Insecticide Risk Exposes Threat to Aquatic Life in Surface Water Bodies and its Remedying

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Abstract

The pesticide risk due to spray drift, runoff or drainage has significant pressure on aquatic life resources, which increases the possibility of toxic exposure and effects on aquatic ecosystems. Thus, the purpose of this paper is to present an outline of adverse effects or toxicity of pesticide active ingredients and degradates to aquatic life. Researchers have evaluated comprehensive global insecticides contamination data for agricultural surface waters and found with hints of insecticide concentration in samples, wherein potential reasons for these findings are failures of current risk assessment procedures or farmers' non-adherence to pesticide application prescriptions. What is more, due to the high toxicity of insecticides for aquatic organisms, these short-term spurts lead to substantial and long-lasting adverse effects on aquatic communities. In addition, insecticide concentrations in waters is supposedly well regulated, even then insecticides are threatening global freshwater biodiversity and scientists fear for the loss of world's freshwater ecosystems. Aquatic life contaminations may result from treatment as well as from conditions such as improper use of pesticides, residues from preceding treatments in the soil and cross-contamination. Aquatic organisms may die as a result of pesticide contamination, or they may simply grow poorly, become more susceptible to disease, or become unsuitable for human consumption. Insecticides can adversely impact aquatic macroarthropods which play many important functional roles in wetland ecosystems including as predators of aquatic herbivores, and trophic levels effect on aquatic community composition. For remedying, those who apply chemicals to crops near aquaculture facilities should be aware of the potential risks of contaminating those facilities. Identifying insecticides that pose low risk to aquatic macroarthropods, amphibians and fishes might help to meet increased demands for food while mitigating against potential negative effects on ecosystem functions. The researchers might increase awareness and rise regulation of chemicals harmful to aquatic life, and manufacturers should effort the best for making insecticides and herbicides safer for peoples.

Keywords: Freshwater, Ecosystem, Aquatic Life, Biodiversity Loss, Pesticide Use

1. Introduction

As agricultural expansion and intensification increase to meet the growing global food demand, so too will increase insecticide use, a type of pesticide that are used to specifically target and kill insects, and thus the result is risk of non-target effects. Insecticide pollution poses a particular threat to aquatic macroarthropods, which play important functional roles in freshwater ecosystems. Agrochemical pollution from insecticide run-off can have important negative consequences for non-target taxa (McMahon et al., 2012; Rohr et al., 2008). Within most countries the use of pesticides in agriculture is an accepted practice as it ensures a reliable yield of good quality produce. However, the extensive use of pesticides in developing countries quite often goes along with improper use of chemicals (Ecobichon, 2001; Damalas and

Eleftherohorinos, 2011). The pesticides can enter the aquatic ecosystem through various routes such as spray drift or runoff (Raschke and Burger, 1997; Schulz, 2001; 2004). This may then pose risks to various non-target organisms in the aquatic ecosystem that can cause effects at population, community and ecosystem levels. Pesticides potentially affect human health through the consumption of fish, water and macrophytes from affected surface water (Van den Brink et al., 2007).

As new pesticides are developed and approved for use, it is important that risk assessors can predict the risk of these chemicals pose to non-target wildlife. Pesticides may vary both in their toxicity to organisms and in their estimated environmental exposures, the latter of which is based on recommended application rates and the physicochemical properties of the pesticide. Insecticides with similar modes of action often have similar safe threshold values in terms of toxic units (concentrations of different pesticides that are standardized by dividing the geometric mean of reported EC50 values of the most sensitive standard test species typically Daphnia magna) (Brock et al., 2000). Therefore, pesticides of the same class (i.e., organophosphate vs. pyrethroid insecticides) might be expected to pose similar risk to focal species even though individual pesticide within a class might vary in its relative estimated environmental exposures and toxicities. Specifically, despite the fact that insecticide use is regulated, and cannot surpass legally-accepted regulatory threshold levels, it appears that they are still causing problems for various ecosystems and aquatic life. For marine life in urban areas, water is much less safe. However, although pesticides seeping into rivers have become much safer for humans, they still pose a serious threat to animal life. The research team found that overall; the rivers have pesticide concentrations much higher than suggested guidelines for marine life and the study found that pesticide levels for agricultural and mixed-land-use rivers stayed fairly constant. However, there is a marked increase in pesticides found in urban rivers and streams (Gilliom et al., 2007).

