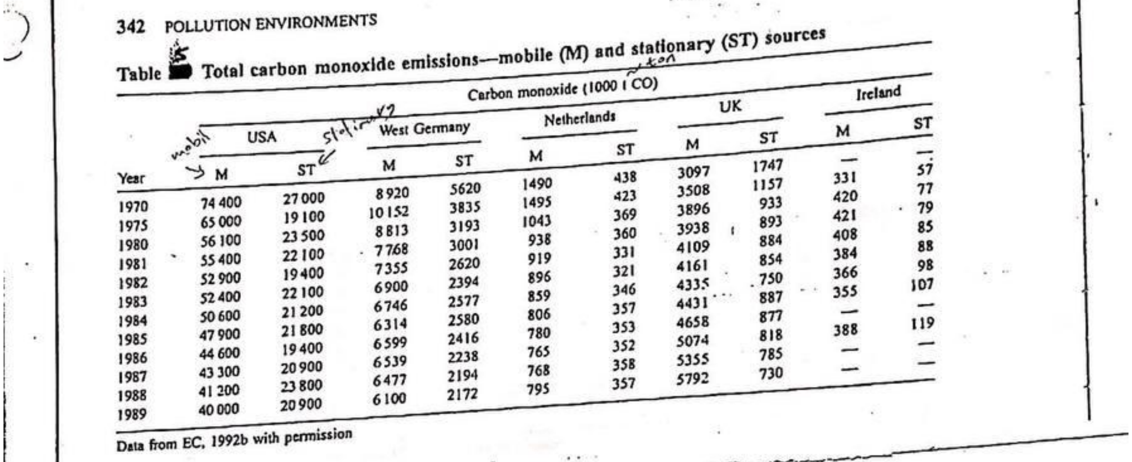


Table 81 Total carbon monoxide emissions per capita

[illegible]

Year	USA	West Germany	Netherlands	UK	Ireland
	Carbon monoxide (kg CO/capita/year)				
1970	495	240	148	87	—
1975	389	226	140	83	122
1980	350	195	100	86	146
1981	337	175	91	86	145
1982	311	162	87	89	142
1983	318	151	85	89	135
1984	303	152	84	90	131
1985	250	146	80	94	131
1986	268	148	78	98	—
1987	262	143	76	103	129
1988	260	141	76	106	—
1989	244	133	78	114	—

Data from EC, 1992b with permission



342 POLLUTION ENVIRONMENTS

Table Total carbon monoxide emissions—mobile (M) and stationary (ST) sources

Carbon monoxide (1000 t CO) ton

mobil stationary?

Year	USA M	USA ST	West Germany M	West Germany ST	Netherlands M	Netherlands ST	UK M	UK ST	Ireland M	Ireland ST
1970	74 400	27 000	8 920	5620	1490	438	3097	1747	—	—
1975	65 000	19 100	10 152	3835	1495	423	3508	1157	331	57
1980	56 100	23 500	8 813	3193	1043	369	3896	933	420	77
1981	55 400	22 100	7 768	3001	938	360	3938	893	421	79
1982	52 900	19 400	7355	2620	919	331	4109	884	408	85
1983	52 400	22 100	6 900	2394	896	321	4161	854	384	88
1984	50 600	21 200	6 746	2577	859	346	4335	750	366	98
1985	47 900	21 800	6 314	2580	806	357	4431	887	355	107
1986	44 600	19 400	6 599	2416	780	353	4658	877	—	—
1987	43 300	20 900	6 539	2238	765	352	5074	818	388	119
1988	41 200	23 800	6 477	2194	768	358	5355	785	—	—
1989	40 000	20 900	6 100	2172	795	357	5792	730	—	—

