The Systemic Insecticides: A Disaster in the Making

Dr. Henk Tennekes

Hampshire Beekeepers Association Convention
10 November 2012
“Knowing what I do, there would be no future peace for me if I kept silent...”

Rachel Carson

• Henk Tennekes graduated from the Agricultural University of Wageningen, The Netherlands in 1974 and performed his Ph.D. work at Shell Research in Sittingbourne in the UK.

• He worked at the German Cancer Research Centre in Heidelberg from 1980-1985, where renowned pharmacologist and oncologist Hermann Druckrey became his mentor.

• In 2009, Tennekes discovered that the dose response characteristics of the toxicity of widely used neonicotinoid insecticides to arthropods were strikingly similar to those of genotoxic carcinogens. The effects of these compounds are reinforced by exposure time.

• Realising the dire consequences of environmental pollution with these insecticides, Tennekes decided to write a book to warn the general public about an impending environmental catastrophe.
Das Ende der Artenvielfalt: Neuartige Pestizide töten Insekten und Vögel

Autor: Dr. Henk Tennekes  |  Illustrationen: Ami-Bernard Zillweger
Herausgeber: Bund für Umwelt und Naturschutz Deutschland e.V. (BUND)
The Legacy of Rachel Carson

Silent Spring (1962)

- In 1962, the American biologist Rachel Carson published her book "Silent Spring", in which she describes rapidly declining biodiversity caused by widespread use of pesticides, such as DDT.

- "Silent Spring" remains one of the most effective denunciations of industrial malpractice ever written and is widely credited with triggering popular ecological awareness in the US and Europe.
The Legacy of Rachel Carson

Silent Spring (1962)

- At the Women's National Press Club, Rachel Carson denounced the links that had been established between science and industry:

  "When a scientific organisation speaks," she asked, "whose voice do we hear – that of science or of the sustaining industry?"

- The question remains as pertinent today as it did in 1962
Nor have matters improved. Neonicotinoids, insecticides used in seed dressing, have been linked to colony collapse disorder in honeybees, a condition that already in 2007 alone saw 800,000 hives wiped out in the US.
DDT Becomes Concentrated In Food Chains

• DDT is highly lipophilic and only slowly metabolised, and becomes concentrated as it passes through a food chain
• The hazard of DDT to non-target animals is particularly acute for those species living at the top of food chains
• Carnivores at the ends of longer food chains (e.g. ospreys, pelicans, falcons, and eagles) suffered serious declines in fecundity and hence in population
• The use of DDT was banned (1972) in the United States
Neonicotinoids Break Food Chains And May Have Adverse Effects on Human Health, Especially On The Developing Brain

- Neonicotinoid insecticides that are currently in use are water soluble (hydrophilic) and permeate the whole plant
- Advantage: Application rates are much lower than for traditionally used insecticides
- Catastrophic Disadvantages: Non-target insects such as honey bees or butterflies that collect pollen or nectar from the crop are poisoned
- Moreover, neonicotinoids may leach from soils, threatening non-target invertebrates in general. Breaking one link on the food chain means that all of the organisms above that link are in threat of extinction
- Neonicotinoids as well as nicotine directly act on mammalian nicotinic acetylcholine receptors (nAChRs), and residues of neonicotinoids in food may have various adverse effects on the human health, especially on the developing brain
Lethal Effect of Imidacloprid on Honey Bees
Toxicity Is Reinforced By Exposure Time


- The lower the exposure concentration, the longer the latent period up to a lethal effect, the lower the lethal dose
- The dose: response relationship is a Druckrey-Küpfmüller equation

\[ \ln T50 \text{ (hrs)} = 5.11 - 0.22 \ln C \text{ (µg. L}^{-1} \text{ or kg}^{-1}) \]
or
\[ C \times T50^{4.5} = \text{constant} \]

<table>
<thead>
<tr>
<th>Concentration C (µg/L)</th>
<th>Latent Period T50 (hours)</th>
<th>Lethal Dose (µg/L x hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>57</td>
<td>48</td>
<td>2,736</td>
</tr>
<tr>
<td>37</td>
<td>72</td>
<td>2,664</td>
</tr>
<tr>
<td>10</td>
<td>173</td>
<td>1,730</td>
</tr>
<tr>
<td>1</td>
<td>162</td>
<td>162</td>
</tr>
<tr>
<td>0.1</td>
<td>240</td>
<td>24</td>
</tr>
</tbody>
</table>
Lethal Effect of Imidacloprid on the Ostracod *Cypridopsis vidua*