Owing to extensive use of pesticides in modern agriculture, it has raised serious public concern regarding the environment especially aquatic life safety. Two common macroarthropod predators, the crayfish *Procambarus alleni* and the water bug *Belostoma flumineum*, have been tested to three insecticides in each of two insecticide classes (three organophosphates: chlorpyrifos, malathion, and terbufos; and three pyrethroids: esfenvalerate, lambda cyhalothrin, and permethrin) to assess their toxicities. Organophosphate insecticides generated consistently low-risk exposure scenarios for both *P. alleni* and *B. flumineum*. Pyrethroid exposure scenarios presented consistently high risk to *P. alleni*, but not to *B. flumineum*, where only, lambda cyhalothrin produced consistently high-risk exposures (Halstead et al., 2015). The sublethal effects of many agricultural chemicals on aquatic life are unknown. Any misused chemical can cause serious problems to an aquaculture operation. Of the various pesticides, some indicate no risk for effects to the aquatic environment, while other are identified as posing the highest risk to the aquatic ecosystem. This is probably due to differences in the physical scenario and may not difference in the pesticide properties. Also, for a larger irrigation scheme, the results for suspended sediment particles indicate higher concentrations. Increased levels of suspended sediment generally result in an increased risk, as pesticides have more substrate to bind, which can potentially affect their toxicities. These models could therefore be useful tools to educate farmers and stakeholders on the effects of pesticides on non-target organisms. They provide information on the specific risks of a pesticide at a given application rate within the specific scenario, thus making it possible for the farmers to choose the lowest risk pesticides or to decrease their pesticide application rates to ensure the least amount of risk to the aquatic ecosystem. However, it must be remembered that these models only provide the risk of pesticides due to spray drift. The potential is there that these risks are an underestimation, as runoff and drainage can potentially increase the risk of pesticides being transported to the river (Malherbe et al., 2013).

2. Mode of Pesticide Risk

Within the last few decades, scientists have learned that some pesticides can leach through the soil and enter the groundwater below. While 50% of the nation depends upon groundwater as drinking water, and almost 95% of the households in rural areas use groundwater as their primary source of drinking water. The impact of agricultural chemicals on surface and groundwater quality has become an issue of national importance globally. The states have the responsibility under a variety of statutes to protect the quality of the nation's ground water as well as direct responsibility for regulating the availability and use of pesticide products. Each pesticide product has inherent risks associated with it (Sarwar, 2015 a; 2015 b; 2015 c; 2015 d; 2015 e), and potentially detrimental impacts of pesticides include:-

1. Acute poisoning from a single or short-term exposure can result in death of aquatic life.
2. Chronic impacts of long-term exposure to pesticides, including pesticide residues in food, could also result in death of aquatic life.
3. Natural resources can be degraded when pesticide residues in storm water runoff and enter streams or leach into groundwater.
4. Pesticides that drift from the site of application can harm or kill nontarget plants, birds, fish, or other wildlife.
5. The mishandling of pesticides in storage facilities and in mixing and loading areas can contribute to soil and water contamination.

3. Preliminary Risk Assessment of Pesticides

Unlike other chemicals, agricultural pesticides are intentionally applied to the environment to help farmers to control insects, weeds and other potentially harmful pests threatening agricultural production. They can therefore affect land ecosystems but also surface waters due to runoff. The analysis provides a global map of hotspots for insecticide contamination that are a major risk for biodiversity in water bodies. The researchers intend to use the global map to sensitize citizens and authorities about this issue in vulnerable regions and to incite local investigations. Buffer zones along the edge of water bodies can significantly reduce negative impacts for example. Efficient environmental management and conservation efforts in the future should focus on informing authorities and farmers about the costs, impacts and alternatives. Ultimately, mitigation and management takes place at the local level, determining the extent to which a water body will be affected under the application of such chemicals (Ippolito et al., 2015; Spangenberg et al., 2015).

The global threat that insecticides pose to aquatic biodiversity has been revealed in a recent modelling study that pinpoints certain areas at greatest risk. In various localities, the pesticides are found to pollute every stream and most of wells sampled in a study by the geological survey. Pesticide residues have also been found in rain and groundwater. Studies further showed that pesticide concentrations exceeded those levels that are allowable for drinking water in some samples of river water and groundwater. Pesticide impacts on aquatic systems are often studied using a hydrology transport model to study movement and fate of chemicals in rivers and streams. During some early decades quantitative analysis of pesticide runoff has been conducted in order to predict amounts of pesticide that would reach surface waters. There are four major routes through which pesticides reach the water, it may drift outside of the intended area when it is sprayed, it may percolate or leach through the soil, it may be carried to the water as runoff or it may be spilled, for instance accidentally or through neglect, but they may also be carried to water by eroding soil. Factors that affect a pesticide's ability to contaminate water include its water solubility, the distance from an application site to a body of water, weather, soil type, presence of a growing crop, and the method used to apply the chemical (Papendick et al., 2007).

