IMPACTS OF CLIMATE CHANGE ON WATER POLLUTION

Dave Sheahan

Centre for Environment, Fisheries and Aquaculture Science (Cefas), Pakefield, Lowestoft

Executive Summary

Climate change scenarios (Defra, 2002) indicate annual average temperature increases of 2 and 3.5°C by the 2080s; wetter winters (winter daily precipitation up to 20% heavier), and drier summers with the largest relative changes in the south and east where summer precipitation may decline by up to 50%. Sea levels are also expected to rise around the UK – between 26 and 86 cm by 2080s.

Changing climate has implications for land use and the fate and behaviour of anthropogenic and natural chemicals particularly with respect to their interaction with the hydrological cycle. Climate change may influence mobilisation and fate of chemicals applied to land, increasing discharge to surface and groundwater. Discharge volumes of storm water containing various contaminants may also increase. The bioavailability of sediment-associated contaminants present in the aquatic environment may also be changed by increases in temperature, changes in salinity regimes and increased storm events.

Until the 1970s the major biological impact on estuarine and coastal areas was probably the discharge of poorly treated sewage (Matthiesen & Law, 2002). Improved sewage effluent treatment has lead to a greater focus on chemical contaminants with specific modes of action and which often have subtle and chronic effects. These include products that remain active in treated sewage effluent discharges e.g. steroidal chemicals, pharmaceuticals and personal care products, chemicals present in surface runoff from agricultural land e.g. pesticides and nutrients, and contaminants arising from diffuse sources in surface runoff and storm overflows. With the increased development of ports and coastal areas handling of historically contaminated sediments is also an issue of increasing concern and its redistribution in the environment will be influenced by storm events.

Higher temperatures may make biodegradation of chemicals more rapid in water and contribute to reduction in toxic effects, but for many chemicals toxicity will increase with temperature as the rate at which a chemical is accumulated by an aquatic organism via food and respiratory or other body surfaces also increases.

Changes to rainfall patterns may result in changes to the movement and distribution of chemicals e.g. increased leaching of pesticides applied to agricultural land during certain periods of the year. Increased storm events during the winter will increase storm water flows in rivers and potentially

inputs of untreated sewage effluent. Decreased river flows in the summer particularly in the South of England will result in higher relative contributions of treated sewage effluent. The biological oxygen demand will increase because of the increase in organic matter from treated sewage as well as any rise in temperature, which will increase bacterial respiration. Heavy storm events during summer periods are likely to result in flushing of untreated sewage effluent and diffuse pollutants from surface runoff in storm overflows.

Increased risk of flooding because of climate change has implications for the inundation of land that is contaminated. There may therefore be a greater risk of contaminants being remobilised in floodwater and of contaminated sediment and water reaching the freshwater and marine environment. Estimates indicate that there may be 100,000 sites affected by contamination in England and Wales with 5-20% requiring action to reduce risk of harm to people and the environment (EA, 2003). Contamination may arise through historic or recent industrial activity or due to natural processes. Just under half of the sites formally determined as contaminated thus far present a risk to controlled waters. The location of coastal industries e.g. power generation will need to take account of the increased risk of flooding in some coastal areas.

The use and fate in the marine environment of specific chemicals may also be influenced by climate change because of changes in farming practice (e.g. increased use of some pesticides) and consumer choice (e.g. increased use of UV sunscreens and fate and effects in the aquatic environment (Buser *et al*., 2006))

Level of Confidence

Much monitoring effort has focussed on selected chemicals identified as of priority concern (e.g. metals such as mercury and organics such as hexachlorocyclohexane). In many cases, the concentration of these chemicals has declined with the introduction of tighter discharge consents and the improvement of sewage effluent treatment. With a few exceptions (e.g. in relation to sewage sludge disposal sites (Rees *et al.* 2006), Tributyltin (Rees et al. 2001) and steroidal chemicals), where contaminant-related biological effects are well characterised, changes in chemical concentrations have not been linked to changes in biological effects. Links between chemical concentrations, biological effects and climate change factors are not yet developed in the literature and where time series datasets do exist confidence in showing these links is low.

Key sources of Information

See supporting evidence

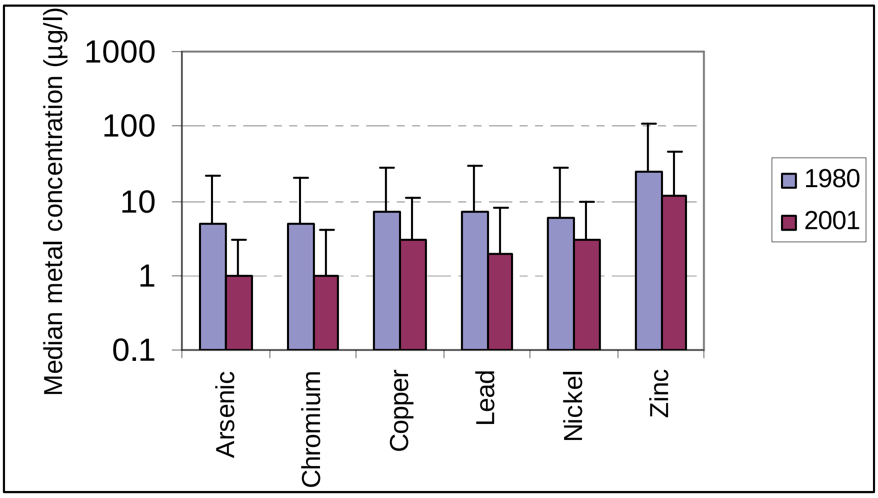
Supporting Evidence

Datasets for contaminants that are of relevance for investigation of climate change influence upon contaminant fate and effects in the marine environment relate to discharges to rivers and estuaries that will ultimately reach the sea and to monitoring data for coastal and offshore sites.

