Bioaccumulation and Biomagnification

What is bioaccumulation?

Pollution and bioaccumulation

The term 'pollutant' is a very wide-ranging term. When the introduction or action of something into our environment causes harm it is considered a pollutant.

This could be a harmful chemical such as smoke from a chimney, or it could be a more subtle and transient effect such as floodlights at an evening football match preventing stargazing.

There are many examples of how society has responded to pollution, such as the removal of lead in petrol which affected human health, or the banning of chlorofluorocarbons (CFCs), which damaged the ozone layer.

In both these cases, when the pollution source was removed the levels of them in the environment reduced and consequently so have the effects – albeit with a time delay.

By definition, persistent organic pollutants (POPs) do not break down, so continued introduction of even minute levels of them into an environment leads to accumulation and perhaps magnification of potential harm.

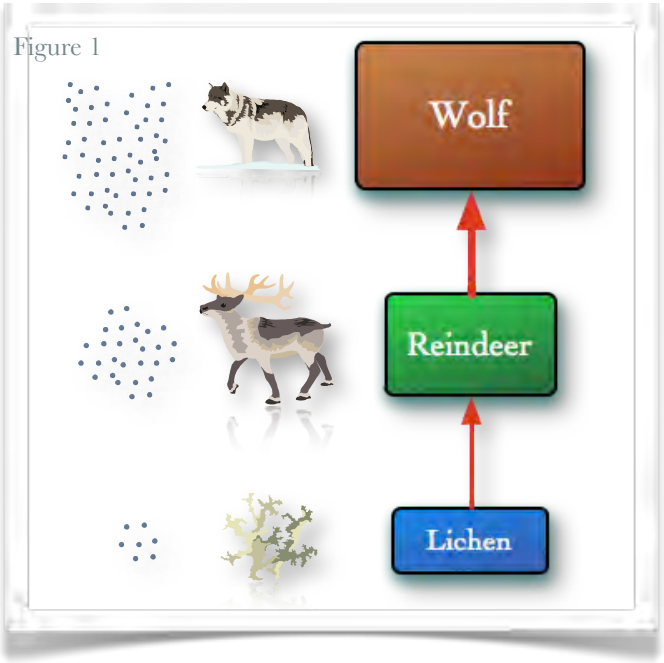
For example, at a landfill site the PBDE a (POP) level is likely to increase with time. Animals around that landfill may ingest PBDEs directly, but the level that accumulates in their tissues may be so small that it does not cause problems to any particular animal.

However, a predator such as a cat might eat dozens of rats that live around the landfill, so it would receive the combined dose that each of these rats had within it. If this dose were subsequently absorbed by the cat then the resulting accumulated level could be significantly more harmful.

This concentration of pollutants at higher levels in the food chain is called **bioaccumulation**, and the result is that higher predators can be poisoned and suffer harm while animals at lower levels in the food chain are apparently unaffected.

Bioaccumulation in the Artic

Figure 1



Canadian researchers have found small quantities of POP's in lichen in the Arctic. Thee amount of these POP's increase dramatically in concentration up the Lichen - Caribou (reindeer) - Wolf food chain. Bioaccumulation in action?

Task 1:

In your own words explain how bioaccumulation happens in the Wolf population in within the Canadian Arctic

What about other species?

Figure 2

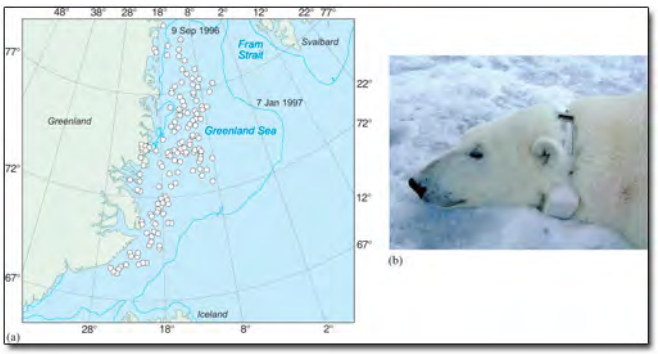


Figure 2 shows the movements of one satellite-tracked female between 1994 and 1998 (Wiig, 2003). Over four years this bear travelled more than 14 500 km, covering an area of almost 500 000 square kilometres in search of its main prey species – the seal.

Attaching a satellite tracking device to polar bears is not easy and they have to be drugged. This gives an opportunity for them to be weighed, measured, tagged, and have various samples such as hair, fat and teeth removed for later chemical analysis.