4. Pesticide Risk to Aquatic life

Pesticide's surface runoff into rivers and streams can be highly lethal to aquatic life, sometimes killing all the fish in a particular stream. Fish and other aquatic biota may be harmed severely by pesticide-contaminated water. Application of herbicides to bodies of water can also cause fish kills when the dead plants decay and consume the water's oxygen, suffocating the fish. Herbicides such as copper sulfite that are applied to water to kill plants are toxic to fish and other water animals at concentrations similar to those used to kill the plants. Repeated exposure to sublethal doses of some pesticides can cause physiological and behavioral changes that reduce fish populations, such as abandonment of nests and broods, decreased immunity to disease and decreased predator avoidance. Application of herbicides to bodies of water can further kill plants on which fish depend for their habitat. Pesticides can accumulate in bodies of water to levels that kill off zooplankton, which are the main source of food for young fish. Pesticides can also kill off insects on which some fish feed, causing the fish to travel farther in search of food and exposing them to greater risk from predators. The faster a given pesticide breaks down in the environment, the less threat it poses to aquatic life. However, insecticides are typically more toxic to aquatic life than herbicides and fungicides (Vos et al., 2000; Arias-Estevez et al., 2008).

5. Pesticide Risk to Amphibians

Within the past several decades, amphibian populations have declined across the world, for unexplained reasons which are thought to be varied, but of which pesticides may be a part. Pesticide mixtures appear to have a cumulative toxic effect on frogs and toads. Tadpoles from ponds containing multiple pesticides take longer to metamorphose and are smaller in size, decreasing their ability to catch prey and avoid predators. Exposing tadpoles to the organochloride endosulfan at levels likely to be found in habitats near fields sprayed with the chemical, kills the tadpoles and causes behavioral and growth abnormalities. The herbicide atrazine can turn male frogs into hermaphrodites, decreasing their ability to reproduce. Both reproductive and nonreproductive effects in aquatic reptiles and amphibians have been reported. Crocodiles, many turtle species and some lizards lack sex-distinct chromosomes until after fertilization during organogenesis, depending on temperature. Embryonic exposure in turtles to causes a sex reversal and disorders such as decreased hatching success, feminization, skin lesions, and other developmental abnormalities have been reported. About similar situations occur in case of Daphnia, which is a genus of small planktonic crustaceans (Kashian and Dodson, 2002; Ansara-Ross et al., 2008; Rattner, 2009; Kohler and Triebskorn, 2013).

The mapping exercise conducted by the researchers reveals that aquatic life in water bodies within 40 per cent of the global land surface is at risk from insecticides running off the land. The potential insecticide contamination hotspots, explain that tropical and subtropical regions need to pay urgent attention to threats of biodiversity loss from insecticide use. Farmers in many developing countries are changing from subsistence farming to market-oriented intensive crop farming resulting in increased insecticide uses. The findings suggest that the current regulatory risk assessment schemes and pesticide authorization procedures fail to protect the aquatic environment, and these need to be changed. The researchers recommend improving basic global conventional agricultural systems and adopting approaches from organic farming as possible ways to both provide enough food for a growing human population, and protect global ecosystems from agricultural insecticides (Crain and Guillette, 1998).

It is very helpful for environmental risk assessment and environmental management to have the information on insecticide occurrence on the landmass of countries. Then it can be identified where to find exposure hotspots and where it is most relevant to plan mitigation measures. Mitigation methods include buffer strips, alongside water bodies which are free of insecticide use, who also suggest more efficient environmental management to combat the risk. The mode of action of insecticides is responsible for their higher or lower toxicity to non-target organisms. However, the large variations in susceptibility among different animal taxa indicate that certain biochemical traits particular to a group of organisms are responsible for a specific level of sensitivity. Aquatic arthropods are most susceptible to all types of insecticides because they share many physiological features with the target insects. Other aquatic organisms, such as fish and amphibians, are very sensitive to broad-spectrum neurotoxic and respiratory inhibitor insecticides, but not so much to selective insecticides such as insect growth regulators and stomach poisons. Terrestrial vertebrates are also sensitive to most neuro-toxicants and respiratory inhibitors, with the exception of those insecticides derived from natural toxins produced by plants or fungi (e.g., few pyrethroids, neonicotinoids, avermectins, spinosad), which appear to have little or no toxicity in birds and mammals (Lin et al., 2013).

