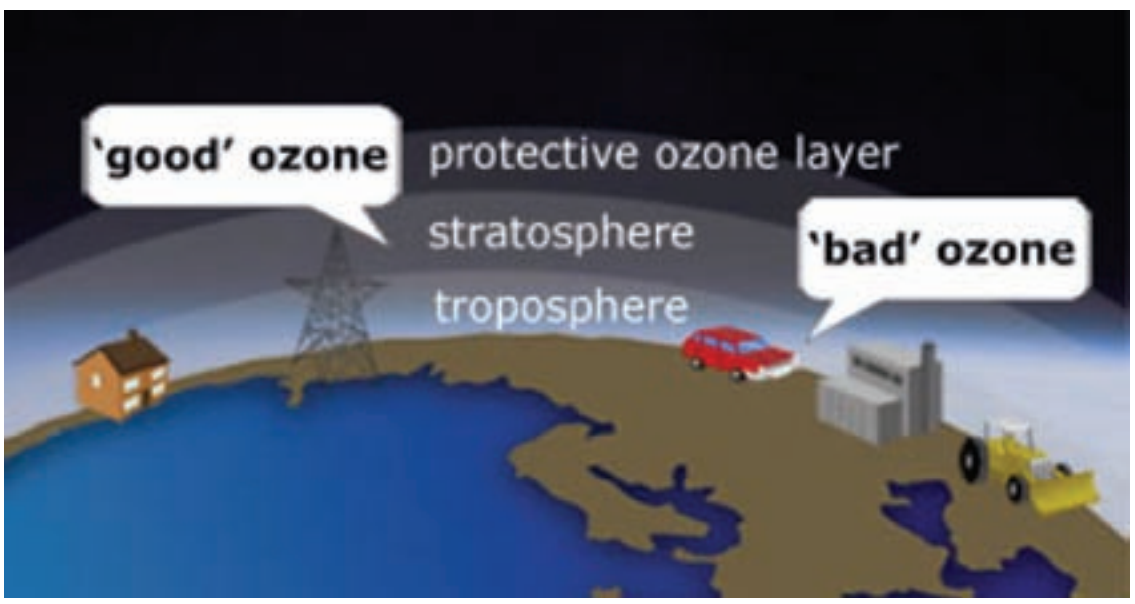
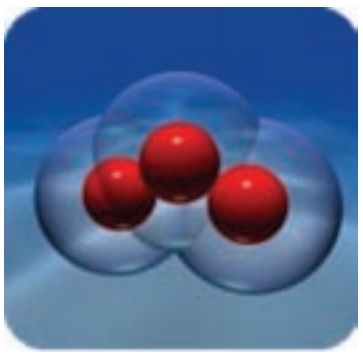
The Truth Behind Ozone

This article presents the applications of ozone monitoring. What is ozone? How does it impact air quality? Why is it important to monitor ozone concentrations? What are the industrial applications of ozone?

Ozone (O_3) is a triatomic molecule consisting of three oxygen atoms. It is a colorless gas with a pungent smell. Ozone at ground level – in the air we breathe – is an air pollutant and is not to be confused with the ozone layer in the upper atmosphere. Ozone in the upper atmosphere filters potentially damaging ultraviolet light from reaching the Earth's surface.

In the troposphere, near the Earth's surface, human activities lead to ozone concentrations several times higher than the natural background level.

