

Air Quality

Introduction

Ireland has, and should continue to have, very clean air due to the *prevailing winds* bringing in air from the wide empty expanses of the Atlantic Ocean. A relative lack of both *urbanisation* and heavy industry also contribute to our air quality.

We always think about the quality of our water. If water is even slightly cloudy or tastes a little different we complain vigorously, but until a few decades ago, we took little notice of air quality. Nowadays things are very different; air quality is monitored carefully at numerous testing stations around the country, some static and some mobile.

Poor air quality has the greatest effect on the elderly and those suffering from heart and lung conditions, including *asthma*. It can also affect people who are engaged in strenuous exercise.

Air quality is usually worse in urban areas but this is not always the case; e.g. pollen counts and *ozone* levels are frequently higher in rural areas.

Anti-cyclones (high pressure) stationary over Ireland result in clear, calm, sunny weather — hot in summer and cold in winter — but unfortunately they also result in pollutants from mainland Europe being carried over Ireland and prevent the dispersion of locally produced *pollutants*. In general the air in Ireland is clean and is likely to remain so except for weather induced episodes.

Most of our recorded concentrations for pollutants fall below the limits set under the 2008 Clean Air for Europe (CAFÉ) directive.

Biological Indicators

As a student I remember my *ecology* lecturer saying, when selecting a good, safe place to live, "All a person needs is air fresh enough for lichens to grow and water fresh enough for trout." These are *biological indicators* of air and water quality and are a useful quick reference but they are no substitute for careful scientific measurements. They give an indication of long term conditions rather than present conditions.

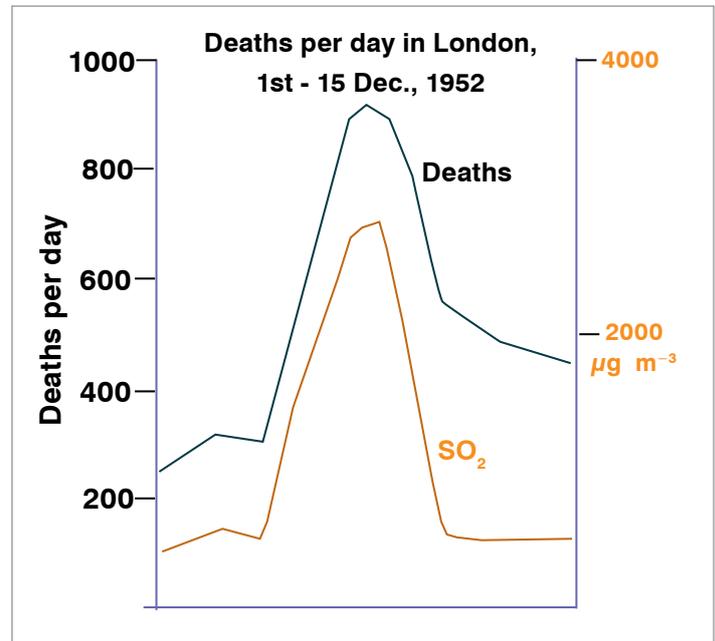


Fruticose lichen indicating excellent air quality

Lichens are composite organisms consisting of *symbiotic mutualistic algae* and *fungi*. They are good indicators of air quality as they are generally very sensitive to sulphur dioxide (SO_2) pollution and they can also accumulate radioisotopes from the atmosphere. The abundance of branched (*fruticose*) lichen is an indicator of air quality.

Pollutants

Particulates are very important as they can be drawn deep into our lungs. The smaller the particles the deeper they penetrate into the lungs and the more damaging they tend to be. These were of concern in the Beijing Olympics and were responsible for the city *smog* (a mixture of smoke and fog) of the 1950's, which killed many thousands in London. Particulates are produced by the burning of solid fuels, especially



bituminous coal, in open fires. Natural examples include volcanic ash from Eyjafjallajokull volcano in Iceland, and of course pollen produced in vast quantities from hay fields. Heavy metals including lead (Pb), mercury (Hg), cadmium (Cd) and nickel (Ni) are also important.