The Environment Agency manages a pollution inventory (established in 1998) to collect information on chemical and radioactive substances from industrial sites in England and Wales. This inventory covers the main emissions to controlled waters (river, estuary, sea) and sewer for different industry sectors. A similar pollutant release inventory has recently been made available by the Scottish Environmental Protection Agency. Data from these sources enables load calculations to be made and trends over time to be compared.

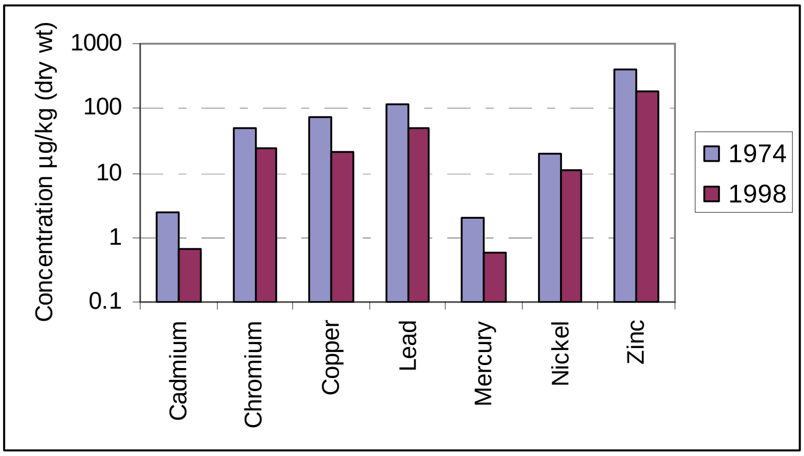
Figure 1 shows the change in concentration of a range of trace metals measured in UK surface waters at over 200 sites in England and Wales between 1980 and 2001. In each case, there is a decrease in dissolved metal concentration over this period. Figure 2 shows a similar decreasing trend in the concentration of some of the same trace metals in sediments of the River Mersey. The decrease shown in both cases is largely related to the control of various point sources such as industrial and sewage treatment works effluent discharges.

Figure 1 Median site mean trace metal concentrations and upper 90th percentile for six trace metals measured at over 200 surface water sites in the England and Wales in 1980 and 2001 (EA, 2000)



Various Departments and Agencies in the UK also contribute to monitoring programmes for the marine environment. Data on contaminants and biological effects from these programmes is integrated to provide an overview of the quality of the marine environment via the UK National Marine Monitoring Programme (NMMP). The NMMP ensures co-ordinated quality status monitoring between the UK Government Departments and agencies with environmental responsibilities. Phase one of the NMMP was carried out in 1993-95 and 1996-1998 by a spatial survey at monitoring stations in estuarine, intermediate and offshore locations. This included the National Coastal Baseline Survey operated by the EA and its forerunner, the National Rivers Authority (NRA). Phase two of the programme (NMMP2) was started in 1999, concentrating on temporal trend monitoring and also introducing new biological effects studies. Based on over 100 locations, the programme monitors contaminants (trace metals, organic compounds) in water, sediment and biota (shellfish and fish); biological effects (health status of organisms); nutrients in water; and temperature and salinity. A full description is given at http://www.defra.gov.uk/environment/water/marine/uk/science/monitoring.htm

Figure 2 Mean sediment trace metal concentration* measured in the River Mersey in 1974 and 1998 (Harland *et al.*, 2000)



* trace metal concentration is normalised to 40% silt content

In terms of historical contamination in the marine environment data derive from surveys of UK estuaries and ports (Table 1. and 2). PAH concentrations measured in a number of English estuaries shows high concentrations of PAHs at some sites.

Table 1 PAH concentrations µg/kg dry weight in sediment samples from English estuaries collected between 1993 and 1996 (Jones and Franklin, 1998)

Location	Individual PAH range	Total PAH range
River Tyne	<17-2417	236-10790
River Wear	7-2264	753-12252
River Tees	3-1973	581-7817
River Humber	8-981	545-2972
River Thames	13-1071	597-5350
Blackwater	89-1542	4011-8463
River Exe	n/d-876	n/d-4654
River Tamar	<30-1102	6025-6194
River Mersey	<5-1242	6-5236

Sediment metal concentration is also likely to be high in areas that are subject to dredging. The highest concentrations were measured at sites associated with industrial activity with the exception of some parts of Cornwall for which natural high background concentrations of arsenic are present.

Table 2 Mean metal concentration range measured in dredged material (mg/kg wet weight) sampled from English estuaries, 1995-1997. The number of samples exceeding OSPAR guidelines is also shown. Based on Cefas data (Jones and Franklin, 2000)

Metals sampled	Mean concentration Range	Number of sites exceeding OSPAR guidelines
Arsenic	3.94-44.00	6>50
Cadmium	0.01-3.43	29>2.5
Chromium	4.46-400.75	12>200
Copper	4.70-314.07	29>200
Mercury	0.01-2.44	24>1.5
Nickel	0.90-28.64	1>100
Lead	4.30-224.67	21>250
Zinc	14.00-450.33	31>400

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