Data from EC, 1992b with permission

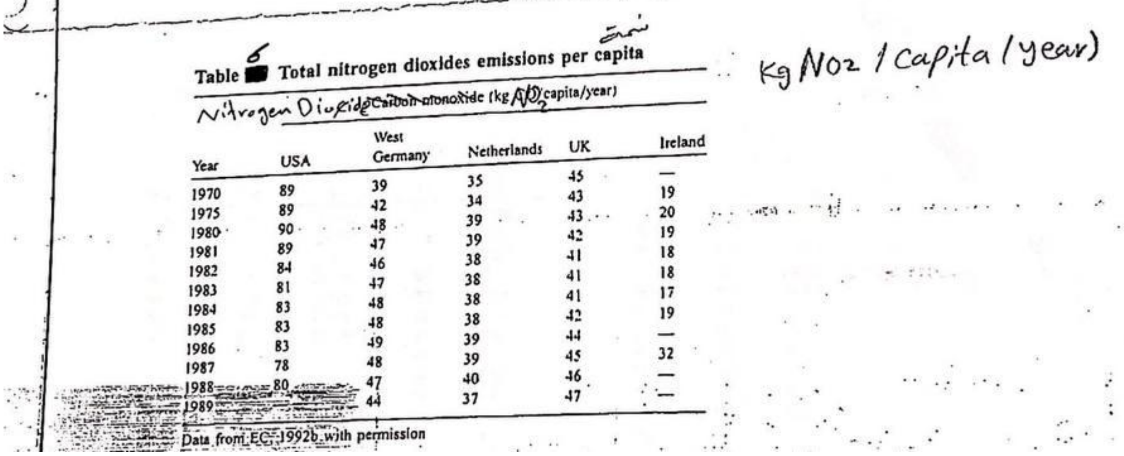


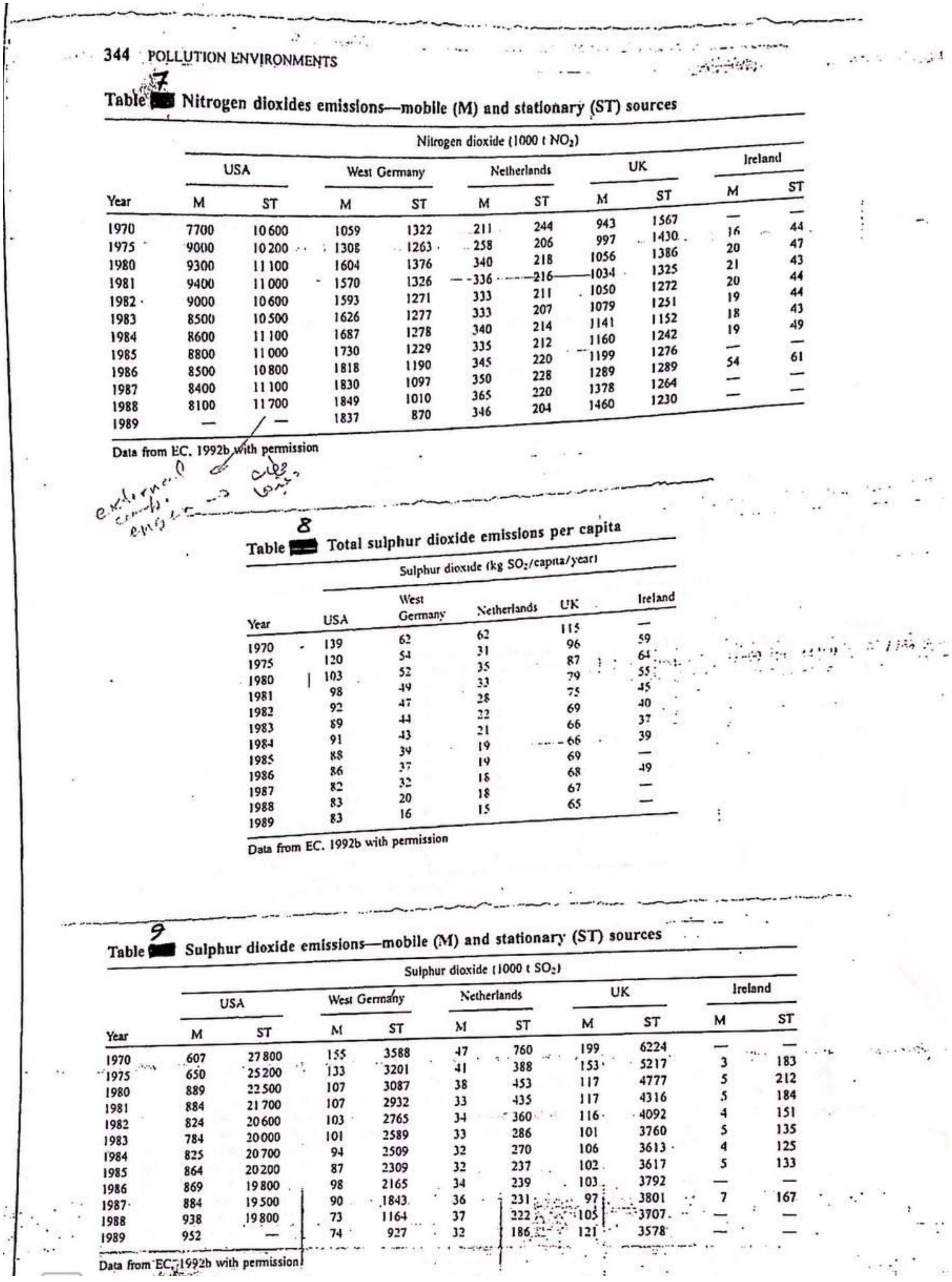
Table 6 Total nitrogen dioxides emissions per capita نسمة

Kg NO2 / capita / year)

Nitrogen Dioxide ~~Carbon monoxide~~ (kg ~~CO~~ NO_2/capita/year)

Year	USA	West Germany	Netherlands	UK	Ireland
1970	89	39	35	45	—
1975	89	42	34	43	19
1980	90	48	39	43	20
1981	89	47	39	42	19
1982	84	46	38	41	18
1983	81	47	38	41	18
1984	83	48	38	41	17
1985	83	48	38	42	19
1986	83	49	39	44	—
1987	78	48	39	45	32
1988	80	47	40	46	—
1989	[illegible]	44	37	47	—

Data from EC, 1992b with permission



344 POLLUTION ENVIRONMENTS

Table [redacted] 7 Nitrogen dioxides emissions—mobile (M) and stationary (ST) sources

	Nitrogen dioxide (1000 t NO_2)									
	USA		West Germany		Netherlands		UK		Ireland	
Year	M	ST	M	ST	M	ST	M	ST	M	ST
1970	7700	10 600	1059	1322	211	244	943	1567	—	—
1975	9000	10 200	1308	1263	258	206	997	1430	16	44
1980	9300	11 100	1604	1376	340	218	1056	1386	20	47
1981	9400	11 000	1570	1326	336	216	1034	1325	21	43
1982	9000	10 600	1593	1271	333	211	1050	1272	20	44
1983	8500	10 500	1626	1277	333	207	1079	1251	19	44
1984	8600	11 100	1687	1278	340	214	1141	1152	18	43
1985	8800	11 000	1730	1229	335	212	1160	1242	19	49
1986	8500	10 800	1818	1190	345	220	1199	1276	—	—
1987	8400	11 100	1830	1097	350	228	1289	1289	54	61
1988	8100	11 700	1849	1010	365	220	1378	1264	—	—
1989	—	—	1837	870	346	204	1460	1230	—	—

Data from EC, 1992b with permission

external comb. engine [illegible]