Toxicity Is Reinforced By Exposure Time


- The *lower* the exposure concentration, the *longer* the latent period up to a lethal effect, the *lower* the lethal dose

<table>
<thead>
<tr>
<th>Concentration (µg/L)</th>
<th>Latent Period (days)</th>
<th>Lethal Dose (µg/L x days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,000</td>
<td>0.9</td>
<td>3,600</td>
</tr>
<tr>
<td>250</td>
<td>2.3</td>
<td>575</td>
</tr>
<tr>
<td>64</td>
<td>3.3</td>
<td>211.2</td>
</tr>
<tr>
<td>4</td>
<td>5.2</td>
<td>20.8</td>
</tr>
</tbody>
</table>
The lower the exposure concentration, the longer the latent period up to a carcinogenic effect, the lower the carcinogenic dose.

<table>
<thead>
<tr>
<th>Daily Dose (mg/kg)</th>
<th>Latent Period (Days)</th>
<th>Carcinogenic Dose (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9,6</td>
<td>101</td>
<td>963</td>
</tr>
<tr>
<td>1,2</td>
<td>238</td>
<td>285</td>
</tr>
<tr>
<td>0,3</td>
<td>457</td>
<td>137</td>
</tr>
<tr>
<td>0,075</td>
<td>840</td>
<td>64</td>
</tr>
</tbody>
</table>

The Dose:Response Characteristics Of Genotoxic Carcinogens (Right) And Neonicotinoids (Left) Are Strikingly Similar

Druckrey-Küpfmüller Equations $C \times T_{50}^n = \text{constant}$, with $n \geq 1$

Risk Assessment of Neonicotinoids

C. Maus & R. Nauen (2011) Toxicology 280: 176-177

- Drs Christian Maus and Ralf Nauen of Bayer CropScience asserted that “there is no substantiation for concerns that effects like described by the Druckrey–Küpfmüller equation might entail a higher chronic toxicity than currently determined”.

- They refer to numerous studies providing evidence that “there is under realistic conditions no correlation between exposure of honey bees to imidacloprid-treated crops and increased colony mortality”.

Neonicotinoids are lethal to honeybees at infinitesimal exposure concentrations:

\[ \ln T_{50} \text{ (hrs)} = 5.11 - 0.22 \ln C \text{ (\(\mu g\). L-1 or kg-1)} \]

or

\[ C \times T_{50}^{4.5} = \text{constant} \]

<table>
<thead>
<tr>
<th>Food Source</th>
<th>Imidacloprid Content (ppb)</th>
<th>Expected Lethal Effect (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nectar</td>
<td>1</td>
<td>6.9</td>
</tr>
</tbody>
</table>
Current Toxicological Risk Assessment Can Lead To Serious Underestimates Of Actual Risk
Neonicotinoids Are A Case In Point

• The traditional approach to toxicity testing is to consider dose (concentration)-effect relationships at arbitrarily fixed exposure durations which are supposed to reflect ‘acute’ or ‘chronic’ time scales.
• This approach measures the proportion of all exposed individuals responding by the end of different exposure times.
• Toxicological databases established in this way are collections of endpoint values obtained at fixed times of exposure. As such these values cannot be linked to make predictions for the wide range of exposures encountered by humans or in the environment.
• An increasing number of researchers are using a variant of the traditional toxicity testing protocol which includes time to event (TTE) methods.
• This TTE approach measures the times to respond for all individuals, and provides information on the acquired doses as well as the exposure times needed for a toxic compound to produce any level of effect on the organisms tested.
• Consequently, extrapolations and predictions of toxic effects for any combination of concentration and time are now made possible.
The Risk Of Imidacloprid For Honey Bees Is Underestimated

Bonmatin JM et al., 2007. Environmental fate and ecological effects of pesticides. Pp. 827-834

- Druckrey-Küpfmüller equation

\[
\ln T_{50} \text{ (hrs)} = 5.11 - 0.22 \ln C \text{ (µg. L}^{-1} \text{ or kg}^{-1})
\]

or

\[C \times T_{50}^{4.5} = \text{constant}\]

