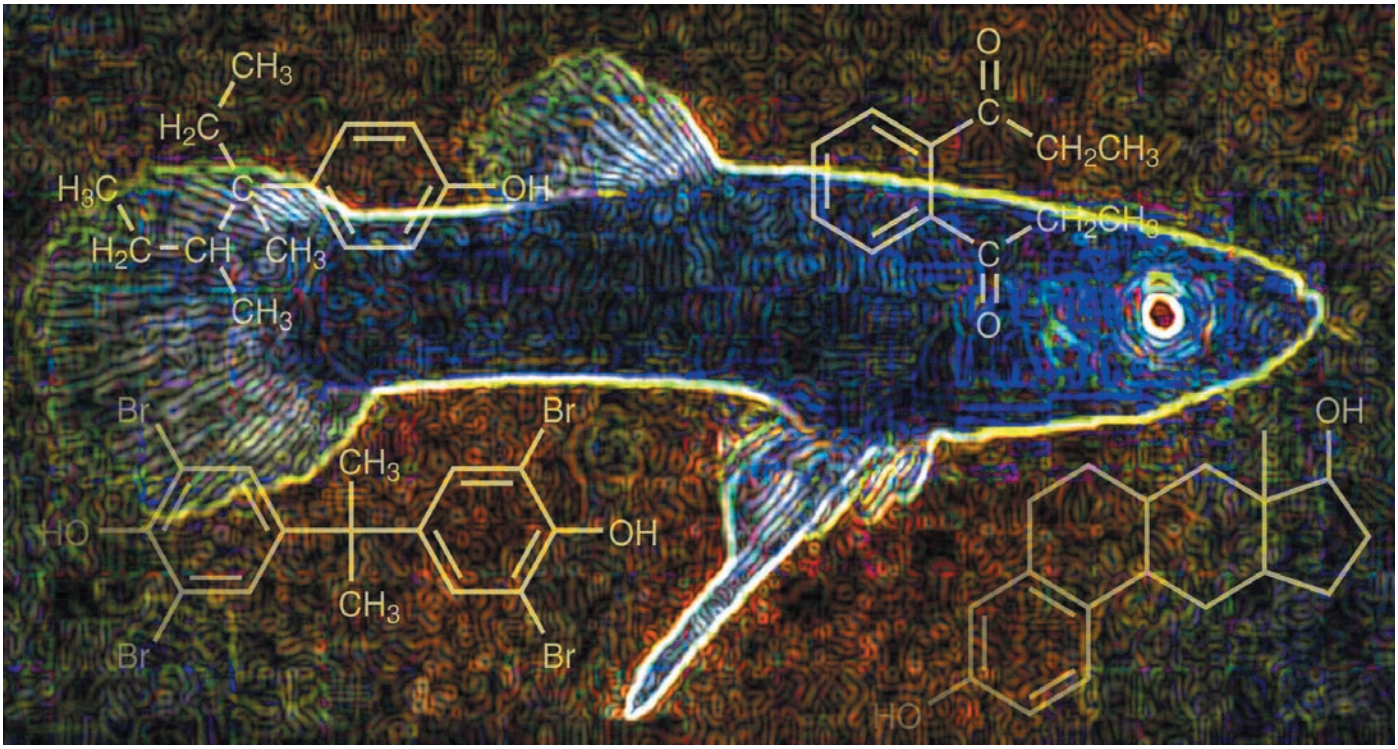


Dr Richard Lim and others have found some evidence of EDC effects from the use of recycled sewage effluent for irrigation. Mosquitofish living downstream from sewage treatment plants had shorter anal fins, and their sex drive was also reduced compared to males living in uncontaminated streams. David Morgan/James Kelly

On the trail of sexual chemistry

Australia is behind in understanding the levels of endocrine-disrupting chemicals in waterways and their effects on wildlife reproductive systems. Now concerted research efforts are being made to better assess local impacts. **Wendy Pyper** reports.

Since the late 1930s scientists around the world have been documenting unusual changes to the reproductive behaviour and anatomy of wildlife with elevated concentrations of 'endocrine-disrupting chemicals' – EDCs – in the environment.

In British rivers and streams, steroid hormones are thought responsible for the feminisation of male fish. At Lake Apopka in Florida, reproductive abnormalities in alligators have been attributed to unusually high levels of organochlorines from industry. And in Australia and Japan, female marine shellfish exposed to tributyltin – a biocide used in anti-fouling paints on ships – grow male sex organs and can become infertile.

It wasn't until the early 1990s, and the publication of the book *Our Stolen Future* in 1996, that EDCs got real attention. Since then, a range of international research programs have followed to address and prioritise the impacts of EDCs.

Science has shown that endocrine disrupters have the potential to mimic or interfere with the natural hormones controlling development and behaviour, thereby altering the body's response. Tests are now being refined so that a wide range of chemicals can be screened for these effects, including natural and synthetic hormones such as androgens (male sex hormones) and oestrogens (female sex hormones), and selected pesticides, heavy metals, pharmaceuticals, phytoestrogens (plant hormones), and detergent by-products. Such chemicals are released from a variety of sources including domestic sewage, agricultural activities, industrial wastes, mining activity and landfills, and eventually filter down to waterways.

