Air Quality

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Abstract

Air quality standards are set in each country. The WHO air quality guidelines are designed to offer guidance in reducing the health impacts by regarding local circumstances carefully before using the guidelines directly as legal standards. This work describes air quality guideline in general and the measurements of air quality.

1. Air quality guideline

Air quality means the state of the air around us. Good air quality refer to clean, clear, unpolluted air. Clean air is considered to be a basic requirement of human health. Poor air quality occurs when pollutants reach high enough concentrations to endanger human health. Air pollution has become a serious problem worldwide. According to World health report 2002, more than 2 million premature deaths each year can be attributed to the effects of air pollution [1]. The WHO air quality guidelines are designed to offer guidance in reducing the health impacts. The guidelines are written for worldwide use, and are intended support actions aiming for the optical achievable level of air quality in order to protect public health in different contexts. Air quality standards are set in each country will vary according to specific approaches to balancing risk to health, technological feasibility, economic considerations and other political and social factors. The guidelines recommended by WHO acknowledge this heterogeneity and recognize in particular that, in formulating policy targets, governments should consider their own local circumstances carefully before using the guidelines directly as legal standards.

The first edition of the WHO air quality guidelines for Europe was published in 1987 [2], since when scientific knowledge about the effects of exposure to air pollution and the magnitude of its public health impact has increased exponentially. In the early 1990s, the growing scientific knowledge allowed WHO to initiate a process for revising the guidelines, resulting in publication of the second edition in 2000 [3]. The second edition considered health risk appraisal of particulate matter (PM), but did not set a guideline value for PM, and instead offered guidance for risk managers in the form of a statistical model relating exposure to risk, suggesting that they quantify the risk ant locally relevant exposure levels and use those local estimates to guide policy-making.

Since the publication of the second edition there has been an increasing awareness among scientists and policy-makers of the global nature and magnitude of the public health problems posed by exposure to air pollution, based on hundreds of new studies published in the scientific literature [4]. The project "Systematic review of health aspects of air pollution in Europe", carried out by the WHO Regional Office for Europe to support the development of the European Union's Clean Air for Europe (CAFE) program in 2002–2004, concluded that this new evidence warranted revision of the air quality guidelines for PM, ozone and nitrogen dioxide [5]. Of particular importance in deciding that the guidelines should apply worldwide was the substantial and growing evidence of the health effects of air pollution in the low- and middle-income countries of Asia, where air pollution levels are the highest. WHO's comparative risk assessment quantified the burden of disease due to air pollution worldwide and, as noted above, found the largest burden in the developing countries of Asia.

The update of air quality guidelines set a guideline value and interim targets for PM [6]. Based on known health effects, both short-term (24-hour) guideline (Table 1) and long-term (annual) guideline (Table 2) are needed for PM. Besides the guideline values, three interim targets (IT) were defined, which have been shown to be achievable with successive and sustained abatement measures. Countries may find these interim targets helpful in gauging progress over time in the difficult process of steadily reducing population exposures to PM.

Table 1. Air quality guideline and interim targets for PM: 24-hour mean

Annual mean level	PM10 (μ g/m^3)	PM2.5 (μ g/m^3)	Basis for the selected level
WHO interim target 1 (IT-1)	150	75	Based on published risk coefficients from multicenter studies and meta-analyses (about 5% increase in short-term mortality over AQG)
WHO interim target 2 (IT-2)	100	50	Based on published risk coefficients from multicenter studies and meta-analyses (about 2.5% increase in short-term mortality over AQG)
WHO interim target 3 (IT-3)	75	37.5	About 1.2% increase in short-term mortality over AQG
WHO air quality guidelines (AQG)	50	25	Based on relation between 24-hour and annual PM levels

Table 2. Air quality guideline and interim targets for PM: annual mean

Annual mean level	PM10 (μ g/m^3)	PM2.5 (μ g/m^3)	Basis for the selected level
WHO interim target 1 (IT-1)	70	35	These levels are estimated to be associated with about 15% higher long-term mortality than at AQG levels.
WHO interim target 2 (IT-2)	50	25	In addition to other health benefits, these levels lower risk of premature mortality by approximately 6% (2-11%) compared to IT-1.
WHO interim target 3 (IT-3)	30	15	In addition to other health benefits, these levels reduce mortality risk by approximately another 6% (2-11%) compared to IT-2 levels.
WHO air quality guidelines (AQG)	20	10	These are the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase with more than 95% confidence in response to PM2.5 in the ACS study. The use of the PM2.5 guideline is preferred.

