

Learning Unit 3: Air pollution and climate change

GGH2604



Sources to consult

- **Atlas:** Mauna Loa volcano in Hawaii, Los Angeles, Mexico City and London
- **Map 3:** Cities at risk due to sea level rise.
- **Prescribed book:** Chapter 3, "Air: Science and the atmosphere", on pages 42-64 in Whitehead (2014)
- **Case Studies 3.1 and 3.2:** Climate change in Africa and Climate resilience in Rwanda
- **Additional Resources on myUnisa:** YouTube videos and Podcast

Learning Outcomes

- Examine the causes and impacts of human activities on the atmosphere
- Discuss the consequences of air pollution and climate change on human life and the environment
- Discuss the role of science in identifying and explaining the linkages between human activities and the atmosphere
- Describe remedial measures that can be taken to address climate change

Thomas Midgley and the Ultraviolet Century

- In 1921 Thomas Midgley discovered that adding lead to petrol could combat the problem of engine knocking in vehicles. While the addition of lead to petrol was beneficial for the operation of vehicles, it resulted in a spike in the levels of lead in the atmosphere. Lead, which is toxic, then entered human bloodstreams and ecological systems.
- In the 1930s Midgley realised that the use of chlorofluorocarbons (CFCs) could improve the safety of refrigeration, however, CFC production led to a decrease in the planet's ozone layer. Ozone depletion has been linked to higher levels of skin cancer, plant damage and dwindling plankton populations in the oceans.

Thomas Midgley and the Ultraviolet Century

- Cumulative forms of pollution are forms of pollution that gradually accumulate in the environment over long periods of time, for example the air pollution associated with leaded petrol.
- Systemic forms of pollution refer to the ways in which certain pollutants can actually change the ways in which large-scale ecological systems (such as the ozone layer) operate.
- In the Anthropocene, science and scientists are not only involved in generating atmospheric problems, but also in helping to identify and address them.

Air pollution: From Mauna Loa to Mumbai

- The greenhouse effect is a naturally occurring process that is responsible for regulating the Earth's temperature. Greenhouse gases operate like a blanket that keeps the planet warm and suitable for life. Without greenhouse gases the Earth's average temperature would dip to -18° Celsius. Examples of greenhouse gases are the following:
 - Carbon dioxide (CO_2)
 - Methane (CH_4)
 - Water vapour (H_2O)
 - Ozone in the troposphere (O_3)
 - Nitrous oxide (NO_x)
 - Aerosols (dust and smoke)
 - Sulphur hexafluoride (SF_6) (Cook 2012 and Whitehead 2014)

Air pollution: From Mauna Loa to Mumbai

- Keeling's work in the thin air of Mauna Loa, Hawaii (3000 metres above sea level), revealed increasing levels of carbon dioxide in the atmosphere. When Keeling started his study, he recorded carbon dioxide at levels of 310 parts per million (ppm). Measurements at the Mauna Loa Observatory in April 2017 recorded the level of carbon dioxide in the atmosphere as 406.17ppm (Tenenbaum et al. 2017). Collectively, Keeling's observations led to the production of the Keeling Curve. The curve shows increasing levels of carbon dioxide in the atmosphere over time. The increase in carbon dioxide levels coincides with studies indicating that average global temperatures have increased by 1.5 degrees Celsius over the last 250 years.
- **Watch** the YouTube video titled "400 Parts in a million: The world's biggest experiment" from the link:
<https://www.youtube.com/watch?v=ikGLNs3nYlc>
- **Vote** in Poll 3.4 on myUnisa. The poll question is:
 - Whitehead (2014) expresses doubt about the motivation for cutting funding for Robert Keeling's work. Do you think Whitehead's doubts are justified?

Air pollution: From Mauna Loa to Mumbai

- Population growth, the expansion of railways, textile, steel and alkali production industries contributed to the increased combustion of coal and hydrogen chloride emissions which affected the air quality of London from the 17th century.
- The combustion of coal and petroleum releases sulphur dioxide (SO₂) and nitrous oxides (NO_x) into the air. These gases react with water molecules to produce sulphuric or nitric acid. Once produced, this acid can be transported over long distances before being deposited on ecosystems – known as acid deposition or acid precipitation.
- Acid rain can:
 - lead to biodiversity loss
 - inhibit the hatching of fish eggs
 - weaken trees by attacking their leaves and inhibiting their ability to absorb nutrients
 - deplete the soil of nutrients
 - damage tree roots
 - lead to impaired photosynthesis (Park and Allaby 2017)

Air pollution: From Mauna Loa to Mumbai

- Photochemical smogs are a product of sunlight reacting with NO_x and volatile organic compounds (VOCs), which are emitted from vehicular exhausts, producing ground-level ozone and airborne particles.
- Photochemical smog may affect human health by increasing incidents of asthma, acute respiratory infections, cardiopulmonary disease and cancers of the lungs and trachea.
- Unlike industrial cities where the cold air of winter associated with high-pressure weather systems trap air pollution, Los Angeles's fog is a phenomenon of the late summer.

