First scientific support plan for a sustainable development policy (SPSD I)

Programme "Sustainable management of the North Sea"

Evaluation of possible impacts of endocrine disruptors on the North Sea ecosystem

Summary of the research

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Introduction

In recent years, there has been increasing concern by scientists, regulators and the general public about the possible adverse effects of chemicals present in the environment on the endocrine system of humans and wildlife. The regulation and action of hormones are very precise processes with the purpose of maintaining homeostasis in the organism. A disruption in the natural balance of these hormones can therefore have serious consequences.

Endocrine disruptors can be natural compounds that are produced by humans and animals (natural hormones) or plants and fungi (phyto-hormones) or anthropogenic chemicals used in industrial, household or pharmaceutical products (xeno-hormones).

A large number of these compounds have been shown (or suggested) to cause endocrine disruptive effects in mammals, fish, reptiles, amphibians, birds and invertebrates in laboratory exposures. Much more important, are the examples of endocrine disruption observed in the wild: feminisation of alligators in Lake Apopka in Florida, feminisation of gulls, disrupted reproduction in panthers in Florida, developmental perturbations in turtles in the Great Lakes, imposex- and intersex phenomena in marine gastropods, feminisation of fish near paper mill effluents,… The possible relation between the exposure to endocrine disruptors and reductions in male sperm quality and reproductive capacity and the higher incidence of certain cancers (breast, testicle, cervix) in humans, are currently very important research subjects.

Compared to the information available for freshwater ecosystems, little is known about the possible effects of endocrine disruptors in the marine environment. However, since the sea is the final sink for many (persistent) pollutants, these endocrine disruptive chemicals are also thought to affect marine organisms.

Goals

In Belgium the research on environmental endocrine disruption, in general, is still very preliminary. In addition, globally, no uniform definition for the concept of endocrine disruption exists, nor are any standardised assays for the evaluation of possible effects of endocrine disruptors available. This project aims at establishing a clear overview of the increasing volume of available scientific literature on endocrine disruption. Specific objectives are: to address the uncertainties presently associated with the issue of environmental endocrine disruption; to specify future research and policy needs; to accomplish these tasks specifically for endocrine modulating activity in the marine environment.

Based on the available scientific literature a list and electronic database of chemicals with (potential) endocrine disruptive activity was developed. This relational database contains information on the hormone disrupting potential, including effects and physico-chemical properties of these chemicals. Chemicals of which enough data was available on the environmental concentrations in the North Sea and the sources and endocrine effects they cause were prioritised. Finally, future research and policy needs were formulated based on these results.

Method

To get as broad an image as possible, a large amount of literature on endocrine disruption was screened. Different databases were searched and national and international experts and organisations were consulted. Among the consulted databases were Poltox 1, Medline, Current Contents, CAB Abstracts, Biological Abstracts, Agris, Agricola, Web of Science en

Oxford Journals. A lot of information was also gained through the websites of following institutes and organisations: United States Environmental Protection Agency (USEPA), The Centre for Bioenvironmental Research at Tulane and Xavier Universities (CBR), Organisation for Economic Co-operation and Development (OECD), World Wildlife Fund Canada (WWF Canada), Institute for Environment and Health (IEH), National Institute of Environmental Health Sciences (NIEHS) (Research on Environmental-Related Disease), National Institute of Health Sciences (NIHS), The European Commission, The European Chemical Industry homepage (CEFIC), Air & Waste Management Association, The EXtension TOXicology NETwork (EXTOXNET), Instant Reference Source, Inc., Introduction to hormone disrupting chemicals.

Ecologic effects of endocrine disruption

Reproductive disruptions in humans and animals in their natural ecosystems have been extensively described, but few studies have been able to show a causal relationship between endocrine disruption and the exposure to pollutants. A general overview of the publications on endocrine disruption in humans and other mammals, birds, reptiles, fish and invertebrates are depicted in the final report. In addition, the situation in Belgium and the Netherlands are described separately. The strong decline in Flanders of the sperm quality in young healthy sperm donors is remarkable. Other important published examples of endocrine disruption are the reduction of the seal population in the Waddenzee (Netherlands), de disruption of fish eating bird species in the Scheldt estuary, feminisation of flounder in the Ijsselmeer, the Euro estuary and the North Sea canal, the feminisation of rudd and tench in Flemish waters and the effects on purpura and whelk along the coasts of the North Sea and the Eastern Scheldt.

Emission of natural and synthetic hormones in the environment

The excretion of endogenous sex steroids occurs mainly via urine and faeces. Synthetic hormones used as contraceptives or for medical purposes are excreted in the same way. Total hormone emissions to the environment were calculated, based on Belgian population figures of 1998 and the seize of the livestock in Belgium. Data on the livestock were obtained from the Agricultural Statistic Year Book 1997.

The total emission in Belgium of natural estrogens to the environment by human excretion is about 1,3 kg per day. The total estimate of the emission of estrogens by humans and animals (including cattle, sows and poultry) in Belgium is 5,7-7,7 kg per day. On a yearly basis, this adds up to an estrogen emission of 2,08-2,81 tons!

