



Indicators for the Scheldt-estuary

Loads of pollutant substances



In recent decades consumers, industry, agriculture, transport and traffic, as well as other sectors have addressed major efforts to reduce the loads of environmental pollutants such as heavy metals, pesticides and nutrients in the Scheldt estuary. The load of nutrients (nitrogen and phosphorus compounds) in the Scheldt river basin in Flanders and the Netherlands has decreased overall in the last 20 years. In 2009, 95% of designated bathing waters in the Scheldt estuary achieves the mandatory European standards for bathing water quality. The proportion of 'highly polluted' sediments in the Flemish part of the Scheldt estuary decreased from 70% to 54% in the period 2000-2007. In 2009, all samples of dredged material in the Westerschelde meet the quality standards. The measured levels of environmental pollutants in the food web of the Scheldt estuary have declined in recent decades.

Why monitor this indicator?

The Water Framework Directive [1] states that all European surface waters should be in at least a good ecological and chemical status by 2015. The Long-term Vision for the Scheldt estuary (LTV, [2]) therefore targets by 2030 a water quality that is no longer limiting to the ecosystem and a significant reduction in the delayed delivery of pollutant substances from sediments. The quality of the aquatic environment of the Scheldt estuary is a crucial prerequisite for a healthy estuarine ecosystem and its living environment, including humans.

The surface water is affected by the emissions to water from point sources (industries, sewage treatment plants) that discharge directly or indirectly to surface waters and from diffuse sources (e.g. leaching of substances from agricultural run-off). Besides soil and water, there is also the influx from atmospheric deposition.

Water pollution in the Scheldt estuary by environmental pollutants such as heavy metals, pesticides and nutrients not only affects the quality of surface water (see indicator 'surface water quality') but also determines bathing water quality, riverbed sediments quality and levels of environmental contaminants in food sources. Polluted bathing water is a threat to bathers and the environment. Contaminated sediments may be a continuing source of contamination and thus prevent the improvement of water quality and ecological restoration of the watercourse. Soluble substances can accumulate in high concentrations in biota (living organisms) and as such negatively affect aquatic life and human health.

Insufficiently treated sewage in one EU Member State, can have serious consequences for another. Therefore the European Union issued the Urban Wastewater Treatment Directive [3] in 1991, which explains the standards that each State must comply with in terms of treatment of urban wastewater. With the Nitrates Directive [4], the European Union intends to reduce water pollution caused by nitrates from agricultural sources and prevent further contamination. The European Bathing Water Directive [5] requires Member States to monitor at regular intervals whether the water is safe for swimming. Specific legislation and objectives are developed and legally embedded in the Water Act in the Netherlands [6] and the Decree on Integrated Water Management [7] in Flanders.



What does the indicator show?

Nutrient losses to the Scheldt estuary (Scheldt river basin)

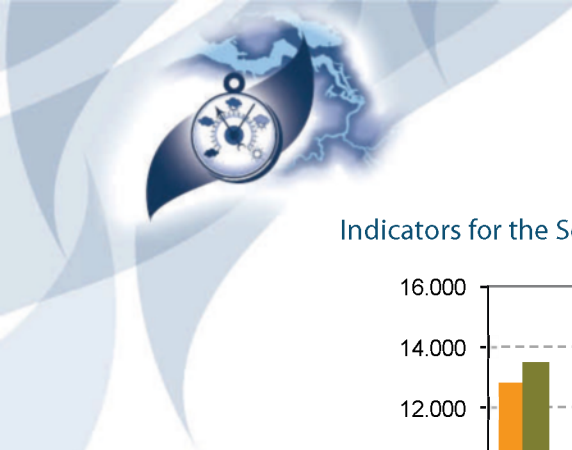
Nitrogen (N) and phosphorus (P) are nutrients or elements for plants nutrition and essential for growth of (water) plants. These nutrients occur naturally in the environment, but are also discharged in large quantities by households, agriculture, industry and other sectors. Too much nitrogen and phosphorus compounds in the surface waters – called 'eutrophication' - creates an impact on aquatic life mainly due to the explosive development of microscopic algae and aquatic plants. Eutrophication will almost always lead to a decline in species richness or biodiversity.

The nutrient balance in surface waters is affected by the discharges from point sources (direct and indirect) and diffuse sources. This summary focuses on the pressure indicators (loads of N and P), as a fairly direct reflection of the efforts of the sectors – in response to the policy measures – to reduce environmental pressures. The emissions N and P from the various 'sectors' (FL) or 'target groups' (NL) comprise the sum of direct and indirect discharges of nitrogen and phosphorus, including discharges in effluent from the wastewater treatment plants (RWZI) and discharges from overflow of sewages (in cases of heavy rainfall). Fluctuations in emissions from diffuse sources such as leaching from agricultural land are strongly influenced by weather conditions (precipitation). This eutrophication issue receives special attention and monitoring by the Netherlands and Flanders.

The indicators for N and P are extensively discussed in the Compendium of Environmental Assessment [8] for the Netherlands at national level, and for Flanders in the Environmental report MIRA [9] and the background documents 'surface water quality' [10] and 'eutrophication' [11]. The models for calculating emissions and loads are quite complex, background information on measurement and calculation methods is available in the technical fact sheet of this measurement. Because of the hydrological aspects of drainage and discharges, the emissions from all basins in the Scheldt river in Flanders and the Netherlands are taken into account. Due to the differences in the monitoring networks and the measurements, the data from the Dutch and Flemish models are not directly comparable. The data for emissions in the NL include atmospheric deposition, this is not the case in FL where the atmospheric deposition in surface water is relatively less important. The definitions of the different sectors are also not comparable. Therefore, the contributions by different sectors are not comparable. Yet similar trends are observed in both datasets (see figure 1).

Nitrogen compounds

In the Flemish part of the Scheldt river basin, the emissions of nitrogen in wastewater from households in the period 2000-2007 decreased from 12,800 tonnes to 8,500 tonnes N. Earlier data show that the greatest efforts by companies were made before this period: in 1993 the emission of N by this sector was 6,600 tonnes and between 2000 and 2007 this value continued to decline from 3,600 to 2,200 tonnes. The nitrogen losses from agriculture fell from 13,500 tonnes N in 2000 to 11,300 tonnes in 2007. Investment in more and increasingly efficient sewage treatment plants has also led to a further reduction of the nitrogen loads in the effluent.



