Environmental Studies
FACT SHEET
www.curriculum-press.co.uk
Number 060

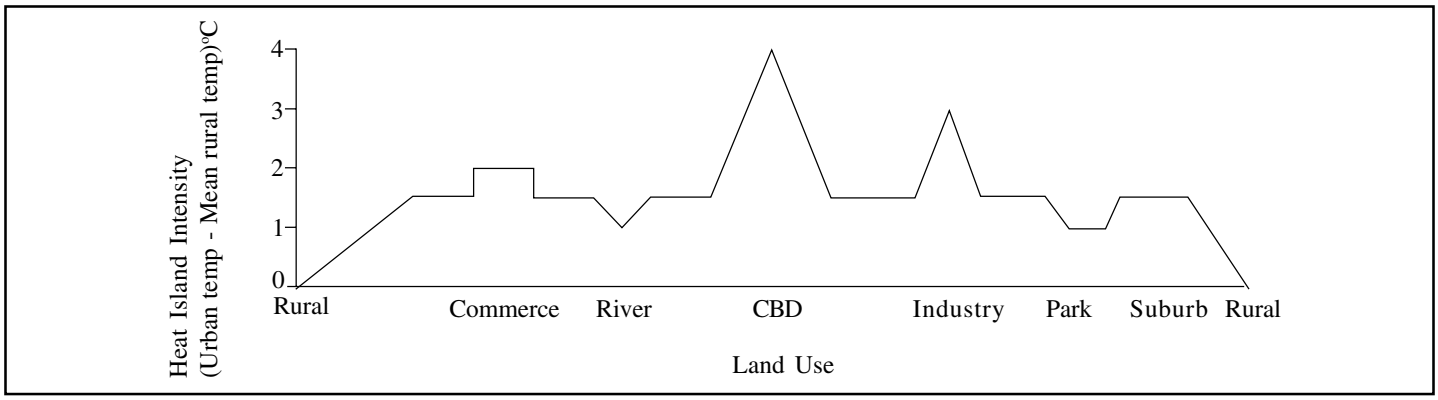
Cities and Climate

Cities have an effect on climate. This Factsheet summarises the main effects and outlines the types of question that come up in the exam.

Urban Heat Islands

Fig.1 shows how temperature varies with land use. As you can see, the temperatures over the city, especially the centre of the city (the CBD or Central Business District), is higher than in the surrounding rural areas. This is known as an **Urban Heat Island** (UHI) effect.

Fig 1. Urban Heat Island

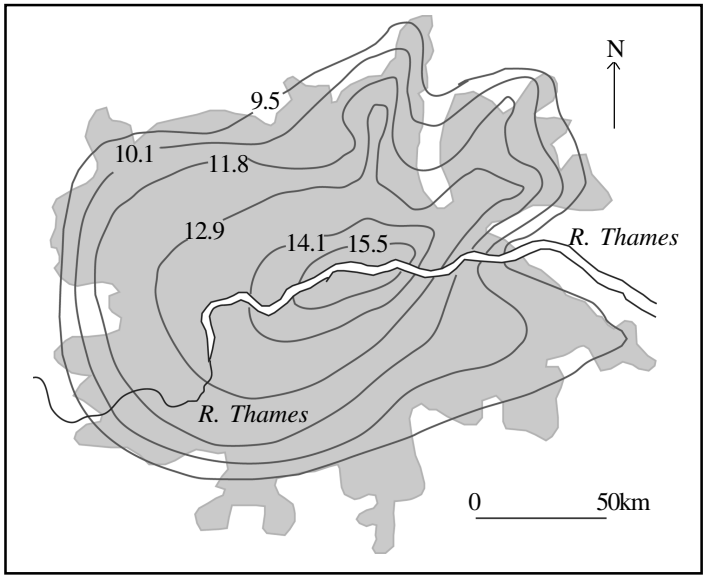


Typically, you might be asked to describe the main characteristics of the Urban Heat Island. The main characteristics include:

- Steep increase at edge of city
- Peak temperatures at areas of concentrated human activity (commerce, industry and CBD)
- Generally, the greater the building density, the greater the temperature.
- Toughs in areas of lower human activity (river, park)

Fig 2 shows the UHI effect in a different way. Look at the line labelled 12.9. All the places along this line had a temperature of 11.9°C. These lines of equal temperature are called **isotherms**.

