

Anniversary article

Environmental chemistry: a twenty year perspective

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As part of the ECG *Bulletin's* twentieth anniversary edition, committee members reflect on the past and present of soil, air, and water quality management in the UK.

Introduction

During the 20th and 21st centuries, society became a function of capitalist ideologies. As a consequence of this, consumerism is now a dominant and ubiquitous paradigm. If this is true, and since there is no altruism or aesthetic in capitalism, damage to the environment only becomes relevant when it impinges on profit. In my view this can occur in two ways, either as a collateral effect of the profit motive when a damaging action reduces profitability (e.g. when a commodity such as water or oil becomes so scarce/expensive that consumption is reduced) or when government is provoked (e.g. by popular action) to introduce legislation. In relation to the latter, it is noteworthy that in capitalist societies, many aspects of environmental legislation are justified economically, most often based on human health arguments constructed around the costs to the state of reduced economic activity and/or costs to national health systems. Legislation outside of these two categories is hard-won.

Arguments about the value, aesthetics, and long-term significance of the environment that cannot be couched in terms of economic value (profit) rarely attract the genuine commitment of governments. Without effective legislation by government, the preservation of the environment becomes a romantic and futile notion. In other words, legislation is currently the only tool at humanity's disposal that offers a route by which the complexity and wonder of the natural world can be preserved; the introduction and implementation of environmental legislation is vital.

I hope this personal view of the world we live in will suffice to introduce three brief surveys of the state-of-play of environmental legislation with regard to land, air and water in the UK and EC; readers may draw their own conclusions about its effectiveness and whether it will suffice.

Leo Salter

Contaminated land management

In the UK, throughout late industrial and post-industrial society, legislation began to reflect the need to protect human health and the environment from pollution leading to a landmark regulation with the 1990 Environmental Protection Act (EPA). New policy initiatives and various pieces of specific legislation were introduced following enactment of the EPA.

Prior to the EPA, and with respect to soils and contaminated land, the Inter-Departmental Committee for the Development of Contaminated Land (ICRCL, formed in 1976) provided various Guidance Notes on land contamination. These included (a) advice to Local Authorities against development on landfill sites, (b) guidance on asbestos (1990) (c) trigger and intervention values for soil contaminants (1987) (to compare with site concentrations) as part of an emerging, risk-based assessment practice that had developed over the previous twenty years.



Following explosions in buildings on sites during the 1980s, where ground gas accumulation was identified as the source, technical guidance was introduced. Establishing ground gas conditions over the past twenty years has become a common feature of land redevelopment.

Today in the UK, land contaminated with pollutants is dealt with by two main approaches:

1. Part II(a) of the 1990 EPA (as amended) addresses contamination present on existing land uses; and
2. The Local Authority Planning System, which addresses contamination *via* land redevelopment.

Part 2A of the 1990 EPA (as amended) was introduced under Section 57 of the Environment Act 1995, and in this, the statutory definition of contaminated land is "*any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of*

substances in, on or under the land, that—

(a) significant harm is being caused or there is a significant possibility of such harm being caused; or

(b) significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused”.

Through the 1990s, the common approach to assessing the human health risks from land contamination involved a simplistic approach of testing soil for ICRL listed contaminants and comparing soil concentrations with ICRL trigger values (1987). Some practitioners also derived in-house values or adopted international values such as Dutch- or USA-derived assessment criteria, but these values were not necessarily directly applicable in the UK. The ICRL trigger values (1987) were withdrawn in 2002 when the Environment Agency (EA) began the publication of Soil Guideline Values (SGVs). These are a key tool for generic assessment of health risks from land contamination. SGVs were derived using an exposure model called CLEA. SGVs now form part of a more comprehensive risk assessment framework, along with largely industry derived assessment criteria (published since 2002) for soil contaminants. Although significant progress has been made in contaminated land risk assessment since the withdrawal of ICRL trigger values, with the low number of SGVs produced and a current lull in the EA backed SGV programme, practitioners are reliant on generating their own assessment criteria and/or purchasing values derived by other organisations. The maintenance of a generally accepted risk assessment dataset for deriving generic assessment criteria is also a problem. Toxicity data and physiochemical and exposure parameters can be revised over time, and these changes will affect generic health risk assessments of land contamination.

Criteria used to assess surface water and groundwater contaminants are usually adopted from drinking water standards or Environmental Quality Standards for inland and coastal waters. Although many contaminants found in groundwater and surface water have an appropriate water quality standard, this dataset could be enlarged. Many common contaminants, e.g. total petroleum hydrocarbons, do not have a UK standard.

Today, the contaminated land risk assessment framework, which has developed over several decades,

helps to protect human health and the environment from soil and groundwater contamination. There is scope for improvement, but it can be argued that practitioners today conduct a far more comprehensive risk assessment of soil and groundwater contamination than twenty years ago.

