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How climate change exacerbates pollution and threatens human health

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Pollution of our environment has been recognised as a problem for eons. Early humans knew that separating waste from consumables was essential to health, even if they did not understand the true reasons why. Pollution has often been separated from climate change as though they are two separate issues and that the problems of dealing with pollution are unrelated to the issues of climate change. As this chapter will explain, they are often interlinked and will become more so as human civilisation adapts to a changing climate. The problems of pollution are exacerbated by a changing climate.

First, we must define what we mean by 'pollution'. This chapter specifically references pollution when referring to anthropogenic influence. There are some chemicals, largely metals, that arise by natural geologic processes, and these would not be considered pollution. Pollutants are put into the environment by human processes. However, as will be mentioned later, sometimes pollution is also when natural chemicals end up in places where they should not be, most often from human processes, and now from climate change.

In the scientific community there is often a distinction between the effects of climate change and the effects of pollution. Pollution is seen as something that has a direct effect on

human health through exposure to dangerous chemicals, and climate change is seen as a threat in the form of increasingly intense heat waves, droughts and storms. However, only more recently has there been discussion about how these two issues might affect each other. Climate change is not only caused by human influence, it also exacerbates it. The scenarios discussed in this chapter will outline how climate change can affect pollution and whether there are solutions.

Water

One of the more recent examples of climate change's effects on pollution was during the bushfires in Australia during December–January, in 2019–2020. The bushfires were severe and intense, and the immediate devastating effects on the population of humans and animals that live in those areas was apparent. When the rain finally came, it washed all of the ash, debris and firefighting chemicals from the fires into nearby rivers, creeks, streams, lakes and reservoirs. This unprecedented influx of ash and debris threatened to overwhelm the water treatment systems in place and decrease the quality of the drinking water delivered to the communities of southern Australia, and in some areas this resulted in 'Do Not Drink' or 'Boil Water' directives .[1] These waterways are often already polluted. Water treatment facilities face an ever-increasing list of pollutants they must treat in order to maintain safe drinking water supplies for the populace. And with population growth, the volume of those pollutants is only increasing. An increasing rate of bushfire events brought about by climate change will put further pressure on the water treatment plants. It threatens the security of clean drinking water.

Climate change is causing bushfires like those that devastated Australia is 2019–2020 to increase in frequency and intensity. Having these sorts of events more often will very quickly overwhelm the ability of infrastructure to deal with them. Water treatment facilities and water management authorities must take the increasing frequency of these events into account when planning future infrastructure projects. As further discussed below, fresh drinking water is already a shrinking resource in much of the world; and particularly in Australia, pollution threatens this already vital resource. With the addition of bushfire ash, debris and firefighting chemicals, the precious drinking water we rely on is being put under pressure from the twin threats of climate change and pollution.

In a large portion of the world, one of the most often seen effects of climate change is drought. Droughts are happening with increasing frequency and duration. In southern Australia some areas have been in drought for most of the last 25–30 years. According to the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the duration of droughts is expected to increase over the southern portion of the continent. These effects are similar for other drought-prone areas such as California in the United States, Southern Africa and central Chile.

Drought exacerbates pollution. In many areas of the world, drought is becoming the new normal and access to fresh water is becoming limited. This puts further pressure on fresh water resources that may already be polluted. Or, if the water is not polluted it increases the risk to those water supplies if there is a pollution event. This is the case with surface water resources,

such as reservoirs and dams. During the Millennium Drought in southern Australia from the late 1990s to the early 2000s, the water level in the dams that fed most of the major cities was less than 50% of capacity, and in some cases 20% or less. This was an issue not only because of water supply, but also that the water supply was now more vulnerable to pollution.

Nowhere was this more evident than during the Black Saturday bushfires in 2009. Melbourne Water, which is the entity responsible for the resourcing and treatment of water for Melbourne, moved more than 10 billion litres of water from dams that were threatened by fire because of the risk of pollution runoff.[2] This movement of water ensured that Melbourne's drinking supply was not affected, but as these fire events become more frequent, movement of water may not be an option, and further treatment facilities will need to be built to deal with the effects.