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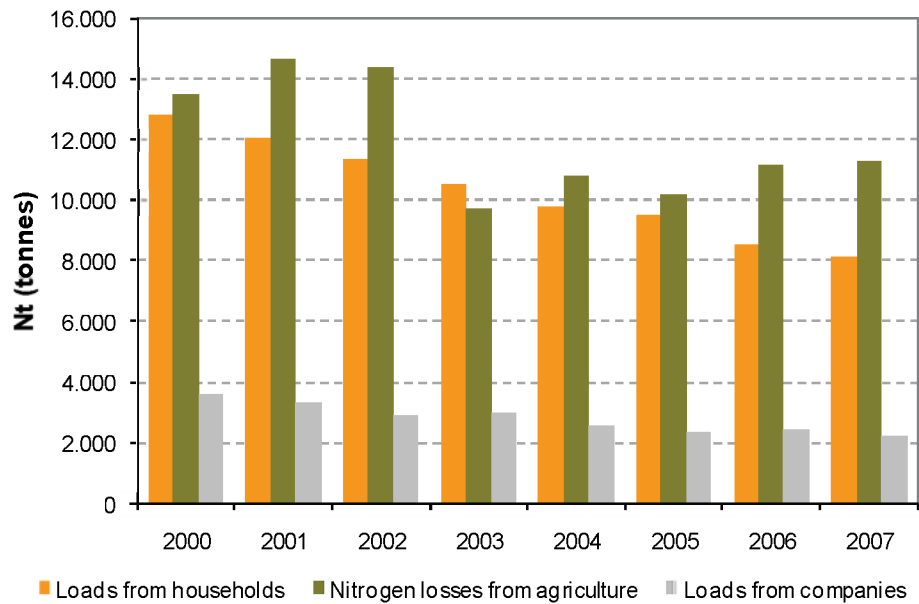


Figure 1: Evolution of the loads of Nt (x 1000 kg total nitrogen) to the Scheldt river basin in Flanders, by sector. Loads discharged by companies discount for the loads already present in the water uptake. Source: Flemish Environment Agency (VMM).

Similarly an important effort was made to reduce nitrogen discharges in the basin of the Scheldt in the Netherlands (Westerschelde and Oosterschelde). Given the fact that the NL data were reported over a longer period, the effects of efforts are more visible. The N-load by consumers fell by more than 90% in the period 1990 - 2007 from 70 tonnes to 5 tonnes. From the chemical industries the N-loads decreased from 353 tonnes to 142 tonnes and the refinery sector reduced its loads from 32 to 1.6 tonnes. Nitrogen losses from the disposal of waste (from 7 to 30 tonnes) and from agriculture (from 1,630 tonnes to 4,128 tonnes) however, increased between 1990 and 2007. In this part of the basin, the investment in more efficient sewage treatment plants had a strong positive effect on the N in surface water in the Scheldt (from 1,993 tonnes to 836 tonnes N) (see figure2).

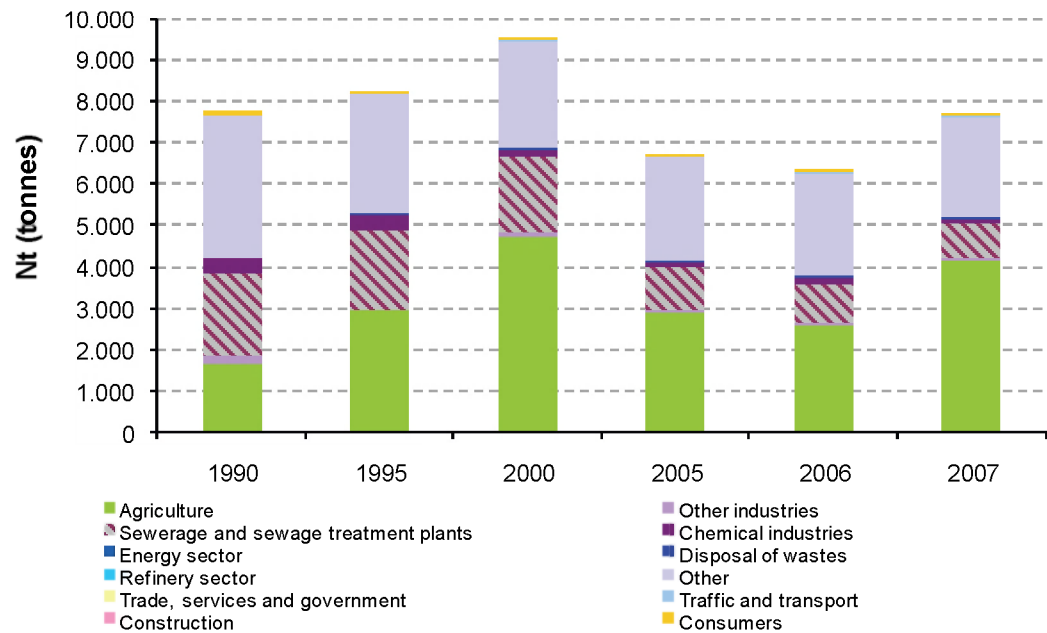


Figure 2: Evolution of the total load of Nt (x 1000 kg total nitrogen) to the Scheldt river basin in the Netherlands by target group. Source: The Netherlands Pollutant Release and Transfer Register.



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Given the final concentrations of nitrogen in surface water in the basin of the Scheldt, both in Flanders and the Netherlands still a lot of work needs to be done to continue to address both the diffuse sources (including the eutrophication from soil leaching in agriculture) and the point sources.

Phosphorus compounds

Efforts to reduce phosphorus loads have achieved a significant effect: in the period 2000-2007, total net P-discharges by households in the Flemish part of the basin of the Scheldt decreased from 1,560 to 1,068 tonnes (> 30%) while the efforts of the companies lead to a decline of almost 47% from 465 to 242 tonnes. For nitrogen losses from agriculture the decrease is less pronounced (15%) but constant (from 822 tonnes to 695 tonnes, see figure 3).

