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Chapter 9

Impacts of pesticide application on aquatic environments and fish diversity

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Chapter contents

Abstract

In this chapter, we provide opinions of the latest clinical findings on health results and preference valuation of health dangers associated with insecticides and the position of benefit-value analysis in regulations associated with insecticides. Aquatic animals and aquatic sources are precious herbal belongings. Better productivity and protein yield as is offered by aquatic animals as compared to agriculture or animal husbandry and have much less power expenditure for food manufacturing. Besides protein, fish flesh consists of sufficient quantity of vitamins and minerals, which are vital for the boom. Agrochemicals publicity durations and levels, kinds of agro-chemicals used (regarding toxicity and endurance), and diverse environmental circumstance of the areas are also factors for acute and chronic poisoning on the aquatic animal as well as human fitness and environment. This chapter provides information about the dangerous effect like

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cancer, neural issues, beginning defects, reproductive and developmental anomalies, mutagenicity and other fitness related problems and environmental dangers related to agrochemicals.

Keyword: Accumulation, Agriculture, Contamination, Fish, Pesticides, Toxicity

Introduction

Aquatic Toxicology is the study of the impacts of pollutants on the aquatic spectrum, such as pesticides, insecticides, etc. on the physical condition of fish species or other aquatic organisms (Pereira *et al*., 2009). Pesticides are used for various agriculture purposes to control pests mainly insects, aquatic weeds, different types of plants diseases, and aquatic snails that carry the cause of schistosomiasis. Pesticides have been found to be vastly noxious not only to fish species but also for other aquatic organisms, which constitute the tropic food chain. Pesticides are wide-ranging, are used very widely in various agriculture practices, in different forestry and in veterinary practices (Fabra *et al*., 1997; REBECA, 2007).

Pesticides are categorized into various types according to their objective use. Mainly pesticides are categorized into the three major types are herbicides (used for weed control), insecticides (used for insect control), and fungicides (use for mycotic control), but in comparison to all three types, insecticides are the more and acute toxic. Fishes species are the imperative wellsprings of proteins and lipids for humans and domestic animals, so the health of fish species is very essential for human beings. Insecticides are the synthetic compounds used to control various types of insects by killing or preventing them from engaging in undesirable behaviours or destructive.

Surface water contaminated by pesticides is notorious to impact on the aquatic and terrestrial ecosystem, the toxicant traveling from the lithosphere, hydrosphere and atmosphere shown in the Figure 9.1, To affect the survival and reproduction of the aquatic organism. Unfortunately, along with various advantages, of pesticides are threatening for the lasting survival of major ecosystems by interruption of ecological relationships between aquatic organisms and loss of biodiversity. Different types of pesticides used are organophosphate, carbamates, organochlorine, pyrethroids, and nicotinoids. The residues of the pesticides used for intensive agriculture practices can contaminate the water (surface runoff and surface drainage) generally within a few weeks after the appliance. Use of insecticides results in a decrease in the rate of growth and also causes many metabolic and reproductive disorders. Especially in fish species, it may cause histopathological changes in gills, liver, hematopoietic tissue such as the spleen, kidney, and renal tubules, in endocrine tissues as well as brain, neurological, behavioural disorder and also cause genetic defect on exposure to insecticides. Some fish species are very sensitive to the environmental contamination of water (Maurya and Malik, 2016a). Hence, insecticides pollution in water may drastically damage in certain physiology and biochemical processes can cause serious mutilation

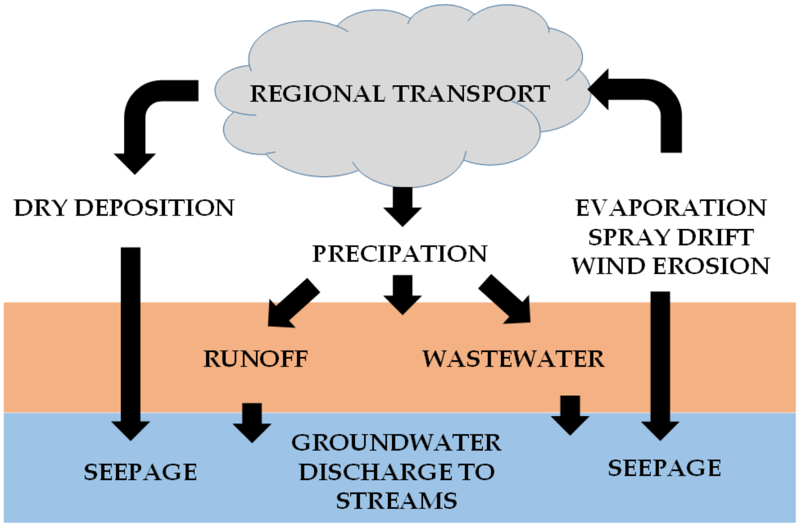

Figure 9.1. *Transportation of pesticides through atmospheric rotation.*

to physiological and health status as well as the structure of fish species. Aquaculture is solitary fastest growing fish food-producing sectors, supplying on an approximately 40-45% of the world's fish food (Mullen *et al*., 1997).