- The concentrations of imidacloprid detected in nectar or pollen cause lethal effects in honey bees within a week

<table>
<thead>
<tr>
<th>Food Source</th>
<th>Imidacloprid Content C (µg/kg or ppb)</th>
<th>Expected Latent Period (T50) (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nectar</td>
<td>1</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5.4</td>
</tr>
<tr>
<td>Pollen</td>
<td>0.7</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>4.2</td>
</tr>
</tbody>
</table>
Nicotine Is A Neuroteratogen
Nicotine Alters The Developmental Trajectory Of The Brain

- Nicotinic acetylcholine receptors (nAChRs) regulate critical aspects of brain maturation during the prenatal, early postnatal, and adolescent periods
- Nicotine disrupts the normal developmental influences of acetylcholine
- Neonicotinoids as well as nicotine directly act on mammalian nAChRs and, therefore, may have various adverse effects on the human health, especially on the developing brain.
Neonicotinoids May Be Washed Out Of The Soil Into Waterways and Groundwater

- Not only are neonicotinoids water soluble and mobile in soil, they are also quite persistent in soil and water.
Neonicotinoids Are Diffusing Through The Environment
Breaking The Food Chain

- Imidacloprid is diffusing through the environment, killing or debilitating non-target insects and possibly other arthropods, and by doing so progressively reducing invertebrate prey for higher organisms
Immune Suppression by Neonicotinoid Insecticides At The Root Of Global Wildlife Declines

• There is experimental evidence of immune suppression in bees and fish by neonicotinoids
• There have been outbreaks of infectious diseases in honey bees, bumble bees, fish, amphibians, bats and birds in the past two decades
• The disease outbreaks started in countries and regions where neonicotinoid insecticides were used for the first time, and later they spread to other countries
Nicotine Causes Many Adverse Effects On The Normal Development Of A Child


- Perinatal exposure to nicotine is a known risk factor for sudden infant death syndrome, low-birth-weight infants, attention deficit/hyperactivity disorder (ADHD), autism
- The Graph on the Right →: The rise of autism in California since the introduction of the neonicotinoid insecticides in the early 1990s
A Generation in Jeopardy
How pesticides are undermining our children’s health & intelligence
PESTICIDE ACTION NETWORK NORTH AMERICA, OCTOBER 2012
The Widely Used Neonicotinoid Insecticide Imidacloprid Has Caused Major Contamination Of Dutch Surface Water Since 2004

Red dots (right hand side) : Maximal Permissible Risk Level (MRL) Exceeded At Least Five Times In 2005, MRL Exceeded 25,000 Times at Noordwijkerhout (Flower Bulb Cultivation)
Imidacloprid
Estimated Annual Agricultural Use in the US in 2002
US Geological Survey National Water-Quality (NAWQA) Program

Average annual use of active ingredient per square mile of agricultural land in county:
- no estimated use
- 0.001 to 0.004
- 0.005 to 0.015
- 0.016 to 0.053
- 0.054 to 0.202
- >= 0.203

<table>
<thead>
<tr>
<th>Crops</th>
<th>Total pounds applied</th>
<th>Percent national use</th>
</tr>
</thead>
<tbody>
<tr>
<td>sorghum</td>
<td>95355</td>
<td>26.36</td>
</tr>
<tr>
<td>potatoes</td>
<td>59336</td>
<td>16.40</td>
</tr>
<tr>
<td>tobacco</td>
<td>43392</td>
<td>11.99</td>
</tr>
<tr>
<td>lettuce</td>
<td>35573</td>
<td>9.83</td>
</tr>
<tr>
<td>cotton</td>
<td>18147</td>
<td>5.02</td>
</tr>
<tr>
<td>grapes</td>
<td>17093</td>
<td>4.72</td>
</tr>
<tr>
<td>tomatoes</td>
<td>15211</td>
<td>4.20</td>
</tr>
<tr>
<td>citrus fruit</td>
<td>13295</td>
<td>3.68</td>
</tr>
<tr>
<td>apples</td>
<td>11268</td>
<td>3.11</td>
</tr>
<tr>
<td>pecans</td>
<td>10001</td>
<td>2.76</td>
</tr>
</tbody>
</table>
Imidacloprid Contaminates Surface Waters in Agricultural Regions of California