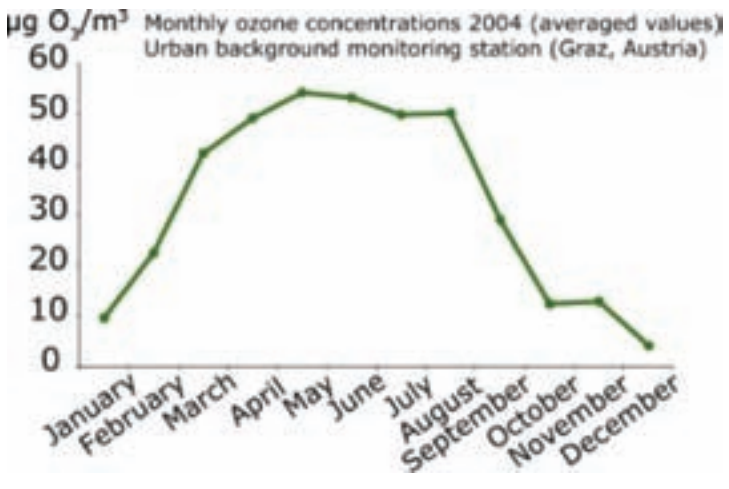




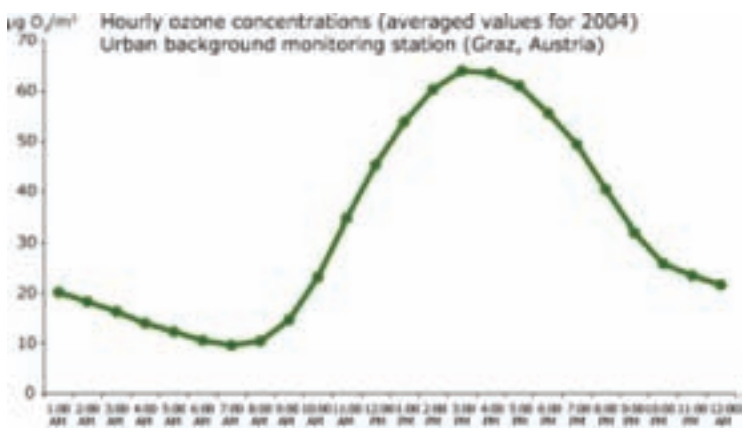
Ozone impact on air quality

Ozone is the main product of complex photochemical processes in the lower atmosphere involving oxides of nitrogen and volatile organic compounds as precursors. Ozone is a strong photochemical oxidant. The main sectors that emit ozone precursors are road transport, power and heat generation plants, household (heating), industry, and petrol storage and distribution. The dominant issues determining short-term air quality are nitrogen dioxide, particulate matter and ozone. All three pollutants are strongly related to the use of fossil fuels. Ground-level ozone (O_3), unlike other pollutants mentioned, is not emitted directly into the atmosphere, but is a secondary pollutant produced by reaction between nitrogen dioxide (NO_2), hydrocarbons and sunlight. Sunlight provides the energy to initiate ozone formation; consequently, high levels of ozone are generally observed during hot, still sunny, summertime weather. During the day, ozone concentrations will usually build up and peak in the afternoon. At night-time, ozone concentrations decline.

Ozone concentrations peak in summer-time:



...And in the afternoon, because the formation of ozone needs sunlight:



The highest concentrations of ozone are not always found in city centers where the pollutants that form ozone are emitted. The reason is that where there is an abundance of nitrogen oxide from traffic, ozone formation is suppressed. As a result, its concentration is sometimes low in busy urban centers. Ozone may also be transported by the wind over distances of 400-500 km a day. Hence, ozone pollution may eventually be found in suburban and rural areas far away from the sources of the pollutants. So, ozone levels in suburban areas can actually be higher than in urban centers. When ozone mixes with other air pollutants like particulate matter (PM) and nitrogen oxides (NO_x), it can form harmful smog.

Importance to monitor ozone concentrations for health and crop

Two pollutants, fine particulate matter and ground-level ozone, are now generally recognized as the most significant in terms of health impacts. Long-term and peak exposure can lead to a variety of health effects, ranging from minor effects on the respiratory system to premature mortality.

The main health effects of short-term (a few hours) exposure to ozone include irritation of throat and eyes, coughing, wheezing. Ozone causes breathing difficulties because it attacks the lining of our lungs. This means that the lung function may be affected and the lining may lose some of its ability to serve as a protective barrier against microbes, harmful chemicals and allergens. It can also trigger asthma attacks. These effects may occur when the ozone concentration reaches a level higher than 180 µg/m^3 (EU information threshold). Ozone exposure has been linked to a number of health effects and is thought to be the cause of the premature deaths of thousands of people in Europe each year. Children, because they breathe more air per kilogram of body weight and have smaller lungs than adult, and people with asthma or other respiratory illnesses are particularly high-risk groups. Also, recent research studies suggest that long-term exposure to ozone may be associated with lung cancer. Ozone can aggravate asthma and may also worsen other respiratory illnesses such as pneumonia and bronchitis. Asthma is now the most common respiratory disease among western European children, afflicting 7% of children aged between 4 and 10.

Ozone also has serious ecological and economic effects. It can reduce crop yields and damage vegetation that are not marketable anymore. High ozone concentrations can affect not only plant growth and aspect, but soil fertility. Plants that are exposed to high ozone concentrations metabolise less carbon dioxide, so less carbon is available in the soil, and fewer soil microbes grow and thrive. In order to take into account such effects, an indicator called AOT, Accumulated exposure Over a Threshold, has been introduced. This indicator is calculated as the cumulative exceedance of a given pollutant concentration, over a selected period. The hourly concentration of 40 ppb (part per billion) was proposed as the threshold for vegetation. The critical AOT 40 level of 3, 000 ppb.h responds to decrease in agricultural

crops yield by 5%. Consequently, the costs of ozone pollution are of major concern for national health services, farmers, foresters and others.