Building more facilities was the result of fires in 2003 around Canberra in the Australian Capital Territory. A major fire in January 2003 burnt through the area surrounding the dams that feed Canberra its drinking water. This fire was followed by a storm event that washed the ash, debris and pollutants from the fire into the dam, which overwhelmed the water treatment systems. Safe drinking water could only be provided from one reservoir, which already had lower water levels from the ongoing drought. Canberra was put on mandatory water restrictions and a new water treatment plant was built to deal with the ongoing pollution effects.[3]

The effects of drought exacerbating water pollution are also very evident in small islands throughout the Pacific. Many of

these islands use groundwater as a drinking supply. With decreasing rainfall the groundwater is unable to recharge and the water supplies on these islands decreases, making them vulnerable to pollution problems. Human activities can contaminate the soil and groundwater in urban areas, which is a problem when groundwater levels are already decreasing as a result of drought.

The Republic of Kiribati is a Pacific nation made up of 32 coral atolls, with over half of the population living on the Tarawa Atoll. The islands are dependent on rain for freshwater, and what is not collected in tanks is harvested through groundwater. Both drought and an increasing population has put pressure on these water resources. This increasing population has also resulted in pollution of the groundwater. Although the government has tried to limit the use of land in areas of groundwater recharge, space is limited on the islands, and on one particular island — Bonriki — squatters have established market gardens and pig pens on the water reserve. This has resulted in contamination of the groundwater with e. coli. When water is already scarce from drought, the pressures of pollution have caused public health problems in Bonriki.[4]

The issues on Norfolk Island are another example of climate change exacerbating pollution problems. Norfolk Island is a small Pacific island that is governed as a territory of Australia. It is a remote island where water resources are usually collected in rainwater tanks and occasionally groundwater bores (CSIRO, 2019).[5] However, there have been increasing years of drought on the island and this has resulted in more residents using groundwater rather than tank water. This has become a

problem as per- and poly-fluoroalkyl substances (PFAS) have been found in the water on the island (Department of Infrastructure, 2020).[6] PFAS are man-made chemicals present in many different consumer goods, such as food packaging, paints, non-stick coatings and firefighting foams, and some types of PFAS have been linked to cancer and other health issues. It is firefighting foams from the firefighting facility at the airport on Norfolk Island that are suspected of causing the pollution. The PFAS have been found in groundwater on the island, and this can pose a problem with a population that is increasingly relying on groundwater resources. PFAS are colourless and odourless, and the treatment processes can be expensive, so the need to investigate and remediate the pollution is becoming urgent. In the meantime, it is possible that Norfolk Island will need to obtain their drinking water from other sources, including potentially desalination, as the island is experiencing water stress as a result of climate change induced drought, and the pollution of drinking water is only making these problems worse.

Rising temperatures caused by climate change will also increase water temperatures. Increased water temperatures can have several knock-on effects, but possibly the most dangerous to human health are algal blooms. Algal blooms are caused by a combination of warm temperatures and increased nutrient inputs into the water, either from agricultural fertilizer runoff or runoff from fire-burnt land. Not all algae are harmful to human health, but there are several species of blue-green algae that often bloom when conditions are right and cause issues with drinking and recreational water quality. The health effects of

harmful algae include skin, eye and respiratory irritation. Toxins from harmful algae can build up in edible fish and shellfish, which is then ingested by humans and can cause poisoning. This often leads environmental regulatory agencies to warn against ingesting fish or shellfish caught in these areas.

The frequency of harmful algal blooms (HABs) is expected to increase with a warming climate.[7] This is for multiple reasons, including that warmer water temperatures are a better environment for the toxic species of algae. The warm water provides a better environment for the algae to grow by preventing water from mixing and creating an environment that makes it easier for the algae to move through the water. This is further exacerbated by the fact that when algae start growing, they warm up the water through sunlight absorption, therefore making an even better environment for themselves to grow in, perpetuating a cycle.

Fertiliser runoff from agricultural land is a recognised source of nutrients to river systems throughout the world and is already known to cause blooms of toxic blue-green algae and decrease the quality of the drinking and recreational water. When combined with warmer water temperatures as a result of climate change, this can make for a potent combination. In Florida in the United States there are regular blooms of harmful algae (called 'red tides') that release toxins into the air which cause respiratory problems.[8] These toxins are harmful to beach-goers and those with asthma seem to be particularly susceptible and may feel the detrimental effects long-term. The severity of red tides in 2018 caused the governor of Florida to declare a State of Emergency for the affected coastal communi-

ties.[9] There are predictions that these red tides and other algal bloom events will occur more frequently with increasing warming, and in the case of algal blooms, one of the ways they can be controlled is through decreasing anthropogenic pollution of the waterways. This strategy was called for in a letter written by several scientists as one way to tackle this ongoing health issue.[10]

