LEARNING TOXICOLOGY THROUGH OPEN EDUCATIONAL RESOURCES

SOURCES OF GASEOUS POLLUTANTS IN URBAN ATMOSPHERE

Dana PERNIU, Ileana MANCIULEA

Transilvania University of Brasov

d.perniu@unitbv.ro, i.manciulea@unitbv.ro

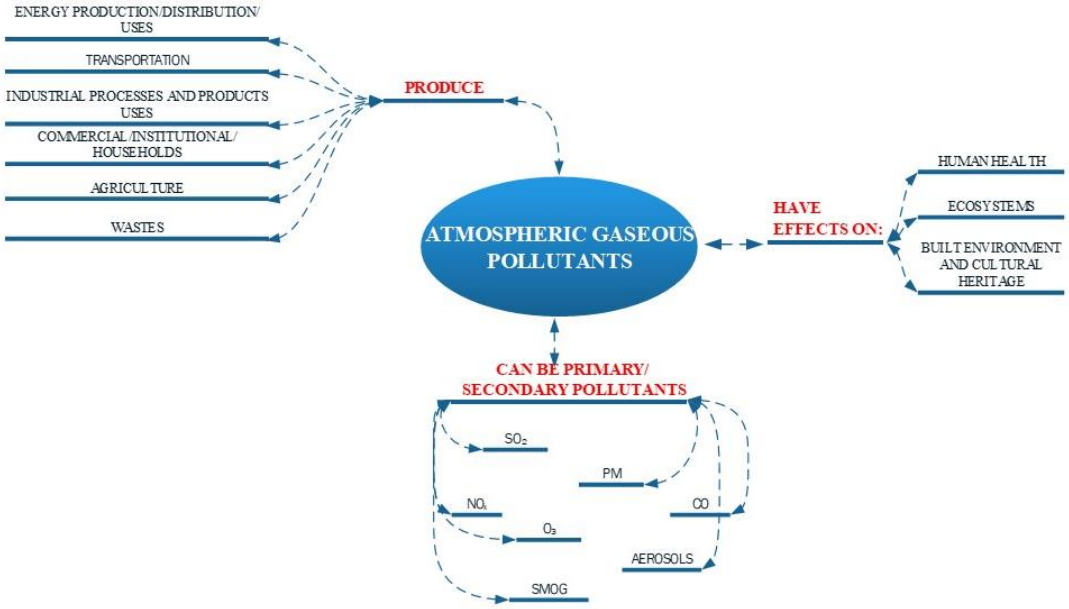
Universitatea TRANSILVANIA din Braşov

Erasmus+

1. INTRODUCTION

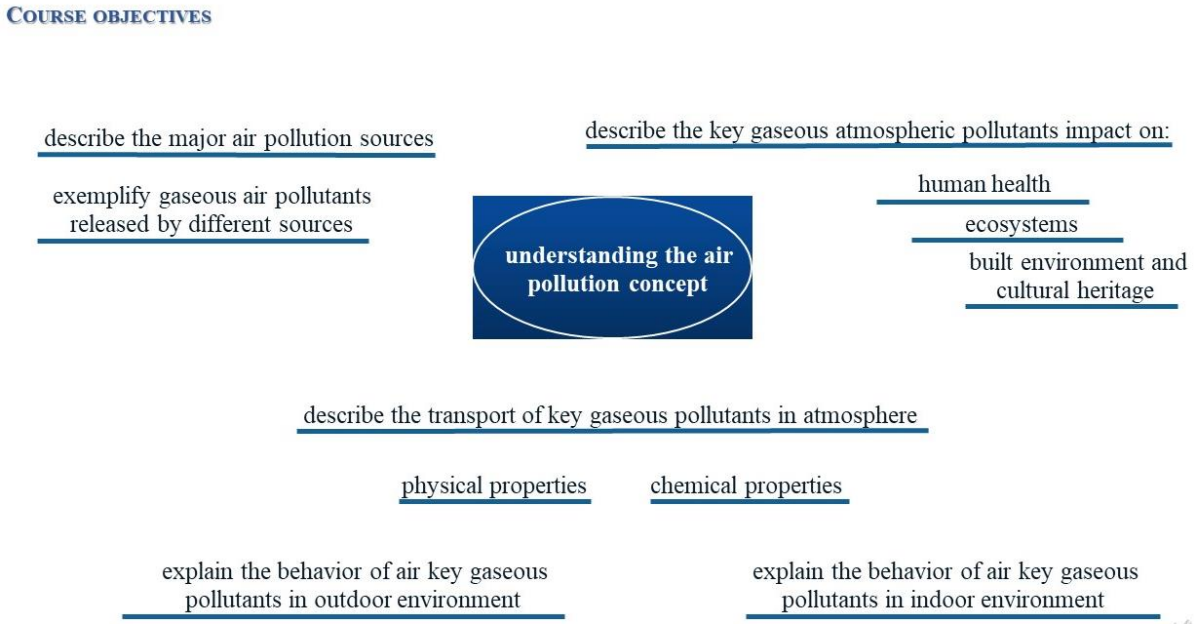
The course is constructed to offer you an integrated view on gaseous air pollutants. The course approaches the primary and secondary pollutants which are produced by various pollution sources and have adverse effects on human health and on natural and/or built environment.

