Ecological Impacts of Systemic Pesticides - 16 April 2013

Macro-invertebrate decline in Dutch surface waters polluted with imidacloprid

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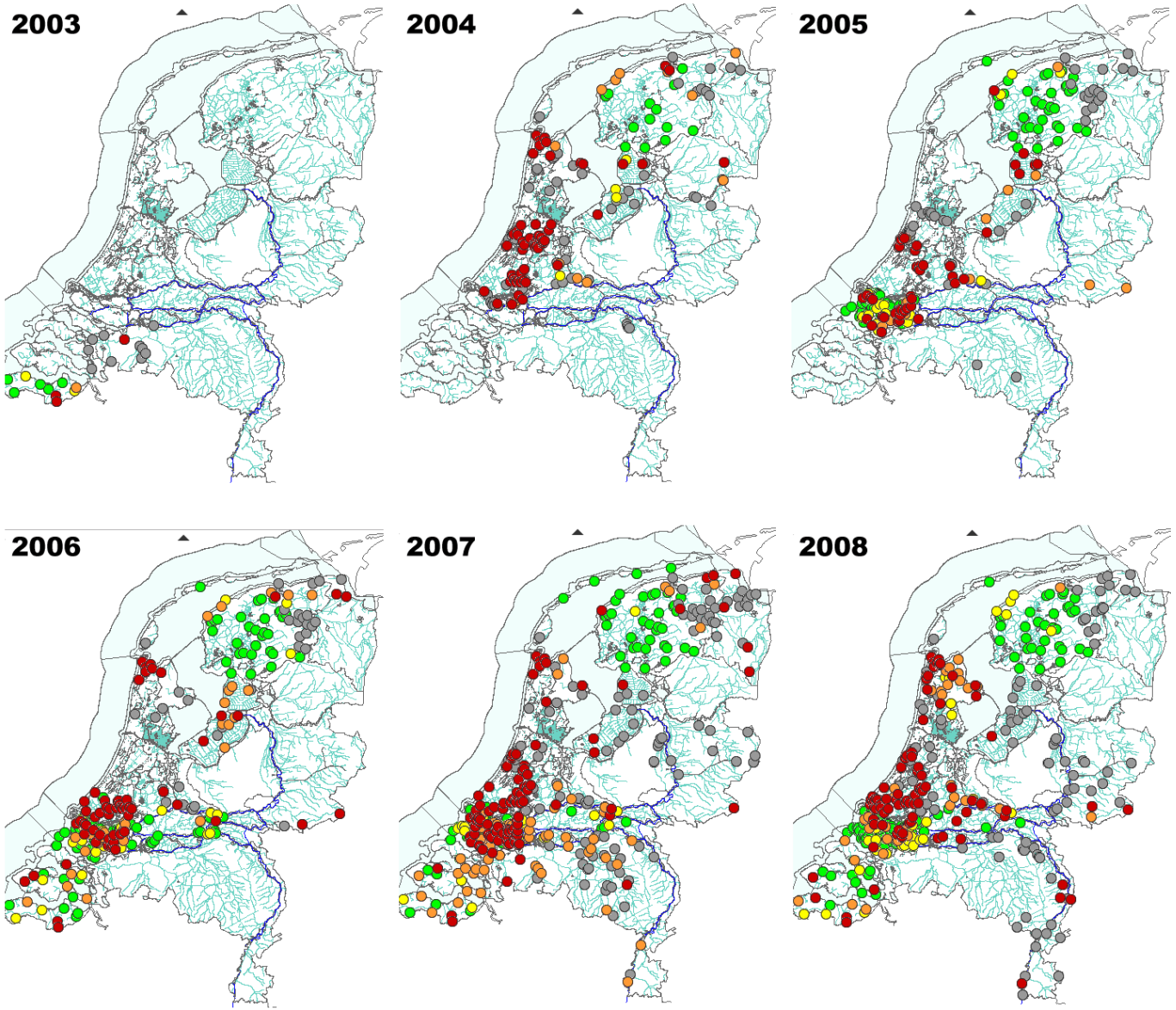
Only 1.6 to 20% of applied neonicotinoid is absorbed by the growing crop (Sur & Stork 2003)
80 to 98.4% leaches to soil & water!

