Air sustainability

Introduction

Starting from the 70s in all the industrialized Countries, the number of circulating vehicles has been increasing constantly. Through fine dust, carbon dioxide, nitrogen oxide and volatile organic compound emissions cars and other means of transport contribute in a preponderant manner to determining the low quality of air in the urban centres. Limiting the levels of concentration of pollutants, in particular fine dusts in our cities must take place principally by decreasing traffic of motor vehicles.

Air

An unstable balance

We have seen that atmospheric pollution derives from a series of substances that are produced by one or more ‘sources’ (industries, cars and others). Luckily, after a more or less long time spent in the atmosphere, nature can “remove” a certain amount of it. For instance, the carbon dioxide produced by the combustion of fossil fuels and by the breathing of animal and vegetal living organisms is absorbed not only by the vegetation (through the photosynthesis), but is also largely counteracted by seawater, that can fix it through the phytoplankton and stabilise it in carbonated sedimentary rocks. The composition of the atmosphere is therefore in a state of dynamic balance, whose stability depends on the ability of these ‘self-depuration’ processes to counteract or at least reduce the negative effects of man’s activities. The problem arises when the amounts of pollutants emitted in the atmosphere exceed its “self-depurating” ability, increase their concentrations in the air and reach limits that are harmful to man and to nature. In this case, the development model of man and of a country may be no longer “sustainable” in the long term.

Air monitoring

To be able to develop and enforce measures (that taken together make up an “environmental policy”) that may effectively bring a country’s development back to the environmental sustainability principle, the health conditions of the environment in the different geographical areas that compose a territory need to be accurately known. Then, the causes that have led to environmental degradation can be identified and measures can be proposed for reclaiming the environment and reducing or removing the sources of pollution. In the case of the atmosphere, natural or artificial methods are used to monitor the state of the environment. As far as artificial methods are concerned, man builds a complex network of detectors placed in strategic points of the area concerned that analyse the air by detecting the presence of some pollutants (aerosol observation methods).
Air quality control measures the concentration levels of atmospheric pollutants and checks if the threshold values are exceeded or not. The threshold (or guiding) value of a given pollutant is calculated on the basis of criteria that differ in each country, but that are still related to the protection of the health of man and nature. Only a small fraction of the atmospheric pollutants is measured, since there are not sufficiently accurate and precise measuring techniques, that may detect them 24 hours a day, available for all of them. These pollutants can however accurately indicate the level of pollution of the atmosphere.

Bio-monitoring

Another method to check air quality, this time a natural method, is bio-monitoring, i.e. the use of living organisms to monitor environmental alterations. Bio-monitoring studies the effects of air pollution on organisms and their communities, such as lichens.

Montreal and Kyoto

Aware of the negative impact of the depletion of the stratospheric ozone layer and the climatic changes on the development of large regions of the Earth, the international community has lately enforced a series of measures for the

protection of the atmosphere. The Montreal Protocol enforced in 1987 initiated a global strategy for the protection of the ozone layer by forbidding the industrialised countries and from 2004 the developing countries as well to produce and consume those substances that are assumed to be responsible for the destruction of stratospheric ozone. Through the 1997 Kyoto Protocol, the industrialised countries (responsible for over 70% of the global emissions of “greenhouse gases”) have committed themselves (not yet in a binding way) to reduce their emissions by 5.2% compared to those of 1990 by 2008-2012. It is a particularly demanding task, also in financial terms, since it requires a change in the energy systems and in other sectors in each country (less consumption of fossil fuels, higher use of renewable or less polluting energy sources, such as natural gas), with huge investments in the development of new high-efficiency and low environmental-impact technologies. There is no doubt that, in order to reduce or eliminate the risk that human activities may cause the climate to change, the international community must soon agree on the definition and acceptance of effective measures. Scientists agree that, even if the emissions of ‘greenhouse gases’ should disappear today, it would still take many years before the concentrations of these gases could be brought back to the levels of before the industrial development, because of the long time spent in the atmosphere by this type of emissions.