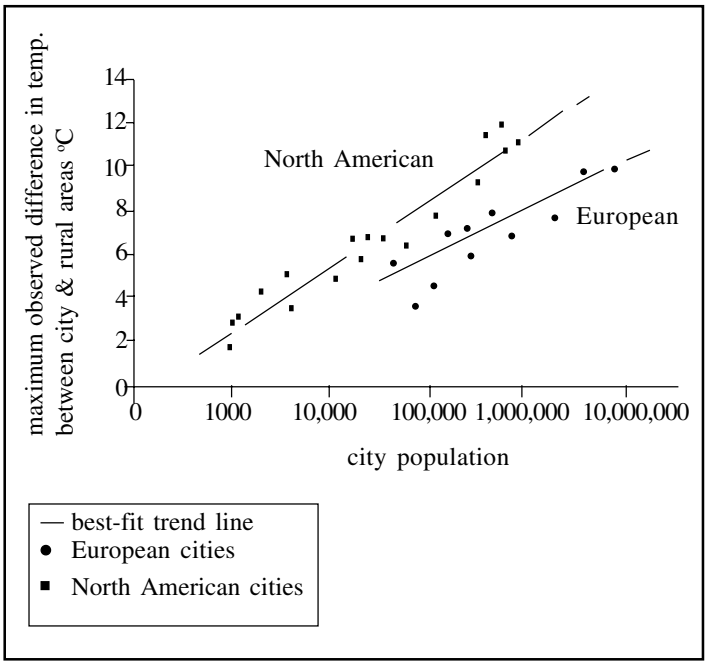
Fig 2. Urban Heat Island



Again, you can see that the highest temperatures are found in the center of the city.

So cities are warmer than the surrounding rural areas. Fig.3 shows that the temperature difference becomes greater as cities get bigger.

Fig. 3 City/rural temperature difference (°C)



The most common exam question asks you to explain why UHIs exist:

Why causes the UHI effect?

The UHI is the product of a variety of factors:

Heat given off by people,machines, space heating escaping from buildings, air-conditioners,industrial processes and cars. Multiple reflections of incoming solar radiation from tall buildings that enable absorption to take place on more than one surface.

The lower albedo of the urban surfaces enable them to absorb more of the incoming solar radiation. The higher heat capacity of the urban surface materials allow them to absorb the heat and store it. This is released when the air begins to cool at night.

The efficient drainage of the urban surface removes a lot of water. Thus there is less capacity for evaporation to take place with its concomitant cooling effect. This is coupled with the lower amounts of vegetation which cool the air by transpiration.

The dome of particulate and NO_2 pollution allows the shortwave radiation in from the sun but absorbs and reflect the outgoing longer wave radiation, slowing its escape. Particulate pollution also increases cloud cover over the urban area and this reflects outgoing radiation back to the surface. The rough urban surfaces reduce the wind speed and its ability to flush out the warm air.

The third type of question is a bit trickier. You might be asked how UHIs can affect other aspects of the urban microclimate.

Typical Exam Question

Explain how an urban heat island may affect:
(i) Wind flow
(ii) Rainfall
(iii) Intensity of sunlight

Answers

(i) Warm air rises/convection;
creates local low pressure;
draws in air from surroundings;
increases wind speed;

(ii) Ref to dew point;
more evaporation;
rising air/convection;
more condensation nuclei/dust;
direction/explanation of effect;

(iii) Reduced;
increased atmospheric albedo/reflection;
by clouds/particulates/smoke/dust/smog;
light absorption;
by clouds/particulates/smoke/dust;