Gaseous pollutants include: sulphur dioxide (SO_2) from the combustion of coal and oil; nitrogen dioxide (NO_2) from high temperature combustion in car engines and power stations; carbon monoxide (CO) from the incomplete combustion of organic compounds (including cigarette smoke) and fossil fuels; *volatile organic compounds* (VOC) and *benzene* from unleaded petrol and tobacco smoke; *ozone* (O_3) from the reaction of NO_x , CO and VOCs in the air in the presence of sunlight and *polycyclic aromatic hydrocarbons* (PAH) from fossil fuel combustion and *backyard burning*.

Effects of pollutants

Carbon dioxide in the atmosphere dissolves in rain making it very slightly acidic due to the formation of carbonic acid. The presence of sulphur dioxide and nitrogen dioxide in the air are responsible for the formation of *acid rain*, which damages both plant and animal life and accelerates corrosion of metals and limestone. These gases (SO_2 and NO_2) can cause irritation of the eyes and *pulmonary tract* and may *exacerbate* existing medical conditions, such as *asthma*. Nitrogen dioxide is involved in the production of *photochemical smog*.

Ozone is more of a problem in the countryside where it can damage crops and cause respiratory tract irritation. In the city ozone is generally less concentrated as it is used up in the formation of photochemical smog. Particulates, especially the smaller particles, cause and magnify both *cardiovascular* and *respiratory* disorders.

Putting things right

The most obvious improvement came with the ban on burning *bituminous coal* in Dublin (1990) after several severe episodes of winter smog. The amounts of particulates in the atmosphere dropped significantly and the

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Smog over Dublin city

air became noticeable clearer. This ban has now been extended to more than twenty other urban centres. Less obvious, but equally important, was the reduction it produced in other pollutants, e.g. SO₂ and PAHs

Lead — which was formerly used in an *anti-knock agent* in petrol — can cause mental impairment, especially in the very young. Lead levels in the air dropped steadily after the introduction of unleaded fuels in the 1980s and the total ban in 2000. The same is true of the *aromatic hydrocarbon* benzene which has had its limit in petrol reduced from 5% to 1%.

The introduction of *catalytic converters* in the 1990s also made a significant impact to the levels of atmospheric pollution in towns and cities by reducing the amounts of carbon monoxide (CO), nitrogen dioxide (NO₂), volatile organic compounds (VOCs) and unburned hydrocarbons. The introduction of the National Car Test (NCT) in 2000 for all vehicles over four years old, also helped by checking the exhaust emissions from motor vehicles. The introduction of special bus lanes, the Cycle to Work Scheme and the Dublin Bikes Scheme have also had an impact by encouraging people not to use their cars, and thus reduce pollution.

Monitoring

The Environmental Protection Agency (www.airquality.epa.ie) is responsible for monitoring air quality in Ireland. It produces the Air Quality Index for Health (AQIH) by monitoring the air quality in many towns and cities around the country as well as at mobile stations. Five major pollutants, namely ozone, nitrogen dioxide, sulfur dioxide, PM2.5 particles (2.5 *micrometres* or less in diameter) and PM10 particles (10 micrometres or less in diameter), are measured and the index is compiled based on the worst of these. It indicates local conditions on a scale.

Air Quality	Value
Good	1-3
Fair	4-6
Poor	7-9
Very Poor	10



The Environmental Protection Agency (EPA) is at the front line of environmental protection and policing. It ensures that Ireland's environment is protected, and it monitors changes in environmental trends to detect early warning signs of neglect or deterioration.

Protecting our environment is a huge responsibility, and the EPA works with a number of organisations that carry out specific environmental functions.

The EPA is an independent public body established under the Environmental Protection Agency Act, 1992. The other main instruments from which it derives its mandate are the Waste Management Act, 1996, and the Protection of the Environment Act, 2003.

The Environmental Protection Agency has a wide range of functions to protect the environment.

Regulation - Implement effective regulation and enforcement compliance systems to deliver good environmental outcomes and target those who don't comply.



How we do it – Through Licensing, Enforcement and Guidance.

Knowledge - Provide high quality, targeted and timely environmental data, information and assessment to inform decision making at all levels.



How we do it – Through Monitoring and Assessment, Research and Reporting.

Advocacy - Work with others to advocate for a clean, productive and well protected environment and for sustainable environmental behaviour.



How we do it – Through Education, Awareness Raising and Behaviour Change.