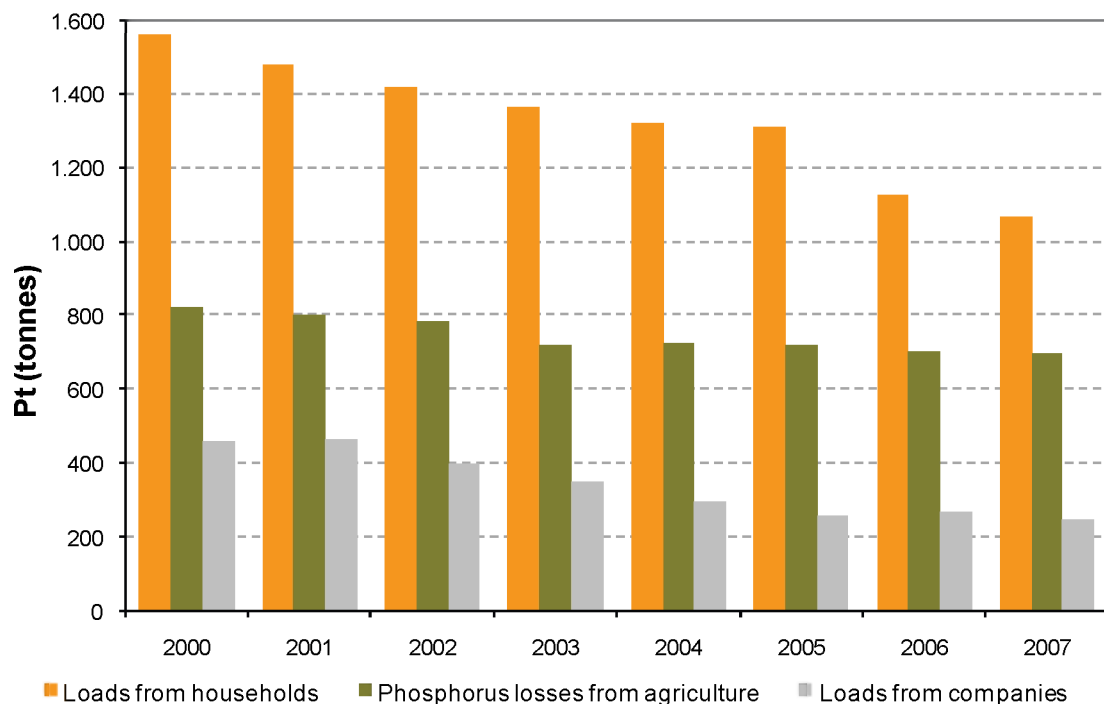


Figure 3: Evolution of the loads of Pt (x 1000 kg total phosphorus) to the Scheldt river basin in Flanders, by sector. Loads discharged by companies discount for the loads already present in the water uptake. Source: Flemish Environment Agency (VMM).

The loads of phosphorus in the sub-basin of the Scheldt in the Netherlands in the period 1990 - 2007 almost halved (see figure 4). Again, the share of the (chemical) industry decreased from 351 to 29 tonnes of P (> 90% decrease). Although consumers contribute a smaller share of total P-loads, a decrease of more than 90% was also achieved in this group (from 10.6 tonnes in 1990 to 0.9 tonnes in 2007). The phosphorus load from agriculture has almost doubled compared to 1990 and reached 255 tonnes in 2007.



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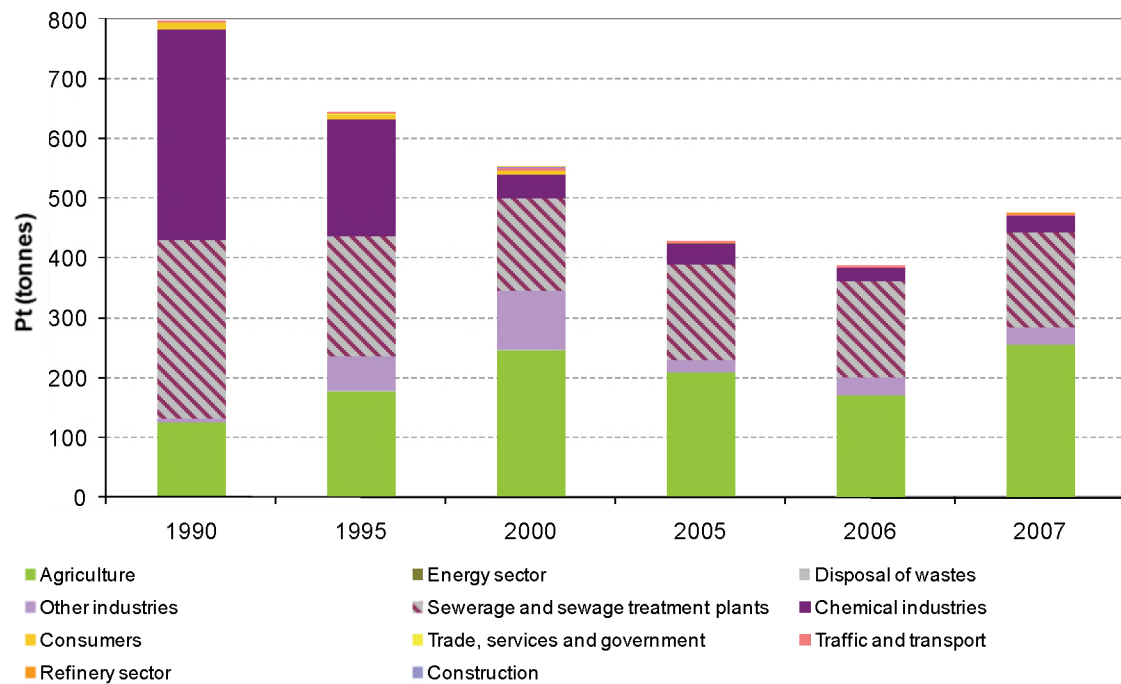


Figure 4: Evolution of the total load of Pt (x 1000 kg total nitrogen) to the Scheldt river basin in the Netherlands by target group. Source: The Netherlands Pollutant Release and Transfer Register.

Bathing water quality in the Scheldt estuary

European Member States are obliged to monitor water quality in their designated bathing waters according to a common European methodology to allow for a comparison between different countries and regions. However the figures need to be interpreted with caution because there are no rules for the number and location of the sampling points. Bathing water quality, according to the EU Bathing Water Directive (1976) was determined based on a number of microbiological and physico-chemical parameters, whereas according to the new Directive (2006) bathing water quality is determined based on two types of bacteria [5].

In 2009, 95% of all designated bathing waters in the Scheldt estuary achieves the mandatory European standards for bathing water quality (see figure 5). The boundaries of the study area are those of the Nature Development Plan for the Scheldt estuary (see fact sheet of the measurement). In the period 1996 - 2008 also more than 90% of bathing waters in the Scheldt estuary achieved the mandatory standards. The percentage of bathing waters meeting the guide values in the same period showed an erratic trend. The low percentage of bathing waters that meet the guide values (and hence the mandatory standards) in the period before 1996 is due to the large number of data points that were insufficiently sampled. The percentage of bathing waters that did not meet the mandatory standards remained below 10% over the entire period.



