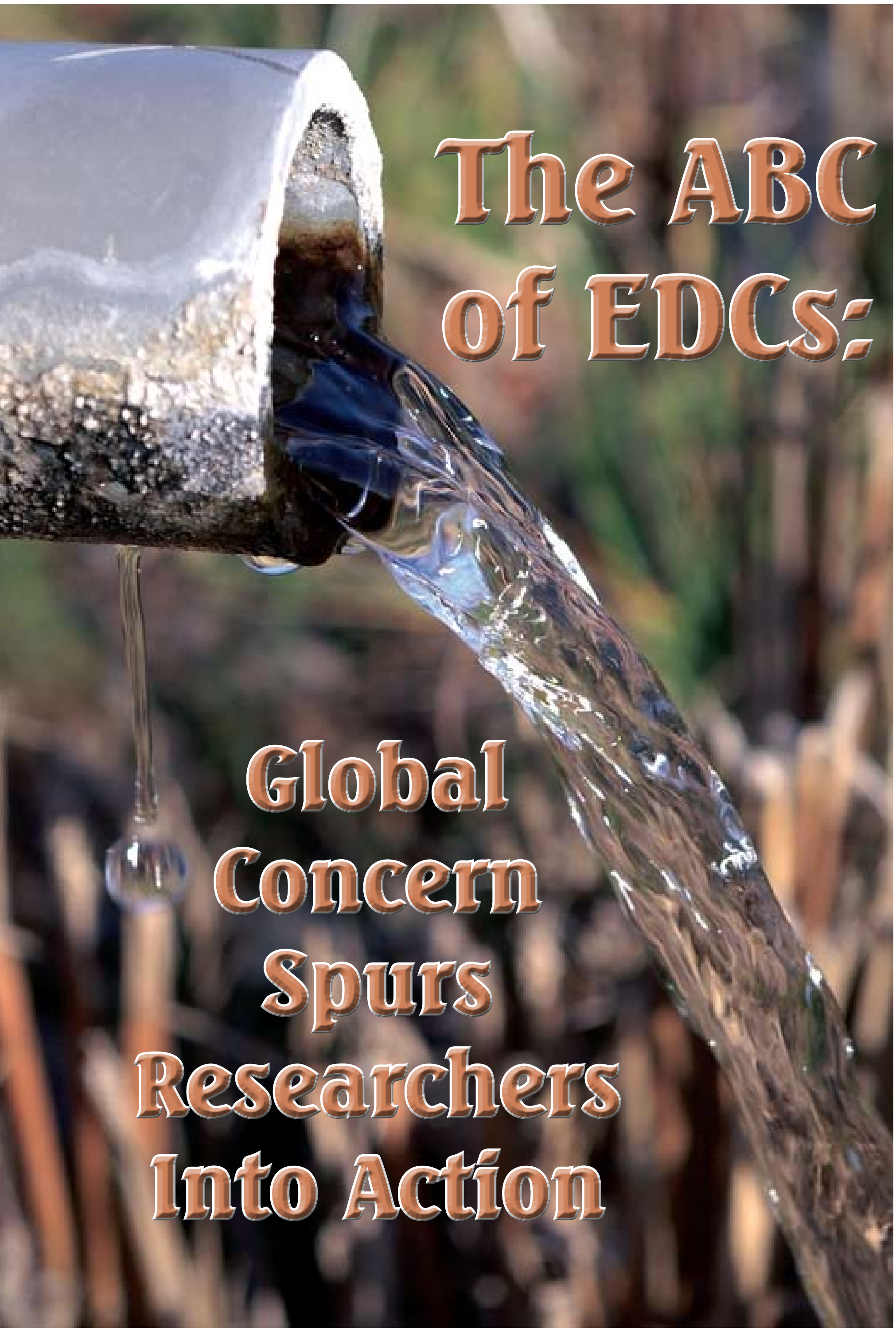

The ABC of EDCs: Global Concern Spurs Researchers Into Action

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In Part One of a series on endocrine disruptors, Lani van Vuuren looks at the increasing awareness of the potential risks of man-made chemicals to humans and wildlife as well as the start of South Africa's EDCs Research Programme.

Over the past two decades there has been growing concern, public debate and lack of scientific consensus about the potential effects of a number of chemicals that have the potential to alter the normal functioning of the endocrine system. The endocrine system is the set of glands and the hormones they produce, which help guide the development, growth, reproduction and behaviour of animals and humans.

