Regulating air quality

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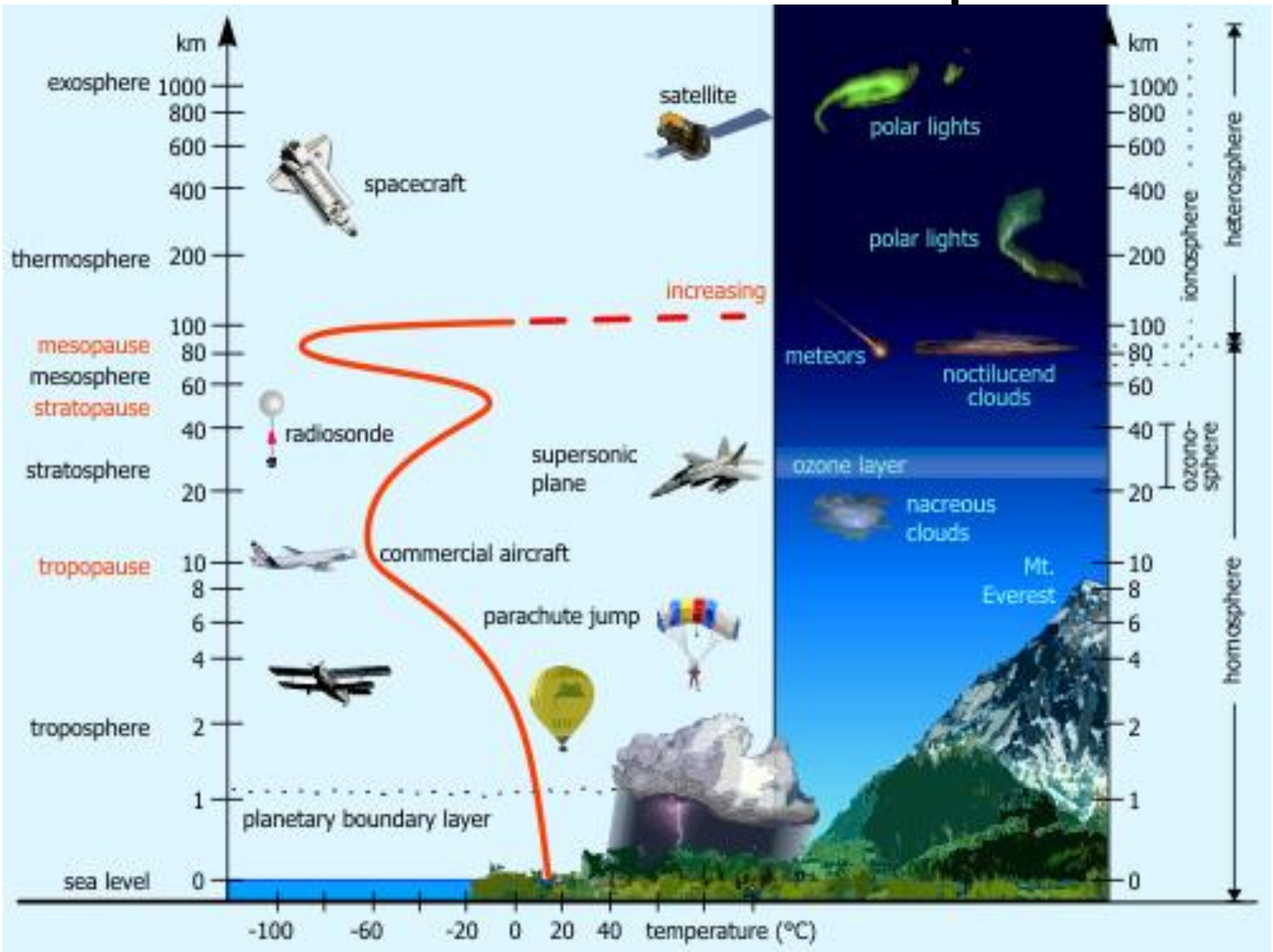
The structure of atmosphere



Air quality standards

- Air quality standards establish permissible rates of harmful substances both at production area (intended for industrial enterprises, pilot plants, research institutes, etc), and atresidential areas (intended for housing, public buildings and facilities, settlements).

Air pollutants may be divided into two broad categories, natural and human-made (synthetic).

