Urban climate issues and management
3.2.3.4 Urban environments

What you need to know
What the urban heat island is and how its created.
How precipitation varies in an urban area.
How urban structures impact upon wind in an urban area.
How cities affect air quality.
How air pollution can be reduced.

Introduction:

Due to the building density, material type, transport emissions and urban form, the climate may be significantly different in a city to that of its rural neighbour regions.

Urban heat island

This is where the urban area is significantly warmer than its rural surroundings. The main cause of this feature is the contrast between natural rural and artificial urban surfaces.

- Natural surfaces absorb high levels of radiation without re-radiating to the same extent and release water vapour through evapotranspiration, which cools the local environment. Removal of the natural environment removes the ability to regulate the climate in this way. Urban surfaces are often dark and composed of materials that readily absorb short-wave solar radiation, which is then later re-radiated as long-wave heat at night. Tall, dense buildings absorb heat energy and trap it within the urban area too.

- Rural areas have vegetation coverage which intercepts incoming radiation and stops it being absorbed by the shaded ground. Within a city, where there is parkland there is a noticeable drop in temperature compared with the city streets and buildings which shows that the temperature changes across a city. The absence of shading across the majority of urban areas leads to direct absorption of solar radiation by asphalt, concrete, brick, steel and similar materials.

- Heat generated by atmospheric pollutants to the urban area, the production of heat from air conditioning and refrigeration systems, as well as from industrial processes and traffic, such as cars, have been recognised as additional causes.

- Equally important is the impact of building structures on air flow. Incoming winds from rural areas which enter the city are intercepted by buildings and therefore can't disperse the heat, which is retained and added to.

- There is an uneven spatial distribution of heat across a city. Higher building densities and areas in a city such as shopping malls and stadiums have a noticeably higher temperature due to the use of electricity in these areas giving

off heat as a waste product. Compare this with an area of parkland or alongside a city river, and the temperatures can be 5 degrees Celsius cooler.

- The urban heat island (UHI) effect usually reaches its highest contrast on summer nights, where the air is calm and there is a lack of cloud. This is because construction materials have a high thermal inertia due to their colouring and composition (i.e. a low response to temperature changes). As a result, they continue releasing heat slowly after sunset and even near dawn, whilst the lack of cloud means rural areas will have cooled significantly by this time.

Precipitation

In order for precipitation to occur it's important to recognise why cloud cover is greater over urban areas than rural. Cloud cover is increased by human activity. Convection currents are generated by the higher temperatures in the urban area and condensation occurs at a much greater rate, hence leading to increased cloud cover. The large amount of pollution and dust from traffic exhausts and industry generates condensation nuclei larger than normal around which water vapour condenses readily and which then forms dense, low-altitude cloud. It may result in low-lying fog on cooler mornings. As a result of this cloud formation the mean annual precipitation total and the number of days experiencing more than 5mm of rainfall are greater in urban areas. Also, the rainfall is often accompanied by thunderstorms, with an increase of 25% frequency compared to nearby rural areas as a result of more intense convection currents above cities.

In winter it is less likely to snow in an urban area and should the region be experiencing snow, it is likely that this will turn to sleet when it reaches the city due to the urban heat island effect. Any snow that settles on the ground is likely to melt sooner.

Wind

Generally, winds are weaker in urban areas than in the suburbs or rural areas. The reason for this is that winds get intercepted, blocked and deflected due to the high buildings.

However, local urban winds can be strong. Tall buildings cause frictional drag in the movement of the air. The frictional drag creates turbulence which causes the wind to start to circle (eddying). The gusts affect the windward side of a building differently to the leeward side. The windward side of the building experiences high pressure due to the wind blowing against it. The leeward side, which is on the opposite side of the building, experiences low pressure and as the wind moves around the building it creates a localised pressure gradient which makes the winds whip around faster. This process occurs a lot where tall buildings occur in high density, whereas in urban areas where buildings are widely spaced it has the opposite impact and winds are lighter.

Specific urban form can lead to an increase in winds as the straight streets between the buildings act as wind channels, whereby the wind travels at fast speeds. This sudden increase in wind speed can be powerful enough to blow pedestrians over. Many US

cities experience this phenomenon due to their dominant grid system of streets. Open areas within cities, such as parkland, are areas where strong winds will lose their strength and diminish in velocity.