The problem of acid rain

Whenever substances are released by industrial stacks or vehicles, they mix up in the atmosphere with water vapour and generate new acid compounds. These compounds fall back on the ground during precipitations, causing serious damage to the flora, the soil and the water. The problem of acid rains can be solved by reducing the emissions of nitrogen oxides and sulphur oxides in the atmosphere. To reduce these emissions, the use of fossil fuels with a high sulphur content (such as coal), the use of cars and the traffic of our cities need to be reduced. A number of technologies have been developed over the last few years that can remarkably reduce the sulphur content of the raw materials used to produce electric energy from fossil sources (coal reclamation, desulphurisation systems and others). In addition, the stacks of power plants and industries have been fitted with filters that collect the sulphur compounds contained in the exhaust fumes, so that they will not disperse in the atmosphere. The emissions of nitrogen oxides, mainly from cars, can be reduced by installing catalytic exhaust pipes. In particular, the cars of a country (i.e. the cars driven by its people) need to be new, since last-generation cars are equipped with devices that can reduce the emissions of nitrogen oxides much better than in the past. It takes many years for an ecosystem damaged by acid rains, such as a lake or a river or a forest, to go back to its original balance. But man can help by speeding up this process through some specific measures: for instance, by adding lime to acidified lakes or rivers to bring their pH back to neutral (‘calcification’). But these techniques are expensive and have a limited life. In these cases, prevention is certainly better than the cure and the alleviation of the damage.

Taking care of the air

What can be done to prevent the risk of a climatic alteration caused by man? International organisations, national governments and companies may commit themselves to reducing the emissions of “greenhouse gases” by enforcing specific environmental policies. Good results have already been obtained in some countries and the companies are trying to reduce more and more emissions of pollutants in the air. But each one of us can help, by developing some good habits in his or her daily life: - whenever possible, walk, use a bicycle or public transport to move around; - do not drive unless it is really necessary; - use new cars that consume less petrol and emit less pollutants; - reduce power consumption and waste at home (do not leave the lights on when they are not needed!); - buy household appliances that use less energy (for instance, class “A” fridges, washing machines or dishwashers, that bear a special tag); - do not overheat homes and offices during the winter; - do not overcool the rooms with air conditioning during the summer; - use insulating materials in the house in order to save on heating. Through these simple tips, we will not only help to reduce the emissions of pollutants in the air, but we will save money as well.

There is something in the air

A large part of air pollutants are originated by energy-producing combustion processes. All the good practices mentioned in the previous pages ultimately aim at reducing the emissions caused by these processes, either by saving energy or by

using “clean” technologies. This seems to be the most promising way to go in order to solve most air pollution problems. Many scientists and engineers are actually trying to find solutions to minimise the amount of pollutants emitted in the atmosphere when using traditional fossil fuels, while others are studying and testing the use of alternative “clean” energy sources to get rid of the problem altogether.

Meteorology

Cities and local climate

Anyone who lives in suburban areas and works in the city has surely experienced the differences in the climate of large urban conglomerations compared to the climate in zones that are far from the city. Cities are generally much warmer than the surrounding areas, besides being more polluted, and in the winter months the conditions for thermal inversion are often present. In other words, large cities seem to modify local climatic conditions. What is this phenomenon due to? The progressive replacement of land and vegetation by tar, asphalt and cement is the first cause. These materials absorb large quantities of heat, that they then release slowly, behaving as “heat wells”. In this manner, the temperatures in the cities are sensibly higher than in the surrounding areas. Secondly the fact that the buildings that are grouped together, close to one another, hinders air circulation, which also favours the heating process. The progressive increase of cement surfaces prevents infiltration of water in the ground, therefore the land that is built up with cement and covered with asphalt is less humid than natural soil. The air in the cities, therefore is generally dryer. Since the evaporation of atmospheric humidity contributes to cooling the air itself, in this case this characteristic favours heating of the air and also a slower cooling after sunset. For this reason the inhabitants in the cities do not experience the night’s cooling effect on warm summer nights. In summer, most of the heat released by the large cities favours convectional phenomena and the formation of storms. Apparently the presence of very high buildings seems to favour the formation of cumulonimbus clouds. Also the greater emission of polluting substances in the form of gases and dusts, that are typical of industrialized areas with a high population density, contribute to modifying the characteristics of the atmosphere, in particular the capacity to absorb and radiate heat. Statistical studies show that the increase in the temperatures in the cities is proportional to the density of the population.

A global climatic model

Man has always tried to understand the climate and make forecasts on the weather. For agricultural activities, for travel, for transportation, weather forecasts are indispensable in order to plan human activities, but also for the realization of housing, roads, bridges that must resist against the most adverse weather conditions. It is difficult for us to understand a complex system such as the climate on a planetary scale. In fact in order to understand how the climate functions and in order to build a valid and realistic model, it is necessary to understand that the climate is a complex system, a chaotic system made up of a set of orderly sub-systems. In other words, while we are able to understand the single events that take place (a thunderstorm, a snow storm, a cyclone) and to write about the physical laws governing them, we are unable to describe the behaviour of a system, where single events can be summed, using mathematical formulas. In order to describe the climate, therefore, it is necessary to elaborate models that are as similar as possible to reality, however we must be aware that any model will only be a schematic and incomplete representation of the real climatic system.