Natural sources of air pollutants include the following:

1. Windblown dust
2. Volcanic ash and gases
3. Ozone from lightning and the ozone layer
4. Esters and terpenes from vegetation
5. Smoke, gases, and fly ash from forest fires
6. Pollens and other aeroallergens
7. Gases and odors from natural decompositions
8. Natural radioactivity

Human-made sources cover a wide spectrum of chemical and physical activities.

Air pollutants

Air pollutants may also be classified by origin and state of matter. Under the classification by origin, the following subdivisions pertain:

- primary—emitted to the atmosphere from a process;
- secondary—formed in the atmosphere as a result of a chemical reaction.

Under the state of matter, there exist the classifications particulate and gaseous.

Particulates have been defined as solid or liquid matter whose effective diameter is larger than a molecule but smaller than approximately 1000 mm (micrometers).

Some Gases and Aerosol Particle Components Important for Specified Air Pollution Topics

Indoor Air Pollution	Outdoor Urban Air Pollution	Acid Deposition	Stratospheric Ozone Reduction	Global Climate Change
Gases				
Nitrogen dioxide Carbon monoxide Formaldehyde Sulfur dioxide Organic gases Radon	Ozone Nitric oxide Nitrogen dioxide Carbon monoxide Ethene Toluene Xylene PAN	Sulfur dioxide Sulfuric acid Nitrogen dioxide Nitric acid Hydrochloric acid Carbon dioxide	Ozone Nitric oxide Nitric acid Hydrochloric acid Chlorine nitrate CFC-11 CFC-12	Water vapor Carbon dioxide Methane Nitrous oxide Ozone CFC-11 CFC-12
Aerosol Particle Components				
Black carbon Organic matter Sulfate Nitrate Ammonium Allergens Asbestos Fungal spores Pollens Tobacco smoke	Black carbon Organic matter Sulfate Nitrate Ammonium Soil dust Sea spray Tire particles Lead	Sulfate Nitrate Chloride	Chloride Sulfate Nitrate	Black carbon Organic matter Sulfate Nitrate Ammonium Soil dust Sea spray

Volume Mixing Ratios of Fixed Gases in the Lowest 100 km of the Earth's Atmosphere

Gas	Chemical Formula	Volume Mixing Ratio	
		Percent	ppmv
Molecular nitrogen	$N_2(g)$	78.08	780,000
Molecular oxygen	$O_2(g)$	20.95	209,500
Argon	Ar(g)	0.93	9,300
Neon	Ne(g)	0.0015	15
Helium	He(g)	0.0005	5
Krypton	Kr(g)	0.0001	1
Xenon	Xe(g)	0.000005	0.05

Volume Mixing Ratios of Some Variable Gases in Three Atmospheric Regions

Gas Name	Chemical Formula	Volume Mixing Ratio (ppbv)		
		Clean Troposphere	Polluted Troposphere	Stratosphere
Inorganic				
Water vapor	$H_2O(g)$	3,000–4.0(+7)[a]	5.0(+6)–4.0(+7)	3,000–6,000
Carbon dioxide	$CO_2(g)$	365,000	365,000	365,000
Carbon monoxide	$CO(g)$	40–200	2,000–10,000	10–60
Ozone	$O_3(g)$	10–100	10–350	1,000–12,000
Sulfur dioxide	$SO_2(g)$	0.02–1	1–30	0.01–1
Nitric oxide	$NO(g)$	0.005–0.1	0.05–300	0.005–10
Nitrogen dioxide	$NO_2(g)$	0.01–0.3	0.2–200	0.005–10
CFC-12	$CF_2Cl_2(g)$	0.55	0.55	0.22
Organic				
Methane	$CH_4(g)$	1,800	1,800–2,500	150–1,700
Ethane	$C_2H_6(g)$	0–2.5	1–50	—
Ethene	$C_2H_4(g)$	0–1	1–30	—
Formaldehyde	$HCHO(g)$	0.1–1	1–200	—
Toluene	$C_6H_5CH_3$	—	1–30	—
Xylene	$C_6H_4(CH_3)_2(g)$	—	1–30	—
Methyl chloride	$CH_3Cl(g)$	0.61	0.61	0.36

[a]4.0(+7) means 4.0×10^7. —, indicates that the volume mixing ratio is negligible, on average.