James Lymer

Air quality management

1995 was a pivotal year for air quality management in the UK, marking a transition from source-based to effects-based standards for managing ambient air quality. Part IV of the Environment Act 1995 set out the new legislative requirements for the Secretary of State, the Environment Agency and local authorities in relation to Local Air Quality Management (LAQM). Shortly after, the first National Air Quality Strategy (NAQS), published in March 1997, established health-based standards for eight air pollutants [benzene, 1,3-butadiene, carbon monoxide, lead, nitrogen dioxide, ozone, PM₁₀ (particulate matter with an aerodynamic diameter of 10 µm or less) and sulphur dioxide] based on advice from the Expert Panel on Air Quality Standards (EPAQS). These standards mirrored and were amended by EU air quality legislation in the form of Council Directive 96/62/EC and its subsequent daughter directives, later consolidated into Directive 2008/50/EC, to which Member States were required to adhere.

Whereas industry and agriculture still make a significant contribution to local air pollution in continental Europe, in the UK the main source is road traffic. Over the past twenty years, the greatest emissions reductions have been

for lead, sulphur dioxide and benzene, achieved through fuel quality standards imposed by the EU, which resulted in these pollutants being virtually eliminated from vehicle emissions by 2001. Possibly the most important factor in reductions of nitrogen dioxide and PM₁₀ has been the adoption of European vehicle emission standards (Euro standards). Between 1990 and 2011, UK NO_x emissions reportedly fell by 64%, largely as a result of new fuel and engine technologies. However, recent evidence suggests that those NO_x estimates may have been overstated by as much as 25%. In the past ten years, actual NO_x and primary NO₂ emissions from Euro standard vehicle classes have not fallen by as much as test-track trials predicted. In addition, the greatest



Air pollution. Credit : Cornfield/Shutterstock

decreases in nitrogen dioxide expected with the latter Euro standards have been confounded by an increase in the proportion of primary NO₂ from diesel vehicles, effectively caused by the implementation of these technologies and by the climate change policy tax incentives that have ultimately led to the large growth in diesel vehicles in the UK.

At the same time, epidemiological studies have begun to reveal the breadth and severity of the health impacts of air pollution beyond previously recognised respiratory and cardiovascular effects. In October 2013, the World Health Organization's (WHO) International Agency for Research on Cancer (IARC) Working Group unanimously classified outdoor air pollution as carcinogenic to humans, and in 2014, a large scale cohort study in Europe (ESCAPE) identified a broad range of air pollution health effects. It has been estimated that in the UK, anthropogenic air pollution accounts for nearly 29,000 deaths annually (range 4,700 to 51,000 deaths) and may reduce birth-cohort life expectancy by an average of 1 to 12 months, presenting a greater mortality burden than passive smoking or road traffic accidents. These estimates are based on long-term exposure to fine particles (particulate matter with aerodynamic diameter below 2.5 µm, PM_{2.5}) and therefore likely underestimate the cumulative impact of other pollutants (including NO₂) and of short-term acute exposure. While PM_{2.5} is regulated for Member States under Directive 2008/50/EC, it is not currently a requirement for UK local authorities under LAQM.

Although most regulatory goals for pollutants regulated under national and EU legislation have been achieved in the UK over the last twenty years, the health-based standards set for NO₂ are still widely exceeded in the UK, leading the European Commission to launch legal proceedings against the UK Government, on 20th February 2014, for "its failure to cut excessive levels of nitrogen dioxide". With the immediate 'low hanging fruit' of technological solutions already picked and rotted, in order to improve air quality and avoid EC fines, the UK government must now face some politically unpalatable alternatives, including reducing road traffic dependence as part of a more holistic, sustainable approach to air quality management.



Water pollution. Credit: Armograph/Shutterstock

Water quality management

In the UK and worldwide, the field of water science has seen substantial changes over the past *ca.* twenty years. These changes are largely due to increasing awareness of water pollution and demands for water protection. This section will focus on three aspects related to the field of water environmental chemistry that have resulted in some of the biggest changes in the field: legislation, water monitoring methodology, and emerging contaminants.

In the past twenty years or so, changes to water regulations within the UK have been largely driven by EU legislation. These include the adoption of the Urban Waste Water Treatment Directive (1991), the Nitrates Directive (1991), the Directive for Integrated Pollution and Prevention Control (IPPC) (1996), the Drinking Water Directive (1998), the Groundwater Directive (2006), and the Marine Strategy Framework Directive (2008).