The amount of body fat on a bear indicates whether it has been eating well or is starving. But a chemical analysis of this body fat gave a surprise: polar bears have measurable amounts of a family of chemicals called polybrominated diphenyl ethers (PBDEs) in their fat a POP

The same discovery was made in Arctic ringed seals. PBDEs are a group of synthetic chemicals developed over the twentieth century as fire retardants. Fabrics and furniture are impregnated with them with the sole aim of slowing the rate at which they burn, and they have been very successful.

Figure 3: Concentration of PBDE in Polar bear and seal fat across the Arctic

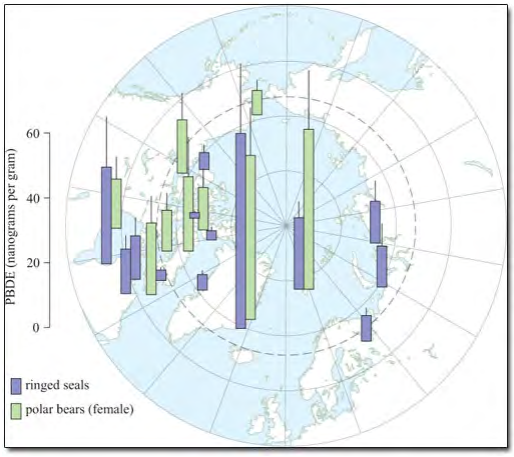
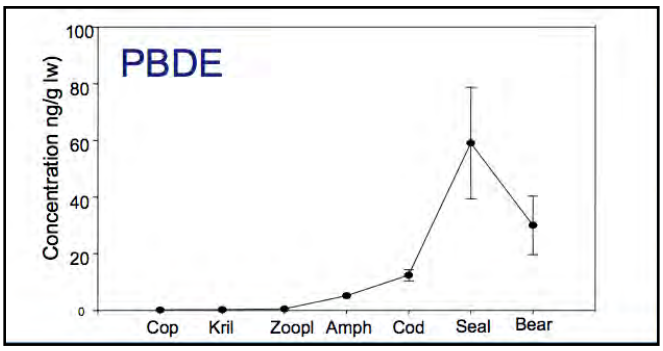


Figure 4 below illustrates the fate of PBDE's within Polar bear food chain on the island of Svalbard in the Arctic circle.

Figure 4: Concentration of PBDE in Polar bear food chain. Units = ng/g lipid weight. Cop = Copepods, Kril = Krill, Zoopl = Zooplankton, Amph = Amphipods (Sørmo et al. 2006)



Task 2.

Figure 4 helps to illustrate the concept of **biomagnification**. Use the graph to help you create your own definition for biomagnification, also estimate approximately the amount of magnification between Amphipods and Cod, Cod and Seals and Amphipods and Seals.

Task 3.

The concentration of PBDE within Polar bear fat is lower than in Seal blubber: suggest reasons why this may occur.

So how did the POP's get there?

In the early 1980s scientists began to detect POPs in the tissues of fish and shellfish close to populated areas. Concentrations were then detected in human breast milk, and the levels were shown to be increasing with time – perhaps through direct exposure to PBDEs or through bioaccumulation.

The migration of PBDEs into humans and shellfish was explained by proximity to where they were used. While it is relatively simple to see how PBDEs can get into subjects close to their source, it is not so clear how they end up in polar bears and ringed seals in the Arctic.

Task 4.

Brainstorm some possible ways in which PBDE's may have entered the Arctic food chain.

Figure 5: Winds, ocean currents and river flows in Temperate and Arctic regions

Task 5.

Examine the map shown in Figure 5. PBDE's are manufactured and used mainly in populated areas, using evidence from the map evaluate your previous brain storm and draw some conclusions about how PBCE's could end up in the Polar bear food chain.

The evidence

Winds, ocean currents and flow from rivers can all carry pollutants from their source to the Arctic. On a stereographic plot, the routes of wind-borne contaminants from the warmer, populated areas of Earth to the cooler, Arctic are clear (Figure 5). These winds can transport contaminants to the poles, where they are removed from the atmosphere most likely through snowfall and are then absorbed by animals, perhaps through direct contact. The North Atlantic Current shown in Figure 7 flows directly past the waters off western Europe, likely to be a major source of PBDEs. For top predators such as polar bears, there is also likely to be bioaccumulation from the high levels of PBDEs in their prey, the seals.

Task 6.

Using all of the information and ideas write a short paragraph explaining the difference between bioaccumulation and biomagnification.

References

Text adapted from; Environment: Following the flows. Open University, 2010. http://openlearn.open.ac.uk/mod/oucontent/view.php?id=397988&direct=1

Plus:

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Wiig, O., Born, E. W. and Pederson, L. T. (2003) 'Movements of female polar bears (Ursus maritimus) in the East Greenland pack ice', Polar Biology, vol. 26, no. 8, pp. 509–16.