- 75 surface water samples from three agricultural regions of California were collected and analyzed for contamination with imidacloprid
- Imidacloprid was detected in 67 samples (89%);
- Concentrations exceeded the U.S. Environmental Protection Agency’s (EPA) chronic invertebrate Aquatic Life Benchmark of 1.05 μg/L (micrograms per liter) in 14 samples (19%).
One Of The Most Obvious Services Insects Render, Albeit Unknowingly, Is Pollination

May Berenbaum (Entomologist, University of Illinois) NZZ Folio 07/01 - Theme: Käfer und Co

• Because plants for the most part can’t move around, most rely on animal partners to bring males and females together for mating
• Insects provide that service (in the form of pollen transport) for a remarkable number of plants, particularly species that have become important to human economies and lifestyles.
• About one-third of the Western diet results directly from the pollination activities of insects.
From Big Mac to McBun

May Berenbaum (Entomologist, University of Illinois) NZZ Folio 07/01 - Theme: Käfer und Co

- A McDonald’s Big Mac burger in an insect-free world would have no meat, no lettuce, no cheese, no pickle, no onion, and no ketchup; basically, it would be a McBun.
Our Fiber Needs Are Met In Large Part As A Result Of Insect Activity

May Berenbaum (Entomologist, University of Illinois) NZZ Folio 07/01 - Theme: Käfer und Co

- The cotton plant is insect – pollinated

- Wool and leather come for the most part from sheep and cattle that have eaten insect-pollinated legumes in their diet.

- Silk, of course, is a natural fiber produced directly by an \textit{insect}—\textit{Bombyx mori}, the Japanese silkworm
Most Vertebrates Rely Heavily On Insects In Their Diet

May Berenbaum (Entomologist, University of Illinois) NZZ Folio 07/01 - Theme: Käfer und Co

• Approximately 40 to 90% of the diet of **freshwater fish** consists of insects

• Among the **amphibians**, frogs, toads, and salamanders depend on insects; about 75% of the diet of the common toad is made up of insects

• Among the **reptiles**, insects are the food of choice for lizards, chameleons, green glass snakes, and horned toads.

• About one-third of the diet of **game birds and songbirds** are insects and their relatives
Most Orders Of Mammals Contain Insect-Eating Species

May Berenbaum (Entomologist, University of Illinois) NZZ Folio 07/01 - Theme: Käfer und Co

- spiny anteaters, duck-billed platypuses, opossums, cuscuses, caenolestid rat opossums, bandicoots, marsupial moles, hedgehogs, moles, tenrecs, solenodons, shrews, most bats, anteaters, armadillos, pangolins, some mice, and raccoons all consume insects on a regular basis.

- Even among the primates, our closest relatives, insect-eating is the norm; lemurs, aye-ayes, lorises, tarsiers, marmosets, and several of the great apes are to various degrees entomophagous.

- Both gorillas and chimpanzees fashion sticks into tools to help them extract termites and ants from their nests.
Honey Bee Declines in the US and Europe Are Linked To Infections


• Neonicotinoids are weakening the insects’ immune systems, and thus allowing infections to spread through a hive
• One thing common to bee colonies that go on to collapse is a greater variety and higher load of parasites and pathogens than other colonies
Imidacloprid Is Weakening The Immune Systems of Freshwater Fish

• While studying Japanese medaka fish in experimental paddy fields, Sánchez-Bayo and Goka observed physiological stress in juvenile medaka and massive infections of the weaker fish by a *Trichodina* ectoparasite where rice was treated with imidacloprid, compared with medaka in control rice fields
The Collapse of Wild Salmon Populations in the Proximity of Salmon Farms is Linked to Infections


- In 1994 there was an epidemic of parasitic salmon lice *Lepeophtheirus salmonis* in salmon farms sited on the Atlantic coast of Canada.

- The first epidemic of *L. salmonis* involving the wild pink salmon populations on the Pacific coast of British Columbia occurred suddenly in spring 2001.

