

Risk assessment of dioxin-contaminated sediments

Ecological risks

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Parts of the Noordzeekanaal are contaminated by dioxins due to an accident more than 40 years ago. For nautical reasons, parts of the channel have to be dredged. To assess the ecological risk of the sediments, remaining after the dredging is completed, an extensive field study was carried out.

Methods

Sediment samples were collected from the bed sediment beneath the layer to be dredged and from the surface layer from the areas not to be dredged. The sediment samples were tested with 4 bioassays (Table 1).

Table 1 Summary of the bioassays.

Test	No of samples	Parameter	Risk analysis
Microtox® solid phase	100	Toxicity units	Dutch indicator values for dredged materials
<i>Corophium volutator</i>	125	Mortality	Significance from control
DR-CALUX	191	Dioxin-like toxicity	Dutch indicator values for dredged materials
<i>Nereis virens</i> accumulation	52	Bioaccumulation	Dutch limits for biomagnification (MTR)

* Tissues of ragworms (*Nereis virens*) were analyzed for dioxins (n=52), PAH, PCB and organochlorines (n=27) and for heavy metals (n=10).

Results

For the Microtox® Solid Phase test no toxicity was observed. In most of these samples, the silt fraction (<63 µm) was very high, dimming possible effects caused by contaminants.

With the *Corophium volutator* test (Figure 1), highly significant mortality (p<0.01, mortality >40%) was found in 53% of the samples, while in 34% of the samples mortality was comparable to reference tests (p>0.05, mortality <20%).

The DR-CALUX response exceeded the indicator value for dredged material (>100 ng/kg) in 56% of the samples. The highest response was 8800 ng/kg. For 29% of the samples the response was <25 ng/kg, considered ecologically safe (Figure 2).

For the *Nereis virens* accumulation test, biomagnification in tissues was >95% determined by dioxins accumulation. In 60% of the samples an unacceptable ecological risk was observed. The observed dioxin accumulation showed a good correlation with DR-CALUX (Pearsons r 0.814: p<0.0001).

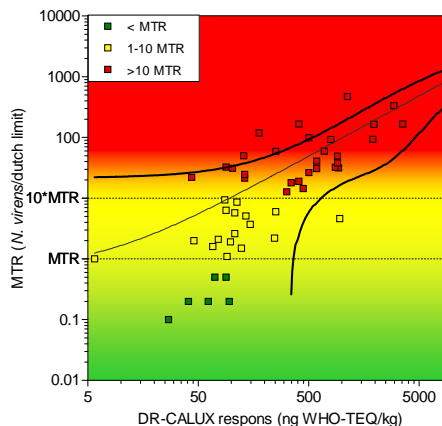


Figure 3 Regression of DR-CALUX and measured *N. virens* concentrations of dioxins in tissues.

The correlation is expressed by regression techniques (Figure 3). Due to the large confidence interval, clear risk limits could not be derived at. Therefore, the limits were established by comparing calculated results with measured dioxin concentrations in tissues (Table 2). The calculated accumulation exceeded the unacceptable ecological risk limits in 41% of 191 samples. For 45% samples no ecological risk was indicated (Figure 4).

Table 2 Summary of the limits established for biomagnification based upon the regression curve for dioxins and measured concentrations in *N. virens*. Given are the measured DR-CALUX concentrations divided in classes, number of samples tested in bioassays, % of samples corresponding with the class and the concluding ecological risk.

Measured DR Calux (ng WHO-TEQ/kg dw)	<50	50-100	100-350	>350
No. of samples (<i>N. virens</i>)	5	11	16	20
< MTR (0.614 ng/kg)	40%	36.4%	0%	0%
1-10 MTR	40%	36.4%	37.5%	5%
> 10 MTR	20%	27.3%	62.5%	95%

Conclusions

- The combination of tests applied, yielded a clear picture of the ecological risk that the remaining sediment will pose after the dredging operation is completed.
- DR-CALUX is more conservative than biomagnification.
- *C. volutator* test was complementary to DR-CALUX and *N. virens* accumulation tests.
- Combining results, it was concluded, that 70% (133 samples) posed an unacceptable ecological risk and 16% (31 samples) were 'ecologically safe'.

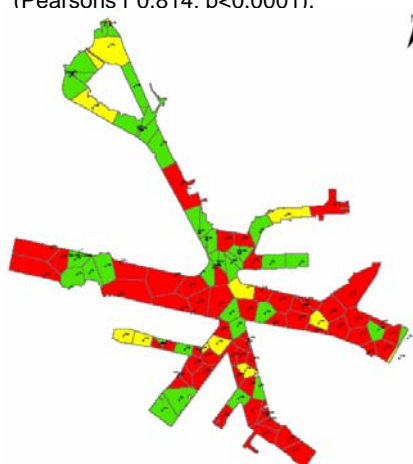


Figure 1 Risk chart: mortality of *C. volutator*.

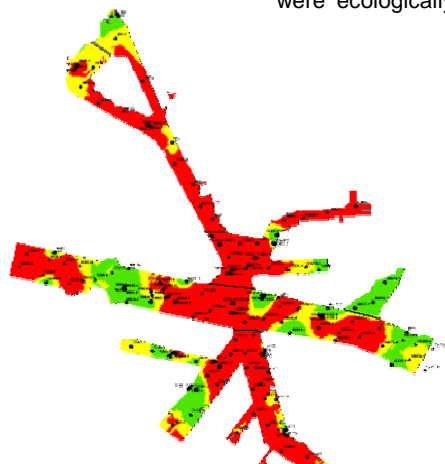


Figure 2 Risk chart: DR-CALUX response.

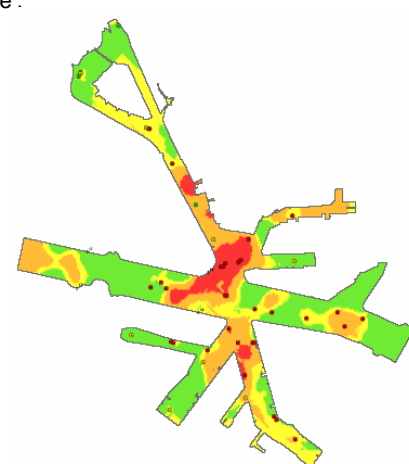


Figure 4 Risk chart: biomagnification of dioxins in *N. virens* based on DR-CALUX responses (area) and on measured concentrations (dots)