However, it is without doubt that the main influence in European water policy has been the introduction of the Water Framework Directive (WFD) in October 2000 and its transposition into UK national law through a series of regulations in 2003. The WFD encompasses most of the directives mentioned above. Unlike traditional limit value approaches to water pollution, the WFD does not set specific environmental quality standards and target limits. Rather, the directive focuses on means of achieving a 'good status' for all water bodies in terms of ecological and chemical considerations, without specifying target values. Additionally, it introduced the concept of water body management on the basis of river basins, some of which pass through several administrative and political borders.

The field of water monitoring has been driven not only by the implementation of these regulations, but also by substantial technological improvements in water sampling and analysis. Water sampling has seen a shift toward production control and pollution prevention through trend monitoring (as per the IPPC directive) and away from reactionary sampling following a pollution event or other cause for concern. An additional key shift has been toward automated sampling and online monitoring of water bodies, arising from

advances in such varied fields as microfluidics, electronics miniaturisation and wireless technologies. In addition to these technological advances, in recent years, the field of water monitoring has also seen some interesting shifts away from technological advances and into citizen science initiatives; for example, the OPAL water survey asks recreational anglers to report whether they have seen a specific type of fish.

There has also been an increasing focus on 'emerging contaminants', such as persistent organic pollutants (POPs), which were not on the agenda twenty years ago. This is evidenced, for example, by the adoption of the Stockholm Convention on POPs in 2001 (with implementation in the UK initiated in 2007) and the UK Water Industry Research (UKWIR) Chemicals Investigation Programme in 2009; the latter investigates trace contaminant concentrations in UK wastewater treatment works effluents and is now in its second phase. In addition to regulatory requirements, advances in mass spectrometric techniques, particularly tandem mass spectrometric and high resolution techniques, have undoubtedly been one of the main factors that have allowed this shift to occur.

Cecilia Fenech and Ian Forber

Further reading

Introduction

Some of these issues are discussed in a compendium of brief comment articles in *Nature*, **515**, 27-31 (2014) and pp. 32-33 (*ibid*) (E. B. Barber, *Account for the depreciation of natural capital*). For evocative descriptions of the same phenomena, I suggest *Wolf Totem* by Jiang Rong (translated by Howard Goldblatt, Penguin Press, 2008). *Engineers of the Soul* by Frank Westerman (translated by Sam Garrett, Vintage Books, 2010) discusses the impact of canal building in the 1950s on Turkmenistan and Kazakhstan. I also recommend *Rowing the Eternal Sea: the story of a Minamata fisherman* by Oiwa Keibo (narrated by Ogata Masato and translated by Karen Colligan-Taylor, Rowman and Littlefield Inc, 2001).

Contaminated land

An overview of regulations regarding contaminated Land may be found at www.york.gov.uk/info/200364/contaminated_land/490/contaminated_land. Technical guidance is available at www.gov.uk/government/collections/land-contamination-technical-guidance. For information on the USA perspective see www.epa.gov/superfund/about.htm.

For information on the Australian perspective see www.public.health.wa.gov.au/3/1144/2/contaminated_sites.pm. The book *Assessment and Reclamation of Contaminated Land* (edited by R. M. Harrison, R. E. Hester and published by the RSC in 2001) covers topics from the origins and extent of contaminated land problems, including effects on human health, through investigative measures, to specific techniques of remediation.

Air quality

Barnes, J. (2014) A critical evaluation of local air quality management and its contribution to meeting the EU annual mean nitrogen dioxide limit value. PhD, University of the West of England.

R. Beelen *et al.*, Effects of long-term exposure to air pollution on natural-cause mortality: an analysis of 22 European cohorts within the multicentre ESCAPE project. *Lancet*, **383**, 785 (2013).

S. D. Beevers, E. Westmoreland, M. C. de Jong, M. L. Williams, D. C. Carslaw, D.C. (2012) Trends in NO_x and NO₂ emissions from road traffic in Great Britain, *Atmospheric Environment*, **54**, 107 (2012).

COMEAP (2010) The Mortality Effects of Long-Term Exposure to Particulate Air Pollution in the United Kingdom. Health Protection Agency. Environment Act 1995. Chapter 25. (1995) London: The Stationery Office.

J. W. S. Longhurst, J. G. Irwin, T. J. Chatterton, E. T. Hayes, N. S. Leksono, J. K. Symons, The development of effects-based air quality management regimes, *Atmospheric Environment*, **43**, 64 (2009).

Water quality

Water Framework Directive Interactive Maps for Europe: <http://www.eea.europa.eu/themes/water/interactive/by-category/wfd>

Rapid Measurement Tools: ESKTN Business Case, <https://connect.innovateuk.org/documents/2832130/6075062/Rapid+Measurement+Tools.pdf/e0646f10-ef12-42eb-9477-8eae26341665>

European waters – current status and future challenges – a synthesis, EEA Report No 9/2012, <http://www.eea.europa.eu/publications/european-waters-synthesis-2012>