2. Air quality measurement

Instruments for measuring air pollutants may vary greatly in complexity and price, from the simplest passive sampler to the most advanced and expensive automatic remote monitoring system based on light absorption spectroscopy of various kinds. Relatively simple equipment is usually adequate for determining background levels, estimating long-term average concentrations and observing trends. Passive samplers may also be adequate for undertaking simple screening studies. For the complete determination of air pollution distributions and relative source impacts and the operation of warning systems, however, more complex and advanced monitoring systems are needed. Also, when data are needed for verification of model performance, expensive monitoring systems are usually needed.

Particulate air pollutants comprise material in solid or liquid phase suspended in the atmosphere. Such particles can be either primary or secondary and cover a wide range of sizes. Newly formed secondary particles can be as small as 1–2 nm in diameter (1 nm = 10^{-9} m), while coarse dust and sea salt particles can be as large as 100 μm (1 μm = 10^{-6} m) or 0.1 mm in diameter. However, the very large particles have a short atmospheric existence, tending to fall out rapidly through gravity and wind-driven impaction processes. Thus in practice there are few particles in the atmosphere exceeding 20 μm in diameter, except in areas very close to sources of emission. Particulate matter can be separated from atmospheric gases by drawing air through a filter fine enough to retain the particles, or by accelerating air through a jet that fires them at a fixed plate, onto which the particles impact and are collected. Particulate air pollutants have very diverse chemical compositions that are highly dependent on their source. They are also diverse in terms of particle size. PM10, PM2.5 and ultrafine particle fractions are typically those measured within the atmosphere for the purposes of health effects studies; the first two fractions are also used for compliance monitoring.

Information about the ambient air pollution levels have been based on measurements representative for different types of area and microenvironment, such as:

- Traffic, near roads and in streets;
- Urban areas, representative for the kilometre scale inside the urban airshed
- Rural areas, away from local sources representative for residential areas

The selection of representative measurement sites, as well as the use of different measurement methods, has made the interpretation and comparisons of the data difficult.

Air quality measurements have revealed air pollution problems in many of the major urban areas of the world. Some typical ranges of concentrations of the PM indicator found in a selection of cities around the world are summarized in Table 3.

Table 3. Ranges of annual average concentrations ($\mu g/m^3$) of PM10 for different regions, based on a selection of urban data.

Region	PM10 (annual average concentration)
Africa	40-150
Asia	35-220
Australia/New Zealand	28-127
Canada/United States	20-60
Europe	20-70
Latin America	30-129

The highest concentrations of PM10 are found in Africa, Asia and Latin America. Trends in air quality development differ in respect of the indicator pollutants. In Europe, PM10 levels had decreased by the end of last century but have tended to rise again, which may be partially explained by changing weather conditions. Even though large Asian cities have seen a slightly reduction in PM10 levels over the last few decades, PM10 and PM2.5 is still the major air pollutant in Asia. Many of the large cities in Latin America, as well as Mexico City, still experience high levels of PM.

Air pollution in megacities around the world has been an issue for several years. There were 24 megacities each with more than 10 million inhabitants. Twelve of these megacities are located in Asia, four in Latin America and two in Africa: Cairo in Egypt and Lagos in Nigeria. According to the World Bank some African cities are growing by more than 10% annually. In many megacities, such as Beijing, Calcutta, Mexico City, Rio de Janeiro and Cairo, high levels of PM constitute a major problem. Air pollution levels are normally higher in developing countries than in highly developed industrialized countries. PM levels indeed present serious problems in the developing countries. PM10 concentrations have been reported from countries such as India and Pakistan to be 4–5 times international air quality limit values.

