Water Research Foundation & Sponsors

Authors: Rob Wilby & Kathy Miller

Date: 30 April 2009

Technical Briefing Paper (9): Water Quality Impacts and Utility Responses

Synopsis To date, the scientific community has devoted much less attention to water quality impacts than to water scarcity and resource management. However, climate variability and change directly and indirectly affect freshwater quality and thereby potable water supply and environmental quality. Faced with large uncertainty about regional climate change projections as well as the effectiveness of measures, the costs of measures, and apportionment of water quality problem(s) between sectors, adaptation options that can perform well under a wide range of conditions should be favored. These deliver water quality benefits regardless of the realized climate. Integrated river basin management provides a framework for harmonizing cross-sectoral responses to climate change.

Explanation Some water quality impacts may be directly related to climate drivers. For example, intense precipitation events may mobilize sediment and contaminants, while lower summer river flows imply increased concentrations of conservative pollutants downstream of point discharges. Increasing water temperatures and sunlight may favor algae growth including those that can release toxic compounds. Indirect water quality impacts may arise from climate mitigation and/or adaptation responses. For example, there may be benefits to water quality due to reductions of greenhouse gas emissions (such as smaller areas receiving nitrogen deposition above critical loads). Alternatively, changes in growing season or crop type could affect exports of diffuse nutrients from agricultural soils.

Direct climate driver	**Direct climate impacts**
Rising sea levels and surges	Upstream migration of saline water in estuaries and its intrusion into groundwater; consequential changes to freshwater ecology; interruption of abstracted water supplies; damage to sewers and inundation of waste water treatment works
Higher air temperatures	Increased mineralization of nitrogen in soils; improved performance of waste water treatment works
Higher water temperatures and sunlight	Increased rates of chemical and biological processes; enhanced algal growth and toxic blooms; lower dissolved oxygen (DO) concentrations; increased costs of raw water treatment; loss or northward migration of iconic freshwater species; faster die-off of bacteria; enhanced decay of nitrate in rivers and estuaries
Drier summers and droughts	Higher proportions of effluent in receiving water courses downstream of point discharges; an increased risk enhanced algal growth including those which may be toxic; increased frequency of fish kills; nitrate flushing at drought termination
Increased rainfall intensity	More frequent overloading of urban drainage systems and foul water flooding; increased mobility of microbiological pathogens, sediments and allied contaminants at times of high flow; increased nitrate, carbon and pesticide leaching from soils; hypoxia (low oxygen) episodes in coastal and estuarine waters; more acidic pulses in headwaters
Increased storm intensity and frequency	Increased mixing of lake water column; changes in the timing and assemblage of algal blooms; increased costs of water treatment to address taste and odour problems; increased occurrence of acidifying chloride (sea salt) deposition in uplands
Indirect climate driver	**Indirect climate impacts**
Reduced nitrogen emissions to air	Smaller area of acidic deposition and area of ecosystems adversely affected by excessive nitrogen (eutrophication)
Increased bio-fuel production	Increased groundwater acidification caused by enhanced acid deposition to forestry and removal of soil cations during harvesting
Increased water supply and storage	Higher concentrations of conservative pollutants due to water re-use; river regulation and inter-basin transfers change thermal and chemical composition of downstream waters
Longer growing seasons	Changing cropping patterns, agricultural pesticide and fertilizer use; changes in soil tillage; diffuse runoff quality; water demand for irrigation
Changing fire management regime	Controlled burns in headwaters; contamination of groundwater resources; increased export of organic carbon, sediments and toxics
Measures to reduce flood risk	Improved urban water quality due to upgrading of sewerage systems to cope with higher rainfall intensity; increased saline intrusion due to managed retreat of coastal defences