Table [redacted] 8 Total sulphur dioxide emissions per capita

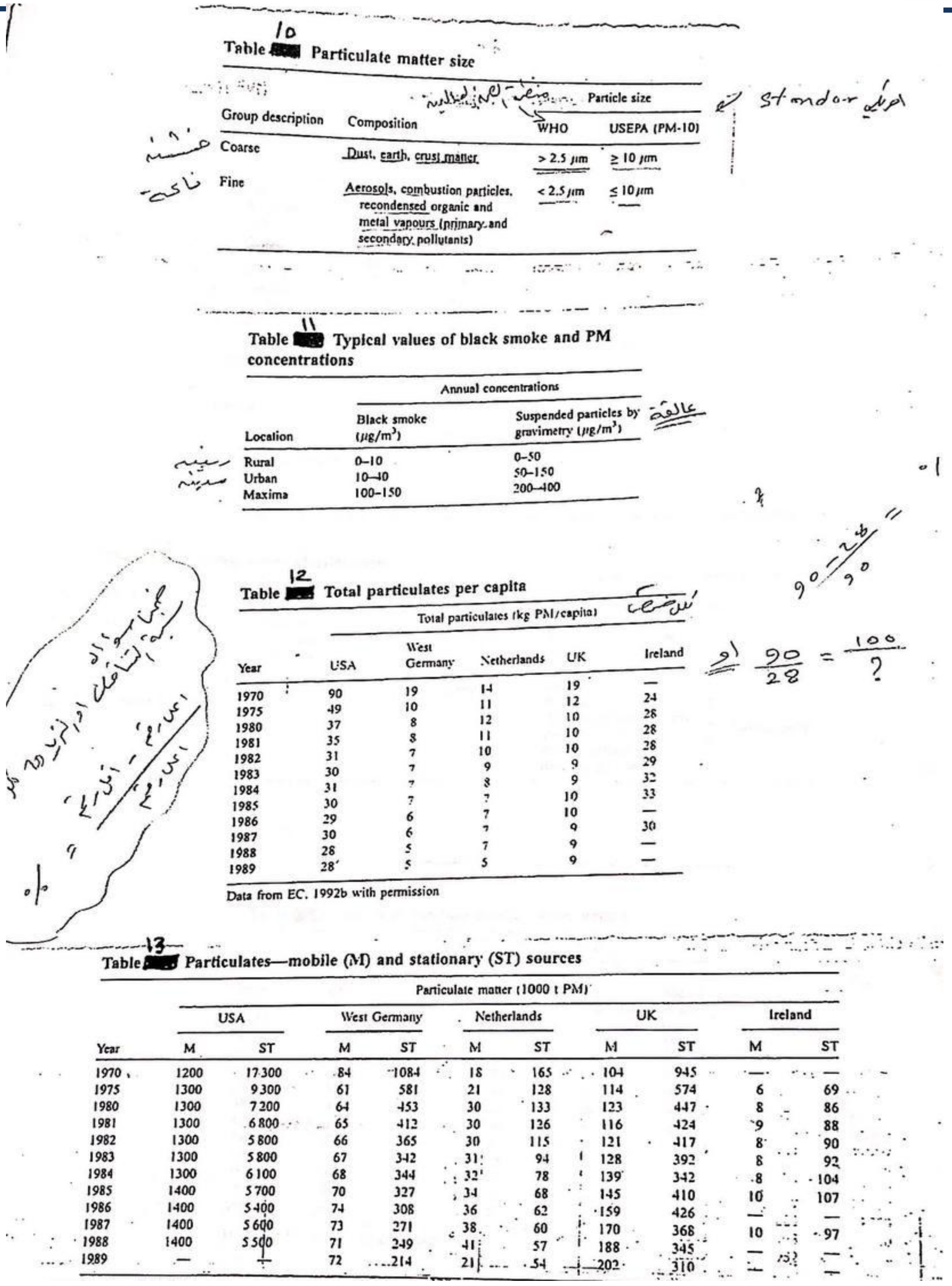
	Sulphur dioxide (kg SO_2/capita/year)				
Year	USA	West Germany	Netherlands	UK	Ireland
1970	139	62	62	115	—
1975	120	54	31	96	59
1980	103	52	35	87	64
1981	98	49	33	79	55
1982	92	47	28	75	45
1983	89	44	22	69	40
1984	91	43	21	66	37
1985	88	39	19	66	39
1986	86	37	19	69	—
1987	82	32	18	68	49
1988	83	20	18	67	—
1989	83	16	15	65	—

Data from EC, 1992b with permission

Table [redacted] 9 Sulphur dioxide emissions—mobile (M) and stationary (ST) sources

	Sulphur dioxide (1000 t SO_2)									
	USA		West Germany		Netherlands		UK		Ireland	
Year	M	ST	M	ST	M	ST	M	ST	M	ST
1970	607	27 800	155	3588	47	760	199	6224	—	—
1975	650	25 200	133	3201	41	388	153	5217	3	183
1980	889	22 500	107	3087	38	453	117	4777	5	212
1981	884	21 700	107	2932	33	435	117	4316	5	184
1982	824	20 600	103	2765	34	360	116	4092	4	151
1983	784	20 000	101	2589	33	286	101	3760	5	135
1984	825	20 700	94	2509	32	270	106	3613	4	125
1985	864	20 200	87	2309	32	237	102	3617	5	133
1986	869	19 800	98	2165	34	239	103	3792	—	—
1987	884	19 500	90	1843	36	231	97	3801	7	167
1988	938	19 800	73	1164	37	222	105	3707	—	—
1989	952	—	74	927	32	186	121	3578	—	—

Data from EC, 1992b with permission



10

Table [redacted] Particulate matter size

منظمة الصحة العالمية

standar اولية

Group description	Composition	Particle size WHO	Particle size USEPA (PM-10)
Coarse	Dust, earth, crust matter	> 2.5 μm	≥ 10 μm
Fine	Aerosols, combustion particles, recondensed organic and metal vapours (primary and secondary pollutants)	< 2.5 μm	≤ 10 μm