AIR QUALITY STANDARDS (EPA)

There are two types of standards -- primary and secondary:

- Primary standards protect against adverse health effects;
- secondary standards protect against welfare effects, such as damage to farm crops and vegetation and damage to buildings.
- Because different pollutants have different effects, the NAAQS are also different. Some pollutants have standards for both long-term and short-term averaging times. The short-term standards are designed to protect against acute, or short-term, health effects, while the long-term standards were established to protect against chronic health effects.

National Ambient Air Quality Standards (NAAQS) (EPA)

Pollutant [final rule cite]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide [76 FR 54294, Aug 31, 2011]		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead [73 FR 66964, Nov 12, 2008]		primary and secondary	Rolling 3 month average	0.15 µg/m^3 (1)	Not to be exceeded
Nitrogen Dioxide [75 FR 6474, Feb 9, 2010] [61 FR 52852, Oct 8, 1996]		primary	1-hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	Annual	53 ppb (2)	Annual Mean
Ozone [73 FR 16436, Mar 27, 2008]		primary and secondary	8-hour	0.075 ppm (3)	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution Dec 14, 2012	$PM_{2.5}$	primary	Annual	12 µg/m^3	annual mean, averaged over 3 years
		secondary	Annual	15 µg/m^3	annual mean, averaged over 3 years
		primary and secondary	24-hour	35 µg/m^3	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24-hour	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide [75 FR 35520, Jun 22, 2010] [38 FR 25678, Sept 14, 1973]		primary	1-hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

Air Quality Standards

- In Finland, the air quality standards limit values and guidelines are based on the European Union's Air Quality directives that define the health based limit values for the most common pollutants.
- The main purpose of the EU air quality legislation is to protect human health and the nature from the negative effect of pollutants in the air.
- In Finland, there are altogether 14 regulated compounds (SO_2, NO_2, NO_x, PM_{10}, $PM_{2,5}$, Pb, C_6H_6, Co, O_3, As, Cd, Ni, B[a]P, TSP, TRS,).

EU air quality standards

Pollutant	Protecting	Period of analysis	Value	Status
Nitrogen dioxide (NO_2)	Human health	Annual mean	40 $\mu g\ m^{-3}$	Limit value; valid from 2010
	Human health	Hourly mean; exceedances may occur for a maximum of 18 hours per year	200 $\mu g\ m^{-3}$	Limit value; valid from 2010
Nitrogen oxides (NO_x)	Vegetation	Annual mean	30 $\mu g\ m^{-3}$	Critical level
Particulate matter (PM_{10})	Human health	Annual mean	40 $\mu g\ m^{-3}$	Limit value; valid since 2005
	Human health	Daily mean; exceedances may occur for a maximum of 35 days per year	50 $\mu g\ m^{-3}$	Limit value; valid since 2005
Particulate matter ($PM_{2.5}$)	Human health	Annual mean	25 $\mu g\ m^{-3}$	Target value, to be reached in 2010; limit value, enters into force in 2015
	Human health	Annual mean	20 $\mu g\ m^{-3}$	Indicative limit value; valid from 2020, to be reviewed by the Commission in 2013
Ozone (O_3)	Human health	Maximum daily 8 hour mean; exceedances may occur for a maximum of 25 days per calendar year, averaged over three years	120 $\mu g\ m^{-3}$	Target value; to be reached in 2010
	Vegetation	AOT40, accumulated over May to July, averaged over five years	18 000 ($\mu g\ m^{-3}$)·h	Target value; to be reached in 2010
Sulphur dioxide (SO_2)	Human health	Hourly mean; exceedances may occur for a maximum of 24 hours per calendar year	350 $\mu g\ m^{-3}$	Limit value; valid since 2005
	Human health	Daily mean; exceedances may occur for a maximum of 3 days per calendar year	125 $\mu g\ m^{-3}$	Limit value; valid since 2005
	Vegetation	Annual / Winter (1 October to 31 March) mean	20 $\mu g\ m^{-3}$	Critical level
Benzene	Human health	Annual mean	5 $\mu g\ m^{-3}$	Limit value; valid from 2010
Carbon monoxide (CO)	Human health	Maximum daily 8 hour mean	10 $mg\ m^{-3}$	Limit value; valid since 2005
Lead (Pb)	Human health	Annual mean	0.5 $\mu g\ m^{-3}$	Limit value; valid since 2005
Arsenic (As)	Human health	Annual mean; for the total content in the PM_{10} fraction	6 $ng\ m^{-3}$	Target value; to be reached in 2013
Cadmium (Cd)	Human health	Annual mean; for the total content in the PM_{10} fraction	5 $ng\ m^{-3}$	Target value; to be reached in 2013
Nickel (Ni)	Human health	Annual mean; for the total content in the PM_{10} fraction	20 $ng\ m^{-3}$	Target value; to be reached in 2013
Benzo(a)pyrene (as a marker for the carcinogenic risk of PAHs)	Human health	Annual mean; for the total content in the PM_{10} fraction	1 $ng\ m^{-3}$	Target value; to be reached in 2013