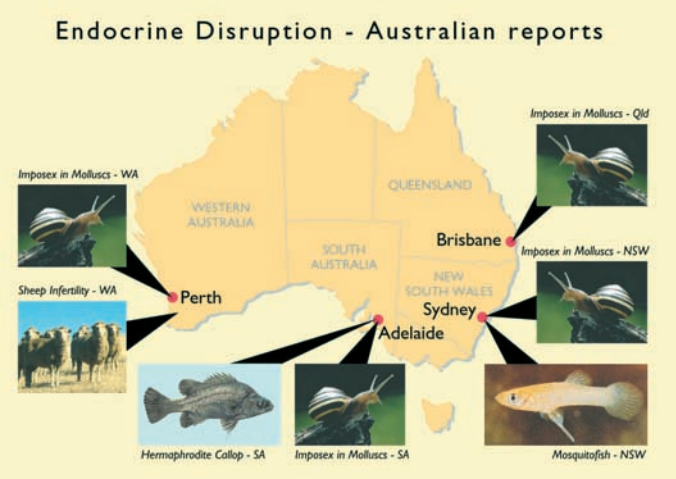
While most EDC research has focussed on aquatic ecosystems, human and animal waste (such as sewage sludge) commonly applied as fertiliser in some countries also contains a variety of natural and synthetic EDCs, potentially exposing terrestrial organisms to such compounds.

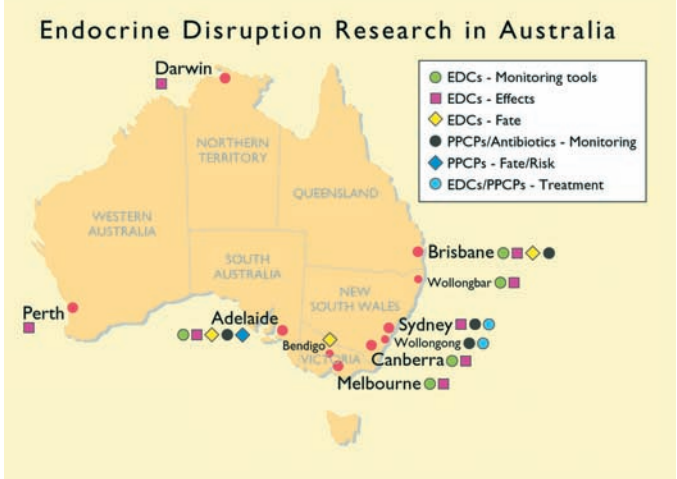
Research in Europe and North America has given good insight to the occurrence of EDCs in streams, aquifers and sediments, and their movement and fate. Both continents have also invested large amounts of resources in the biological effects of EDCs, and screening and testing programs.

The potency of many EDCs has been established by comparing their endocrine disrupting effect against 17β-estradiol (the natural female sex hormone). Highly potent EDCs such as oestrogens may be present in small amounts in the environment, but generally contribute more to the endocrine disruption effects than other less potent chemicals that may be present at higher levels.

Australian research needs

In Australia, the body of research is much less comprehensive, but scientists are





The location of current reports of EDC effects and project research sites across Australia. Rai Kookana, CSIRO Land and Water

already involved in some 30 projects on EDC monitoring, effects, environmental fate, and on the development of models and tools to assess their risks. However, according to CSIRO Land and Water scientist, Dr Rai Kookana, the time is right for a more pro-active and coordinated approach to understanding the extent and fate of EDCs in our environment, and on the consequences to wildlife and human health, although there is as yet no clear direct evidence that human health is affected.

Kookana also says that resources targeted to the right areas of investigation will also allow Australia to pursue its new water recycling and reuse initiatives with confidence.

'Reuse of wastes and water are critical for the future of Australia,' he says.

'The environmental concentrations of EDCs, their persistence, mobility and their potency, need to be considered together with the nature of our unique Australian fauna, so that we can assure the public that our practices are safe for both human and ecosystem health.'

Mr Dana Kolpin, a research hydrologist coordinating the US Geological Survey Emerging Contaminants Project, and a keynote speaker at a recent EDC workshop in Australia, says we can use overseas research as a guide, but that additional local research is needed to account for differences in our local environmental conditions.

'The persistence of these compounds may differ in Australia due to variations in climate and sunlight intensity, such that a pharmaceutical that behaves relatively conservatively in a US stream, for example, may be rapidly degraded in an Australian stream,' Kolpin says.

Kookana agrees and adds that while we know the potency of some of the EDCs and the sort of levels that cause problems, we don't know the exposure levels in the Australian environment.

There are also differences in the response of Australian organisms to EDCs. Work on frogs by CSIRO ecotoxicologist Dr Anu Kumar, for example, has shown that some native species don't respond to EDCs in the period of testing suggested by overseas studies.

'We need to identify indicator species and develop tests that are locally relevant and that reflect our environmental conditions,' Kumar says.