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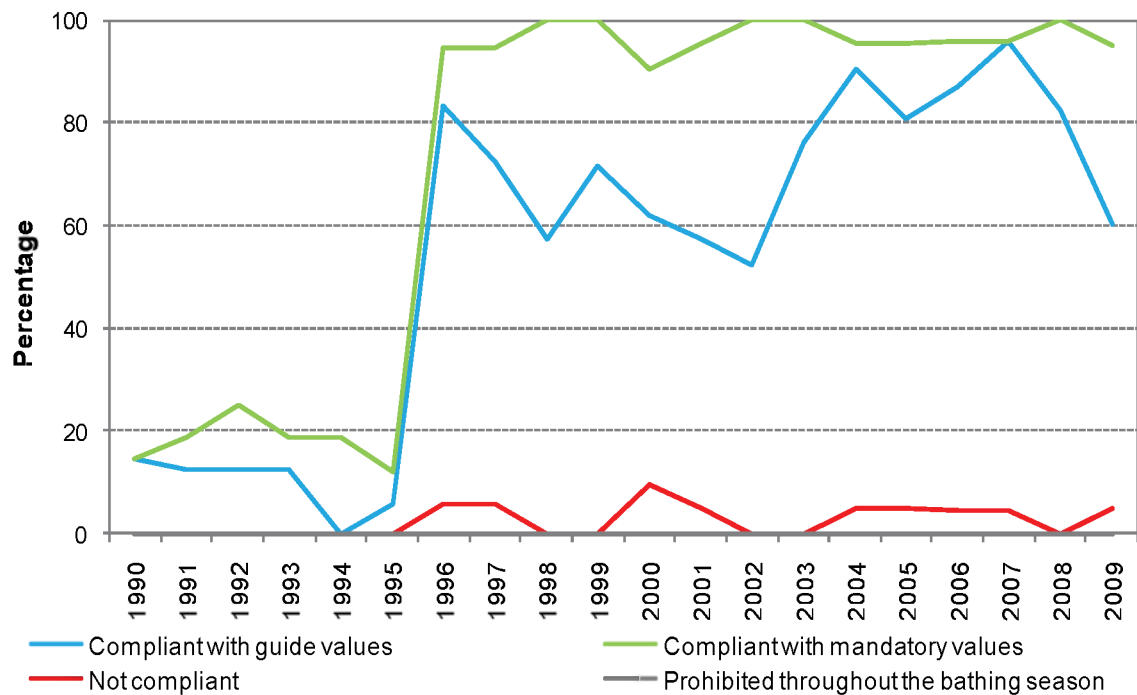


Figure 5: Percentage of identified bathing waters in the Scheldt estuary that meet each of the categories of the European bathing water quality assessment. Source: European Environment Agency (EEA).

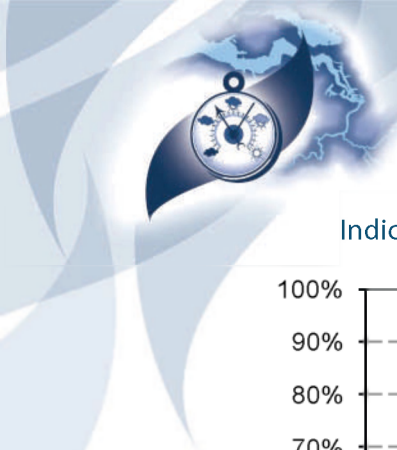
Quality of the river sediment in the Scheldt estuary

To assess the current environmental quality of river sediments in Flanders, the 'triad concept' is applied. The triad assessment consists of three components: a physico-chemical, an ecotoxicological and an biological component which together provide enough information for a comprehensive assessment of the river sediments. In the Westerschelde, there is currently no regular monitoring of the waterbody sediments. The assessment of sediment quality in the Westerschelde is based on data collected under the permit system for the disposal of dredged material (WVO - Surface Water Pollution Act). The Salt-Dredging-Test (Zoute-Bagger-Toets ZBT) is an instrument which, based on a number of chemical parameters, determines whether dredged material may or may not be re-disposed of in saline waters. For comparison, the results of the ZBT in the Beneden-Zeeschelde (Lower Sea Scheldt) are also displayed.

Triad assessment in the Flemish part of the Scheldt estuary

In 2008 none of the assessed water bodies in the Flemish part of the Scheldt estuary (NOPSE-study, see fact sheet of the measurement) achieved the highest triad score 'unpolluted' (see figure 6). This statement however only applies to about one third of the water body sediments since each sediment is sampled every four years.

In the period 2004 – 2007, 3 of the total 61 studied sediments were not polluted. The proportion of highly contaminated sediments decreased from 70% to 54% in the period 2000-2007. Consequently, the share of 'contaminated' sediments increased. In 2008 this trend seems to continue, however further monitoring has yet to confirm this for the remaining sediments in the Flemish part of the Scheldt estuary.



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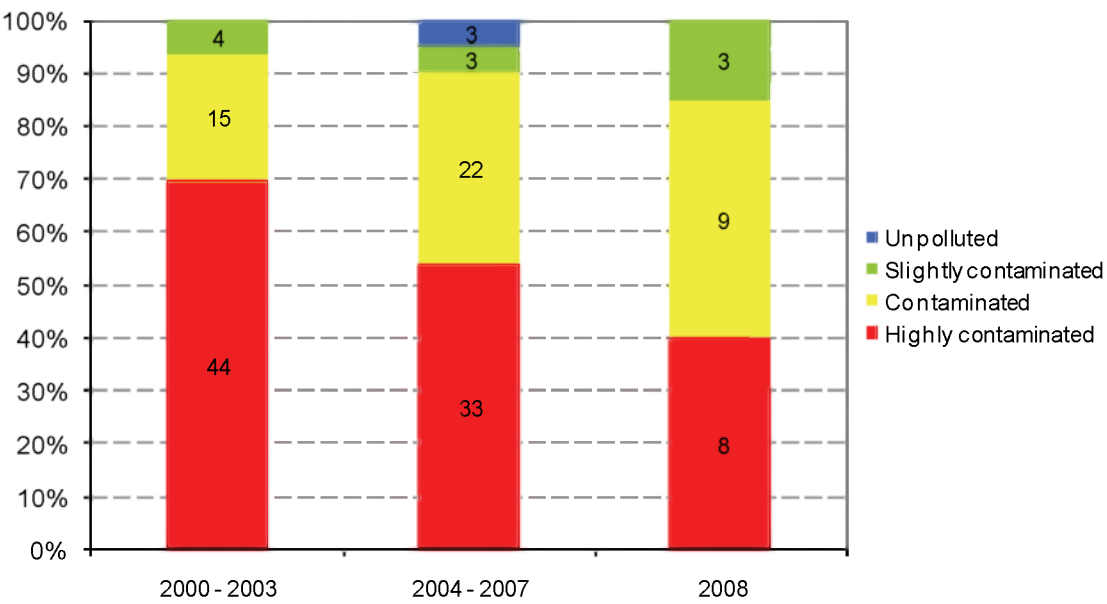


Figure 6: Percentage of sampling points in the Scheldt estuary (Flemish part) according to the four classes of triad assessment for sediment. The numbers in the bars refer to the absolute number of sampling points. Source: Flemish Environment Agency.

