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Promoting safe and sustainable alternatives to hazardous pesticides

Impacts of pesticides on biodiversity and the environment - what do we now know?

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Reducing the use of pesticides in tropical agriculture
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Case Study: Ecuador

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- 2005 - 1st sign of apple snails
- 2010 - 1st became a problem
- 2011 - > 60% of rice growing area invaded
- 2012 - ~ 80% of rice area invaded

➢Led to heavy use of pesticides, including endosulfan

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Proportion of farmers using different chemicals to control *P. canaliculata* who also reported problems with planthoppers (n = 143)

Chemicals used to control apple snails	Proportion of farmers reporting problems with *T. orizicolus* and RHBV
Methaldehyde (51)	0.82
Endosulfan (34)	0.35
Neonicitinoids (9)	0.33
Methaldehyde and endosulfan (19)	0.63
Methaldehyde and neonicitinoids (3)	0.33
Methaldehyde, endosulfan and neonicitinoids (7)	1.00
None (25)	0.24

Horgan *et al*., 2014

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Introduction

- Global species extinction rate is now 10s - 100s x higher than the average rate over the past 10 million years (UNEP,2021)
- Absolute abundance of wild organisms has alarmingly decreased by half over the past 50 years

➢ e.g. farmland bird populations in Europe have halved and insect biomass in Germany has declined by 76%.

- The drivers of biodiversity loss are many, but numerous scientific studies have highlighted the major role **pesticides** play, from terrestrial through to aquatic ecosystems.

➢ Pollution (including **pesticides**) = 4th biggest driver of terrestrial and marine biodiversity loss, 3rd biggest driver of freshwater biodiversity loss and the 2nd biggest driver of insect decline.

Introduction

- In 1962, Rachel Carson's pivotal book 'Silent Spring' brought global attention to the detrimental effects of pesticides on our environment and human health – resulting in certain highly hazardous pesticides (HHPs), e.g. DDT, being banned from use in agriculture.
- However, overall pesticide use has continued to increase globally, with many HHPs still in use. Some of which we may not understand their exact harms until several years or decades after their release
- In addition, it may take years for accumulated pesticide residues to breakdown, even after a pesticide has been banned

➢ e.g. DDT was recently detected in soils within the European Union, even though it faced a ban 36 years previously.

- Pesticides by their very nature are designed to kill, but less than 0.1% of pesticides applied for pest control reach their target pests (Pimental, 1995).

➢ more than 99.9% of pesticides used move into the environment

Effects on land

- Pesticide use is most pronounced in agricultural environments, where they have negative impacts for many types of terrestrial organisms.
- These include many beneficial organisms, such as predators, parasites or infective agents of crop pests and diseases.
- Destruction of these beneficials by pesticides undermines the very systems that can keep pest populations in check.
- Removing such systems creates a problem of ‘resurgence’ of pest populations, often leading to an escalating cycle of pesticide use and destruction of beneficial organisms.
- The widespread use of pesticides also affects other important ecosystem services, such as pollination, decomposition of organic material and bioavailability of plant nutrients.

Effects on pollinators

- Broad scientific consensus that pesticide use is one of the main reasons for the decline of beneficial insects and pollinators (Hallmann et al., 2017)
- Serious pesticide adverse effects have been observed in different pollinator taxa, e.g., neonicotinoids have been well proven to cause bee and butterfly mortality as well as behavioural effects that reduce their survival (Colin et al., 2019; Mule et al. 2019)
- Additionally, recent studies have shown that the changes in the gut microbiome of bees following glyphosate exposure reduces resilience, making the bees more susceptible to diseases (Motta et al., 2018).

Effects on birds and mammals

- Bird and mammals are especially at risk due to biomagnification – by consuming persistent pesticide residues via contaminated organisms at lower levels of food chain
- e.g. secondary poisoning of raptors and carnivores from rodenticides
- in the UK, raptor populations also collapsed due to eggshell thinning as a result of consuming prey exposed to DDT, dieldrin and aldrin
- Pesticides may also alter the feeding behavior of birds, as observed in raptors (Mitra et al., 2011)

Effects on soil life

- A recent systematic review of 400 studies indicates that pesticides of all types pose a clear hazard to soil invertebrates (Gunstone, 2021)
- Soil organisms perform a variety of different ecosystem services essential for agricultural sustainability.

➢ e.g. some organochlorines suppress symbiotic nitrogen fixation, resulting in lower crop yields (Fox et al., 2007), other studies have shown negative effects on earthworms (Giessen, 2021)

- Seed treatments are especially harmful by directly exposing soil organisms to high doses

➢ in USA, almost all non-organic corn is treated with seed-applied fungicides and neonicitinoids, 80% or more of which remain in the soil

Effects in water

- Numerous studies have highlighted pesticide residue levels of concern in various water bodies, including ground water supplies

➢ e.g. large-scale study in **Germany** identified that measured pesticide concentrations exceeded current regulatory acceptable concentrations in 81% of the 101 agricultural streams investigated (Liess et al., 2021)

➢ Concluded that pesticide pollution was the major driver in reducing vulnerable aquatic insect populations

➢ Perkins et al. 2020 found that fipronil, a common product for pet flea treatment that is banned for agricultural use, was detected in 98% of samples from a survey of 20 English rivers , and at levels that exceeded chronic safety thresholds five-fold.

- Also, negative impacts on coral reefs/marine ecosystems – pesticides even detected in the Antarctic waters

➢ e.g. in Mexico, endosulfan and chlorpyrifos residues close to acute toxic levels for the small aquatic invertebrates and shrimps were detected in a coastal lagoon system (Carvalho et al. 2015).