COURSE DESCRIPTION



The aim of the course is to offer information to understand the pollution concept, which means:

- to describe the important air pollution sources and to exemplify the pollutants emitted by different sources;
- to describe the pollutants transport in atmosphere, which needs knowledge on pollutants' physical and chemical properties;
- to exemplify the pollutants behavior in outdoor and indoors.



Based on these information, you will be able to describe the gaseous pollutants' effects on human health and/or the natural and built environment.

We thanks for selecting our course and wish you success in developing your own knowledge.

2. GASEOUS POLLUTANTS IN ATMOSPHERE

Clean air represents the basic need to ensure a healthy life and welfare. However, the humanity strive for improving the quality of life, lead to technological and economic development, causing harm for environmental quality in general, and for the air quality in particular.

In our presentation we will give you basic information on air pollution caused by gaseous pollutants released in atmosphere by anthropic activities.

3. ATMOSPHERIC COMPOSITION

The Earth is surrounded by the gaseous atmosphere, divided in 5 vertical layers determined by their composition and temperature, which varies with altitude: troposphere, stratosfere, mesosphere, thermosphere, and exosphere.

The closest layer to Earth's surface is the ***troposphere***, simply called air, contains roughly a 80% from the entire atmospheric mass an practically the total mass of water.

Excluding water, which has a variable concentration, the air has a constant composition till 10 km. It contains major components, which account approximately 99.6% from total atmospheric mass and trace components.

The **major gases** in atmosphere accounts 99.96% (vol) from its total mass are:

Nitrogen, N_2 (78%, vol) – is the most common atmospheric gas. It does not react with other substances in atmospheric conditions;

Oxygen, O_2 (21%, vol) – is the second common gas, is required for respiration of all animals on Earth, from humans to bacteria. It is a highly reactive gas;

Argon, Ar (0.93%, vol) – is an inert noble gas;

Carbon dioxide, CO_2 (about 0.03%, vol) – is a gas with low percentage in atmosphere, but is an essential raw material for photosynthesis, being vital for the life on the Earth. The carbon dioxide plays important role in maintaining the Earth's heat balance. In the last century, as consequence of anthropic activity the atmospheric concentration of carbon dioxide increased resulting in climatic change.

Among the **trace gases**, which account 0.04% of total mass are:

Noble gases (Kripton, Xenon, Hellium)

Ammonia (NH_3)

Organic matter

Methane (CH_4)

Nitrogen oxides (N_2O, NO, NO_2)

Ozone (O_3)

Sulfur dioxide (SO_2)

Various salts and suspended solid particles

The **water** (in vapor state) is found variable amounts, depending on temperature, precipitation, rate of evaporation, location. It can vary in the range 0.1% up to 5%. If water vapor is excluded,

the composition of tropospheric air is constant. Water vapor is an element of hydrologic cycle and is an important greenhouse gas.

4. UNITS FOR CONCENTRATION OF AIR COMPOSITION

To estimate the air composition, different units are used, like:

% (m) – mass percent

% (vol) – volumetric percent

mg/m^3 – milligrams of component per cubic meter of air

µg/m^3 – micrograms of component per cubic meter of air

parts per million in volume (ppmv) – volume parts of component per million volume parts of air

parts per billion in volume (ppbv) – volume parts of component per billion volume parts of air

The volume fractions ppmv respectively ppbv express the number of volume parts of air component in one million or one billion of volume parts of air or the number of molecules of gaseous component in one million/billion of air components molecules.