Since 2004, Netherlands surface water is heavily polluted with Imidacloprid



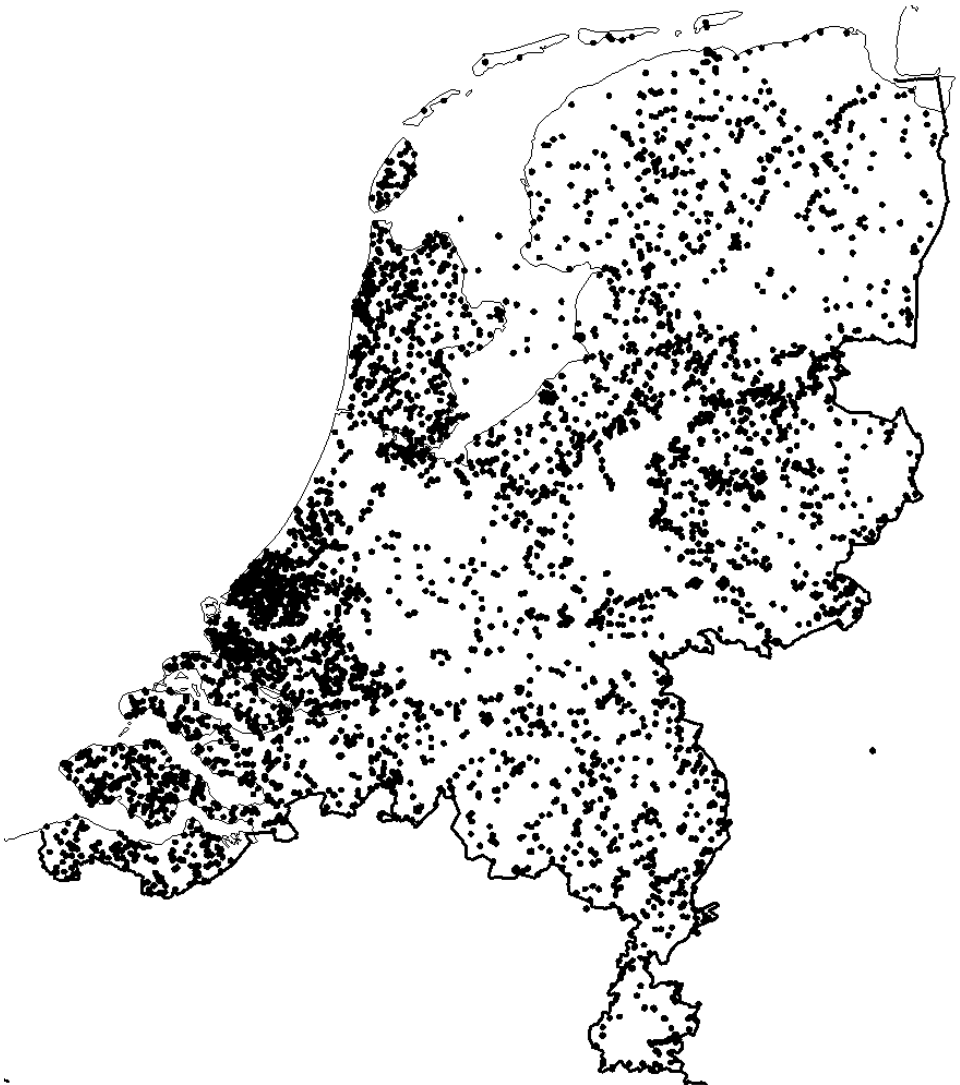
Imidacloprid in Dutch surface water 2003-2008
Exceedances of the Maximum Tolerable Risk standard
MTR = 13 nanogram / liter