Air Monitoring in Russia

The priority of the Russian air quality legislation is the protection of human life and health, the present and future generations.

The aim is to ensure favorable environmental conditions for living, labour and leisure and to prevent the irreversible environmental consequences of the air pollution. The state regulation for the pollutant emissions to the air and for the negative physical impact on the air is obligatory.

The principles of the air quality legislation include the transparency, completeness and reliability of the information on the state of the ambient air and on the air pollution. The legislation aims to scientific, systematic and integrated approach to the air protection and to the environmental protection in general.

Air quality standards determine allowable limits for hazardous substances both in the industrial and residential areas.

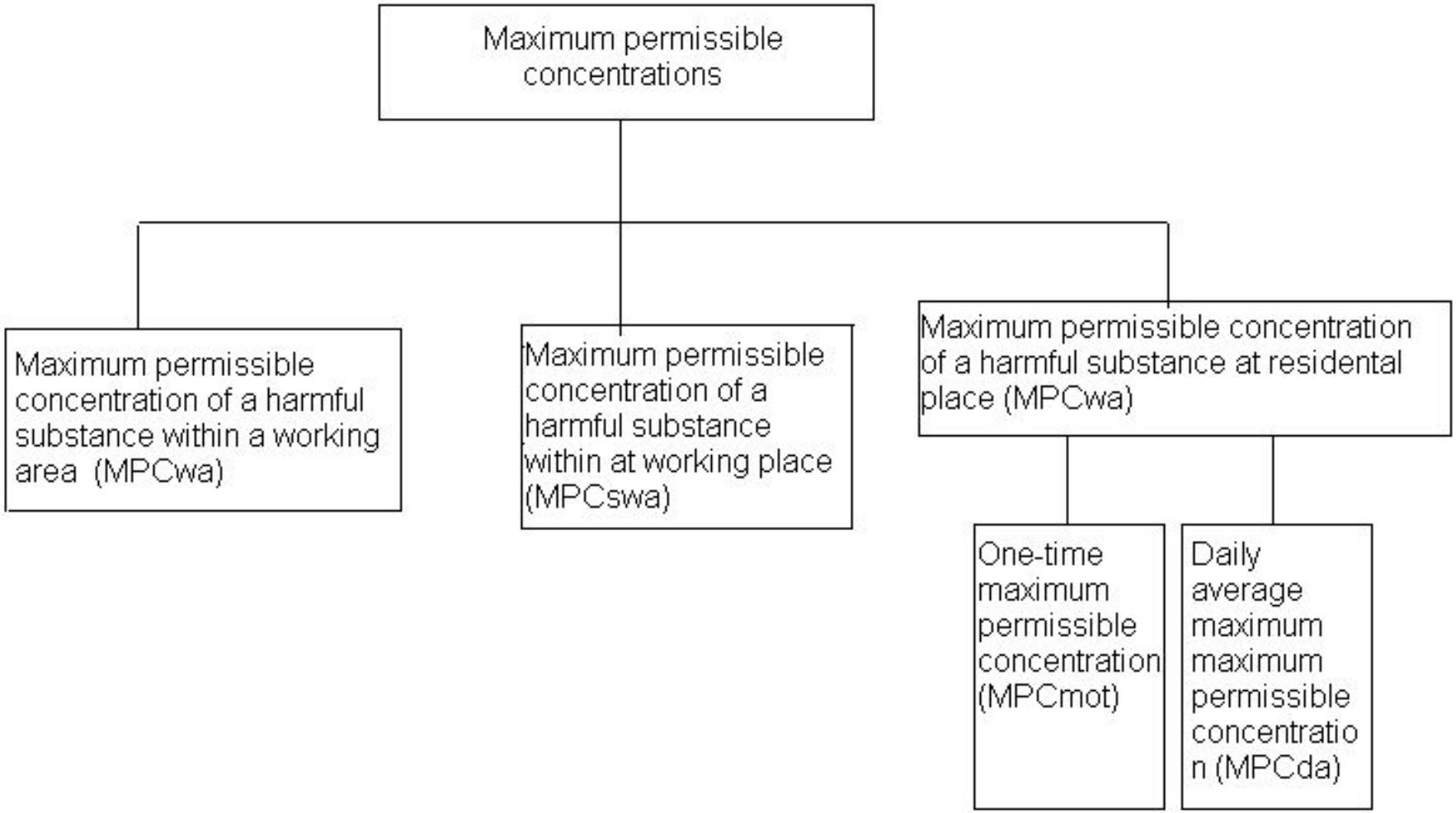
There is a range of air quality standards:

- **Maximum allowable concentration** of hazardous substance **in the working area** air (MACwa) is a concentration which, with daily (except weekends) work of 8 hours a day or of other duration, but not longer than 41 hours a week, throughout the length of service should not cause a disease or any deviation in the state of health detected by modern research methods in the process of work or during remote periods of life of current or future generations.
- **Maximum allowable concentration**, maximum non-recurrent (MACmnr) is a concentration of a hazardous substance in the air of a locality which does not cause, when inhaled for 20 minutes, any reflex reactions in the human body.
- **Maximum allowable concentration, daily average** (MACda) is a concentration of a hazardous substance in the air of a locality which should not have any direct or indirect impact on a human being when inhaled for an indefinitely long period (years). MACda is calculated for all population groups and for an indefinitely long period of impact and, therefore, it is the most stringent sanitary and hygiene standard setting concentration of a hazardous substance in ambient air.
- The “Atmosphere Pollution Index” (API) is most common in the list of integrated atmosphere pollution indicators.

Air Monitoring in Russia

The maximum permissible concentrations are established by the sanitary and epidemiologic regulations and standards “Hygienic requirements to the air quality in residential areas SanPiN 2.1.6.1032-01”. The bases of the regulation for the air quality in residential areas are the hygienic standards – maximum permissible concentrations (MPC) of chemical and biological pollutants. MPC are established to prevent odours, irritant action and reflex reactions and acute impact of the air pollution on human health during short-term raise of concentrations, as well as prevention of negative impact on the human health resulting from long-term exposure to the air pollutants (EU-Russia Program of Cooperation, 2008).

MPC


Maximum permissible concentrations
Maximum permissible concentration of a harmful substance within a working area (MPCwa)
Maximum permissible concentration of a harmful substance within at working place (MPCswa)
Maximum permissible concentration of a harmful substance at residental place (MPCwa)
One-time maximum permissible concentration (MPCmot)
Daily average maximum maximum permissible concentratio n (MPCda)

Ratio of various MPCs in air (for several substances)

Substance	MPCwa, mg/m^3	MPCmot, mg/m^3	MPCda, mg/m^3
Nitrogen oxide (II)	0,06	0,6	30
Cobalt sulfate	0,0004	0,001	0,005
4-chloroaniline	0,01	0,04	0,30

Atmospheric Pollution Index

$$API = \sum_{i=1}^{N} \left(\frac{q}{MPCcc} \right) Ci$$

q — average concentration of the i substance;
MPC— MPC for i substance;
Ci — numerical constant of adjustment of harmfulness of the i substance

The level of air pollution	API
Low	≤5
Heightened	5-7
High	7-14
Very high	≥14

Facility-specific emission limit values in Russia

- **Air emission limit value (so-called PDV)** is a mass of a substance in flue gas, the maximum allowable for emission into the atmosphere per unit of time.
- PDV is set **for each source** of pollution of atmosphere (and for each ingredient released from that source) so that air emissions do not lead to ground level concentrations exceeding MACmnr;
- ELVs are set at complete production capacity and normal operation of gas treatment equipment.
- ELV can be expressed in g/second or tone/year, taking into account the uneven nature of emissions over time, including due to scheduled repairs of process and gas treatment equipment.