5. CONVERTING CONCENTRATIONS

Due to the lack of consensus on a single scale for air components' concentration, the conversion relations from one unit to other are needed.

The transformations are based on the Ideal Gas Law ($pV=nRT$) which stipulates the proportionality between the gas volume and the total number of molecules.

transformation		**relation**
from	**to**	
mg/m^3	ppmv	$\mathbf{ppmv} = \frac{\mathbf{mg}}{\mathbf{m^3}} \cdot \frac{[273.15 + (°C)]}{M} \cdot 0.08205$
mg/m^3	ppbv	$\mathbf{ppbv} = \frac{\mu\mathbf{g}}{\mathbf{m^3}} \cdot \frac{[273.15 + (°C)]}{M} \cdot 0.08205$
ppmv	mg/m^3	$\frac{\mathbf{mg}}{\mathbf{m^3}} = (\mathbf{ppmv}) \cdot \frac{M}{[273.15 + (°C)]} \cdot \frac{1}{0.08205}$
ppbv	mg/m^3	$\frac{\mu\mathbf{g}}{\mathbf{m^3}} = (\mathbf{ppbv}) \cdot \frac{M}{[273.15 + (°C)]} \cdot \frac{1}{0.08205}$

Where,

number of volume fractions of gaseous component in air: *ppmv, ppbv, mg/m^3, µg/m^3*

molecular weight of the gaseous component: *M*

Universal Gas Law constant: *R = 0.08205 atm L mol^{-1} K^{-1}*

temperature *T = [273.15 + (^{o}C)] K*

atmospheric pressure *p = 1 atm*

6. ATMOSPHERIC POLLUTION – HISTORY

The clean air contains only the previously mentioned substances, in the mentioned proportion. As result of anthropic activity, the concentration of some gases is modified, leading to changes in air fundamental properties/functions.

In the history some events leading to changes in air composition are known. Some examples are presented in the following.

One of the first testimony of the discomfort caused by the presence in air of compounds released by coal combustion, is the one of philosopher Seneca. In one of his writings he mentioned the alteration of his disposition caused by the heavy air in Rome, from the fumes form chimneys which bring a mixture of soot, vapors with harmful odor.

Along the centuries, coal was used as principal energy source to satisfy the heating and cooking needs.

In England, during the 14th Century, i.e. 1306, King Edward Ist took the first rule for environmental protection by banning the burn of coal, but this was ignored by population.

Later, in 1661, King Charles the IInd asked one of his Cavaliers, John Evelyn, to write a book to come out the dangers of coal combustion. The result was the first comprehensive study where the air pollution was approached – Fumifugium: or the Inconvenience of the air, and smoke of London dissipated, together with some remedies humbly proposed, proposed for His Majesty and for the Parliament. *Fumifugium* is a composed word, coming from Latin language – *fumus* means smoke and *fugit* corresponds to the verb to run.

Another essential moment is the publication, in 1556 by Georg Bauer, under the pseudonym Gerogius Agricola of the book DeReMetallica, an extensive presentation of mining. It is the first monograph focused on industrial activity, mentioning elements of air pollution.

Together with the industrial revolution, due to the use of coal as energy source for machinery functioning, the coal usage in Great Britain multiplied by 100 between 1800 and 1900

The coal-produced smog, usually called “fog” was known and quite common in the last half of XIX and beginning of the XXth. Writers and scientists, and even painters evoked it in their works:

Charles Dickens, Charles Darwin, James Russel Arthur Conan Doyle, Claude Monet, Camille Pissarot, Edgar Degas, etc.

In 1952, in December after a four days of "fog", 4000 deaths were registered as result of exposure to air charged with pollutant species – sulfur dioxide and particulate matter. The event is well known as "London smog".

In the contemporary period, the emitted pollutants as result of anthropic activity are as diverse as the effects of pollution develop not only at local scale, but at regional and global scale.