www.bestrijdingsmiddelenatlas.nl

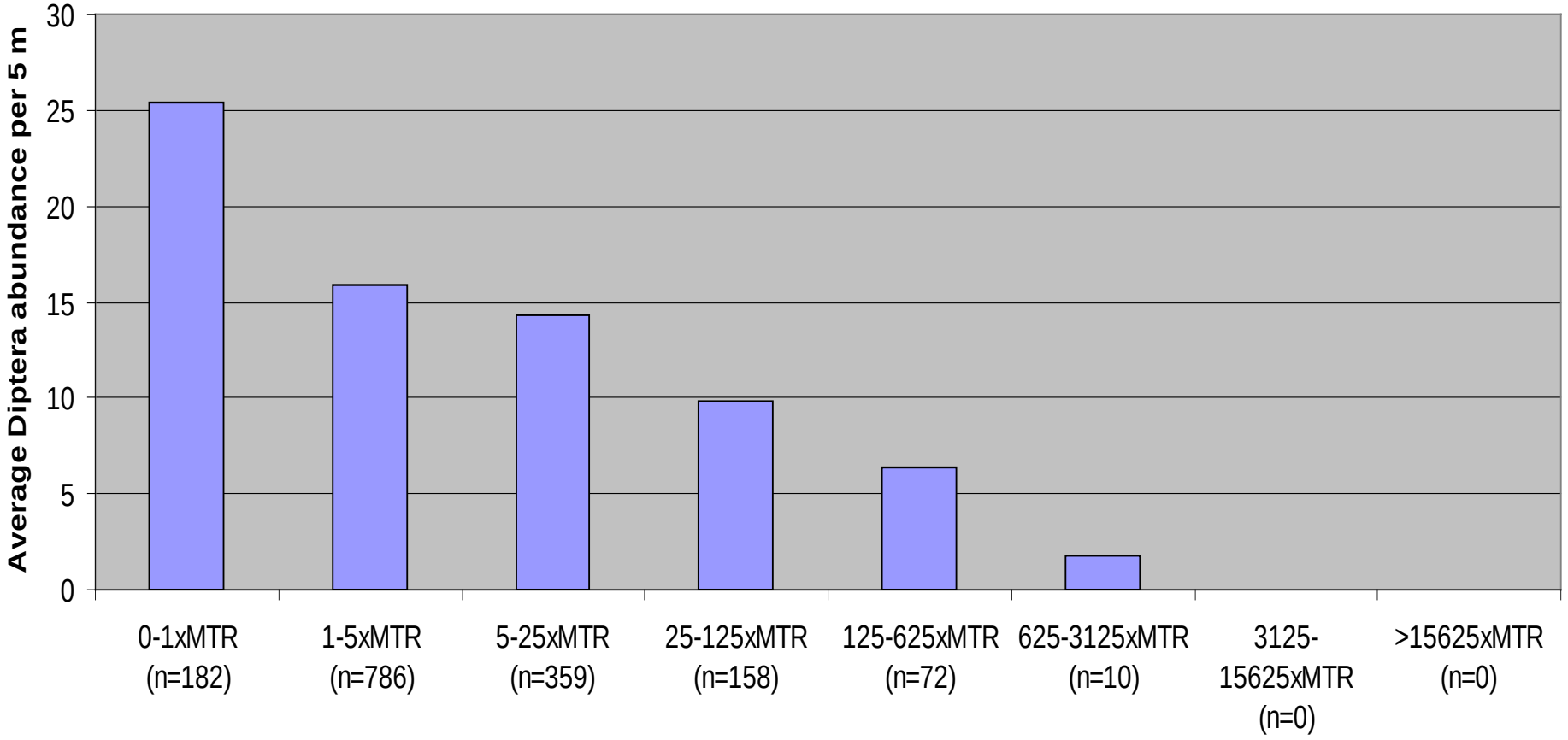
2010 study Van Dijk: http://www.bijensterfte.nl/sites/default/files/FinalThesisTvD.pdf

Positions of 579 imidacloprid measurement locations

Positions of 4479 Limno Diptera measurement locations



Diptera abundance versus nearby imidacloprid concentrations



Average of imidacloprid measurements within a radius of 2 km and a timeframe of minus 160 days relative to the place and time of each diptera abundance measurement (1x MTR = 13 ng/liter)

