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Centre Suisse d'écotoxicologie appliquée
Eawag-EPFL

Endocrine Disruptors in the Environment

Information sheet

Endocrine disruptors – also called hormonally active substances – are being increasingly detected in the environment. They disturb the hormonal balance of organisms by imitating naturally occurring hormones or blocking their effect. In this way, they can affect the development, reproduction, and health of humans and animals.

Which substances act as endocrine disruptors?

The endocrine system of an organism can be influenced by both natural and synthetic substances. These substances belong into the following categories:

- Natural hormones produced in the human or animal body (e.g. estrogens, steroids);
- Natural hormones produced by plants with an estrogen-like effect on animals and humans (phyto-estrogens);
- Synthetic substances produced as drugs with hormonal activity (e.g. ingredients of birth control pills);
- Synthetic substances from everyday products, industry, or agriculture with unintended hormonal activity. This includes, for example, ingredients of synthetic materials (bisphenole A, phthalates) and sunscreen agents (UV filters), fire retardants (brominated diphenyles and diphenyle ether), detergents (alkyphenoles), pesticides (some herbicides, insecticides), and legacy pollution (DDT or PCBs). The occurrence of these synthetic substances in the environment, in particular, has strongly increased in recent years.

How do endocrine disruptors find their way to the environment?

Many endocrine disruptors used in settlement areas reach streams, rivers and water bodies through communal wastewater treatment plants that do not or only partially retain these substances. This applies, for example, to drugs and ingredients of cosmetics. Substances used outside can directly find their way to streams through surface water sewers, also referred to as diffuse sources. This applies, for example, to estrogens from farm animal keeping, pesticides, and seepage water from contaminated sites and landfills.

How are endocrine disruptors measured?

Modern chemical detection methods such as combined liquid chromatography-mass spectrometry (LC-MS) have finally enabled the detection of endocrine disruptors in the environment. However, even the most advanced chemical anaylsis of individual substances may reach its limits because some of the substances are biologically active at very low concentrations. Some estrogens already take effect at concentrations below 1 nanogram per litre. Moreover, the meaningfulness of chemical analysis is limited since the effect of substances with the same mode of action will add up. As a result, the combination of different estrogens, each of which is present in ineffective concentrations, may cause a biological effect. Chemical analysis can be supplemented by ecotoxicological test systems to sensitively determine the effect of hormonally active substances. The accumulated effect of substances with the same mode of action can be identified with *in vitro* tests using genetically engineered yeast cells or cell cultures. *In vivo* tests, on the other hand, are used to investigate the effect on entire organisms such as snails, small crustaceans, or fish. Furthermore, biomarkers such as vitellogenin, the precursor of the egg yolk protein, can be directly analysed in the liver or the gonadal tissue of fish. Vitellogenin is usually only produced to a major extent by females. The production of this protein by males or juveniles indicates the influence of estrogenic substances.

How do endocrine disruptors act?

Various modes of action are possible in the human and animal body. For example, hormone-like substances may bind to the body's hormone receptors and activate them in the same way as the body's hormones do. This mode of action is utilized in some *in vitro* bioassays such as the Yeast Estrogen Screen (YES) or the ER-Calux bioassay. Other endocrine disruptors block the hormone receptors so that the body's hormones can no longer take effect. Some substances may also influence the availability of the body's hormones or indirectly affect the endocrine system.

How do endocrine disruptors affect organisms and populations?

Endocrine disrptors may have a critical influence on the metabolism and the development of animals and humans, the best investigated being the effects on sexual development and reproduction of animals such as changes in sex ratio or sexual behaviour, reduced fertility, or bird egg shell thinning. These mechanisms caused sharp declines in bird populations (due to DDT), otter populations (due to PCBs), snail populations (due to tributyltin), and alligator populations (due to plant protection products). Great attention was attracted by the occurrence of intersex fish in rivers of Great Britain downstream of wastewater treatment plants where endocrine disruptors enter the rivers along with the treated water. The occurrence of intersex fish in a river in France increased due to the wastewaters of pharmaceutical factories. A local fish population in a lake in Canada collapsed after long-term administration of ethinyl estradiol, a synthetic estrogen.
It has not been demonstrated in Switzerland to date that endocrine disruptors in the environment affect the reproduction of wildlife populations. However, the "Fischnetz" (fishnet) project found that the occurrence of endocrine disruptors is likely one of the factors that contributed to the general decline in fish. Increased vitellogenin levels were detected in male fish in several Swiss rivers downstream of wastewater treatment plants within the scope of a research programme on endocrine disruptors

(NRP50) of the Swiss National Science Foundation. Estrogenically active substances may not only affect the developmental and reproductive processes, but probably also weaken the immunity system of fish.

Which bioassays are suitable for the detection of estrogenic substances?

Within the scope of the MicroPoll project of the Federal Office for the Environment, the Ecotox Centre compared various bioassays for the detection of endocrine disruptors in wastewater treatment plants. *In vitro* test systems that detect endocrine disruptors with the aid of genetically engineered yeast cells or human cell cultures proved to be especially suitable for the simple analysis of numerous samples. *In vivo* tests with early life stages of fish were also promising (for more information on the individual test systems, please refer to the project report at http://www.oekotoxzentrum.ch/dokumentation/berichte/doc/Bericht_Micropoll.pdf).

How can endocrine disruptors be prevented from entering the environment?

The contamination of streams, rivers and water bodies with endocrine disruptors can be strongly reduced by introducing additional treatment steps in waste water treatment plants such as ozonation and sand filtration or powdered activated carbon treatment. Such upgrading of large wastewater treatment plants in Switzerland will be politically implemented in the near future. Another possible measures at the source are to refrain from using certain substances or to adapt chemical formulations. DDTs, PCBs, tributyltin and certain fire retardants have already been legally banned. However, the Swiss Chemicals Act does not incorporate endocrine disruption in the regulation as a separate endpoint - these substances were banned due to other toxic properties. The EU REACH Regulation provides for specific restrictions for endocrine disruptors: new endocrine disruptors are subject to approval and may not be approved until risk assessment has been performed.
However, each individual can also make a contribution toward reducing endocrine disruptors in the environment by ensuring the proper disposal of drugs and chemicals or the proper and sustainable use of biocides.

Links

More information on effect assessment within the scope of the MicroPoll project
www.oekotoxzentrum.ch/projekte/micropolleffektbewertung/index_EN

Substances interfering with hormone metabolism (2009) (in German). Fact sheet of Eawag and Empa
www.eawag.ch/medien/publ/fb/doc/fs_eth_bereich_eawag_empa_hormonaktive_substanzen.pdf

National Research Program “Endocrine Disruptors: Relevance to Humans, Animals and Ecosystems” (NRP50) of the Swiss National Science Foundation
www.nrp50.ch

The impacts of endocrine disrupters on wildlife, people and their environments – The Weybridge+15 (1996–2011) report (2012). Comprehensive new report of the European Environment Agencyischen Umweltagentur on the effects of hormonally active substances
http://www.eea.europa.eu/publications/the-impacts-of-endocrine-disrupters

State of the Art Assessment of Endocrine Disruptors (2011). New report of the European Commission on the assessment of hormonally active substances.
http://ec.europa.eu/environment/endocrine/documents/4_SOTA%20EDC%20Final%20Report%20V3%206%20Feb%2012.pdf

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