خشنة

ناعمة

11

Table [redacted] Typical values of black smoke and PM concentrations

عالقة

Location	Black smoke (μg/m³)	Suspended particles by gravimetry (μg/m³)
Rural	0–10	0–50
Urban	10–40	50–150
Maxima	100–150	200–400

ريفية

مدينة

12

Table [redacted] Total particulates per capita

نصيب

Total particulates (kg PM/capita)

Year	USA	West Germany	Netherlands	UK	Ireland
1970	90	19	14	19	—
1975	49	10	11	12	24
1980	37	8	12	10	28
1981	35	8	11	10	28
1982	31	7	10	10	28
1983	30	7	9	9	29
1984	31	7	8	9	32
1985	30	7	7	10	33
1986	29	6	7	10	—
1987	30	6	7	9	30
1988	28	5	7	9	—
1989	28′	5	5	9	—

Data from EC. 1992b with permission

او $\frac{90}{28} = \frac{100}{?}$

$\frac{90-28}{90}$ %

[illegible]

13

Table [redacted] Particulates—mobile (M) and stationary (ST) sources

Particulate matter (1000 t PM)

Year	USA M	USA ST	West Germany M	West Germany ST	Netherlands M	Netherlands ST	UK M	UK ST	Ireland M	Ireland ST
1970	1200	17 300	84	1084	18	165	104	945	—	—
1975	1300	9 300	61	581	21	128	114	574	6	69
1980	1300	7 200	64	453	30	133	123	447	8	86
1981	1300	6 800	65	412	30	126	116	424	9	88
1982	1300	5 800	66	365	30	115	121	417	8	90
1983	1300	5 800	67	342	31	94	128	392	8	92
1984	1300	6 100	68	344	32	78	139	342	8	104
1985	1400	5 700	70	327	34	68	145	410	10	107
1986	1400	5 400	74	308	36	62	159	426	—	—
1987	1400	5 600	73	271	38	60	170	368	10	97
1988	1400	5 500	71	249	41	57	188	345	—	—
1989	—	—	72	214	21	54	202	310	—	—

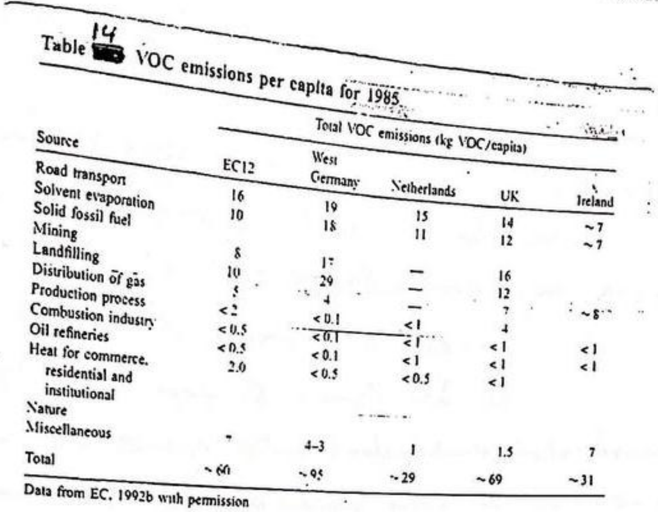


Table 14 [redacted] VOC emissions per capita for 1985

Source	Total VOC emissions (kg VOC/capita)				
	EC12	West Germany	Netherlands	UK	Ireland
Road transport	16	19	15	14	~7
Solvent evaporation	10	18	11	12	~7
Solid fossil fuel					
Mining	8	17	—	16	
Landfilling	10	29	—	12	
Distribution of gas	5	4	—	7	~8
Production process	<2	<0.1	<1	4	
Combustion industry	<0.5	<0.1	<1	<1	<1
Oil refineries	<0.5	<0.1	<1	<1	<1
Heat for commerce, residential and institutional	2.0	<0.5	<0.5	<1	
Nature					
Miscellaneous		4–3	1	1.5	7
Total	~60	~95	~29	~69	~31

Data from EC, 1992b with permission

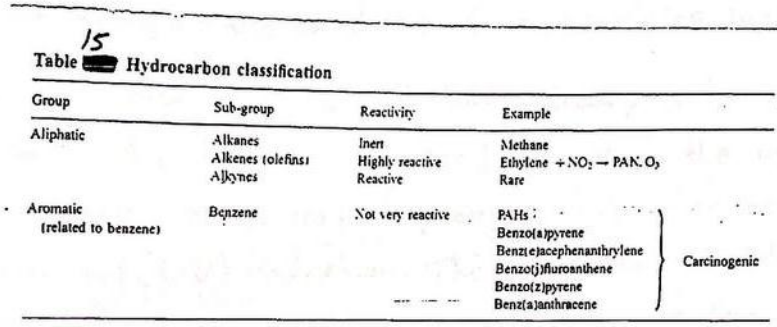


Table 15 [redacted] Hydrocarbon classification

Group	Sub-group	Reactivity	Example	
Aliphatic	Alkanes Alkenes (olefins) Alkynes	Inert Highly reactive Reactive	Methane Ethylene + $NO_2 \rightarrow$ PAN, O_3 Rare	
Aromatic (related to benzene)	Benzene	Not very reactive	PAHs: Benzo(a)pyrene Benz(e)acephenanthrylene Benzo(j)fluroanthene Benzo(z)pyrene Benz(a)anthracene	Carcinogenic