Application Climate change could undermine investments intended to improve freshwater quality. Therefore, measures are needed that deliver intended benefits in a cost-effective way now, and for the future. This means favoring actions that are robust to climate variability (in the near-term) and to climate variability and change (over future decades). Furthermore, actions should be compatible with the wider objectives of carbon accounting and cross-sectoral integration. This means maximizing opportunities for co-delivery of water quality objectives and adaptation through liaison with a broad constituency of stakeholders. Accordingly, the European Commission is developing guidance for river basin management in a changing climate, including the following principles:

- Recognize that climate variability and change are among many factors affecting water bodies so concurrent meteorological, environmental and biological ***monitoring*** are needed to better interpret long-term changes in water quality and ecological status.
- Apply an integrated approach to ***risk assessment*** of pressures arising from the direct impacts of climate change, as well as from autonomous and/or anticipatory measures taken by others to manage non-climatic pressures, mitigate and/or adapt to climate change.
- Favor adaptation ***options that are resilient*** to a wide range of possible climate change because there is a limit to the extent to which investment decisions can be led by highly uncertain regional climate projections.
- Maximize opportunities for ***shared delivery*** of adaptation measures through planning liaison with other groups, stakeholder consultation, and regional spatial strategies.
- Develop ***communication strategies*** to convey the need for action, to improve conditions for sharing experiences at all levels of a business (including external liaison), and showcase integrated adaptation using demonstration field projects and pilot schemes.

Case Study Low-regret, integrated adaptation measures

Climate resilient measures can often be identified without even considering a regional projection. A zero order test is to simply evaluate the measures' performance using the longest available record of past climate variability. Examples of low regret options for water quality management include promoting good practice in soil management, installing buffer strips alongside water corridors, preventing cattle from gaining access to river margins, and controlling runoff from farm buildings. Such measures will yield some benefit regardless of the climate outcome.

However, where climate model projections are available these can be used to bracket the range of values used in sensitivity tests, and hence reveal the amount of climate change needed to exceed design standards for urban drainage systems, nutrient uptake by a reed bed, and so on. Extreme climate scenarios can also be used to compare the performance of alternative measures (Figure 1).

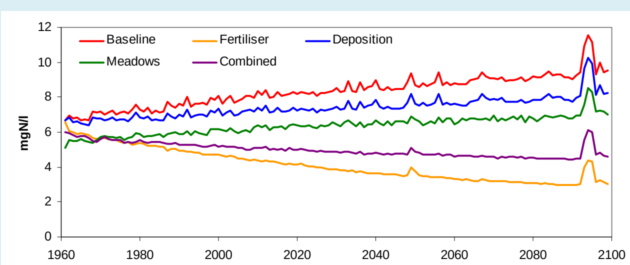

Figure 1 Projected changes in nitrate concentrations in the River Kennet, UK under projected increases in winter flooding and summer drought. The baseline (red line) assumes no adaptation. The other lines show the outcome of different measures: reduced fertilizer application (yellow); water meadow creation (green); more stringent air quality standards (blue); and a lower-level combination of the previous three measures (purple). Reduced fertilizer loads and the combination scenario yield improved river water quality despite adverse change in the climate regime.

Supporting materials and links

Bates, B.C., Kundzewicz, Z.W. Wu, S. and Palutikof, J.P. (Eds.) 2008: *Climate Change and Water*. Technical Paper VI of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 210 pp

Whitehead, P.G., Wilby, R.L., Battarbee, R., Kernan, M. and Wade, A. 2009. A review of the potential impacts of climate change on surface water quality. *Hydrological Sciences Journal*, in press.

Whitehead, P.G., Wilby, R.L., Butterfield, D., and Wade, A.J. 2006. Impacts of climate change on nitrogen in a lowland chalk stream: An appraisal of adaptation strategies. *Science of the Total Environment*, **365**, 260-273.

Wilby, R.L. 2009. *River basin management in a changing climate: Guiding principles to assist adaptation*. Report prepared on behalf of the Environment Agency of England and Wales, Bristol, UK, 19pp.