Find out more about the work of the EPA at www.epa.ie

Find this and other lessons on www.sta.ie

Syllabus References

The relevant syllabus references are:

Leaving Certificate Chemistry

- 5.3 Aromatic hydrocarbons
- 5.5 Oil refining and its products:
- 6.2 Catalytic converters: Environmental benefits
- (Option) Atmospheric Chemistry

Biology

- 1.4.9 Human Impact of an Ecosystem: "Pollution" – definition, areas of effect, its control. Study the effects of any one pollutant. Pollution: the ecological impact of one human activity.
- H1.4.11 Ecological relationships: Symbiosis

Learning Outcomes

On completion of this lesson, students should be able to:

- Know what a biological indicator is and give an example
- Know the value of clean air to health and quality of life
- Know the main pollutants and their sources
- Tell the difference between particulate and gaseous pollutants
- Be aware of the effects of the main pollutants
- Be aware of the main ways air quality has been improved over the years
- Be aware of the monitoring role of the EPA, and the Air Quality Index for Health.

General Learning Points

The following points can be used to enhance the lesson content and to inform discussion.

- Ireland has good quality air and this is very important to the quality of life and general good health. Certain lichens and fish can be used as air quality indicators. In Ireland atmospheric pollutants are normally below the agreed CAFÉ directive levels.
- The pollutants in air come from both natural and manmade sources.
- The natural sources are pollen, ozone, wind-blown dust as well as smoke and ash from volcanoes and fires (initiated by lightning).
- The most significant manmade sources are sulphur dioxide and nitrogen dioxide from the burning of fossil fuels. These gases dissolve in rain making it acidic and as a result it can cause serious damage, corroding buildings, injuring plant and animal life and leaching heavy metals from the soil. Acid rain falling on coniferous trees is made more acidic and so causes even more damage.
- Weather conditions play an important part in pollution episodes. These are normally most serious in calm, warm, dry weather.

Student Activities

1. Burn coal in a porcelain boat in a combustion tube and use a filter pump to draw smoke through a glass tube, then through Universal Indicator solution and finally acidified KMnO_4 . The smoke produced at the start of the combustion process shows the large amount of particulates formed. The glass tube will show tar which has condensed. The indicator will change from green to red, showing that an acid is produced, and the acidified KMnO_4 will change from pink to colourless as it is reduced by SO_2 . The acidity is caused by SO_2 , and to a lesser extent by CO_2 .
2. Conduct a lichen survey of your area. You may find websites such as the following helpful in identifying them:
 - <http://www.opalexplornature.org/Identification>
 - <http://www.lichens.ie/>
 - <http://www.britishlichens.co.uk/>

True/False Questions

- | | |
|--|-----|
| a) Lichens are composed of bacteria and fungi. | F |
| T | |
| b) You are allowed to burn bituminous coal in rural areas. | T F |
| c) Weather can play a major part in levels of pollutants. | T F |
| d) Leaded petrol has been banned since 1950. | T F |
| e) Carbon monoxide causes acid rain. | T F |
| f) Aromatic hydrocarbons have a nice smell and do not cause pollution. | T F |
| g) An Air Quality Index for Health value of 2 is good. | T F |
| h) Backyard burning is the best way to get rid of rubbish. | T F |
| i) Acid rain is an important cause of corrosion. | T F |
| j) Lead can reduce the mental ability of babies. | T F |

Check your answers to these questions on www.sta.ie.

Examination Questions

Leaving Certificate Biology (HL) 2004 Q. 5 (a)

What is meant by pollution?

Give an example of a human activity that results in the pollution of air or water.

Suggest a means of counteracting this pollution.

Leaving Certificate Biology (HL) 2006 Q. 10 (c)

- (i) Explain what is meant by pollution.
- (ii) Give an account of the effects of a named pollutant of domestic, agricultural or industrial origin.

- (iii) Describe one way in which the pollution that you have indicated in (ii) might be controlled.
- (iv) Outline the problems associated with the disposal of waste. Suggest two ways of minimising waste.

Leaving Certificate Biology (HL) 2012 Q. 4 (b, c)

- (b) (i) Explain the term pollution.
- (ii) Pollution may result from domestic, agricultural or industrial sources. Select one of these areas and state an effect that may be produced by a named pollutant.
- (iii) How may the pollution referred to in (ii) be controlled?
- (c) In relation to the incineration of domestic waste, suggest:
 - (i) an advantage of the process.
 - (ii) a disadvantage of the process.