Hazard classes of chemical compounds with regard to their toxicity properties

	Hazard classes			
	I Extremely hazardous	**II Highly hazardous**	**III Moderately hazardous**	**IV Low hazard**
MPC, mg/m^3	Less than 0,1,	0,1-1	0 1-10	Over 10
LD50, when in stomach, mg/kg of the body weight	Less than 15	15-150	150-5000	Over 5000

The air quality index (AQI) - USA

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low}$$

where:

I = the (Air Quality) index,
C = the pollutant concentration,
C_{low} = the concentration breakpoint that is ≤ C ,
C_{high} = the concentration breakpoint that is ≥ C,
I_{low} = the index breakpoint corresponding to C low,
I_{high} = the index breakpoint corresponding to C high.

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*..air quality conditions are:*	*..as symbolized by this color:*
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

AQI Value	Actions to Protect Your Health From Ozone
Good (0–50)	None
Moderate (51–100*)	Unusually sensitive people should consider reducing prolonged or heavy outdoor exertion.
Unhealthy for Sensitive Groups (101–150)	The following groups should reduce prolonged or heavy outdoor exertion: • People with lung disease, such as asthma • Children and older adults • People who are active outdoors
Unhealthy (151–200)	The following groups should avoid prolonged or heavy outdoor exertion: • People with lung disease, such as asthma • Children and older adults • People who are active outdoors Everyone else should limit prolonged outdoor exertion.
Very Unhealthy (201–300)	The following groups should avoid all outdoor exertion: • People with lung disease, such as asthma • Children and older adults • People who are active outdoors Everyone else should limit outdoor exertion.

O_3

AQI Value	Actions To Protect Your Health From Particle Pollution
Good (0–50)	None
Moderate (51–100*)	Unusually sensitive people should consider reducing prolonged or heavy exertion.
Unhealthy for Sensitive Groups (101–150)	The following groups should reduce prolonged or heavy exertion: • People with heart or lung disease • Children and older adults
Unhealthy (151–200)	The following groups should avoid prolonged or heavy exertion: • People with heart or lung disease • Children and older adults Everyone else should reduce prolonged or heavy exertion.
Very Unhealthy (201–300)	The following groups should avoid all physical activity outdoors: • People with heart or lung disease • Children and older adults Everyone else should avoid prolonged or heavy exertion.

PARTICLE POLLUTION

AQI Value	Actions To Protect Your Health From Carbon Monoxide
Good (0–50)	None
Moderate (51–100*)	None
Unhealthy for Sensitive Groups (101–150)	People with heart disease, such as angina, should reduce heavy exertion and avoid sources of carbon monoxide, such as heavy traffic.
Unhealthy (151–200)	People with heart disease, such as angina, should reduce moderate exertion and avoid sources of carbon monoxide, such as heavy traffic.
Very Unhealthy (201–300)	People with heart disease, such as angina, should avoid exertion and sources of carbon monoxide, such as heavy traffic.

CARBONR MONOXIDE

Indices by location

- **In Canada**: The Air Health Indexor (AQHI)
- **Hong Kong**: Air Pollution Index
- **Singapore**: Pollutant Standards Index
- **UK**: Daily Air Quality Index

Long-term observations

- Trends of greenhouse gases like CO_2, CH_4, N_2O, or CFM's
- Stratospheric ozone
- Change of stratospheric chemistry
- The temporal evolution in the abundance of species supplying halogens to the stratosphere (e.g. CFC-and HCFC-species)
- Trend of the tropospheric ozone.

Regional and episodic studies seek

- Monitoring of air pollutants (like O_3, SO_2, NO, NO_2, hydrocarbons)
- Investigation of urban plume evolution (e.g. with espect to O_3 formation downwind of source regions)
- Mapping of continental plumes Observation of the Antarctic Stratospheric Ozone Hole
- Polar boundary-layer ozone loss events (the ‘tropospheric ozone hole’