Salt-Dredging-Test in the Westerschelde (and Beneden-Zeeschelde)

In 2009, all the sampling points in the Westerschelde comply with the ZBT for quality of re-disposal of dredged material in salt water (see figure 7). Historically (before 1994) the chemical pollutant load of the sediments (at selected dredging sites) in the Westerschelde was much higher. In the report "Monitoring the impact of the expansion 48' / 43'" [12], however, it was noted that these samples were taken annually in and around barriers that are regularly dredged to maintain the navigation channel at the required depth. This implies that they are not representative of the chemical quality of the sediments in the Westerschelde as a whole and e.g. the low dynamic (low current flow), shallow waters where contaminated sediments are potentially deposited.

The comparison with data from the ZBT test in the Beneden-Zeeschelde (Lower Sea Scheldt) is an indication that the current problems of contaminated dredging sites (and therefore possibly the sediment quality), is mainly situated in the Flemish part of the Scheldt estuary.

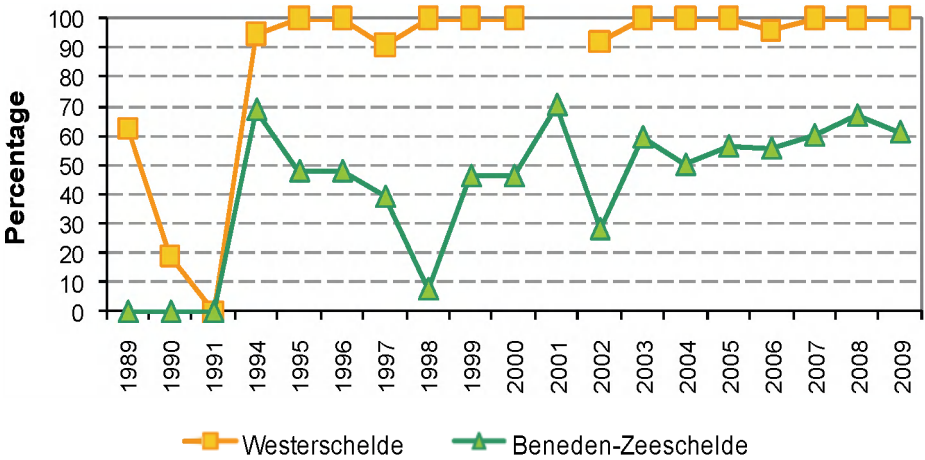


Figure 7: Trend in the percentage of sampling points in the Westerschelde and Beneden-Zeeschelde that meets the Salt-Dredging-Test (ZBT) for disposal of dredged sediments in salt waters. Source: Flemish Environment Agency.



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Pollutants in the food web of the Scheldt estuary

The Department of Public Works collects since 1979 data on contaminants in mussels (*Mytilus edulis*) and flounder (*Platichthys flesus*) from the Westerschelde and other locations in the Netherlands. The Institute for Nature and Forest Research started in 1994 with the monitoring of environmental pollutants in eel (*Anguilla anguilla*) from the Flemish part of the Scheldt estuary (and other water bodies in Flanders). This monitoring was discontinued in 2009. There is currently no joint, cross-border monitoring program for environmental pollutants in biota in the Scheldt estuary and the existing methods are not synchronized.

In this summary, the concentrations of three heavy metals (cadmium, mercury and lead), 7 standard or indicator polychlorinated biphenyls (PCBs 28, 52, 101, 118, 138, 153 and 180) and organochlorine pesticides: p, p'-DDE, p, p'-DDD and p, p'-DDT or TDE (abbreviated as "total DDT's") respectively in eel and mussel of the Flemish and Dutch part of the study is shown. This selection is a pragmatic approach based on the currently available standards (for more information, see the technical description of the measurement).

Heavy metals

The average concentrations of heavy metals cadmium (Cd), mercury (Hg) and lead (Pb) in eel from the Flemish part of the Scheldt estuary, show an erratic trend since 1994 (see figure 8). It should be noted that the number of sampling points fluctuates strongly from year to year and the locations of sampling points change over time (see also technical data from this measurement). Both in mussels from the Westerschelde and in eel from the Flemish part of the study area, the average concentrations of mercury and lead never exceeded European standards for consumption.

In the Westerschelde, the average concentration of these heavy metals in mussel has declined sharply since the 80s (see figure 9).

Only for cadmium in shellfish, there was historically a major problem in the Westerschelde which was significantly reduced in the 80s. In recent years, however the levels increased again (like the levels in the liver of flounder) and the average concentration of cadmium in mussels from the Westerschelde varies closely around the European consumption standard (1000 µg/kg).