Effects on amphibians and fish

- Many studies showed that amphibians are susceptible to pesticides due to their permeable skin and dual aquatic-terrestrial cycle

➢ e.g. glyphosate, causes high mortality of larval tadpoles for several species

- Even sub-lethal concentrations of pesticides have a strong effect on critical behaviors of aquatic vertebrates

➢ A meta-analysis found that exposure to environmentally relevant concentrations of pesticides reduced the swim speed of exposed amphibians and fish by 35%, and reduced overall activity by 72% (Shuman-Goodier et al., 2016)

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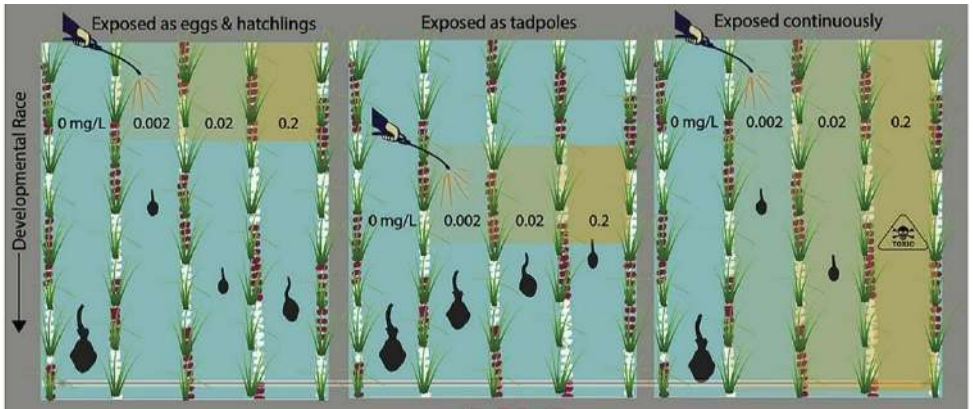
Endocrine disrupters

- There is mounting evidence that a number of pesticides cause endocrine disruption which perturbs development, growth and reproduction in organisms, including humans
- e.g. male frogs exposed to very low levels of atrazine developed symptoms of hermaphroditism and demasculinity (Hayes et al., 2002)
- Shuman-Goodier et al., 2021 found that cane toads exposed to butachlor developed slower and weighed less than controls



Indirect effects

Pest resurgence:

- Pesticide applications can result in pest resurgence via reductions of natural enemies of pests

Reduced quality and availability of food sources:

- Herbicides can lead to reductions of “weeds” and “non-target plants” and surface litter reducing the amount and quality of food for pollinators and herbivorous insects
- Pesticide-induced declines in invertebrate densities can cause food deprivation for birds – e.g. recent research on neonicitinoids (Hallmann et a., 2014)

Other interactive effects:

- e.g. malathion led to decrease in zooplankton diversity, that led to increase in phytoplankton, a decrease in periphyton, and finally decrease in growth of frog tadpoles (Relyea and Hoverman, 2008).

Unknown effects

- **Cocktail effects** and synergistic effects with other factors,eg. bees (Siviter, 2021), soil biota and soil health. (Geissen et al., 2021)
- **Herbicide drift** effects in field margin plant community have been little studied so fa, e.g. In a field trial Nelemans et al. investigated effects of an herbicide (metsulfuron-methyl) on sown plant communities. The herbicide drift affected biomass production, plant cover and seed germination of several plant species
- **Environmental effects**, e.g. temperature – a recent study of common toads (Bufo Bufo) revealed that more pronounced glyphosate effects to their eggs at lower temperatures

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Pesticide Quantity vs Toxicity

- **The toxicities of different kinds of pesticides and their impacts on different non-target species groups vary greatly**.
- Recent data show that while the amount of insecticide used has declined in the US from 1992-2016, total applied toxicity has significantly increased – the toxicity of applied insecticides to aquatic invertebrates and pollinators more than doubled between 2005 and 2015 (Schulz et al., 2021. *Science* 372, 81–84),
- It is quite possible that total applied toxicity values would be higher for the agroecosystems of other countries where pesticide sales increased.
- Has important implications for global and national indicators of pesticide use, e.g. CBD

Helping farmers transition away from pesticide dependance

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- With PAN Ethiopia, PAN UK is working with farmers to help them transition away from pesticides by using agroecological approaches, e.g. food spray
- Developing Biodiversity-Smart Villages in which farming communities value the role of biodiversity in agriculture
- Also engaged in the CBD process to encourage the adoption of targets to phase out HHPs and use toxic load indicators

Other PAN resources to support pesticide reduction

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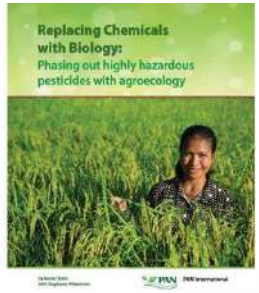
- Grant, I.F. & Tingle, C.C.D (eds.) **Ecological monitoring methods for the assessment of pesticide impacts in the tropics**.
- **The Food Spray Manual**: A Trainers' Guide - Pesticide Action Network UK (pan-uk.org)
- **Replacing Chemicals with Biology by PAN UK**
- **The SHPF toolkit** for the Rotterdam Convention Secretariat - Guidance on how to monitor and report incidents of pesticide poisoning caused by Severely Hazardous Pesticide Formulations.
- **Toxic load indicator** – similar to the Pesticide load indicator, this simple-to-use scoring tool for assessing pesticide toxicity takes into account mammalian toxicity, environmental toxicity and environmental fate. See https://www.researchgate.net/publication/319259870_Toxic_Load_Indicator
- PAN UK app to collect data on incidences of acute poisoning



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Thank you

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