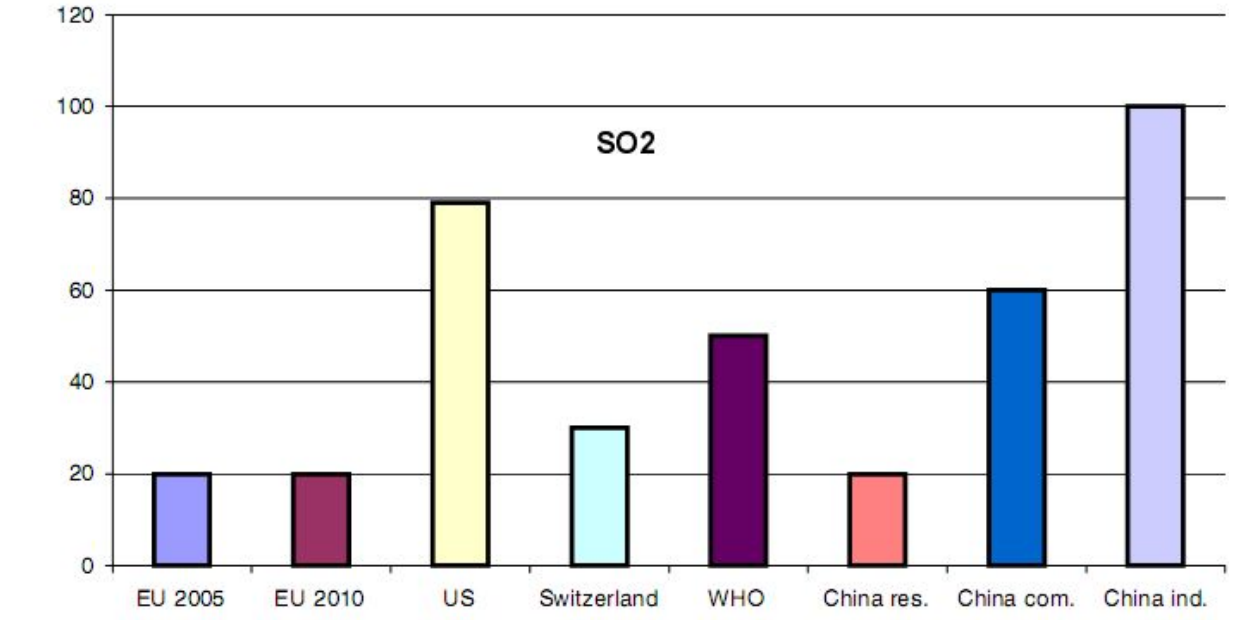
Monitor Types (EPA, USA)

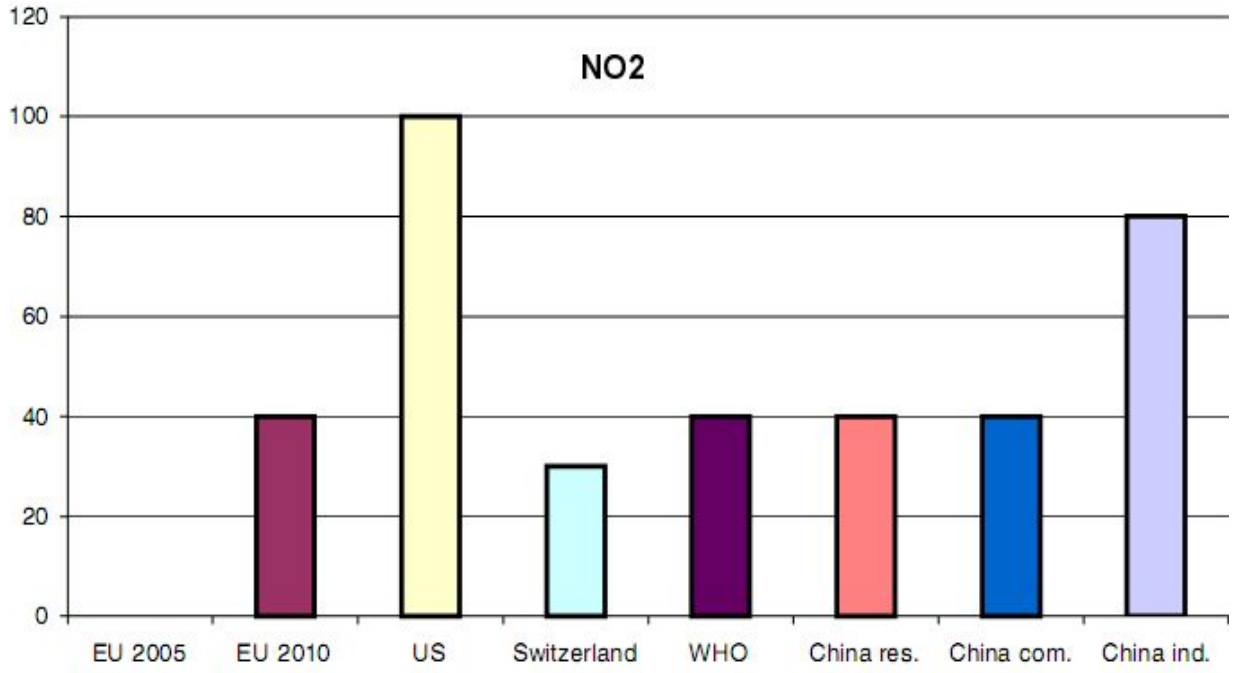
- Clean Air Act requires every state to establish a network of air monitoring stations for criteria pollutants.
- The monitoring stations in this network are called the State and Local Air Monitoring Stations (SLAMS). The states must provide with an annual summary of monitoring results at each SLAMS monitor. To obtain more timely and detailed information about air quality in strategic locations across the nation, established an additional network of monitors: the National Air Monitoring Stations (NAMS).
- A third type of monitor, the Special Purpose Monitor (SPMS), is used by State and local agencies to fulfill very specific or short-term monitoring goals.