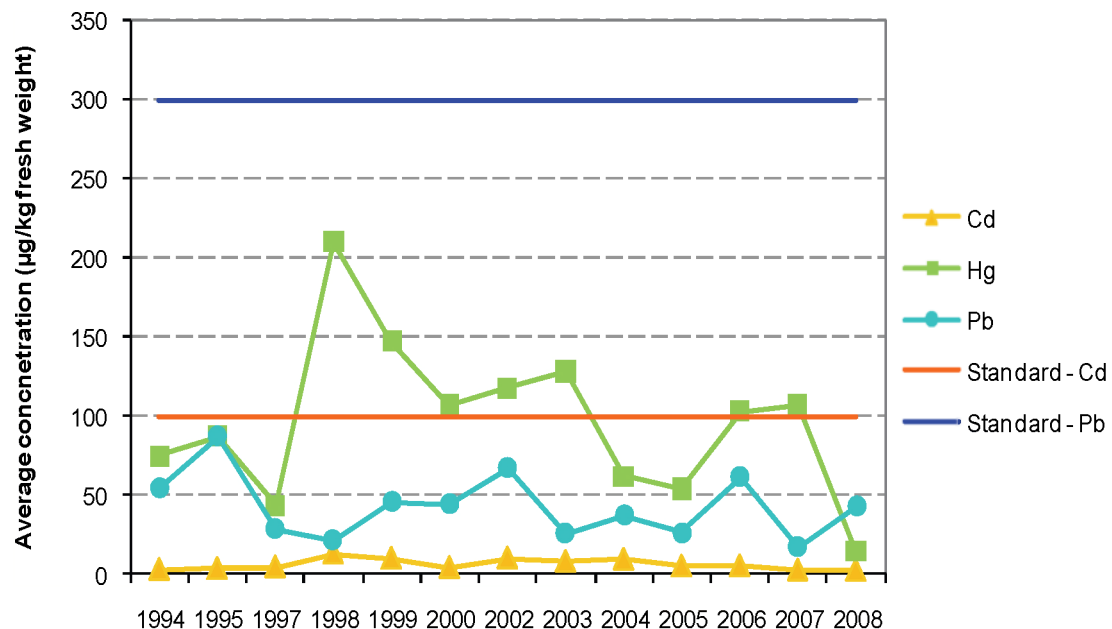


Figure 8: Annual average concentration (µg/kg fresh weight) of heavy metals: cadmium, mercury and lead in eels from the Flemish part of the Scheldt estuary. See the EU standards for food items for eel [13]. The standard for Hg is 1000 µg/kg and is above the chart maximum scale. Source: Institute for Nature and Forest Research.



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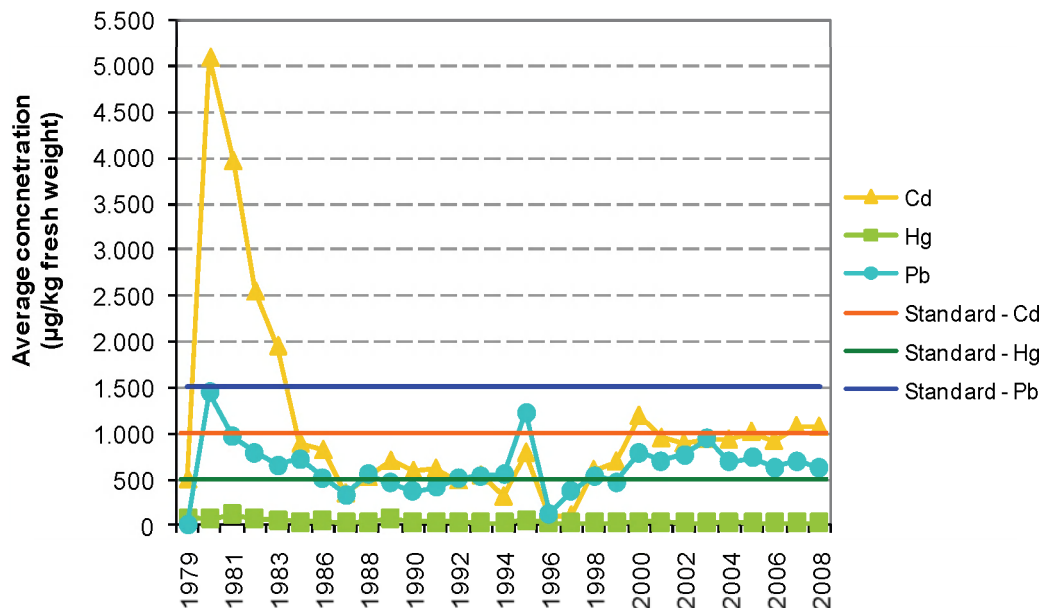


Figure 9: Annual average concentration ($\mu\text{g/kg}$ fresh weight) of heavy metals: cadmium, mercury and lead in mussels from the Westerschelde. See the EU standards for food items for bivalve molluscs including mussels [13]. Source: Directorate General for Public Works and Water Management (RWS), IMARES.

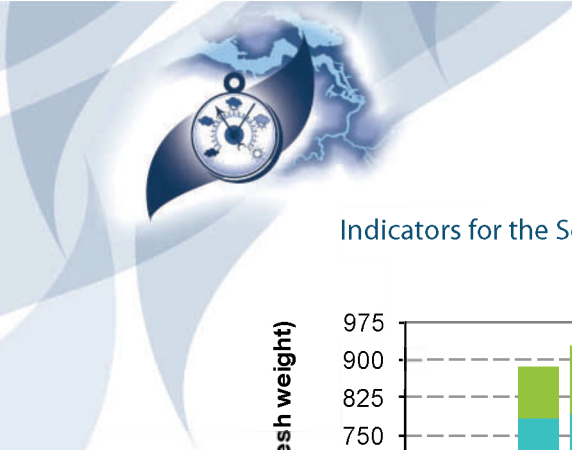
The European environmental quality standard for mercury (and its compounds) in fish, molluscs and other biota is $20 \mu\text{g/kg}$ fresh weight, about 25 or 50 times lower than the consumption norm for respectively mussel and eel. An evaluation has shown that both mussel from the Westerschelde and eel from the Flemish part of the Scheldt do not comply in any of the sampled years.

PCBs

The annual average concentration of 7 standard PCBs in eel from the Flemish part of the Scheldt estuary shows an erratic trend in the period 1994 to 2008 (see figure 10). Again here, the number and locations of sampling points change from year to year (see technical fact sheet of this measurement). In 1998, a peak of $930 \mu\text{g/kg}$ fresh weight was observed. In none of the sampling years, the Belgian consumption norm for the 7 standard PCBs in eel ($75 \mu\text{g/kg}$) was achieved, although in 2008 the concentration was not far off ($77 \mu\text{g/kg}$ fresh weight).

In the Westerschelde, the average concentrations of PCBs in mussel fell significantly during the period 1979 - 2004 (see figure 11). In the liver of flounder in the Westerschelde however an increased concentration was determined in the last years. The Netherlands has stipulated standards for each of the PCBs in fish products, in the legislation on marketable items ('warenwet'). These standards are met both in eel and mussel, but it must be noted that they are less strict than the Belgian consumption standards. For mussels from the Westerschelde, these Belgian standards were only exceeded on a few occasions in the 80s.

The average concentrations of these PCBs in eels from the Flemish part of the study area are classified, according to the reference values of the eel pollutant monitoring network, as 'divergent' ($183 \mu\text{g/kg}$ - $460 \mu\text{g/kg}$) to 'strongly divergent' ($> 460 \mu\text{g/kg}$), except in 2003.