Air

There are several ways climate change is making air quality worse. The Australian bushfires in 2019–2020 released 300,000–900,000 tonnes of smoke into the atmosphere. The smoke from the fires caused health problems in a large portion of the population of Australia, with the major cities of Melbourne, Sydney and Canberra blanketed in smoke for weeks, and other communities surrounding the fires similarly affected (Willis, 2020).[11] This was a clear increase in the air pollution of these cities and only served to increase any negative health effects for those who may already be living in communities with poor air quality due to pollution. Luckily, in Australia the air pollution that is usually present in these cities is mostly low. This is not the case in other parts of the world with regular bushfires.

Brazil also has a dry season that promotes the ignition of bushfires. Sao Paulo, Brazil's most populous state, has air pollution that is considered 'moderately unsafe' according to the World Health Organisation (WHO). The mean concentration of PM2.5 (particles with a diameter of 2.5 micrometres or less) in the country was 13 μg/m3, which is higher than the recommended WHO value of 10 μg/m3. A study of the air pollution in

Sao Paolo found that the fires are contributing significantly to this air pollution, to the extent that the attempts by local authorities to control urban pollution from transportation in the city is mitigated by the smoke. When climate change makes these fires more frequent or severe it will be a continuous battle to control air pollution and reduce the risk of harm to those living in the areas most affected.

Air pollution also has an effect on the incidence of allergens and allergic reactions. Generally, air pollution from vehicle emissions is considered a large contributor to rates of asthma and allergies, and there is significant evidence that living next to a road with heavy vehicle traffic is associated with decreased respiratory health. At the same time increasing temperatures are altering the pollen season, and the plants that cause respiratory stress are flowering and releasing pollen for longer periods of time.[12] Both of these can combine to cause an increasing amount of respiratory problems. This was shown in an Italian study that investigated whether climate is associated with the incidence of asthma and allergy. The researchers found that warmer climates were associated with increased asthma-like symptoms, largely due to pollination events happening year-round, rather than just in the spring-summer seasons. This lengthening of the pollen season is being seen across the northern hemisphere and is likely happening in Australia as well (Khan, 2019).[13] This direct effect of climate change is only exacerbated by anthropogenic air pollution.

Conclusions

It is clear that climate change is exacerbating the health effects of pollution. As this chapter has detailed, the effects of climate

change are wide-ranging, and these increase the health effects that we already know are linked to pollution. Drought and rising temperatures are particular threats to human health as they jeopardise the drinking and recreational water supplies that people rely on.

The examples given in this chapter have largely been from developed nations; however, these problems are worse in developing countries where there may not be the administrative infrastructure to regulate pollution or carbon dioxide emissions. These countries are also often the most affected by climate change, despite most carbon dioxide emissions coming from more developed countries. For example, throughout most of Southern Africa, drought has become an increasing part of daily life, which puts communities that rely on shallow groundwater or surface water at risk.[14] These communities are often rural and rely on agriculture to survive, which usually involves pesticides and other contaminants to run off fields and into local creeks and rivers, further threatening water supplies. This is not just an issue in Australia or on small islands, but worldwide.

Thankfully, there is still hope. The increase in development and uptake of low-emissions, hybrid and electric vehicles is likely to decrease air pollution and climate change. Transportation accounts for 20–25% of global CO_2 emissions, and with an increasingly electrified transportation fleet this is likely to go down. With decreased CO_2 emissions also comes decreased air pollution and improved respiratory health. With effective incentives and policies, it is possible that the concomitance of air pollution and climate change could be eliminated by electric vehicles.

Similarly, there is hope with respect to drought and water pollution. Although droughts are already increasing in frequency and length, water pollution is generally declining. Better filters on local groundwater bores and better technology in water treatment plants has allowed us to adapt to threatened water security. We are also growing crops that do not require as much fertiliser, or species that are better adapted to drying climates. For instance, in Australia there are movements to grow native species of grain better adapted to the dry Australian climate. These are largely lead by Indigenous innovators who have an intimate knowledge of the climate and fauna of the country.[15]

The effects of climate change and pollution on human health go hand in hand despite the scientific literature often treating them separately. Further studies into pollution and its effects on human health need to incorporate climate change, otherwise we will be missing a major piece of the puzzle and will not be prepared to effectively tackle these threats to our health.

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