So-called endocrine disruptors or endocrine disrupting chemicals (EDCs) – also called gender benders – can be natural or man-made substances, and interfere with the normal functioning of the endocrine system in three possible ways:

- By mimicking the action of a naturally-produced hormone, such as oestrogen or testosterone, and thereby setting off similar chemical reactions in the body;
- By blocking the receptors in cells receiving the hormones, thereby preventing the action of normal hormones; or
- By affecting the synthesis, transport, metabolism, and excretion of hormones, thus altering the concentrations of natural hormones.

The potential danger of these substances to humans and the environment first came to light in the 1960s, when the observed effects of wildlife exposure to chlorinated pesticides, such as dichlorodiphenyltrichloroethane (DDT), became known. Today, there are over 80 000 chemicals registered for commercial use, and it is unclear exactly how many are potential EDCs.

We are surrounded by chemicals in our everyday lives, and every person will probably be exposed to a cocktail of potential EDCs through various agents in their lifetime. Suspected endocrine disruptors can be found in pesticides, fertilizers, pharmaceuticals (e.g. birth control), personal care products (medicines, lotions, cosmetics, sun block), and industrial substances (plasticisers, fabric softeners, fire retardants, cooling agents). They find their way into the environment and water resources. We are exposed to these chemicals through the water we drink and the food we eat, the air we inhale, and through contact with our skin.

Because the list of chemicals with possible endocrine disrupting effects is structurally so diverse, it is not possible to define a 'typical' EDC. Of specific concern, however, is the subgroup of EDCs known as persistent organic pollutants (POPs). These compounds do break down extremely slowly, and can remain in the environment for many years. They accumulate in fatty tissue, becoming more concentrated higher up in the food chain over time. For example, fish-eating birds might have higher concentrations of EDCs than the fish on which they feed, such as a study on bald eagles in Alaska showed. Infants can be exposed to their chemicals through the womb and through their mothers' breast milk.

The use of these compounds has generally been banned, but they are still present in the environment. Of equal concern are newer products, with short half-lifetimes to which we are exposed daily, such as pesticides used for domestic pest control and chemicals contained in plastic containers.

SOME EXAMPLES OF ENDOCRINE DISRUPTORS

Phthalates: Add flexibility to a large range of plastic goods. Also found in some paints, inks, adhesives and cosmetic products.
Bisphenol A: Used extensively in the production of polycarbonate and epoxy resins. It can also be found in adhesives, reinforced pipes, interior coatings of tins and drums, flooring, electronic goods, powder paints, lenses, crash helmets, thermal fax paper and some resistant plastic foods and drinks containers.
P-nonylphenol: Found in industrial and household detergents.
Polychlorinated biphenyls (PCBs): PCBs have historically been used as coolants and lubricants in transformers, capacitors, and other electrical equipment. (Production has stopped and these compounds have been banned in some countries, although they are still prevalent in the environment).
DES: Diethylstilbestrol was the first synthetic oestrogen to be developed. It has traditionally been used by pregnant women to prevent miscarriages.
Atrazine: Widely used in South Africa as a herbicide, especially in the maize producing areas.
Dioxin: Byproduct of industrial processes, including waste incineration, food containment.
Organochlorine pesticides: Still widely used in SA, especially in areas where malaria prevails (including DDT).
Estradiol: Form of oestrogen used to treat, for example, symptoms of menopause.
Organophosphate pesticides: Includes chlorpirifos, Azinfos-methyl and Parathion.

ENDOCRINE DISRUPTION IN NATURE

As Natalie Aneck-Hahn of the Department of Urology at the University of Pretoria pointed out in a paper presented at the 2006 Biennial Conference of the Water Institute of Southern Africa (WISA), most of the studies for endocrine disruption in wildlife has come from studies on species living in or closely associated with, the aquatic environment. "This is not surprising given the fact that our rivers and oceans act as repositories for the discharge of tens of thousands of chemicals in large volumes." These field and laboratory investigations indicate that exposure to certain EDCs could contribute to adverse effects in some wildlife populations.

The World Health Organisation (WHO), in its *Global Assessment of the State of the Science of Endocrine Disruptors*, reports that the health effects witnessed in wildlife species vary from subtle changes in the physiology and sexual behaviour of species to permanently altered sexual differentiation. For example, exposure to EDCs has been shown to adversely impact the reproductive and immune function in Baltic seals, resulting in marked population declines, while eggshell thinning and altered gonadal development have been observed in birds of prey exposed to pesticides such as DDT.


Lani van Vuuren

Plastics are one potential source of EDCs.

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PRISTINE WILDLIFE AREA AFFECTED BY EDCs

In 1999 the US Geological Society published the results of a study on bald eagles in the remote and pristine area of Aleutian Archipelago, in western Alaska.