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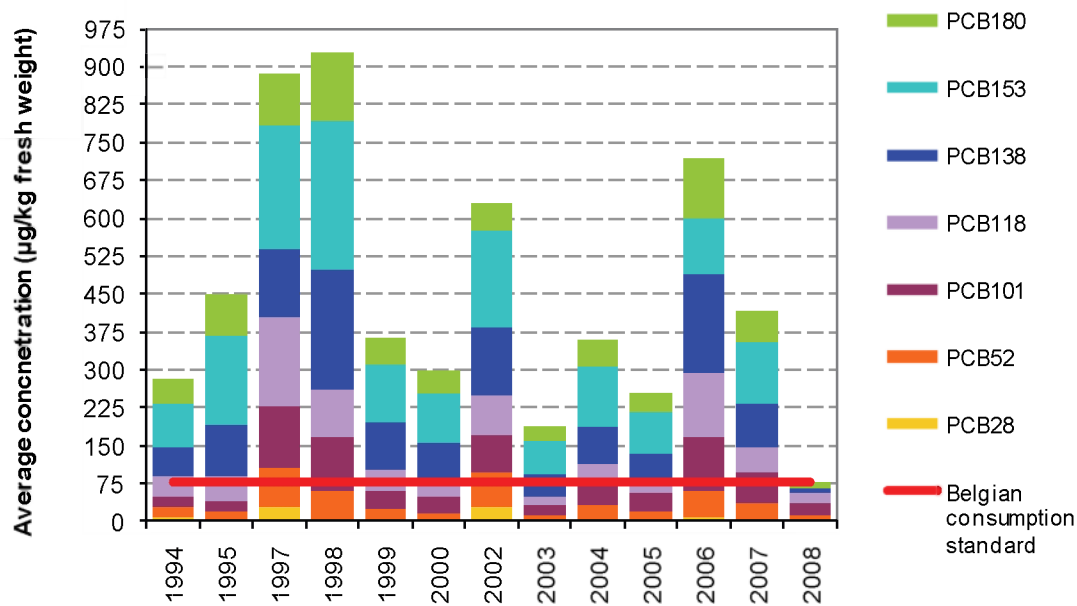


Figure 10: Annual average concentrations (µg/kg fresh weight) of 7 standard indicator PCBs in eel from the Flemish part of the Scheldt estuary. The Belgian consumption standard for the sum of PCBs in fish products is displayed in the graph. Source: Institute for Nature and Forest Research.

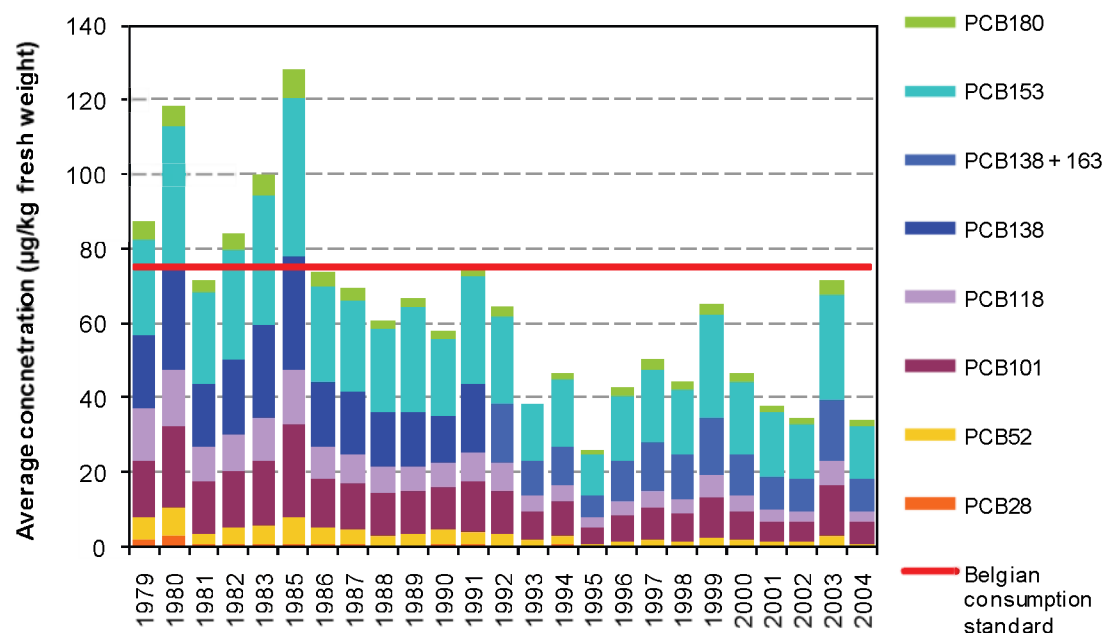


Figure 11: Annual average concentrations (µg/kg fresh weight) of 7 standard indicator PCBs in mussels from the Westernschelde. Since 1996, PCB 138 is reported together with PCB 163 (which is not part of the 7 standard PCBs). The values for PCB 138 that are presented in the measurements are therefore an overestimation. The Belgian consumption standard for the sum of PCBs in fish products is displayed in the graph. Source: Directorate General for Public Works and Water Management (RWS), IMARES.

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Pesticides

The annual average concentration of "total DDT" in eels from the Flemish part of the Scheldt estuary in 2008 decreased compared to the beginning of the measurements in 1994 (see figure 12). In the Westerschelde, the average content of "total DDT" decreased sharply in the period 1986-2008. Both the Westerschelde and the Flemish part of the Scheldt estuary remain under Europe's DDT consumption standard of 1000 µg/kg fresh weight [14].

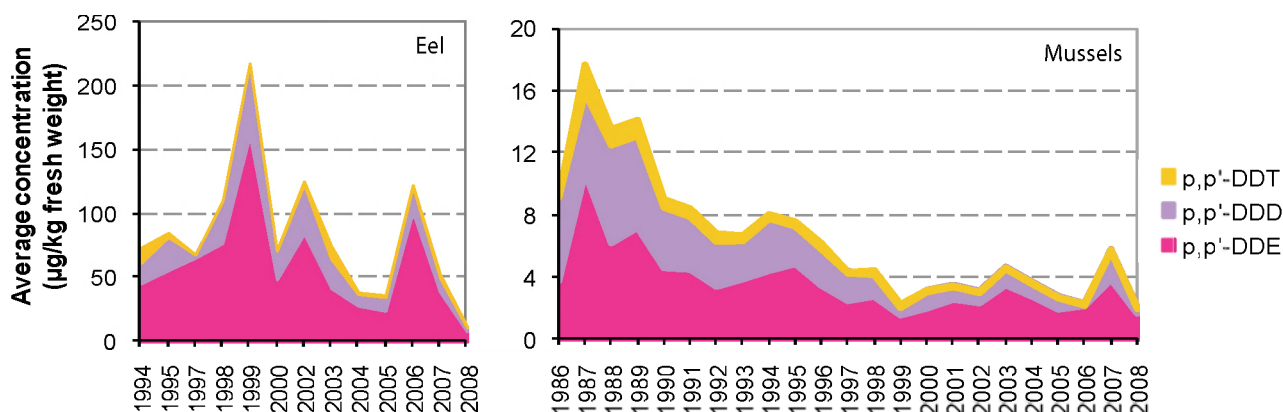


Figure 12: Annual average concentrations (µg/kg fresh weight) of organochlorine pesticides: p, p'-DDE, p, p'-DDD and p, p'-DDT or TDE (abbreviated as "total DDT's"). Left: eel in the Flemish part of the Scheldt estuary, right: mussels in the Westerschelde. European consumption standard for total DDT's in eel and mussel is 1000 µg/kg fresh weight. Source: Institute for Nature and Forest Research, Directorate General for Public Works and Water Management (RWS), IMARES.