Many compounds synthesised by plants have (anti-)estrogenic activity. Through consumption of vegetable food, the daily consumption of phyto-estrogens can be hundreds of milligrams. These compounds are easily biodegraded and show a low ability to bioaccumulate. Certain eating patterns (e.g. vegetarians, veganists) could however lead to an increased intake of phyto-estrogens which could lead to an increased risk for adverse effects. However, a profound estimate of the environmental stress based on plant cultivation, for humans and animals, requires an extensive knowledge of the activity of phyto-hormones, the concentrations in the crop, the consumption and use of these crops by humans and animals. It is therefore too early to disregard effects of exposure to phyto-estrogens, because concentrations in the environment are a lot higher than these of natural estrogens or chemical pseudo-estrogens.

Emission of anthropogenic (potential) endocrine disruptors in the environment

In addition to the natural and synthetic hormones, lots of other chemicals exist which are capable of modulating the endocrine system. These xenobiotics are structurally divers and

rarely show a chemical structure similar to natural hormones. (Potential) endocrine disruptors are for instance certain pesticides such as organochlorines, organotins, organophosphors and triazines; alkylphenols and alkylphenolpolyethoxylates; polyaromatic organocarbons; phthalates, polychlorinated biphenyl's (PCB's); dioxins and bisphenol A.

An extended list of (potential) endocrine disruptors was filed in a database in the line of this research project. Only data with reference to (potential) endocrine disruptors were evaluated. Chemicals of which no or insufficient proof of endocrine disruption was present, were not taken into consideration.

Sources, effects and occurrence of (potential) endocrine disruptors in the North Sea

The final report describes the sources, effects, occurrence and potential risk of the following compounds for the North Sea ecosystem: organochlorines (atrazine, chlordane, DDT and metabolites, dieldrin, dioxins and furans, endosulfan, hexachlorocyclohexaan, pentachlorophenol, polychlorinated biphenyl's, toxaphene, nanochlor), alkylphenols (nonylphenol, octylphenol) and alkylphenolpolyethoxylates, polyaromatic organocarbons, organotins, metals (cadmium, mercury, zinc, cupper, lead), phthalates, trichloorethyleen and hexachloorbenzeen.

Identification of risk substances for the North Sea and describing policy measures

In the line of this study it was stated that chemicals could only be a 'real' risk when they where actually present in the North Sea and/or adjacent estuaries of if they have an endocrine disruptive effect on marine organisms. Based on these criteria, 3 groups were defined (in total, 765 chemicals were identified as potential endocrine disruptors):

- Priority compounds (± 1%): chemicals with an endocrine disruptive effect on marine organisms AND which have been detected in the North Sea and/or adjacent estuaries

- Possible relevant compounds (± 4%): chemicals with an endocrine disruptive effect on marine organisms, for which no exposure data with reference to the Belgian Continental Shelf and/or the Scheldt estuary is available

- Compounds with an unknown relevance (± 95%): chemicals for which no data was found with reference to their endocrine disruptive potential for marine organisms

Based on the available information, it is clear that at this time very little is known about the exposure and effects of endocrine disruptors in the marine environment of the Belgian Continental Shelf and the Scheldt estuary to make a scientifically based risk analysis. Therefore, it is preliminary to state any reduction or sanitation measures at this time. Future policy should initially be aimed at an expansion of the knowledge of exposure and effects of endocrine disruptors in marine organisms. This will allow a future risk evaluation of the effects of endocrine disruptors in the North Sea ecosystem.

Research needs

The following research needs were formulated:

- Identification of indicator species for monitoring endocrine disruption in the marine

environment

- tiered screening approach for the evaluation and detection of effects and determination of the effect concentrations in marine organisms

- lack of analytical data of natural and synthetic hormones and endocrine disruptors in the aquatic environment (surface waters and sediments, urban and industrial effluents, drinking water and the marine environment)

- research on possible 'low dose effects'

- lack of data on hormone concentrations in animal excreta (important for fertiliser issue)

- development of adequate analytical methods and techniques for the detection of endocrine disruptors in different environmental matrices (including organisms), especially with reference to the very low concentrations at which effects may occur

- developing specific norms for endocrine disruptors for the protection of the aquatic environment and the human health, taking into account bioaccumulation, biodegradation, activity and elimination through drinking water production and sewage treatment

- studying other mechanisms than the brain-gonad-axis such as brain-thyroid- and brain-adrenal cortex-axis and pituitary gland and the link with endocrine regulated functions (immunological, neurological)

- fundamental research on invertebrate endocrinology

Knowledge and expertise in Belgium

In order to tune research needs to the shortage in innovating initiatives and expertise in different research fields, they need to be placed within the existing network of expertise and knowledge in Belgium. For this purpose a list of experts with their important references was made up. Additionally, an overview of the international contacts in the research field of endocrine disruption are described. Based on the available expertise, Belgium can play a pioneer role in the research field of endocrine disruption. This can be translated into a stronger participation in international fora and also in the development of national thematic networks. Obviously, research should be initiated taking into account international activities, to avoid overlap.