Industrial applications of ozone

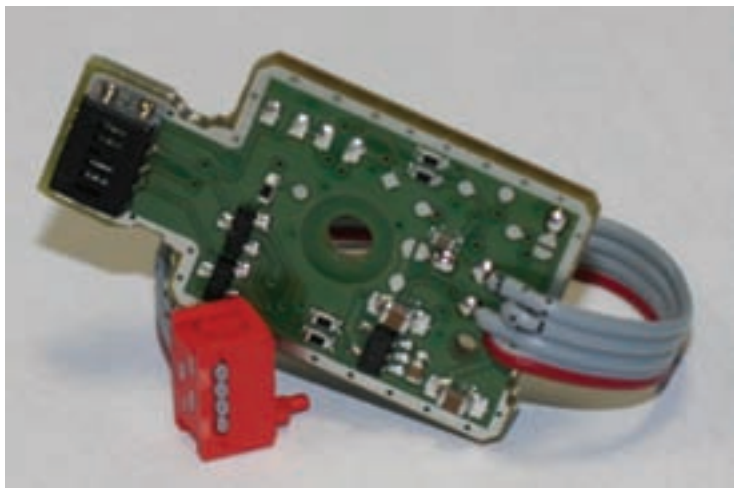
Ozone has many industrial and consumer applications but cannot be stored and transported like other industrial gases (because it quickly decays into diatomic oxygen) and must therefore be produced on site. The largest use of ozone is in the preparation of pharmaceuticals, synthetic lubricants, as well as many other commercially useful organic compounds.

In air

Devices generating high levels of ozone are used to sanitise and deodorise uninhabited buildings, rooms, ductwork, woodsheds, and boats and other vehicles. Ozone is also used in fruit ripening process by ethylene control. Ethylene created by plants increases the intracellular levels of certain enzymes in fruit and fresh-cut products responsible of ripening. Ripening process of fruits and flowers is delayed in an ozonated atmosphere because ethylene is oxidised by ozone and is transformed in carbon dioxide and water. Using sensor-controlled ozone generators allows maintaining ozone level between 2 and 7 ppm. At temperature below 5°C and with such ozone level, it is possible to dramatically slow down ethylene production and prevent over-ripening and problems associated with aging.

In water

Gaseous ozone, created by ultraviolet light or by corona discharge and fed by-oxygen concentrator, is injected into the water to disinfect for bacteria, virus and other microorganisms. Once ozone has entered the cell, it oxidises all essential components (enzymes, proteins, DNA, RNA). When the cellular membrane is damaged during this process, the cell falls apart. Once ozone has decayed, it leaves no taste or odor in drinking water. Ozone is also used for other purposes such as to allow lower temperature wash water and to minimise residuals in wash processes ranging from laundry to semiconductors.



OZ-47: Smart ozone sensor board

Ozone is used in swimming pool and hot tubs to kill bacteria and to reduce the amount of chlorine or bromine required by reactivating them to their free state. Since dissolved ozone does not remain in the water long enough, ozone by itself is ineffective at preventing cross-contamination among bathers and must be used in conjunction with these halogens. Ozonated water is used also to launder clothes and to sanitize food, drinking water, and surfaces in the home. It can also be used to remove pesticide residues from fruits and vegetables.

For any application (bottled water plant, food treatment systems, sterilizing systems, wastewater treatment, aquaculture) ozone should be efficiently dissolved into the water, and the dissolved ozone should be measured at various points in the process to ensure that the process stay efficient over time. Gaseous injected ozone is monitored by ozone in water analyser. Ambient ozone is also controlled by ozone sensors, these ones check if the ozone destructor works sufficiently. Smart sensor located in the right location can communicate the level of ozone generated and control the ozone generator system. This allows keeping a stable process, optimising the power consumption and saving energy.

Conclusions

OMC-3: Ozone Monitoring Cell

Ozone monitoring is used in environmental monitoring for health and crop yield concerns and also in industrial processing. A significant proportion of the urban population still lives in cities where certain air quality limits (set for the protection of human health) are exceeded. The need to reduce exposure to air pollution remains an important issue. Moreover, without emissions restrictions, growing fuel combustion worldwide will push global average ozone up 50 percent by 2100. The population has to be warned and informed of the dangers of air pollution, especially on hot summer days. Improvements in monitoring and availability of information on air pollution are another of the success stories of recent years. In some urban area, when someone is planning a day in a city, this person can log onto web service or cellular network providing a host of regular information on air quality. Using maps, one can scan readings and forecasts for ozone. The data are relayed to the web from monitoring stations around this city. Using SMS service, the mobile network operator can regularly inform customers on air quality around his location. If the level is moderate, high or very high, people will consider following cautionary guidelines. The warning advises people with breathing problems to take precautions such as avoiding strenuous exercise while the ozone levels remain high.

In the earliest days of ozone research, cracks in rubber served as the indicators used by scientists to determine atmospheric concentrations of ozone. There is now a wide range of products suitable for the various ozone monitoring applications. From cost effective solutions with micro systems based on MEMS gas sensors using Metal Oxide Semiconductors (MOS), passive tubes, UV analyser or LIDAR (Light Detection and Ranging).

Micro-sensors stand-alone solution developed to offer an alternative to market at a lower cost than UV-analyser and with much higher accuracy and information content than passive tubes represents a promising technology in several fields of application like the detection of ozone peaks, meshing, micro-meteorology, evaluation of exposure of population.

For new applications and development it is always best to talk directly with the gas monitoring device manufacturer. The application engineers can offer relevant expertise and guide you through your development or buying process.

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