http://www.bijensterfte.nl/sites/default/files/FinalThesisTvD.pdf

Follow up study 2012

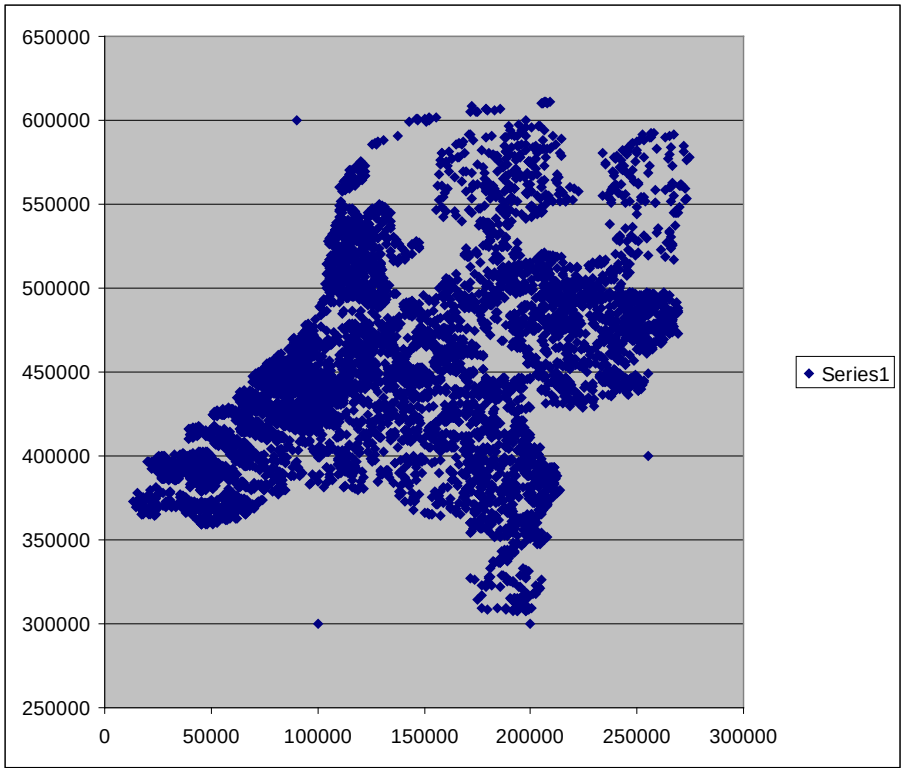
- New dataset constructed from raw data obtained from 23 of 26 NL water boards.
- >600000 data points (x, y, t, species, abundance) of macro invertebrates
- 18898 points with IMI data within 1 km radius & < 160 days time difference
- Much more species included (4009 species from 92 orders) compared to Van Dijk 2010 MSc Thesis

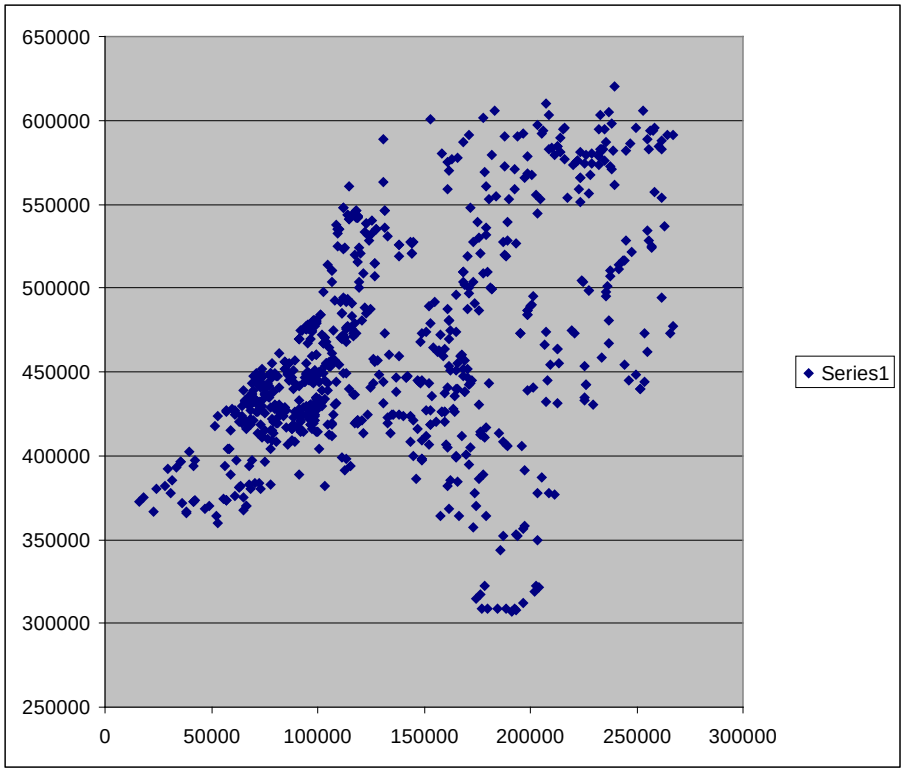
Significant negative relationship between species abundance and imidacloprid concentration found for:

- All orders pooled
- Amphipoda (crustaceans)
- Diptera (true flies)
- Ephemeroptera (mayflies)
- Isopoda (crustaceans)
- Odonata (dragonflies & damselflies)
- Basommatophora (snails)

For one order we found significant positive relation: Actinedida

Unique locations in our new species abundance database (left, 7381 locations) and imidacloprid database (right, 801 locations), years 1998, 2003-2009 pooled





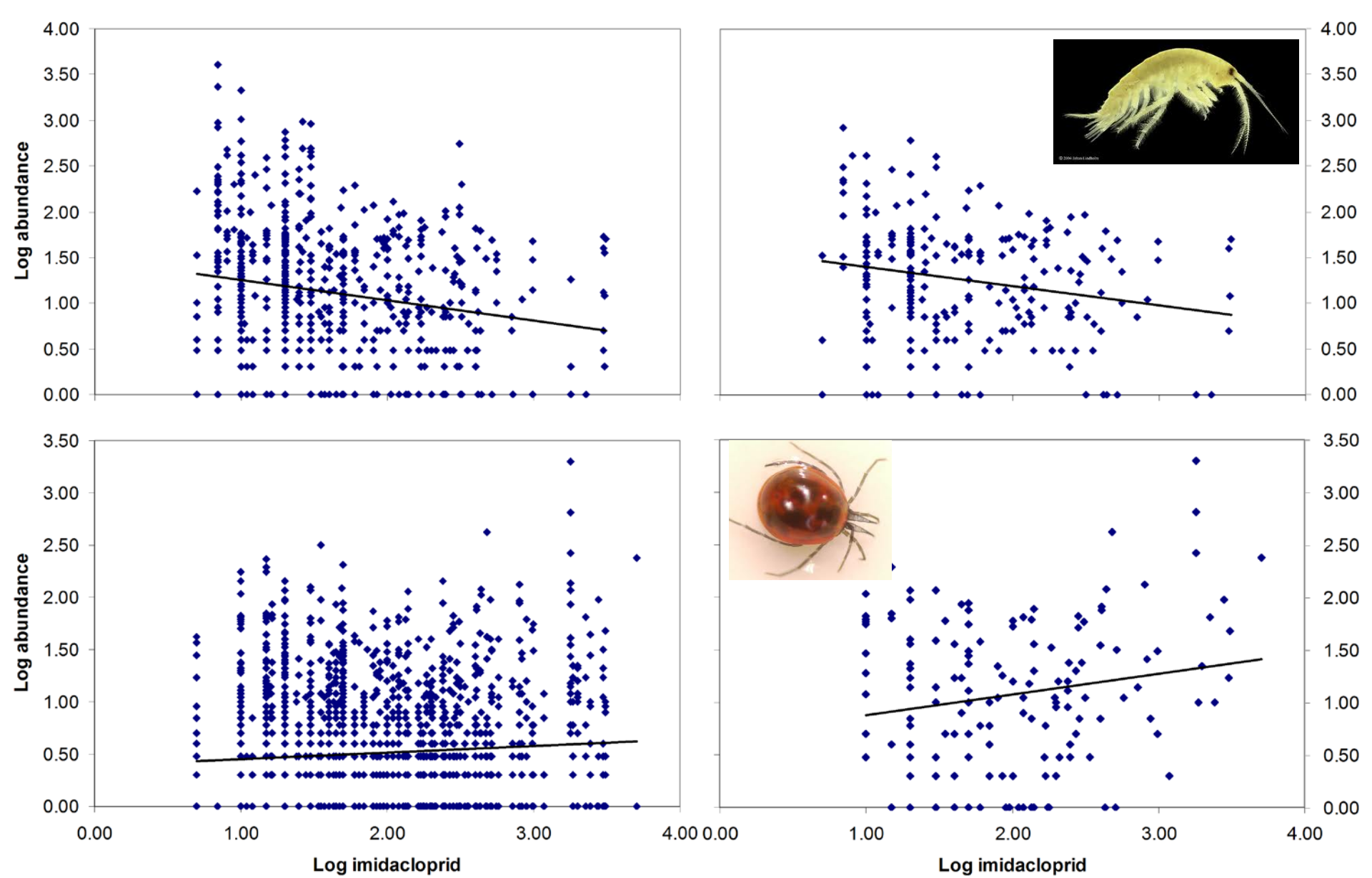
Impact of imidacloprid pollution

Significant negative correlation for abundance of:

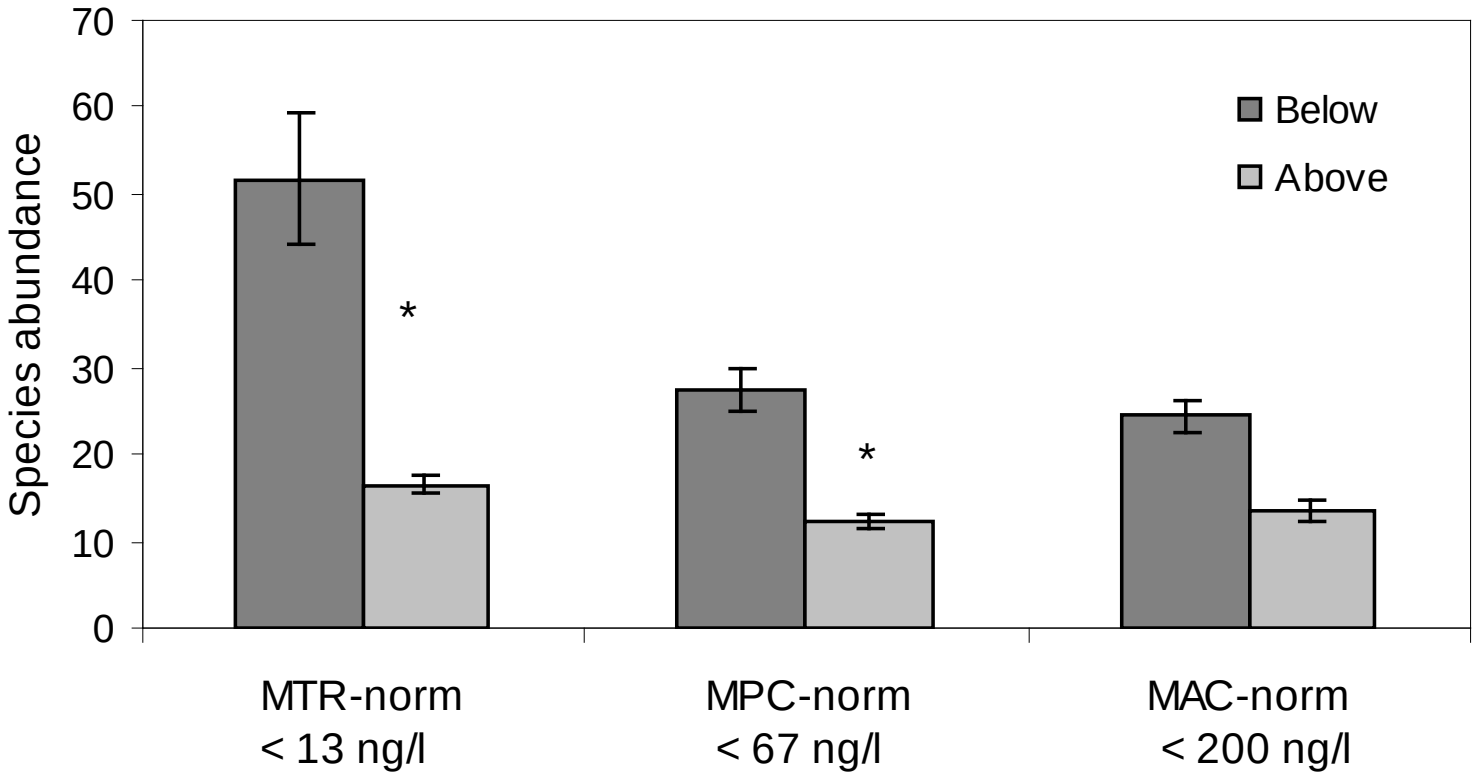
- Amphipoda
- Basommatophora
- Diptera
- Ephemeroptera
- Isopoda
- Odonata
- All marcro invertebrates pooled

Positive correlation:

- Actinedida (water mites)



log10 imidacloprid concentration (ng/l) versus log10 macro-invertebrate species abundance in surface water for a) Amphipoda, b) its most abundant species *Gammarus tigrinus*, c) Actinedida and d) its most abundant species *Limnesia undulata*.