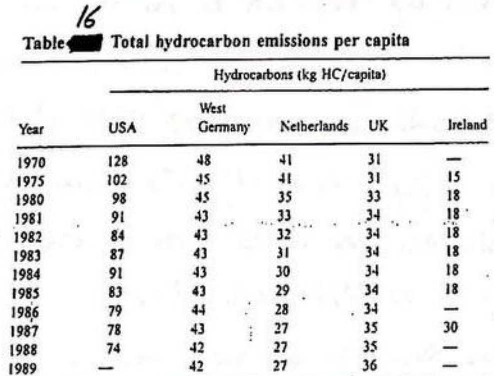


Table 16 [redacted] Total hydrocarbon emissions per capita

Year	Hydrocarbons (kg HC/capita)				
	USA	West Germany	Netherlands	UK	Ireland
1970	128	48	41	31	—
1975	102	45	41	31	15
1980	98	45	35	33	18
1981	91	43	33	34	18
1982	84	43	32	34	18
1983	87	43	31	34	18
1984	91	43	30	34	18
1985	83	43	29	34	18
1986	79	44	28	34	—
1987	78	43	27	35	30
1988	74	42	27	35	—
1989	—	42	27	36	—

Data from EC, 1992b with permission

Lecture No (15)

Toxic Pollutants, Radioactive pollutants, indoor pollutants and Non-Criteria pollutants

1. Class: third Year

2.Subject: other type of air pollutants

3. Number of weeks: one week

4. Central idea: other type of air pollutants

5. The Test:

B- Toxic Pollutants:

Hazardous air pollutants (HAPS), also called toxic air pollutants or air toxics, are those pollutants that cause or may cause Cancer or other serious health effects, birth defects. Example of toxic air pollutants include benzene, which is found in Gasoline; perchloroethylene, which is emitted from some dry cleaning facilities, and methylene chloride, which is used as a solvent and paint stripper by a number of industries.

C-Radioactive pollutants:

Radioactivity is an air pollutant that is both Georginic and anthropogenic. Georginic radioactivity results from the presence of Radionuclides, which originate either from radioactive minerals in the Earth's crust or from the interaction of cosmic radiation with atmosphere gases.

Anthropogenic radioactive emissions originate from nuclear reactors, the atomiz energy industry (mining and processing of reactor fuel), nuclear weapon explosions, and plants that process spent reactor fuel.

Since coal contains small quantities of uranium and thorium, these radioactive elements can be emitted into the atmosphere from coal-fired power plants and other sources..

D-indoor pollutants:

When a building is not properly ventilated, pollutants can accumulate and reach concentrations greater than those Typically found outside. This problem has received media attention as "sick building syndrome."

Environmental tobacco smoke (ETS) is one of the main contributors to indoor pollution.as are CO, NO, andSO2, which can be omitted from furnaces and stoves.

Cleaning or remodeling a house is an activity that can contribute evaluated concentrations of harmful chemicals such as VOCs emitted from household cleaners, paints, and varnishes. Also when bacteria die then release endotoxins into the air, which can cows adverse health effects.

So ventilation is important when cooking, cleaning, and disinfecting in a building. A giogenic source of indoor air pollution is radon.

E-Micro and Macro air pollution:

Air pollution problems may occur on three scales: micro, meso, and macro. Micro scale problems range from discovering less than a centimeter to those the size of a house or slightly larger.

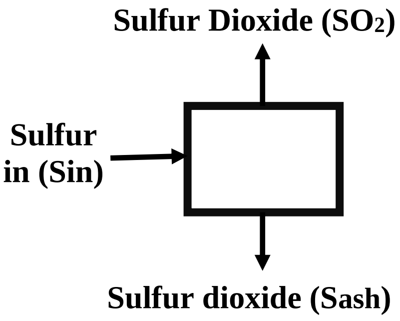
Miso scale air pollution problems are those of a fuel hectares up to size of a city or country.

Micro scale problems extend from countries to States, nations, and in the broadest sens, the globe.

Example 1:

A coal is burned at a rate of 1 kg/s. If the analysis of the coal reveals a sulphur content of 3.0 percent, what is the annual rate of emission of SO_2؟

Solution:



$Sin = Sash + Sso_2$

$Sin = 1 * 0.03 = 0.03$ Kg/s

In one year

$Sin = 0.03 * (3600 * 24) * 365 = 9.46 * 10^5$ Kg/y

Assume that the sulphur in the Ash is 5% of the input sulphur, then:

$Sash = 0.05 * 9.46 * 10^5 = 4.73 * 10^4$ Kg/y

The amount of sulphur available for conversion to SO_2:

$Sso_2 = Sin - Sash = 9.46 * 10^5 - 4.73 * 10^4 = 8.99 * 10^5$ Kg/h

$S + O_2 = SO_2$

$32 + 32 = 64$

$$S_{SO2} = \frac{64}{32}\,(\,8.99 * 10^5\,) = 1.8 * \; 10^6\; Kg/y$$

F- Non Criteria pollutants:

The criteria pollutants of CO, NO_2, SO_2, PM_{10}, VOCs. HC, and Pb are listed in Table 2-B along with the international standards for each and associated exposure time. In addition, there are many other air pollutants for which emission limits from industry are set. The so-called non-criteria pollutants are set out in tables 20 and 21.

Many of these are carcinogenic, mutagenic, and damaging to the central nervous system (CNS) as well as having a host of other negative health effects.

Some of the air pollutants are man-made the synthetic chemical such as 1,2 dichloroethane, while other such as Radon or naturally occurring in the background from the Earth's crustal geology

From those pollutants listed in table 20 and 21 most however, are products of industry and more specifically the chemical, pharmaceutical, petroleum products industries. The heavy metres of Cd, Cr and Hg are ubiquitous in the manufacturing and chemical industries, particularly electroplating, paints, chlorine, Chemicals.