Reflections on the nature of atmospheric science

- The objectivity and universality of modern science are important because they enable the production of more reliable and trustworthy accounts of the real world.
- A crucial factor within the production of scientific knowledge is the notion of *scientific consensus*. Scientific research progresses through the development of consensus, in and through which particular ways of understanding the world become accepted wisdom, whereas other theories are rejected.
- A paradigm is a scientific model that explains how a certain process works. Paradigm shifts occur when two incompatible theories of scientific knowledge contest each other to be the accepted way of explaining how the world works. A paradigm shift could be observed in geography when theories of a flat Earth were rejected.

Reflections on the nature of atmospheric science

- The objectivity of smoke inspectors in London was compromised due to limited visibility, local terrain issues and interference by factory owners. In addition, the decision to locate the majority of the UK's sulphur dioxide monitoring stations in urban areas led to gaps in scientific knowledge concerning the extent of acid deposition in rural areas.
- While an estimated 97% of scientists have reached the consensus that the human enhancement of the greenhouse gas effect is responsible for current climate changes, a range of institutions and individuals are trying to cast doubt on the scientific consensus on climate change.

Reflections on the nature of atmospheric science

- Opponents of the scientific consensus on climate change...have often emphasized scientific uncertainty in order to forestall mitigative action. Those arguments often exaggerate, for political or ideological reasons, the actual degree of uncertainty in the scientific community or imply that uncertainty justifies inaction". It has been established that the opponents of the scientific consensus on climate change have received funding from ExxonMobil, the world's largest oil corporation.
- In 2001 Danish academic Bjørn Lomborg published a book *The Skeptical Environmentalist* wherein he cast doubt on various scientific predictions that climate change would lead to serious socio-ecological problems in the future. The Danish Committees on Scientific Dishonesty felt that the dishonesty in the book was a product of Lomborg's lack of scientific expertise the field of climate change.

Reflections on the nature of atmospheric science

- **Watch** the YouTube video titled “Climate science: What you need to know” from the link:

<https://www.youtube.com/watch?v=ffjlyms1BX4>

- **Watch** the YouTube video titled “Why people don't believe in climate science” from the link:

<https://www.youtube.com/watch?v=y2euBvdP28c>

Climate change in Africa

- **Read** Case Study 3.1: Climate change in Africa
- Africa is warming faster than the global average, with projections of a rise of 3–4 °C this century. This makes climate change a considerable health and economic challenge for the continent. Climate-sensitive diseases such as cholera, meningitis, malaria and Rift Valley fever are likely to spread faster. In some areas, the warming is likely to reduce crop yields and livestock productivity, and cause water scarcity. Extreme weather and climate events such as droughts and floods are expected to be more frequent, with negative impacts on human life and health. Climate change will also lead to wildlife migration due to habitat loss.
- **Listen** to Podcast 3.6 titled “Climate change in Africa” on myUnisa

Adaptation to climate change

- **Read** Case Study 3.2: Climate resilience in Rwanda
- Mitigation strategies involve attempts to stabilise and reduce the human production of greenhouse gases and may include the establishment of carbon taxes, international climate change agreements, carbon markets and trading schemes, carbon offsetting programmes and the development of low-carbon technologies.
- Adaptation involves individuals, communities and states working to try to ensure that people are able to cope with the effects of climate change. Adaptation policies include flood protection, changes in agricultural production techniques, freshwater conservation, the construction of sea defences, responses to extreme weather events and the treatment of climate sensitive health issues.

Adaptation to climate change

- Although various international efforts to address climate change have been adopted, the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) is widely regarded as the most important instrument in adapting to climate change.
- The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.
- **Vote** in Poll 3.7 on myUnisa. The poll question is:
 - On the 1st of June 2017, the US announced its intentions to withdraw from the Paris Agreement. In your opinion, will it be more difficult to achieve the goals of the Paris Agreement without the participation of the US (a country which emits large amounts of greenhouse gases annually)?

Fugitive emissions and Louisiana's Cancer Alley

- Scientists have struggled to assess and monitor the air pollution in Diamond, Louisiana. The large scale of air pollution in the region means that it is impossible for scientists and regulators to monitor all air pollution events. The work of scientists is also hindered by the activities of corporations who use the cover of mist, fog and darkness to hide their air polluting activities. While corporations are expected to keep their own inventories of toxic air pollution releases, the leaks and associated forms of fugitive air pollution tend to go unrecorded and unmonitored. Estimates suggest that in Diamond some 80 million pounds of VOC emissions go unreported due to leaks every year.
- **Participate** in the Discussion Forum Topic 3 on myUnisa:
 - Whitehead (2014) claims that large corporations and industries release pollutants into the air at night to conceal the actual amount of air pollution they release annually. Do you think this claim is valid? Do you know of areas where large corporations or industries might release pollutants at night?

Thank you

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