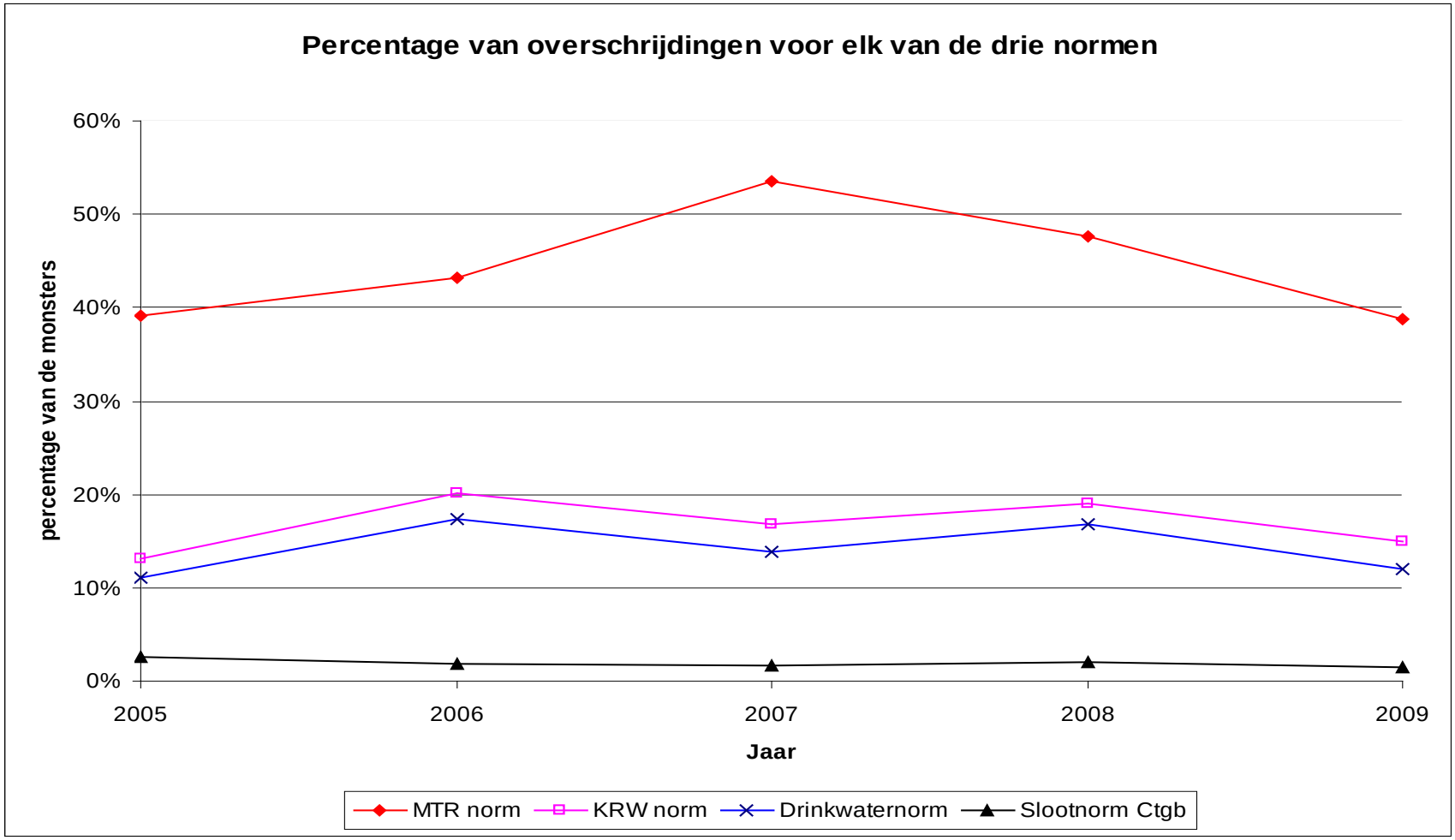
Mean and standard error of aquatic macro-invertebrate species abundance at median imidacloprid concentration in surface water below and above the level of different water quality norms. Dependent variables were tested with the Mann Whithney test separately. * Indicates significant differences at $p<0.05$.