Global Climate Change - Greenhouse Gases:

The major greenhouse gases in order of greenhouse contribution CO_2, CFCs, CH_4, N_2O and O_3. These gases have the effect of absorbing incoming shortwave solar energy (at wavelengths < 4Mm). They also have the ability of absorbing some of the outgoing earth's radiate energy long wavelength (> 4Mm). Each greenhouse gas has its own ideal wavelength bands at which is absorbs solar or Earth's radiation energy. The term greenhouse gases is reserved for those gases that absorb radiation at wavelengths > 4 Mm i.e. gases that absorb the long-wavelength earth radiation.

They therefore trap much of the outgoing Earth's radiative energy, therefore heating the atmosphere and subsequently radiating this energy back to earth and out to space. These greenhouse gases have the effect of acting like a thermal blanket around globe, raising its temperature.

1- Carbon Dioxide (CO_2):

Carbon dioxide is not a pollutant in the conventional sense It is a normal component of the atmosphere (0.033 percent) and is essential for plant growth. Fossil fuel combustion have increased the background levels of CO_2. It is now believed that man-made CO_2 is the most significant of the greenhouse gases.

2- Chlorofluorocarbons (CFCs):

CFCs are man-made molecules that contain chlorine, fluorine and carbon. They absorb a radiation in the atmospheric radiative window range of 7 to 12 Mm. In the atmosphere they have long residence times and are inert and none-water soluble.

Chlorine is freed from CFCs by the process of photolysis by short-wave radiation and drifts to damage ozone layer. The significant CFCs are CFC-11 (trichlorofluoromethane) and CFC-12 (dichlorofluoromethane).

3- Methane (CH_4):

Methane is a naturally occurring gas that is produced anaerobic conditions. This soccer in swamps, rice Fields, cattle stocks, and in the production and consumption of fossil fuels. Like the CFCs, CH_4 has long recidence time of about 10 years, after which it may be oxidized with OH radicals. It absorbs thermal radiation at narroe-band wavelengths around 3.2 and 7.6Mm.

4-Nitrous Oxides (N_2O):

Nitrous Oxides (N_2O) absorbs radiation at the same wavelength as methane 7.6Mm. it is produced in the nitrogen cycle via nitrification, i.e. $NH4 \rightarrow N2 \rightarrow N2O$. It has a residence time of about 150 years and is about 200 times as potent as a greenhouse gas CO_2. Emissions arise from water treatment plants, industrial sources, and gas combustion.

5-Water Vapor (H2O):

Water Vapor (H_2O) is often ignored as greenhouse gas. The examples on power plant emissions show that the amount of H_2O produced are similar to amount of CO_2. Also the long wavelength energy radiation by the Earth is absorbed by H_2O. Water vapor absorbs energy over several bands within the range of 1 to 8 Mm.

Example: compute the annual global natural emission of water vapor by evaporation from the Earth land and ocean surface. Compare this to the amount of water vapor emitted by industrial power plants.

Solution:

It assumed that evaporation from land

$$(Global\ average) \cong 0.45\, m/yr$$

$$Land\ area \qquad = 1.49 * 108\, km^2$$

Therefore water vapor for land evaporation=67*10^{12} m^3/yr

$$Evaporation\ from\ oceans \cong 2.3\, m/yr$$

Ocean area = 3.6 * 10^8 km^2

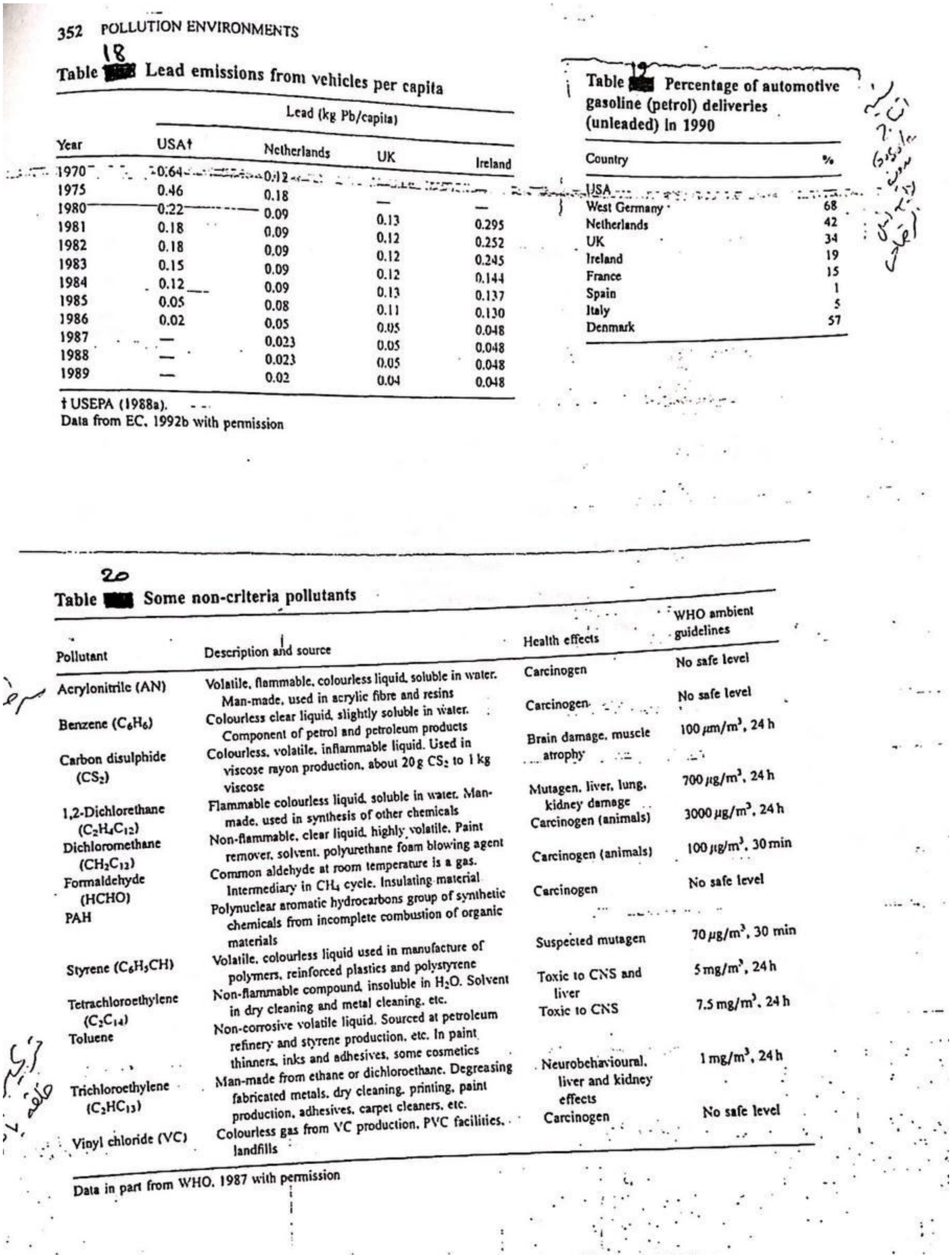
Therefore water evaporated from oceans ≅ 468 * 10^{12} m^3/yr