Where do the data come from?

- The data on the load of nutrients N and P in surface waters in Flanders were provided by the Flemish Environment Agency VMM. The Dutch data come from the Statistics Netherlands (CBS) and The Netherlands Pollutant Release and Transfer Register (National Institute for Public Health and the Environment RIVM, Directorate General for Public Works and Water Management (RWS), Wageningen University, Alterra, SenterNovem, TNO and others).
- Data on bathing water quality of specific points in Europe (including the Scheldt estuary) are provided by the European countries and are redistributed through an online application on the website of the European Environment Agency (EEA).
- The sediment quality in the Flemish part of the Scheldt estuary is determined by the VMM in the sediment monitoring network. In the Netherlands there is currently no specific monitoring on sediment quality in the Scheldt estuary. However, data are available on the chemical quality of dredged material in the context of the Salt-Dredging-Test ZBT.
- Data on environmental pollutants in mussels and flounder in the Westerschelde are collected by Wageningen Institute for Marine Resources and Ecosystem Studies commissioned by RWS under the JAMP (Joint Assessment and Monitoring Program) of the OSPAR Commission. The data on environmental pollutants in eel in Flanders until 2009 were collected by the Institute for Nature and Forest Research through the eel pollutant monitoring network.



Opportunities and threats

The loads of environmental pollutant substances in the surface water, sediments and food web in the Scheldt estuary have generally fallen in the recent decades. This suggests that measures e.g. a declining use of pesticides, the purification of waste water (see indicator 'opportunities for nature') and technological improvements in production processes are achieving results. The European Directives require Member States to further tackle these issues in a similar - and where possible cross-border approach.

Nevertheless, policy and research are facing major challenges. National River Basin Management Plans for the Scheldt and the Scheldt International Management Plan [15], drawn in the context of the WFD contain a comprehensive action program to further reduce the impact on the aquatic environment by pollutants. The eutrophication problem is a cause of continuing concern and requires additional efforts from land users in the coming years to achieve targets in terms of surface water quality. In the Nature Plan for the Scheldt estuary [16] it is also indicated that measures which give space to the river, are necessary for achieving the objectives in terms of naturalness and enhancing the natural purification of the river. Such measures are also part of the Flemish Sigma Plan and the Dutch 'Natuurpakket' (Nature plan) (see indicator 'protection and development of natural areas').

The process of exchange of pollutants between sediment, water column and biota is currently still largely unknown. Harmonization of monitoring in the various water components (sediment, water column and food web), with attention for the possibility of pollutants to accumulate in biota and humans, is required [17]. There is a need for a binding framework concerning standards for environmental pollutants in organisms. Existing standards are often underpinned by different methods or science, and are only available for a limited number of substances (Belpaire, C., pers. comm.). Sustainable cleaning techniques of the river sediments require more adequate research into the nature of the contamination and the depth at which contamination occurs. At present, the quality of 54% of the rehabilitated sediments in Flanders remains at the same level as before, and in 17% of the cases a negative trend is even observed [18]. In the Netherlands action is taken when the riverbed sediments represent an obstacle to the user functions or objectives of the water system, which are related to water quality.

The pollutants considered here are known and measured substances for which standards are often available (in spite of the issues related to these standards). It is becoming increasingly clear that only the tip of the (pollution) iceberg is being considered. Many substances are not measured or there are no good methods available whereas other substances may even not be known or detected.

The specifications of the measurements in this indicator further describe the definitions, data and methodology, and their limitations. The fact sheets are available at: <http://www.scheldemonitor.be/indicatorfiche.php?id=12>

Integration with other indicators / measurements?

The degree of strain on surface water, sediments and biota in the Scheldt estuary by environmental pollutants is closely linked to population pressure and intensive use of space (see indicator 'population pressure'). The economic activities (see indicators 'socio-economic importance of ports', 'environmental effects of ports & shipping', 'soil interfering activities', 'socio-economic importance of residential tourism', and 'fisheries') and surface water quality coming in from other regions of the Scheldt estuary and/or river basin, are also determining factors.

Although the water quality in the Scheldt estuary has been slowly improving in recent years, e.g. in terms of oxygen balance, the reduction of the loads of environmental pollutants is still having insufficient effect. In many places a good ecological and even chemical water quality is still far from reality (see indicator 'surface water quality'). Contamination of sediment, water and the food web also affects the reproduction of organisms such as fish-eating birds and seals [19]. High concentrations of pollutants in biota reduce the chance of a good conservation status of the European Habitats and Birds species and/



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or local focus species (see indicator 'status of species and habitats').

Reducing the pollution of the aquatic environment creates new opportunities, e.g. for fisheries in the Scheldt estuary (see indicator 'fisheries'). The LTV is also committed to an estuary where active (sailing, swimming, surfing) and passive (sun, watching boats, birds and seals) ways of enjoyment are possible. Qualitative bathing waters and the (re) opening of bathing waters in the Flemish part of the Scheldt, adds value to the estuary and has a positive impact on tourists and permanent resident or visitors (see indicators 'socio-economic importance of residential tourism', '(opportunities for) recreation on water and land').

How to cite this fact sheet?

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Online available at <http://www.scheldemonitor.be/indicatoren.php>

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- [3] Urban Wastewater Treatment Directive (91/271/EEC):
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- [4] Nitrates Directive (91/676/EEC): http://ec.europa.eu/environment/water/water-nitrates/index_en.html
- [5] Bathing Water Directive (76/160/EEC, expires after December 2014) and Bathing Water Directive (2006/7/EC)
<http://ec.europa.eu/environment/water/water-bathing/>
- [6] Water Act: <http://www.helpdeskwater.nl/wetgeving-beleid/wetten/waterwet/>
- [7] Decree on Integrated Water Policy
<http://www.ciwvlaanderen.be/wetgeving/vlaamse-wetgeving-1/het-decreet-integraal-waterbeleid-een-mijlpaal-in-het-vlaamse-waterbeleid>
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