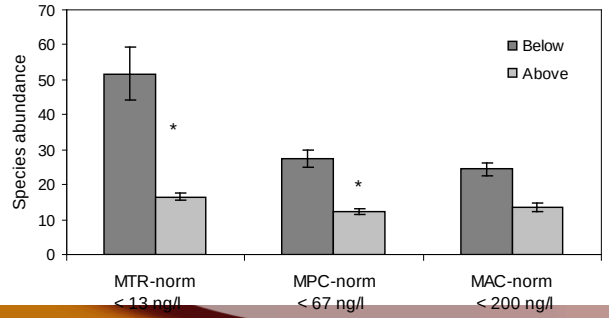
Violations of IMI standards surface water NL

Year	Percentage samples exceeding MTR (>=13 ng/l)	Percentage samples exceeding KRW (>=67 ng/l)	Percentage samples exceeding drinkingwater norm (>=100 ng/l)	Percentage samples exceeding Ctgb "ditchnorm" (>=1470 ng/l)	Highest concen-tration found (ng/liter)	Median (ng/l)
2005	39% (*n*=505)	13% (*n*=898)	11% (*n*=901)	2.6% (*n*=917)	320000	180
2006	43% (*n*=811)	20% (*n*=1073)	17% (*n*=1074)	1.8% (*n*=1090)	38000	80
2007	54% (*n*=1031)	17% (*n*=1839)	14% (*n*=1842)	1.6% (*n*=1876)	54000	90
2008	48% (*n*=1224)	19% (*n*=1932)	17% (*n*=1983)	1.9% (*n*=2053)	94000	70
2009	39% (*n*=1529)	15% (*n*=2072)	12% (*n*=2074)	1.4% (*n*=2133)	12000	60

Average 2005-2009: **45%** of all samples (*n*=5100) on all (*n*=579) Dutch measurement locations had imidacloprid concentrations that **exceed the MTR** (>13 ng/liter)

(MTR="Maximaal Toelaatbaar Risico" maximum tolarable risk)





Compliance with 13ng/l IMI norm might increase macro invertebrate abundance by a factor 3 in about 45% of NL

Bradford Hill Causality Criteria is imidacloprid the cause?

1.	Strength of association	high
2.	Consistency	high
3.	Specificity	many co-causes
4.	Temporality	yes
5.	Biological gradient	strong
6.	Biological plausibility	toxicology well known
7.	Biological coherence	high
8.	Experimental evidence	lab & mesocosms
9.	Analogy	yes

Causal? Clear & convincing evidence

Conclusions

- Current large scale use of imidacloprid in Netherlands has major adverse effects on non-target aquatic macro invertebrates (70% reduction in abundance!).
- There is permanent leaching of IMI year round from fields to surface water
- Meeting the MTR is only possible by a drastic reduction of the use: annual use should be reduced by at least 90%.

Abstract

Imidacloprid is one of the most widely used insecticides in the world. Its concentration in surface water exceeds the water quality norms in many parts of the Netherlands. Several studies have demonstrated harmful effects of this neonicotinoid to a wide range of nontarget species. Therefore we expected that surface water pollution with imidacloprid would negatively impact aquatic ecosystems.

Availability of extensive monitoring data on the abundance of aquatic macro-invertebrate species, and on imidacloprid concentrations in surface water in the Netherlands enabled us to test this hypothesis. Our regression analysis showed a significant negative relationship ($P < 0.001$) between macro-invertebrate abundance and imidacloprid concentration for all species pooled. A significant negative relationship was also found for the orders Amphipoda, Basommatophora, Diptera, Ephemeroptera and Isopoda, and for several species separately.

The order Odonata had a negative relationship very close to the significance threshold of 0.05 ($P = 0.051$). However, in accordance with previous research, a positive relationship was found for the order Actinedida.

We used the monitoring field data to test whether the existing three water quality norms for imidacloprid in the Netherlands are protective in real conditions. Our data show that macrofauna abundance drops sharply between 13 and 67 ng l^{-1}. For aquatic ecosystem protection, two of the norms are not protective at all while the strictest norm of 13 ng l^{-1} (MTR) seems somewhat protective.

In addition to the existing experimental evidence on the negative effects of imidacloprid on invertebrate life, our study, based on data from large-scale field monitoring during multiple years, shows that serious concern about the far-reaching consequences of the abundant use of imidacloprid for aquatic ecosystems is justified.