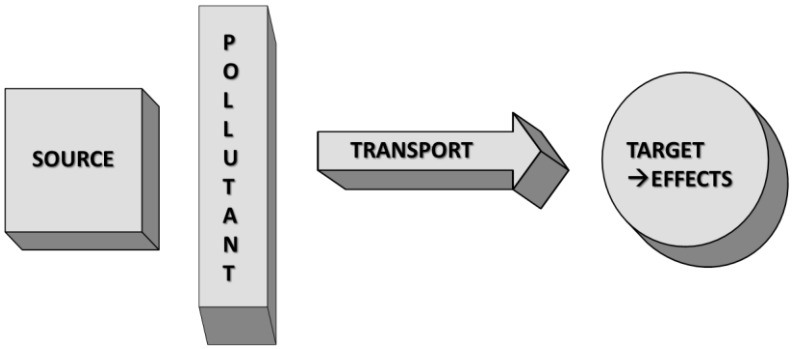
7. AIR POLLUTION APPROACH

The significant changes in air quality by the presence in the air of contaminant or pollutant species, at concentration that interferes with human health or welfare, or produces other harmful effects is called **air pollution**.

Gaseous air pollutants are those present as gases or vapors, i.e. as individual molecules capable of passing through filters provided. They do not adsorb to or chemically react with the filter medium. The gaseous pollutants are readily taken into human respiratory system, although if water-soluble they may very quickly be deposited in the upper respiratory tract and do not penetrate to deep lung.

Due to the complexity of environmental pollution, particularly of the air pollution, the analysis has to use an integrated approach, considering the sources of pollutants emission, their transport in air and the effects they have on human health and on natural and built environment.

Because of didactical reasons, in this section we discuss about air pollution sources. During the 2nd unit we will approach, for selected air pollutants, the environmental transport by physical and chemical processes produced in air, and also their effects.



8. Air pollution sources

The massive diversification of anthropic activity has the major consequence the diversification of the air pollution sources. There are many ways of categorizing pollution sources, in this section we present only a general description.

Considering the nature of the source, the pollutants are emitted by natural and/or artificial sources.

Among ***natural*** sources we exemplify: the volcanic eruption, the desert dust, natural production of sea-spray, emissions released by organic matter decomposition, biogenic emissions from trees and other vegetation.

The ***anthropic*** sources release pollutants as result of human activity or intervention. It is obvious that this type of sources has the main contribution in air pollution.

One of the main distinction is between stationary sources and mobile sources.

The ***stationary*** sources comprise industrial and household emissions.

The ***mobile*** sources comprise road vehicles, railway trains, ships

A useful categorization considers point/line/area sources.

The ***point*** sources refers to sources that appear as individual points. The spatial scale is usually in the area 1 x 1 km. Examples of point sources: power station, even it has more than one chimneys; individual industrial sites.

The ***line*** sources considers road vehicles, railway trains.

The ***area*** sources are more diffuse, spread over a significant spatial region. Example: emissions form boilers used for space heating, considering that most homes possess the own boiler, each is a small source of emission, but it is not treated individually in environmental analysis.

The anthropic sources are analyzed by **sectors**, as they are presented in European Union official documents:

road transportation which is used to describe all road traffic emissions, irrespective of the size or usage of the vehicle. Emissions form vehicles are usually expressed in terms of exhaust. Combustion of gasoline or diesel fuel leads to exhaust gases containing a range of harmful pollutants.

non-road transportation, which include aviation, railways,

commercial institutional and households sector,

the sector of ***industrial processes and product uses***, produce air pollution with "traditional" pollutants but also with "esoteric" pollutants as consequence of particular industrial processes.

the ***energy production and distribution*** – the burning of fossil fuels (in stationary plants) is by far the most important way of energy production in terms of air pollution.

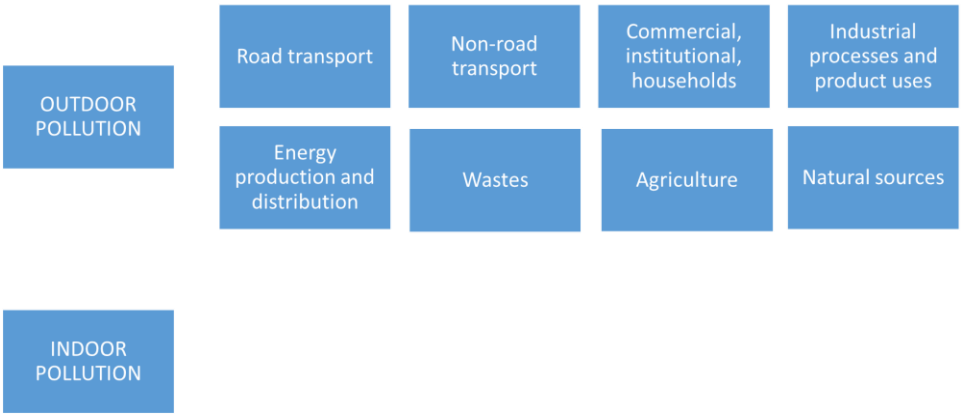
the ***agriculture*** can be both a pollution source and a pollution receptor, considering that emissions from other sources might be harmful for crops.

