March 2017

Fact sheet

Baltic Sea Centre
Stockholm University

Effects shown of endocrine disrupting chemicals in the marine environment

Endocrine disrupting chemicals (EDCs) have lately received a lot of attention in politics and the media, mainly related to hormone-related diseases in humans. But there is a growing concern that declines in wildlife populations and loss of species are linked to chemicals interfering with the endocrine (hormone) system.

Under current legislation, many of today's commercial chemicals have not been tested for potential endocrine-disrupting properties. But the increasing incidences of endocrine-related diseases observed in wildlife today and the increasing number of chemicals identified to potentially have endocrine disrupting properties is a matter of concern. This concern is based on general knowledge of how hormone systems work, in combination with available knowledge about how chemicals can interfere with these systems. This knowledge has been convincingly shown in studies using experimental animals as well as in wildlife. Taken together, this gives reason for concern.

EDCs adversely interfere with hormone functions

Chemicals known or suspected to have endocrine disrupting effects, such as flame retardants, plasticisers, fragrances, preservatives and metals, are used in a wide range of industrial and consumer products. Some examples are personal care products, furniture, electronics, building materials and clothing. Pharmaceuticals, for instance contraceptives and anti-depressants, also contain EDCs.

Disruption of the endocrine system can result in various developmental, reproductive, neurological, immune and metabolic diseases. Over the past years, an increasing number of chemicals have been identified to have endocrine disrupting properties to which humans and wildlife are exposed. These include well known persistent organic pollutants (POPs) that are restricted in the western world, such as PCBs and DDT, as well as chemicals in current use, such as phthalates used in plastics and personal care products, brominated flame retardants found in textiles or electronics, and perflouorinated compounds such as PFOS used

EDCs can reach the marine environment in a number of ways, such as through the air, rivers and human activities at sea. Organisms in the marine food web are exposed to a mixture of chemicals, which can be taken up from the diet, by inhalation or by absorption through the skin or gills. Persistent and fat-soluble chemicals are taken up from the diet where they can accumulate and transfer through the marine food chain resulting in higher levels in top predators.

for firefighting.

Some EDCs are known to cause effects at the present concentrations found in living organisms and the environment. This is worrying since the survival of species depends on normal development and successful reproduction for which a healthy endocrine system is a prerequisite.

EDCs can interfere with the hormone function in a number of ways, causing an adverse effect in the organism, its offspring, or at the population level. Research on endocrine disruptors has particularly focused on the interaction of EDCs with the oestrogen and testosterone hormone system, which play key roles for reproduction, as well as with thyroid hormones, which are important in controlling neurological development, metabolism and skeletal growth in mammals. An increasing number of studies, laboratory as well as human and wildlife studies, show that EDCs can also interfere with other endocrine systems that, for example, control the immune system and fat development.

Currently, roughly 800 chemicals are known or suspected to have endocrine-disrupting properties, which include a wide variety of man-made and natural substances, ranging from pesticides to pharmaceuticals. Some chemicals are persistent in the environment and can accumulate to toxic levels in top predators and stay in the environment long after use of the chemical has ceased. These chemicals include many legacy pollutants such as PCBs and DDT, but also recently restricted compounds, such as the flame retardant PBDE and PFOS. Other substances are rapidly degraded but are still of concern due to their widespread use and continuous release to the environment, or due to exposure at critical time points during organ development. Some metals such as cadmium, lead and mercury have also been identified as EDCs.

A perch, *Perca fluviatilis*, and its roe in the Baltic Sea. Organisms that lay their eggs in water are particularly vulnerable to EDCs since the eggs are directly exposed during the developmental stage.

Significant concentrations of EDCs found in the marine environment

EDCs can reach the marine environment in a number of ways, such as through the air, rivers and human activities at sea. Outgoing water from wastewater treatment plants are known to contain EDCs from a variety of sources such as personal care products, pharmaceuticals, and consumer goods treated with chemicals. Other sources of EDCs include discharges from industrial processes, runoff from agriculture containing pesticides, fertilisers and pharmaceuticals and urban runoff.

Considering the numerous sources of EDCs to the marine environment, organisms and top predators in the marine food web are exposed to a mixture of chemicals, which can be taken up from the diet, by inhalation or by absorption through the skin or gills. Persistent and fat-soluble chemicals are taken up from the diet where they can accumulate and transfer through the marine food chain resulting in higher levels in top predators.

Organisms that lay their eggs in water are particularly vulnerable to EDCs since the eggs are directly exposed during the developmental stage. Organisms that live in or near urban areas or wastewater treatment plants are often exposed to the highest concentrations before dilution occurs and are also continuously exposed to chemicals.

Significant concentrations of known or suspected EDCs have been measured in the marine environment. Particularly old POPs, such as PCBs and DDT, but also new emerging pollutants, such as brominated flame retardants and perfluorinated compounds, are found in top marine predators exceeding concentrations known to cause adverse effects. Although substances that are banned show a corresponding decline in the environment, they are still of concern since they stay in the environment for a long time and accumulate in the food chain.

Brominated flame retardants like PBDEs and HBCDD, listed under the EU regulation on POPs, have been increasingly studied in the environment in the last decade. In the Baltic Sea, PBDE concentrations four times higher than levels known to cause adverse effects in American white-tailed sea eagles, have been found. High levels have also been reported in roach fishes in the Baltic Åland Sea. Measured concentrations of HBCDD in herring exceeded the threshold level in all stations measured along the Swedish coast and an increasing trend can be seen in eggs from common guillemot close to Gotland.