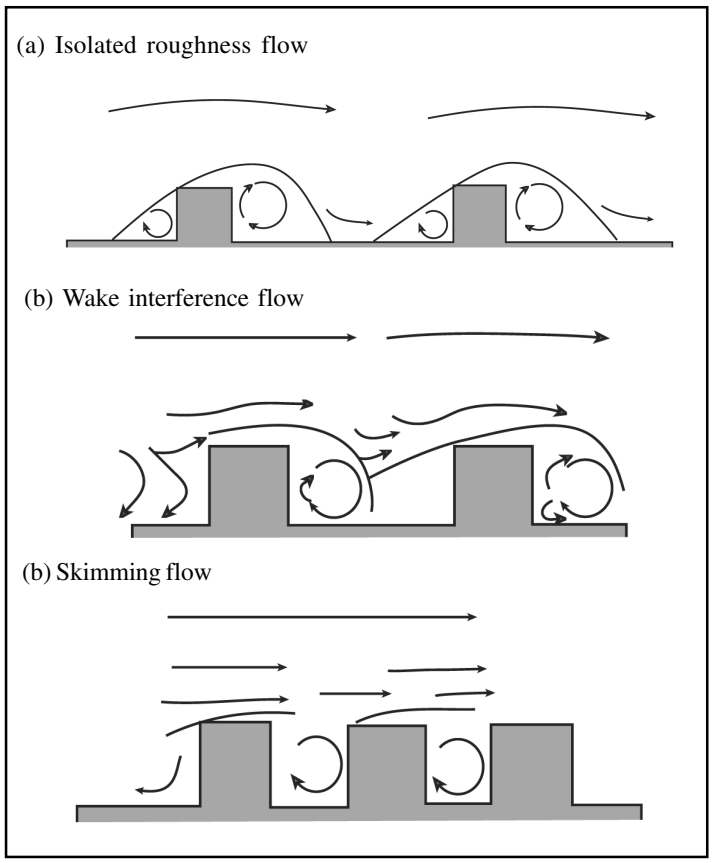
Exam Hint:-

1. *Learn all these basic facts.*
2. *Practise drawing a graph like that in Fig 1*
3. *Make sure you understand the difference between the causes of the UHI and its effects.*
4. *Revise by drawing diagrams like Fig 5.*

Cities and wind flow

Fig 4 shows three types of wind flow in urban areas.

Fig 4. Wind flow in urban areas



Where buildings are far apart, they act as isolated structures. As they get closer, one will interfere with the other. Thus in (b) there is less smooth a flow over the lee building and there isn't such a clear frontal eddy. In (c) the buildings are so close that the wind skims over the upper surface of the buildings, barely affected, but there are eddies in between the buildings caused by the low pressure present. Urban structures can both increase **and** decrease wind speeds

Buildings act as barriers to wind and create a rough surface which slows the wind down by friction. Thus the overall velocity is reduced. Gusting does occur, because the wind has further to travel around buildings than it would if it were linear flow. This shows particularly at the corners of the buildings. The channelling of wind down urban "canyons" (The Venturi Effect) increases the speed, as does the forcing of wind through small gaps between buildings. The main force of the wind hits at approximately 60% of the height. Some of that air is diverted over the building, whereas some of it is diverted downwards, creating gusting at the base of the building. In the lee of the building there is a downwards eddy that blows against the general flow of air and reduces the velocity to zero.

Urban areas reduce average wind speed by increasing the friction between the surface and the moving air. Don't confuse speed and velocity. The velocity is reduced because winds are sent into all directions by reflection and deflection. This does not necessarily reduce their speed. Not only is there increased friction, there are areas completely sheltered from the wind by deflection. This gives zero speed (calm) which can greatly reduce the average speed despite the high speed gusts.

There is an increased frequency of gusts usually as the result of either the Venturi Effect where air is forced through small gaps between buildings or channelled along streets. They are also caused by down-draughts where the upper air speed is transferred to lower levels down the side of buildings. They also occur at the corners of buildings as air rushes from the high pressure upwind side of a building to the low pressure lee.