Leaving Certificate Chemistry (HL) 2008, Q. 11

From July 2008 changes will apply to the way in which taxes are levied on new cars bought in Ireland. Vehicles that, in controlled tests, have higher levels of carbon dioxide emission per kilometre travelled will be subject to higher levels of taxation. The measures are designed to encourage the purchase of cars that are more fuel-efficient and have lower CO₂ emissions.

The manufacturer's specification for a certain diesel-engined car is 143 g CO₂ / km (i.e. the car produces 143 g of CO₂ for every kilometre travelled). The car is used for morning and afternoon school runs totalling 8 km per day. Use the manufacturer's CO₂ emission figure to calculate the amount of CO₂ produced each day during the school runs in terms of

- (i) the mass of CO₂
- (ii) the number of moles of CO₂
- (iii) the volume of CO₂ at room temperature and pressure.

If a large SUV (sports utility vehicle) with a CO₂ emission rating of 264 g CO₂ / km were used instead of the car mentioned above, how many more litres of CO₂ would be released into the atmosphere per day during the school runs?

Did You Know?

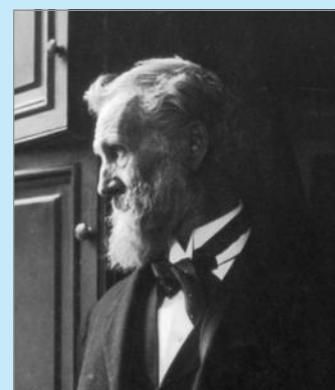
- Smog is a mixture of smoke and fog; It occurs in calm foggy conditions in winter when lots of coal is being burned. It was called a "pea soup fog" because it was so thick (like pea soup), that even in the middle of the day, you could not see your hand held in front of your face. In the winter 1952 it caused over 4000 deaths in London. This prompted the English parliament to pass the Clean Air Act.
- The worst industrial air pollution incident occurred during the night of 2/3 December 1984 in Bhopal, India. About 30 metric tons of methyl isocyanate escaped in an accident at the Union Carbide pesticide plant and drifted over Bhopal killing almost 4000 people immediately and a further 8000 over the following few weeks.

- Unlike most living organisms lichens lack an active absorption mechanism and so cannot control their uptake of chemicals in the environment. They also lack mechanisms to eliminate unwanted chemicals. As a result they accumulate many substances that they do not require, including radioisotopes and ions of heavy metals. Different species can tolerate different levels of pollution. For all these reasons they can be used as indicators of air quality.

Biographical Notes

John Muir (1838 – 1914)

John Muir was born in Dunbar in Scotland in 1838. From an early age he had an interest in nature but his father regarded any interest outside the Bible as frivolous. When he was eleven the family moved to Wisconsin, USA, where they established a farm. He paid his own way through university where he chose a wide range of subjects rather than a standard degree course.



In 1864, to avoid military service, he went to Canada and began wandering the woods and swamps collecting plants. He also set up a saw mill with his brother Dan. In 1866 he returned to the US where his expertise with wood was valued. An accident in 1867 left him blind in one eye. The experience changed his life and he devoted the rest of his life to studying plants. That same year he undertook a 1000 mile walk which he described in a book entitled "A Thousand-Mile Walk to the Gulf".

In 1868 he visited Yosemite, which he later described as "the grandest of all special temples of Nature". He wrote articles and books describing the marvels of nature.

After years of petitioning he succeeded in getting the U.S. Congress to designate Yosemite a national park. He profoundly changed how people perceived the environment.

Revise the Terms

Can you recall the meaning of the following terms? Revising terminology is a powerful aid to recall and retention.

acid rain, algae, anti-cyclone, anti-knock agent, aromatic hydrocarbon, asthma, backyard burning, benzene, biological indicators, bituminous coal, cardiovascular, catalytic converter, ecology, exacerbate, fructose, fungi, gaseous pollutant, lichens, micrometre, mucus lining, mutualistic, NO_x, ozone, particulates, photochemical smog, pollutants, polycyclic aromatic hydrocarbons, prevailing wind, pulmonary tract, respiratory, smog, symbiotic, urbanisation, volatile organic compounds (VOC).

Check the Glossary of terms for this lesson on www.sta.ie