Of the perfluorinated compounds, PFOS is the most commonly found in animals and locations worldwide. In the Baltic Sea, the highest levels of PFOS have been measured in marine predatory birds and mammals. Although PFOS is restricted and has been phased out in many parts of the world, more than 3000 substances that are structurally similar and produced in significant quantities are currently still in use. For most of them, little is known about their exposure or adverse effects but based on available evidence they may be of similar concern as PFOS. Since only a few selected of these substances are actively monitored in the environment, the exposure to them may consequently be greatly underestimated.

Pharmaceuticals are also a threat to the marine environment due to their inherent design to have biological effects on living organisms. Concentrations of pharmaceuticals in rivers in Baltic Sea countries have been measured above levels for which there are indications that they can change the behaviour of aquatic organisms. Active ingredients of antidepressants, human contraceptives and antiepileptic medicines have also been found in tissues of aquatic organisms close to outgoing water from wastewater treatment plants.

Overall, exposure to even very low concentrations of EDCs during critical times in development may have significant effects on the health and survival of individuals. Thus, it is challenging to determine safe levels of EDCs as well as assess the relevance of effects seen on the individual level to population level.

EDCs lead to reproductive failure for marine wildlife

Observed effects on population levels, such as reproductive failure and outbreaks of diseases, can in several cases be linked to EDC exposure in the marine environment. There are some historic cases where exposure to EDCs, such as PCB and DDT, are strongly correlated with effects seen in wildlife including reproductive impairment in seals, eggshell thinning in predatory birds, feminisation of fish and masculinisation in marine snails. Some examples include:

- Several field- and semi-experimental studies show that EDCs prone to accumulate in fatty tissue do so at levels in marine mammals that may cause adverse effects.
- Birds, exposed to new emerging EDCs, show adverse endocrine disrupting effects, which may have consequences for populations of wild birds. For example, exposure of PBDE at environmentally relevant concentrations to captive American kestrels affected among other things courtship behaviour, hatching success and eggshell thickness.
- For fish, reproductive effects including feminisation of males, masculinisation of females and reduced fertility have been reported. Feminisation in fish has been extensively investigated and is caused by oestrogenic compounds, found for instance in contraceptives, in outgoing water from wastewater treatment plants.
- The clearest example of exposure to EDCs and subsequent population changes is the masculinisation of marine snails close to marinas when exposed to TBT, a constituent in marine antifouling paint used on boats. This has been shown even at very low concentrations where the masculinisation results in sterile individuals which causes reproductive failure and subsequent population declines.

The clearest example of exposure to EDCs and subsequent population changes is the masculinisation of marine snails close to marinas when exposed to TBT, a constituent in marine antifouling paint used on boats. This has been shown even at very low concentrations where the masculinisation results in sterile individuals which causes reproductive failure and subsequent population declines. The mud snail, *Peringia ulvae*, is one of the species used in the marine monitoring program in the Baltic Sea.

Foto: Nicklas Wijkmark/Azote

Identification and testing need to be developed

Several knowledge gaps hinder understanding of the full scale effects of EDCs in the marine environment. Even less is known about endocrine disrupting effects on marine invertebrates although they make up 95% of all known animal species and constitute large groups of the marine ecosystem that are ecologically relevant.

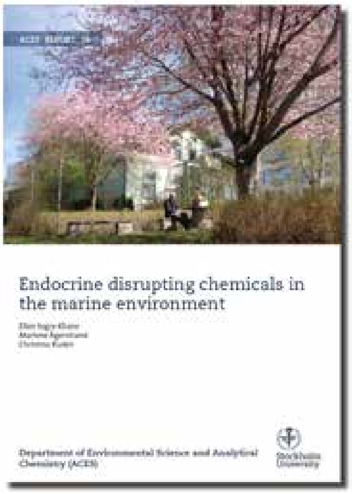
Many routes and sources of EDCs are unknown which makes it difficult to assess the full extent of exposure. For example, marine species living close to wastewater treatment plants' outgoing water are likely exposed to a great number of not-yet-identified EDCs. In addition, we have insufficient knowledge of all the possible ways EDCs can interfere with the hormone system and how exposure during critical time periods of development may contribute to diseases at later life stages or be passed on to offspring. Many of the validated toxicological tests used today are not designed for detecting endocrine-disrupting effects. In general, the implication of effects seen in experiments can be difficult to translate to effects on population levels.

Identifying the cause to the effects and exposure of a single chemical is difficult as the observed effects can be a result of the interaction of several chemicals. Furthermore, monitoring of chemicals in the environment focuses to a large degree on POPs of which many are already regulated. Hence, we know little on the exposure of new emerging EDCs.

Given the current knowledge on EDCs, it is likely that more resources spent on screening of chemicals for endocrine disrupting properties, monitoring of EDCs in the environment and the development of toxicological tests designed to detect EDCs will confirm the suspicion that risks with EDCs are currently underestimated.


Foto: Eva Kylberg/Azote

Brominated flame retardants, HBCDD, are found in eggs from common guillemot, *Uria aalge*, at Stora Karlsö close to Gotland.



This fact sheet is a summary of the full report *Endocrine disrupting chemicals in the marine environment* by Ellen Ingre-Khans, Marlene Ågerstrand and Christina Rudén at the Department of Environmental Science and Analytical Chemistry (ACES), Stockholm University.

BALTIC EYE – BRIDGING THE GAP BETWEEN SCIENCE AND POLICY

This fact sheet is produced by Baltic Eye, a part of the Baltic Sea Centre at Stockholm University.

Baltic Eye is a team of scientists, policy, and communication experts.

We analyse and synthesise scientific research on the Baltic Sea and communicate it to stakeholders in the decision-making process.

Read more: www.balticeye.org

CONTACT

Hanna Sjölund, Advocacy and analysis officer
+46 (0)8 16 31 27, hanna.sjolund@su.se