Thunderstorms

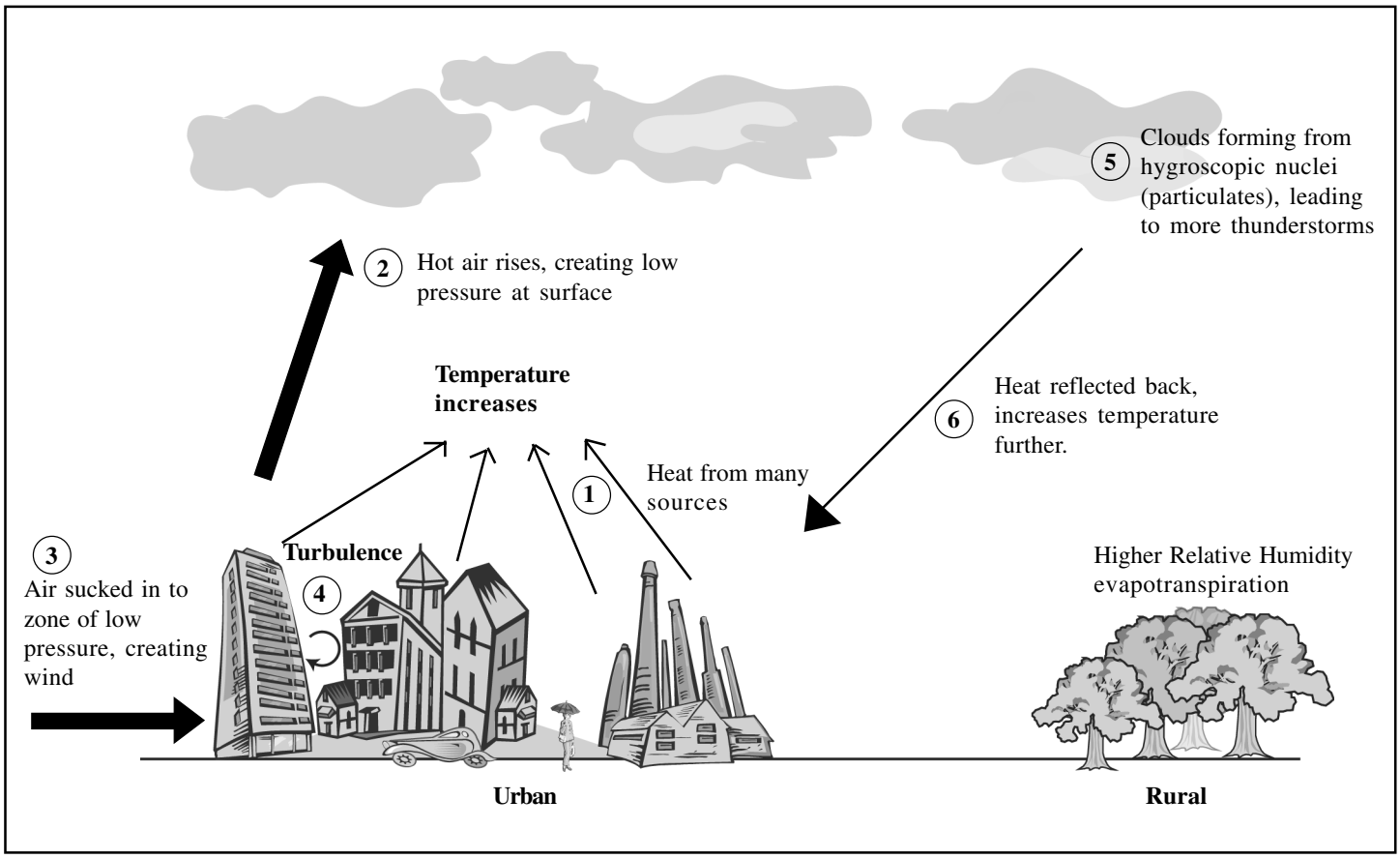
There are more thunderstorms in urban areas than in surrounding rural areas. There are 2 reasons for this:

1. The UHI creates a localised area of low pressure which draws in air from the surrounding area. As the air approaches the urban area it warms up. This warm air is then subject to convectional uplift. This uplift accelerates as the rate of cooling of the rising air is less than that of the surrounding air, making the temperature difference even greater. Large cumulonimbus clouds develop and storms occur.
2. Particulate pollution create hygroscopic nuclei, around which water droplets condense. Thus, cloud formation is accelerated in urban areas.

Fog

Although relative humidity in urban areas is usually lower than relative humidity in rural areas, fogs are more common in urban areas because of the presence of the hygroscopic nuclei

Fig 5. Urban Microclimate: Summary



Acknowledgments: This Factsheet was researched and written by Kevin Byrne.
Curriculum Press, Bank House, 105 King Street, Wellington, Shropshire, TF1 1NU

ISSN 1351-5136