Air quality

Air quality in urban areas is poorer than rural areas due to the greater use of fossil fuels in urban areas. Emissions may come from domestic heating and cooking systems, factories, traffic, waste incineration and power-stations. It can vary, however, between cities, according to the urban function and infrastructure. For example, in a city where industrial output is high, air quality is poorer. Equally important is the transport arrangement. In a city where there is free movement of cars, air quality tends to be worse than in a city where sustainable public transport has been introduced.

Particulate matter

This is all the liquid and solid particles that are suspended in the air. This is particularly significant in an urban area as lots of soot and ash is given off from transport and factory emitters. These particles are particularly hazardous to human health as they are breathed in and can cause damage to lungs, particularly to the very young, elderly and those with congenital breathing difficulties – such as asthma sufferers.

Carbon monoxide

This is produced during vehicle combustion and is found to be highly dangerous to humans. It is also produced from power stations and waste incinerators.

Sulphur dioxide

This gas is produced during the combustion of fossil fuels. In the atmosphere emissions commonly mix with water vapour to produce sulphuric acid. This can then fall as acid rain and damage buildings. In the wider context, the acid rain may be carried out beyond the urban area by prevailing winds and can cause serious damage to vegetation and crops, forests, lakes and waterways in the downwind rural area.

Ozone

Tropospheric (ground-level) ozone is produced from the reaction between sunlight and emissions from power stations and internal combustion engines. It is formed when nitrogen oxide and volatile organic compounds combine at lower levels on warm days. It is often not recognised as being one of the most important gases in terms of danger to human health but it is corrosive when breathed in and regular exposure to it can lead to chronic lung conditions.

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Carbon dioxide

This is produced as a result of fossil fuel combustion. Similar to other gases in urban areas it is dangerous to human health, leading to many more cases of respiratory illness and asthma than in rural areas. Combining with water vapour it contributes to acid rain.

Photochemical smog

This is where pollutants, such as nitrogen dioxide and hydrocarbons in the troposphere react with sunlight. Low-level ozone is formed and combines in a chemical 'soup' with particulates and other emissions. Cool, stable air can sink downwards under high pressure anticyclonic conditions. The temperature inversion (warmer upper air forming a capping layer above cold air chilled by the ground) together with negligible wind can force the smog to remain stationary over a city for days at a time. It can be so damaging to health that people may be warned to stay indoors and keep windows closed. In urban areas, where there are high concentrations of photochemical smog, the death rate is significantly higher. Los Angeles is notorious for being covered in a chemical smog haze on a number of days each year.

Air pollution reduction:

The most common strategies to improve urban air quality are as follows:

1. **Encourage walking & cycling.** By creating cycle paths and making park areas safe, both cycling and walking can be encouraged in cities. This reduces use of cars and means that the remaining vehicles will experience less congestion and therefore air pollution levels will be lower. Many cities are introducing bike-hiring schemes.

2. **Pedestrianise areas and have congestion charging zones.** By restricting access to areas within a city, there are fewer vehicles. Having pedestrianised areas in the CBD encourages people to visit more but without the added air pollution. Congestion zones charge vehicle-users for entering, such as the one in central London.

3. **Improve construction industry standards**. When constructing new buildings within a city, the number of particulates such as dust, wood, grit and sand which rise into the atmosphere can be managed. The design of actual buildings themselves should adhere to strict codes of practice regarding energy efficiency and emissions.

4. **Restrict polluting vehicles.** A number of cities have said they will restrict access to central cities by older vehicles and diesel engines, such as Paris. Some cities have introduced an alternative registration plate system such that odd-number-ending plates are allowed on certain days; even- ones on the others, such as Athens (Greece) and Bogotá (Colombia).

5. **"Green" the city.** Maintaining and enhancing green spaces within cities can help counteract the warming effect of the urban heat island. Plants have also been found effective at absorbing particulate matter and nitrogen oxides, which would be better for health. 'Green roof' schemes are becoming far more popular on new buildings.