wastes sector can be considered a ***intermittent*** pollution source, since emissions are often unplanned. As example, during waste incineration, or accidental fires, dioxins are released, sporadic, unintentional products, difficult to be monitored, with severe adverse health effects.

It is important to mention the diversity of contribution of air pollution sources by the geographic location and the specificity of the activity in the region. Thus, air pollution, in urban environment is characterized by emissions from road transportation, industrial activities, commercial, institutional and household activities, and also from wastes sector. The energy production and distribution contributes also to gaseous pollutants emissions in urban environment.

In rural environment, the activity in agriculture sector brings and important contribution to the decrease in air quality.

If we discuss about the impact of air pollutants on human health we have to mention modern people spend over 90% time in interior. Thus, ***indoor***, by specific activities/products is an important pollution source. In the 3rd unit the indoor pollution is approached.



To exemplify the emissions from different sources, we present the contribution of each activity sector to the most important gaseous air pollutants. The data correspond to emissions registered by European Union countries, in 2015, and are presented in the "Air quality in Europe - 2017 Report".

The sector with the highest contribution in sulfur dioxide emission is the energy production and distribution. This is not surprising, considering that in 2015, in Europe, 18.9% from the energy production was based on coal.

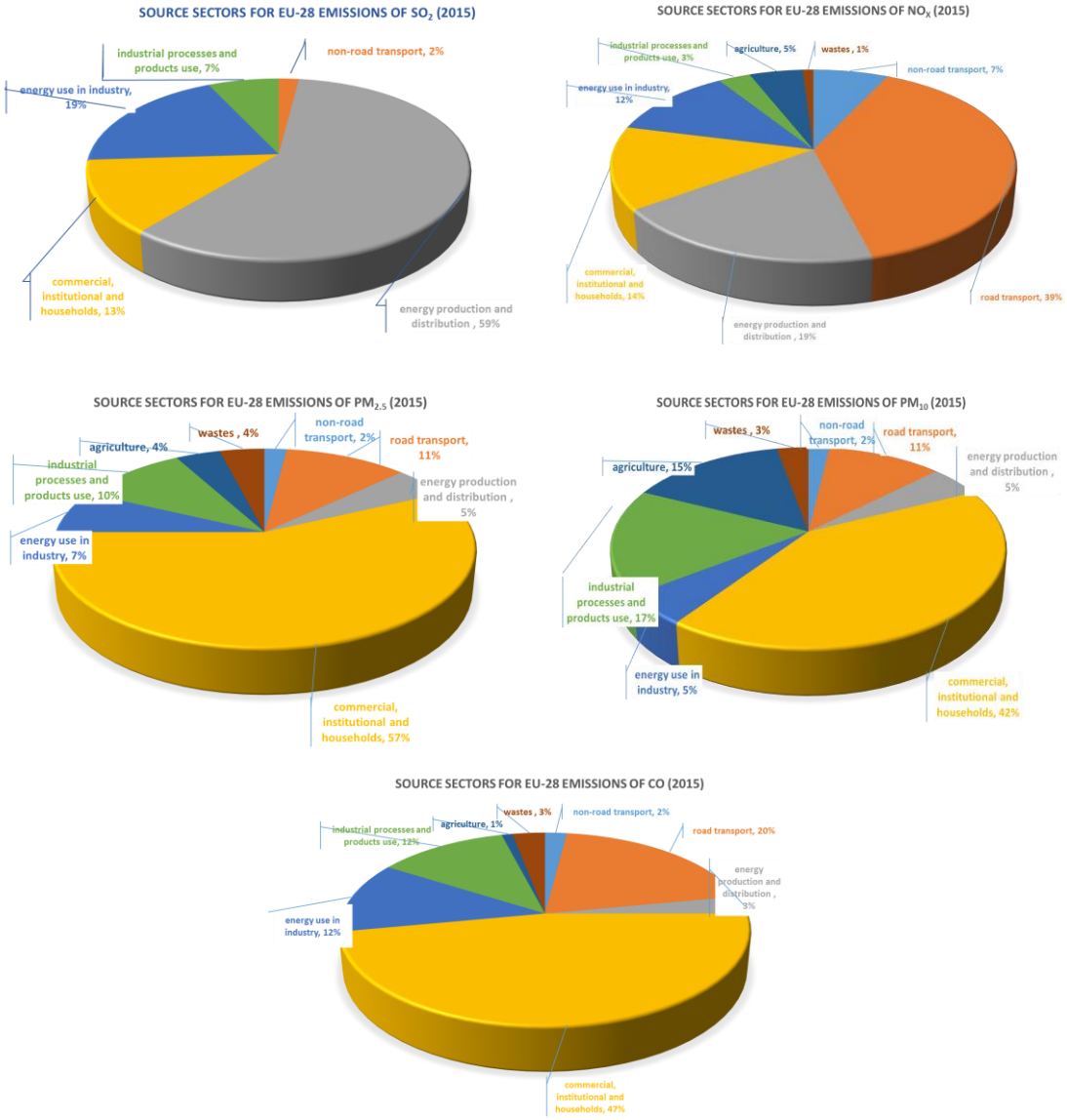
The most important source for nitrogen oxides emission is the road transportation. Energy production and distribution, the commercial, institutional and household activities have also significant contribution.