- It became apparent that in areas without salmon farms, the prevalence of infestation was low whereas there was collapse in the wild salmon populations in the proximity of farms.
The Massive Bumble Bee Declines in the US and Europe Are Linked To Infections


- Comparing results with museum records of bumble bees showed that the relative abundances of four species had declined historically by up to 96%. Geographical ranges had contracted by 23-87%, some within the past two decades.
- Those species that had declined had significantly higher infection levels of the pathogen *Nosema bombi*
- Exposure to neonicotinoid insecticides is likely to have occurred and may have weakened immune systems, such that they became more susceptible to pathogens
The Massive Declines in Amphibian Populations Are Linked To Infections

The Chytrid Fungus Is Devastating Frog Populations


• Two species of once common frogs that had inhabited the thousands of lakes and ponds in California’s Sierra Nevada are being wiped out by chytridiomycosis

• Exposure to small doses of neonicotinoid insecticides is likely to have occurred and may have weakened the amphibian immune systems, such that they became more susceptible to pathogens
The Massive Decline Of Bat Populations Is Linked To Infections
www.fws.gov/whitenosesyndrome

- A powdery white nose tip was pathognomonic of the disease and when the powder was cultured a fungus, *Geomyces destructans* was grown. This infected the skin and wing membranes of bats and was associated with unprecedented numbers of deaths.
- It was first found in a cave in New York State in the 2005/6 winter and rapidly spread through the north-eastern states.
- The thousands of invertebrates consumed in their diet will inevitably have exposed bats to small cumulative doses of neonicotinoids.
Declines Due To Pathogens In Birds In the US

- A mycoplasmal conjunctivitis was first reported in wild house finches (*Carpodacus mexicanus*) in February 1994 in suburban Washington, DC.
- It was identified as *Mycoplasma gallisepticum*, a pathogen of poultry that had not previously been associated with wild songbirds.
- In the first three years it killed an estimated 225 million finches. There was a dramatic spread of disease to house finches in the mid-West and South East.
Declines Due To Pathogens In Birds In Europe

In Europe epidemics caused by a variety of novel pathogens in wild birds began in early 2000

Greenfinch (*Carduelis chloris*) numbers in Europe have been devastated by infections with *Trichomonas gallinae*, a protozoal organism which invades the bird’s crop and mucosal lining of the beak. Deaths started in the UK around 2005

At the same time, chaffinches (*Fringilla coelebs*) appeared in gardens with white, crusty growths on their legs and feet caused by a papilloma virus. The mortality is said to be about 20%, so the disease kills more slowly than with the Greenfinch *Trichomonas* infections
Declines Due To Pathogens In Birds In Europe

• In September 2011, mass deaths of Blackbirds (Turdus merula) were reported in the Rhine-Neckar area of Germany
• The Bernhard-Noct Institute for Tropical Diseases and the Friedrich-Loeffler Institute examined four birds and confirmed that it was the tropical Usutu Virus from Africa
• It was first seen in Austria in 2001, followed by reports from Italy, Hungary and Switzerland. In birds it first causes apathy, then signs of a central nervous system disorder, with unnatural movements of the head
• An estimated 300,000 blackbirds were killed by the disease
The Systemic Insecticides: A Disaster in the Making


- Dr Henk Tennekes, an independent Dutch toxicologist, first warned of the dangers of the systemic neonicotinoids in his book: *The Systemic Insecticides: A Disaster in the Making*
- Dr Tennekes says that his book: “catalogues a tragedy of monumental proportions regarding the loss of invertebrates and subsequent losses of the insect-feeding (invertebrate-dependent) bird populations in all environments in the Netherlands.
- The disappearance can be related to agriculture in general, and to the neonicotinoid insecticide imidacloprid in particular, which is a major contaminant of Dutch surface water since 2004.”
- The relationship exists because of crucial (and catastrophic) disadvantages of the neonicotinoid insecticides: the damage to the central nervous system of insects is virtually irreversible and cumulative.
- Tennekes showed that even minute quantities can have devastating effects in the long term.
- They leach into groundwater and contaminate surface water and persist in soil and water, chronically exposing aquatic and terrestrial organisms to these insecticides.
- “So, what, in effect, is happening is that these insecticides are creating a toxic landscape, in which many beneficial organisms are killed off.”
The Number Of Butterflies In The Netherlands Is Presently At The Lowest Point Ever Recorded
The Decline of Grassland Birds In The Netherlands

Black-tailed Godwit

- The breeding population in Germany was halved over the last 15 years
The Decline of Grassland Birds In The Netherlands

Oystercatcher

- Sharp decline observed in Germany as well
The Decline of Grassland Birds In The Netherlands

Northern Lapwing

• Dramatic decline of breeding population in Germany since the 1970s
The Decline of Grassland Birds In The Netherlands