Предельно допустимые концентрации загрязняющих веществ в РФ				
N	Вещество	Класс опасности	$ПДК_{МР}$, мг/м3	$ПДК_{СС}$, мг/м3
1	Оксид углерода	4	5	3
2	Диоксид азота	2	0,2	0,04
3	Оксид азота	3	0,4	0,06
4	Углеводороды суммарные	-	-	-
5	Метан	-	50	-
6	Диоксид серы	3	0,5	0,05
7	Аммиак	4	0,2	0,04
8	Сероводород	2	0,008	-
9	Озон	1	0,16	0,03
10	Формальдегид	2	0,05	0,01
11	Фенол	2	0,01	0,003
12	Бензол	2	0,3	0,1
13	Толуол	3	0,6	-
14	Параксилол	3	0,3	-
15	Стирол	2	0,04	0,002
16	Этилбензол	3	0,02	-
17	Нафталин	4	0,007	-
18	PM_{10}		0,3	0,06
19	$PM_{2,5}$		0,16	0,035

Предельно допустимые концентрации основных загрязняющих веществ в РФ и критерии качества атмосферного воздуха в ЕС, США и ВОЗ

Загрязняющее вещество	Время осреднения	Россия, мг/м3	ВОЗ, мг/м3	США, мг/м3	ЕС, мг/м3
CO	15 мин.	-	100	-	-
	30 мин.	5	60	-	-
	1 час	-	30	40	-
	8 часов	-	10	10	10
	24 часа	3	-	-	-
NO_2	30 мин	0,2	-	-	-
	1 час	-	0,2	-	0,2 Не должна быть превышена более чем 18 раз за год
	24 часа	0,04	-	-	0,125 Не должна быть превышена более чем 3 раза за год.
	Средняя за год	-	0,04	0,1	0,04
O_3	30 мин.	0,16	-	-	-
	1 час	-	-	0,235	-
	8 часов	-	0,12	0,157	-
	24 часа	0,03	-	-	-
SO_2	10 мин	-	0,5	-	-
	30 мин	0,5	-	-	-
	1 час	-	-	-	0,350 Не должна быть превышена более чем 24 раз за год
	24 часа	0,05	0,125	0,365	0,125 Не должна быть превышена более чем 3 раза за год.
	Средняя за год	-	0,05	0,08	0,02
PM_{10}	30 мин.	0,3	-	-	-
	24 часа	0,06	-	0,15	0,05 Не должна быть превышена более чем 3 раза за год
	Средняя за год	-	0,05	0,08	0,02
Бензол	30 мин	0,3	-	-	-
	24 часа	0,1	-	-	-





Comparison of air quality limit values for annual averages for various regions. Unit $\mu g/m^3$

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China: Zone 1: residential areas; Zone 2: commercial areas; Zone 3: industrial areas