The research indicated elevated levels of organochlorine pesticides, such as DDE (a metabolite of DDT) and the industrial compound PCB in the bald eagles leading to low reproduction levels due to eggshell thinning and embryo death.

Studies on sea otters in the same area found they contained almost twice as much PCB than otters from the central California coast, an area known to have agricultural and industrial contamination. While the researchers could not pinpoint the source of the pollutants, their distribution patterns yielded some clues. The PCBs may have come from former military activity on some of the islands, while the DDT could be windborne or waterborne contamination from agricultural use in Asia.

This proved that even remote and pristine areas could potentially be affected by endocrine disrupting chemicals due to the potential of these pollutants to be transported over long distances.

Another well publicised example is the decline of alligator populations at Lake Apopka, in Florida, in the US, following a DDT spill. A decrease in reproductive capability among panthers in the same area was linked to the same incident. In a more recent survey by the US Geological Survey (USGS), more than 80% of male smallmouth bass in the Potomac were found to be growing eggs in their testes (known as feminisation). A seven-year research effort by Canadian biologists found that synthetic oestrogen (such as those found in birth control pills), which were regularly discharged in municipal wastewater into surface waters, had similar feminising effects on wild fish populations living downstream.

WHAT ABOUT HUMAN HEALTH?

According to CSIR senior researcher Bettina Genthe, there is still much debate surrounding the significance of evidence that EDCs are affecting human health, especially since epidemiological studies are almost non-existent. It is assumed, however, that since these chemicals are affecting animals, they must be affecting humans too. A number of reproductive health effects in the human population have been observed in which EDCs could play a role.

Some studies in countries, such as Japan and the US, for example, have reported decreases in sperm numbers in males over the last 50 years as well as a decline in male births. In recent years there has also been an increase in the incidence of congenital malformations in children, such as hypospadias (abnormal positioning of the meatus, the opening from which urine passes) and cryptorchidism (undescended testes). In addition, there are more reports of testicular and prostate cancer in males and breast cancer and endometriosis in women. It is thought that EDCs could also potentially

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affect the immune system and neurological development.

Why is it so difficult to unequivocally prove the human health effects of EDCs? "It is difficult to establish cause and effect relationships for human exposure of EDCs and incidence disease. We have no control, since everyone has been exposed to EDCs at some time or another," explained Genthe during her presentation at WISA 2006. "We encounter a broad range of environmental exposures throughout our lives and frequently to a mixture of chemicals at any one time." This makes it difficult to know which chemicals at what dosages are harmful.

Another challenge is the fact that more recent research suggests that endocrine disruptors have transgenerational capabilities. This means they do not only affect the people presently exposed to them, but could possibly elicit greater effects up to a second or third generation. Also, health effects due to prenatal exposure may not present themselves until later in life. It is generally believed that the earliest stages of life are the most sensitive to endocrine disruption.

THE SOUTH AFRICAN EDCs RESEARCH PROGRAMME

The best way to defend ourselves against this onslaught of chemical influences is to improve our knowledge of EDCs and their presence and effects on the environment. This information can be used by decision-makers to ensure these chemicals are controlled effectively through legislation to reduce risk of exposure.

In the early 1990s awareness grew of the need to conduct large-scale EDC research in South Africa. "Early investigations were very isolated and the country's EDC research capacity was limited," reports WRC research manager Annatjie Moolman. "A need existed for a coordinated programme involving all researchers and other role-players, including government departments, industry and water suppliers. This is especially necessary as EDCs research requires a multidisciplinary approach involving research in disciplines such as zoology, physiology, toxicology and analytical chemistry."

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Lani van Vuuren

Many EDCs are believed to be transgenerational, meaning they do not only effect one generation, but can elicit effects up to a second or third generation.

It is reported that little of the existing analytical data generated in South Africa at that stage was useful for EDC evaluation as most of the data at that time were collected with toxicity in mind. (EDCs have an effect at levels much lower than the toxic effect, and was thus not detected or reported.) Subsequently, the WRC launched an EDCs Research Programme to coordinate and extent present capacity to conduct research in this field and monitor studies being undertaken.

Drinie van Rensburg

Animals living in an aquatic environment are most at risk of EDC pollution.

The main objective of the programme was to monitor the occurrence and source of EDC pollution in South African water systems and determine the potential risks to the local population. The programme focused on a list of priority EDC compounds compiled in collaboration with stakeholders such as the Department of Water Affairs & Forestry and the Global Water Research Coalition.

The early years focused on building much needed capacity at the participating research facilities for activity testing and chemical analysis. Thanks to these efforts, South African EDC researchers and scientists now count among the best in the world.

*In **Part Two**: More on the South African EDCs Research Programme and what studies have shown thus far.*