Skylark

- Substantial decline of breeding population of once common Skylarks in Germany since the 1960s
The Decline of Marsh Birds In The Netherlands

Great Reed Warbler
The Decline of Heath Land Birds In The Netherlands

Northern Wheatear

- On the brink of extinction in Germany
The Decline of Heath Land Birds In The Netherlands

Tawny Pipit

- On the brink of extinction in Germany
The Decline of Coast Birds In The Netherlands

Kentish Plover

- On the brink of extinction in Germany
The Decline of Coast Birds In The Netherlands

Pied Avocet
The Decline of Woodland Birds In The Netherlands

Golden-Oriole
The Decline of Woodland Birds In The Netherlands

Willow Tit
The Decline of Woodland Birds In The Netherlands

Spotted Flycatcher
The Decline of Farmland Birds In The Netherlands
Corn Bunting

- Threatened in Germany
The Decline of Farmland Birds In The Netherlands
Ortolan Bunting

• Threatened In Germany
The Decline of Farmland Birds In The Netherlands

Grey Partridge

• Threatened in Germany
The Decline of Farmland Birds In The Netherlands

Crested Lark

- On the brink of extinction in Germany
The Decline of Settlement Birds In The Netherlands

Starling
The Decline of Settlement Birds In The Netherlands

House Sparrow
Neonicotinoid insecticides act by causing **virtually irreversible** blockage of postsynaptic nicotinergic acetylcholine receptors (nAChRs) in the central nervous system of insects.

The damage is cumulative, and with every exposure more receptors are blocked. In fact, there may not be a safe level of exposure.

The nAChRs play roles in many cognitive processes and neonicotinoids account for worker bees neglecting to provide food for eggs and larvae, and for a breakdown of the bees' navigational abilities. Very small quantities of neonicotinoid insecticides are sufficient to cause collapse of bee colonies.

Food residues of neonicotinoids may adversely affect human health, especially the developing brain.

Neonicotinoid insecticides are persistent and mobile in soil, soluble in water and stable to breakdown by water at neutral pH, and as a result of these properties - the compounds may leach from soils.

Since 2004 major contamination of Dutch surface water with imidacloprid has been detected by the Water Boards, particularly in the western part of the country. Surface water contamination with imidacloprid has also been recorded in agricultural regions of California.

Consequently, high concentrations of imidacloprid are diffusing through the environment, killing or debilitating non-target insects and other arthropods, decimating invertebrate prey for higher organisms.
A Disaster In The Making
Neonicotinoids Break Food Chains

• Invertebrate-dependent bird species in the Netherlands have been declining on a massive scale in recent times, in all kinds of habitats (grasslands, marshes, heathlands, at the coast, woodlands, settlements, farmlands):
  - Skylark, Yellow Wagtail, Oystercatcher, Black-tailed Godwit, Northern Lapwing, Common Redshank, Meadow Pipit, Willow Tit, Spotted Flycatcher, Wood Warbler, Pied Flycatcher, Wood Nuthatch, Willow Warbler, Marsh Tit, Grey-faced Woodpecker, Wryneck, Common Crossbill, Golden-Oriole, Northern House Martin, Barn Swallow, Common Swift, Starling, House Sparrow, Common Redstart, Great Reed Warbler, Bearded Tit and Spotted Crake

• Ground and surface water contamination with persistent insecticides that cause irreversible and cumulative damage to aquatic and terrestrial (non-target) insects must lead to an environmental catastrophe.

• The data presented here show that an environmental catastrophe is actually taking place before our eyes, and that

IT MUST BE STOPPED
http://smallbluemarble.org.uk/
a UK based independent charity dedicated to pesticide safety assessment

- The aims of small blue marble are to:
  - conduct unbiased research into the effects of pesticides – the true eco-toxicological risks associated with pesticides, deficiencies in pesticide safety assessment and the longer term risks of many pesticides
  - publish the results among the scientific community for peer review
  - share this information with the public in an accessible form
  - enable the public and other stakeholders to express informed and on-going views about the impact of pesticides on our planet
  - equip today’s children to be better guardians (than we have been) of tomorrow’s world

Contact:

Dr Bernie Doeser
bernie@smallbluemarble.org.uk

Kate Canning
kate@smallbluemarble.org.uk