In the current climatic model it is postulated that the atmospheric circulation, and therefore the climate on a planetary scale, depends on the differences in solar radiation due to both orbital parameters and the Earth’s inclination on its axis during rotation. These parameters are responsible for the alternating seasons and the difference in energy between the Equator and at the Poles, and therefore atmospheric circulation is organized in six large high and low pressure cells that are also influenced by the interaction with the ocean currents. The present distribution of the climates on the Earth and their variability during the course of the year, derive from this model.

Until significant variations in these parameters and in the physical and chemical characteristics of the atmosphere arise, the present climatic model should theoretically remain valid without any major modifications.

However many parameters that are taken into consideration in the climatic model that is currently proposed, are difficult

to control and to foresee : and therefore, for example, small variations in solar radiation or small modifications in the oceanic circulation may produce big changes in the climatic model. The problem is to succeed in understanding whether the climatic variability that can be observed every year in different parts of the Earth, the “exceptions” to the current climatic model, are only natural and casual fluctuations, or if, instead, these are precursors of a possible change in the global climatic model

Is the weather changing?

In order to understand whether the climate of our planet is really changing, it is indispensable to study what happened in the past. Man has always had an anthropocentric vision of natural events, and for this reason tends to give importance to the more recent facts that affect him directly, or the more catastrophic, “extreme” events that are often seen as a “rule” or as signals of sudden changes. For this reason, every hot summer seems to be the “hottest recorded in the past years”, every cold winter, the coldest. We do not take into account that often, a great quantity of information that reaches us every day from the media can generate confusion: a particularly catastrophic event that takes place makes the attention towards analogous events rise, so that after the passing of a particularly devastating hurricane, for example, the passage of all the other hurricanes are signalled. This may make us think that the number of hurricanes has increased, but is it really so? Has the number of violent manifestations really increased, or is it only their interaction with man that has increased, due to the increasing amount of anthropization in areas that once were uninhabited. As a result, the same data, the same succession of events are interpreted at times in a radically opposite manner by different researchers. In fact, some researchers see an increase in the concentration of greenhouse gases in the atmosphere as the cause of a global heating of the planet in the near future, while others hypothesize that on the contrary we could expect a new ice age. The only objective way to solve this doubt is to observe the series of data on the temperatures in various areas of the Earth, for a reasonably long period of time so that the normal fluctuations around the mean temperature do not influence the readings. Apart from any personal subjective interpretation, only if we use an analysis of the objective data, then is it possible to understand if there are really some changes in the general climatic model, and what is the real trend of the various phenomena. For this type of study on the climate it is therefore indispensable to carry out an accurate analysis of the climatic and meteorological data collected over a period of time. Only by analyzing the series of historical data will we be able to state objectively if there really is a trend of an increase or a decrease in a phenomenon, or if instead it is only a matter of simple casual oscillations around the average. For this it is necessary to take data from a sufficiently long period of time. However, nature is used to changes. The geological and paleo-environmental data enable us to reconstruct climatic variations, even of a very remote past, and the history of the Earth offers numerous examples of climatic changes that were quite drastic and sudden. But, unfortunately, this is not a systematic and tidy collection, but rather a series of incomplete data that are available in a discontinuous manner in space and time. The analyzed time is the geological time, on a scale of millions and billions of years. In order to monitor the “finer” variations, instead, it is necessary to work on a period of time that is shorter than the geological time, but which however is longer than the life span of a human being, and with series of data collected with as much continuity as possible in the same region. Only this way, in fact, will it be possible to understand what are the trends and the changes taking place. Unfortunately a systematic collection of climatic and meteorological data began only slightly over 200 years ago in Europe, and approximately 100 years ago in the United States, and in many Countries it still has not begun. This is precious information, however the observation periods are still too short to enable the construction of long term variation models. In other words, the analysis of a series of historical data still does not enable us to answer the crucial question: is the Earth’s climate really changing? Also because the data of the past cannot take into account one of the factors that is becoming increasingly important, year after year, in introducing possible modifications to the parameters that govern the climate of our planet : the influence of the constantly growing human population.