6. Reducing Risk of Pesticides

Outlined below is an indication of how this phrase can be used in current practice of minimizing pesticides risk to aquatic life. The environmental risk of pesticides, which is mandatory and is conducted by regulatory agencies, is generally seen as an elaborate process, but also farmers themselves must adhere to specific application guidelines, for example, they cannot spray within 20 meters of a surface water body in order to ensure that the contamination is not exceeded in the field. The risk to the aquatic environment or non-target organisms may be managed via the use of buffer zones. It is proposed that this can be accomplished through the respect of an unsprayed buffer zone of distance to be specified to non-agricultural land and surface water bodies (Lamberth et al., 2013).

6.1. Risk Phrases to Protect Aquatic Organisms

Always, do not contaminate water with the product or its container, do not clean application equipment near surface water, and avoid contamination via drains from farmyards and roads. For protecting groundwater or aquatic organisms, apply pesticides only according to soil type or situation to be specified to soils. To protect aquatic organisms, respect an unsprayed horizontal buffer zone distance to surface water bodies when spraying from aircraft, also do not apply on impermeable surfaces such as asphalt, concrete, cobblestones, railway tracks and other situations with a high risk of run-off.

6.2. Risk Phrases for Protection of Water

Principles show that for one or more of the labelled uses, that risk mitigation measures are necessary to avoid contamination of groundwater. For protecting groundwater or soil organisms do not apply unknown or any other product containing unidentified active substance or class of substance, as appropriate, and more than the time period specified.

6.3. Pesticides Drift Risk

Pesticides can contribute to air pollution and pesticide's drift occurs when it is suspended in the air as particles and carried by wind to other areas, potentially contaminating them. Pesticides that are applied to crops can volatilize and may be blown by winds into nearby areas, potentially posing a threat to to aquatic life. Pesticides drift risk can be reduced by using low-volatility formulations, using low pressure, using high volume, using the largest nozzle that is practical, releasing spray near the crop or soil surface, not spraying when the temperature is high, spraying when the wind is low and blowing away from aquaculture facilities, and using spray thickeners when appropriate.

6.4. Pesticides Runoff Risk

Following that, the researchers then estimated the so-called runoff potential, in other words the amount of insecticides that enters streams and rivers through the rainwater from agricultural land. Runoff can carry pesticides into aquatic environments while wind can carry them to other fields, grazing areas, human settlements and undeveloped areas, potentially affecting other species. The study showed that rainwater will run off the land into water bodies based on the slope of the terrain and rainfall; and the runoff hazard ae related to the amount of insecticide used that is likely to contaminate water bodies. An early quantitative analysis of pesticide runoff can be conducted in order to predict amounts of pesticide that would reach surface waters. Reduce the risk of runoff by delaying application if rain is expected, irrigating in accordance with pesticide label instructions and monitoring to avoid runoff and the accumulation of excess surface water, using no-tillage or minimum tillage cropping systems that reduce pesticide runoff, using soil-incorporation methods, using adjuvants that promote the retention of pesticides on treated surfaces, grading the surface and constructing drainage ditches and dikes, and planting border vegetation (Morgan and Brunson, 2002).

With careful management it is possible to protect crops from insects, weeds and diseases while at the same time preventing pesticides from harming aquaculture operations. Near aquaculture, grow crops that require little or no pest control. Scout fields for pests and use chemicals only when necessary. When a pesticide must be used, select a product that is registered for the use intended, and is the least toxic and least persistent of the products available. Always follow exactly the directions on the label. The decline in chemicals harmful to humans coupled with an increase or stagnation in chemicals harmful to other animals suggests that the federal government should impose stricter regulation on chemicals that are dangerous to fish and other marine life. It should be noted that this guidance is still relatively brief and is based on initial interpretation of these requirements, and it is intend to update this guidance occasionally as our experience grows (Relyea, 2009).

7. Conclusion

The increases of pesticides applications make the implications for the environmental and biomedical research for the communities a significant endeavor. Monitoring platforms for pesticides are scarce, particularly in aquatic life and an effective strategy for dealing with insecticide contamination in this environment should have to commence with an assessment of the extent of the problem. However, information on the quality of the state's water resources is of critical interest because it is so integrally linked to the long-term availability of water that is clean and safe for drinking and recreation, and that is suitable for industry, irrigation and habitats for fish and wildlife. Further research on environmental risk assessment of the pesticides used in agriculture to assess the impact on water resources particularly on fisheries and mariculture, ecotoxicological properties of the pesticides and their physico-chemical profile, simulation of the environmental behaviour of the pesticides in relation to the load applied onto the agricultural areas, pesticides approximate concentrations, chemicals at highest risk identification, and risk management measures, is needed. This study could represent a cost-effective method that may be used before engaging in expensive monitoring programs for pesticides where analytical facilities are lacking. Overall, further data would be needed to draw a firm conclusion and to refine the risk assessment of pesticides to aquatic life.

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