The serious consequences of exposure to high levels of urban ambient air pollution were made clear in the mid-twentieth century, when cities in Europe and the United States experienced air pollution episodes. Subsequent clean air legislation and actions reduced ambient air pollution in many regions. The winter smog problems associated with coal combustion that were common in some cities during the 1980s and early 1990s have been eradicated, and it is now mainly emissions from traffic that pose the main threat to good air quality. The main sources for the present air pollution levels in western cities are traffic related. The previously frequent winter smog comprising a mixture of sulfurous compounds and particles (soot) have in this way changed over the years. Suspended particles, and especially submicron particles, combined with secondary pollutants such as oxides of nitrogen and ozone, have become a major problem in the large urban areas around the world. At the same time, the populations of the rapidly expanding megacities of Asia, Africa and Latin America are increasingly exposed to levels of ambient air pollution that rival and often exceed those experienced in industrialized countries in the first half of the twentieth century [7].

In general, the highest concentrations of PM10 were reported from Asia. This region also experiences relatively high background concentrations owing to forest fires and local emissions of particles from the use of poor-quality fuels. A well-known springtime meteorological phenomenon throughout East Asia, causing the Asian dust, originates from windblown dust from the arid region of Mongolia and China and adds to the general level of PM in the region. Chinese cities experience very high airborne particle concentrations due to primary particles emitted from coal and biomass combustion and motor vehicle exhaust, as well as secondary sulfates formed by atmospheric chemical reaction from the sulfur dioxide emitted when coal is burned. PM2.5, whose diameter is 2.5 μm or less is an important indicator of risk to health from particulate pollution, and might also be a better indicator than PM10 for anthropogenic suspended particles in many areas.

High PM2.5 readings will cause a spike in the mortality rate of patients suffering from heart and lung diseases.

Because fine particles are much smaller than inhalable coarse particles, they can penetrate deeper into the lungs and cause more severe effects on human health. Fine particles are responsible for most visibility problems in Asia. Recent measurements in Beijing show PM2.5 concentrations averaging just over 100 μ g/m^3. The monthly average concentrations varied between 61 μ g/m^3 and 139 μ g/m^3. During air pollution episodes, daily mean PM2.5 values can reach 300 μ g/m^3 [8].

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コラム

次のスーパームーンは？

いつごろだれが言い出したのか知らないが，今や普通名詞になっている。天文学用語ではなく多分占い用語だろう。スーパームーンとは満月と近地点通過が同じ日（何時間以内かは知らない）に起こることをいうそうだ。月はかなり扁平な公転軌道を描き，その離心率は0.05もある。地球に最も近い時の距離（近地点距離）と最も遠い時の距離（遠地点距離）の比は（1＋0.05）／（1－0.05）＝1.105　でスーパームーンのサイズは通常時の5％増，最小時の10％増である。去年の8月10日に起こったが次はいつ起こるのだろうか？

月の満ち欠けの周期は朔望月＝29.54日で，月の公転周期は近点月＝27.554日，満月から次の満月までの期間は月が地球の周りを１周する期間より約2日長い。その違いは地球の公転のためだ。この数値の比は1.071714，すなわち満月から次の満月までに月は1.071714回公転するわけで，朔望をｘ回繰り返すと，公転はｙ＝1.071714ｘ回である。それをExcelで簡単に計算してｘ，ｙが整数である最も簡単な組み合わせとして x=14 y=15 が見つかる。すなわち1.071714に近い既約分数は15／14ということで，月は満ち欠けを14回繰り返す間に地球の周りを15回公転する。スーパームーンは14朔望月≒1年1ケ月17日または18日ごとに起こることがわかる。ただしこの計算は長期間続けているとズレが生じるのでご注意。

昨年8月10日より14朔望月後は今年9月28日である。正確には10時46分に近地点通過（35万6877km）で，11時51分に満月となる。ちなみに中秋の名月は旧暦の8月15日で今年は満月の前日9月27日である。

なお，その次のスーパームーンは2016年11月14日に起こる。ということで実はありふれた現象なのだ。