Noticeable effects of EDCs on some aquatic organisms, such as the male mosquitofish, have, however, already been observed by Dr Richard Lim of the University of Technology, Sydney, Dr Louis Tremblay of LandCare Research, New Zealand, and Dr Heather Chapman of the CRC for Water Quality Treatment.

Addressing research needs

Since the formation of the Australasian Society for Ecotoxicology's Special Interest Group on EDCs in 2002, Australian and New Zealand researchers have reviewed the extent of EDC research in both countries through a series of workshops intended to develop a coordinated pool of resources and prevent any duplication of research efforts. The most recent of these was in September 2004 and was sponsored by CSIRO, Land and Water Australia and the Australasian Society for Ecotoxicology.

'A key recommendation from the workshop was development of a position paper on the EDC issues in Australia, which may form the basis of a response by government agencies,' says Dr Kookana.

Research reviewed at the workshop on EDCs included:

- Levels of endocrine active substances in the sediments, water and biota of a dam, wetland and sewage effluent, to identify the level of exposure of humans and wildlife to endocrine disruptors;
- Fate and biological effects of EDCs in sewage;
- Presence of EDCs in reclaimed water;
- Effects of EDCs on aquatic insects, native fish, and unique Australian fauna;
- Involvement in a Global Water Research Coalition to develop a toolkit of biological methods to determine endocrine disrupting activity in environmental waters; and

The Murray rainbowfish, *Melanotaenia fluviatilis*, is being used to develop a set of biological markers which will help evaluate the effect of EDCs on native species. Neil Armstrong

'If we find that EDCs are persisting in our environment, we may be able to tweak our systems to remove them or reduce their impact.'

A newly excavated sewage treatment dam near Perth. Most endocrine disrupting chemicals in Australia's environment come from domestic sources and are not fully removed by the sewage treatment process. Willem van Aken

- Cost-effective removal of EDCs from water by various water and wastewater treatment processes.

While most work in Australia until now has looked at EDCs in sewage effluent in urban areas, Kookana's team at CSIRO is focusing on sources of EDCs in riverine environments, including rural treatment plants discharging into small, low-flow water streams, feedlots, dairy farms and cropping areas, and industrial sources such as paper mills.

With these results, the team will be in a better position to start assessing the potential exposure of the environment and, using overseas results as a starting point, whether the contamination is high enough to affect aquatic organisms and other wildlife.

'If we can identify areas where there's potential exposure of our fauna to these types of compounds, then it makes a case for the next level of investigation – looking at the exposure and effects of EDCs on native fauna and the development of management options,' Kookana says.

The team is also undertaking field and laboratory tests to determine how different EDCs break down in water and soil/sediment under aerobic and anaerobic conditions, and the movement and accumulation of these chemicals in soil and sediments.

'If we find that EDCs are persisting in our environment, we may be able to tweak our treatment systems to remove them or reduce their impact. If we don't find them then that's good news,' Kookana says.

Dr Anu Kumar's team is also using the Murray rainbowfish, *Melanotaenia fluviatilis*, as a native fish model from which a set of biological markers will be developed to enable scientists to evaluate the effect of commonly detected EDCs on native species.

Management guidelines for EDCs

Kookana and his colleague Dr Peter Dillon, also of CSIRO Land and Water, say more intensive and comprehensive EDC research is needed in Australia to provide a scientific basis for managing EDC issues – to ensure rational decision-making about water management and to help prevent alarmist reporting.

Dillon agrees that this will also help the development of guidelines for water reuse and risk management.

'Current draft drinking-water guidelines and emerging water reuse guidelines are going down a risk management pathway that is now being formalised through Hazard Analysis and Critical Control Point Plans, he says.

'These require identification of risks and the means of reducing them to acceptable levels.'

Dillon says the new research will be important for developing strategies to counter adverse EDC effects. Some of these approaches might include substituting benign chemicals for EDCs in surfactants and detergents, improved pesticide management, and improved wastewater treatment. As EDC research has advanced in the US and Europe, some chemicals have been banned from industrial use.

Hazard Analysis assessments, Dillon says, may give confidence that current levels of protection are adequate. However, he points out that any management approach will have both costs and probable environmental impacts (such as greenhouse gas emissions from improved water treatment), which need to be taken into account to 'avoid lurching from one problem to another'.

What can consumers do?

While formal EDC management strategies may be some way off, can the average consumer do anything to minimise EDC release into the environment? Not much at this point, according to Dr Michael Warne of the CSIRO Centre for Environmental Contaminants Research.

'We have only limited information on whether or not EDCs are causing problems in the environment and we have not positively identified actual sources and measured their inputs/outputs so that we can deliver a definitive ranking,' he says.

'There's not a lot we can do about EDCs in sewage either at the moment. The best thing is to raise awareness of this issue and push regulators, industry and others to assess whether they release EDCs, and to quantify them and their environmental impacts.'

More information

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Australasian Society for Ecotoxicology: www.ecotox.org.au/

European Union's research program: www.comprendo-project.org/main800.html

USGS Geological Survey Emerging Contaminants Project: http://toxics.usgs.gov/regional/emc.html

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