And total evaporated water vapor from Earth surface = 535 * 10^{12} m3/yr

Density of water vapor ≅ 0.8 Kg/m^3

Therefore total evaporated water vapor from Earth's surface=428*109 t/yr.

And this ≅ to the emission of water vapor from man-made sources which is about 6 * 10^9 t/yr., i.e. about 1.4 percent of the natural emission values.



18

Table [redacted] Lead emissions from vehicles per capita

	Lead (kg Pb/capita)			
Year	USA†	Netherlands	UK	Ireland
1970	0.64	0.12	[illegible]	[illegible]
1975	0.46	0.18	—	—
1980	0.22	0.09	0.13	0.295
1981	0.18	0.09	0.12	0.252
1982	0.18	0.09	0.12	0.245
1983	0.15	0.09	0.12	0.144
1984	0.12	0.09	0.13	0.137
1985	0.05	0.08	0.11	0.130
1986	0.02	0.05	0.05	0.048
1987	—	0.023	0.05	0.048
1988	—	0.023	0.05	0.048
1989	—	0.02	0.04	0.048

† USEPA (1988a).
Data from EC, 1992b with permission

19

Table [redacted] Percentage of automotive gasoline (petrol) deliveries (unleaded) in 1990

Country	%
USA	[illegible]
West Germany	68
Netherlands	42
UK	34
Ireland	19
France	15
Spain	1
Italy	5
Denmark	57

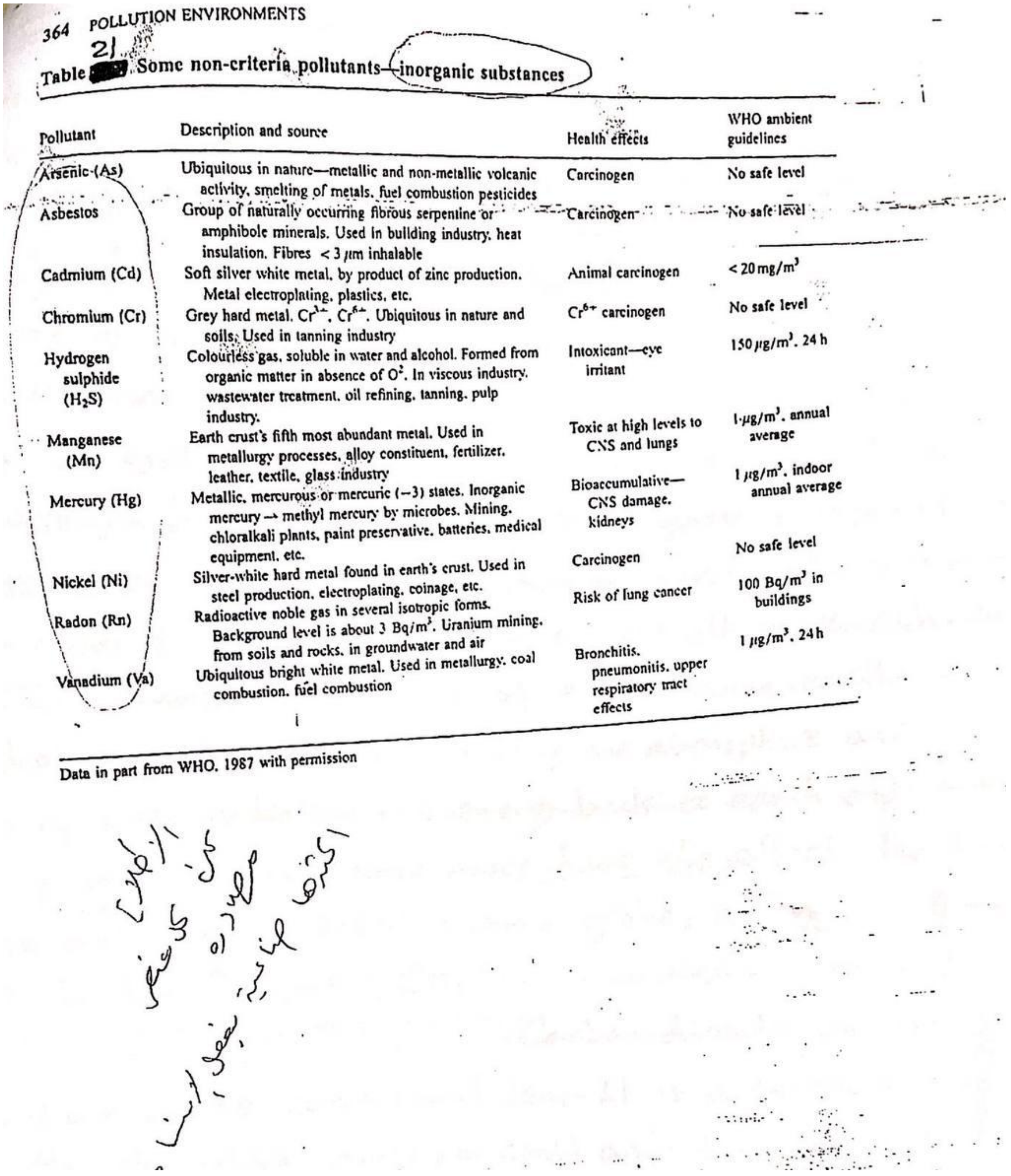
[illegible]