It is to be mentioned that in the period 2000-2015 the nitrogen oxides emissions decreased, this is mainly caused by technological development.

For particulate matter with aerodynamic dimension up to 2.5 micrometers, the most important emission source is the activity in commerce, institutions and households, where, the main energy source is based on fossil fuel.

In analogy, the sources which emit particulates with aerodynamic diameter up to 10 micrometers, are the commercial, institutional and household activities. In this case, an increase on industrial processes contribution is registered.

The carbon monoxide is mainly produced in commercial, institutional and household activities, and also by road transportation.



The information presented in this section are based on data published by European Commission.

In the 2nd unit, for each of the pollutants the specific emission sources will be discussed.

9. REFERENCES

1. https://www.eea.europa.eu/publications/air-quality-in-europe-2017

2. http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2017/evolution-of-who-air-quality-guidelines-past,-present-and-future-2017

3. https://www.eea.europa.eu/help/glossary

4. http://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf

5. http://acmg.seas.harvard.edu/people/faculty/djj/book/

6. http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_production_and_imports

7. http://www.planetgreen.org/2012/03/edward-i-environmentalist-by-a.html

8. https://en.wikipedia.org/wiki/Fumifugium

9. Brimblecombe, P., Attitude and Response Towards Air Pollution in Medieval England, Journal of the Air Pollution Control and Association, Vol 26, issue 10, 1996, https://doi.org/10.1080/00022470.1976.10470341

10. Schorr, D., Art and History of Environmental Law July 19, 2015, Available at: https://ssrn.com/abstract=2633175

11. https://www.brainpickings.org/2016/02/15/seneca-letter-18/

12. http://www.alamy.com/stock-photo/de-re-metallica.html

13. http://historytradeart.blogspot.ro/2010/05/art-and-artistic-reactions-to.html

14. https://aboutartnouveau.wordpress.com/2015/11/20/art-nouveau-is-back/dark-satanic-mills/

15. http://www.dailymail.co.uk/news/article-2243732/Pea-souper-killed-12-000-So-black-screen-cinemas-So-suffocatingly-lethal-ran-coffins-How-Great-Smog-choked-London-60-years-ago-week.html

16. https://www.express.co.uk/life-style/life/771226/cough-air-pollution

17. http://thegreentimes.co.za/the-melting-arctics-dramatic-impact-on-global-weather-patterns/

https://toxoer.com

Project coordinator: Ana I. Morales
Headquarters office in Salamanca.
Dept. Building, Campus Miguel de Unamuno, 37007.
Contact Phone: +34 663 056 665