20

Table [redacted] Some non-criteria pollutants

Pollutant	Description and source	Health effects	WHO ambient guidelines
Acrylonitrile (AN)	Volatile, flammable, colourless liquid, soluble in water. Man-made, used in acrylic fibre and resins	Carcinogen	No safe level
Benzene (C_6H_6)	Colourless clear liquid, slightly soluble in water. Component of petrol and petroleum products	Carcinogen	No safe level
Carbon disulphide (CS_2)	Colourless, volatile, inflammable liquid. Used in viscose rayon production, about 20 g CS_2 to 1 kg viscose	Brain damage, muscle atrophy	100 µm/m³, 24 h
1,2-Dichlorethane ($C_2H_4C_{12}$)	Flammable colourless liquid, soluble in water. Man-made, used in synthesis of other chemicals	Mutagen, liver, lung, kidney damage	700 µg/m³, 24 h
Dichloromethane (CH_2C_{12})	Non-flammable, clear liquid, highly volatile. Paint remover, solvent, polyurethane foam blowing agent	Carcinogen (animals)	3000 µg/m³, 24 h
Formaldehyde (HCHO)	Common aldehyde at room temperature is a gas. Intermediary in CH_4 cycle. Insulating material	Carcinogen (animals)	100 µg/m³, 30 min
PAH	Polynuclear aromatic hydrocarbons group of synthetic chemicals from incomplete combustion of organic materials	Carcinogen	No safe level
Styrene (C_6H_5CH)	Volatile, colourless liquid used in manufacture of polymers, reinforced plastics and polystyrene	Suspected mutagen	70 µg/m³, 30 min
Tetrachloroethylene (C_2C_{14})	Non-flammable compound, insoluble in H_2O. Solvent in dry cleaning and metal cleaning, etc.	Toxic to CNS and liver	5 mg/m³, 24 h
Toluene	Non-corrosive volatile liquid. Sourced at petroleum refinery and styrene production, etc. In paint thinners, inks and adhesives, some cosmetics	Toxic to CNS	7.5 mg/m³, 24 h
Trichloroethylene (C_2HC_{13})	Man-made from ethane or dichloroethane. Degreasing fabricated metals, dry cleaning, printing, paint production, adhesives, carpet cleaners, etc.	Neurobehavioural, liver and kidney effects	1 mg/m³, 24 h
Vinyl chloride (VC)	Colourless gas from VC production, PVC facilities, landfills	Carcinogen	No safe level

Data in part from WHO, 1987 with permission



364 POLLUTION ENVIRONMENTS

21

Table [redacted] Some non-criteria pollutants—inorganic substances

Pollutant	Description and source	Health effects	WHO ambient guidelines
Arsenic (As)	Ubiquitous in nature—metallic and non-metallic volcanic activity, smelting of metals, fuel combustion pesticides	Carcinogen	No safe level
Asbestos	Group of naturally occurring fibrous serpentine or amphibole minerals. Used in building industry, heat insulation. Fibres < 3 μm inhalable	Carcinogen	No safe level
Cadmium (Cd)	Soft silver white metal, by product of zinc production. Metal electroplating, plastics, etc.	Animal carcinogen	< 20 mg/m^3
Chromium (Cr)	Grey hard metal. Cr^{3+}, Cr^{6+}. Ubiquitous in nature and soils. Used in tanning industry	Cr^{6+} carcinogen	No safe level
Hydrogen sulphide (H_2S)	Colourless gas, soluble in water and alcohol. Formed from organic matter in absence of O^2. In viscous industry, wastewater treatment, oil refining, tanning, pulp industry.	Intoxicant—eye irritant	150 μg/m^3, 24 h
Manganese (Mn)	Earth crust's fifth most abundant metal. Used in metallurgy processes, alloy constituent, fertilizer, leather, textile, glass industry	Toxic at high levels to CNS and lungs	1 μg/m^3, annual average
Mercury (Hg)	Metallic, mercurous or mercuric (−3) states. Inorganic mercury → methyl mercury by microbes. Mining, chloralkali plants, paint preservative, batteries, medical equipment, etc.	Bioaccumulative—CNS damage, kidneys	1 μg/m^3, indoor annual average
Nickel (Ni)	Silver-white hard metal found in earth's crust. Used in steel production, electroplating, coinage, etc.	Carcinogen	No safe level
Radon (Rn)	Radioactive noble gas in several isotropic forms. Background level is about 3 Bq/m^3. Uranium mining, from soils and rocks, in groundwater and air	Risk of lung cancer	100 Bq/m^3 in buildings
Vanadium (Va)	Ubiquitous bright white metal. Used in metallurgy, coal combustion, fuel combustion	Bronchitis, pneumonitis, upper respiratory tract effects	1 μg/m^3, 24 h

Data in part from WHO, 1987 with permission

اعلاه
من كل عنصر
مصادره
اكثرها صناعية بفعل الانسان