Besides all these benefits to society, the industry also faces various problems. Exposure of large quantities of pollutants might be an immediate effect as measured by mortality suddenly in large-scale aquaculture, for example, fish mortality caused by pollution of waterways with agricultural insecticides. A small quantity of pollution discharge may result in the accumulation of pollutants in fish species and also by aquatic organisms. This paper presents the further in order to the concerning effects (acute, sub chronic and chronic) of the different types and different concentrations of insecticides on some aspects of fish's biology, physiology, behaviour, the genetic and immune system of fish species. Also, when insecticides must choosing sensibly and are used in combination with various management tools, and also applied safely, in the result to avoid the surface water pollution and contamination of our aquatic life (Maurya *et al*., 2018).

Aquatic and fisheries resources in the form of lake, reservoir, ponds, rivers, seas, and oceans are supplying human with long term reimbursement. Those benefits can be the form of financial support which can provide employment, profit, water requirement, etc. to the humans. For example, the aquaculture and seafood industries provide jobs for commercial fisheries, wholesalers, and retailers. More round about, but equally important, benefits of fish and aquatic ecosystems include recreational activities like boating, sport fishing, swimming and natural beauty (Little *et al*., 1990; Malik and Maurya, 2015).

There are various occupational hazards and security concerns in the aquaculture industry. Some practices have caused environmental degradation. Community perception regarding the farmed fish species is that they are "cleaner" comparable to the wild fish species. On the other hand, various farmed fish have a much higher body burden of natural as well as man-made toxic production, e.g., in the form of antibiotics, insecticides, and pushy organic pollutants, than wild fish species. These types of contaminants in fish species can cause various health issues to unsuspecting consumers, mainly in pregnant or nursing women. The rule and regulations, as well as international oversight for the aquaculture industries, are very complex, in which various agencies indulge in aquaculture practices follow these regulation i.e. selection of site, control over pollution, quality of water, feed and also the safety of food. Different types of agricultural practices used insecticides results estrogenic and anti-estrogenic contaminants in the ecosystem can cause endocrine disruption and also effect on fish reproduction rate. Application of insecticides used for control a wide variety of insectivorous which would otherwise diminish both the quantity and quality of food production. Desolately, in spite of various advantages, the synthesized chemical compounds have significant drawbacks also threaten the long-lasting survival of major environmental disorder in relations between the aquatic organisms and also the loss of biodiversity. There are various major categories of insecticides that are habitually applied chlorinated hydrocarbons, carbamate, organophosphate, pyrethroids, and nicotinoids. Surface water contamination by insecticides is generally due to different agriculture practices combined with surface runoff and surface drainage, usually within a few weeks after application. Fish species are chiefly sensitive to the environmental contamination of water. Hence, pollutants like insecticides may effect on various physiological and biochemical processes that types of insecticides can cause a serious threat to the health status of fishes (Maurya and Malik, 2016a).

In modern agriculture activity, various types of chemical in the form of Pesticides, insecticides are used due to increased demand for productivity. Increased in productivity significantly increased the concentration of a chemical in food as well as in the ecosystem, which causes negative effects on human and other living organism health. (Richter, 2002) described that annually there are above million cases of pesticide poisonings worldwide. Moreover, with the progression of time, it may now better implicit that different pesticides have significant chronic health effects on the organism, including various types of cancer, nerve effects, diabetes, respiratory diseases, infant including fatal diseases, and genetic disorders. This type of health effects are different varied on the degree of exposure as well as the type of exposure. Normally, these effects are frequently for farmers, who are unswervingly exposed to pesticides, compared to the farmers living in rural areas who are less exposed to the following activities. Pesticides not only affect the farmer health but can also affect on consumer's health through residues of pesticide present in the food (Maurya and Malik, 2016b).

Regulation and use of Pesticides have long been controversial (Carson, 1962) in his famous publication made a popular observation in relation to risks associated with DDT (dichlorodiphenyltrichloroethane) and was followed by the US authorities for cancelation of this pesticide in agricultural uses. Various other examples of pesticide cancelation include EDB (ethylene dibromide) in 1983 and methyl bromide in 2005. It is now clear that a significant fraction of pesticides are carcinogenic; for instance, 18% of all insecticides and 90% of all fungicides were found to be carcinogenic (NAS, 1987), also it is well known that residues of the pesticide remain for long periods of time and that they are especially toxic to the young. Also, the uses of pesticides kill domestic animals, aquatic animals especially fishes and bees. Moreover, use of this type of chemical results in the development and evolution of pesticide resistance indifferent type insects, weeds and plant pathogens. All the same hundreds of different types of pesticides are used around the worldwide landscape, and some particular pesticides are used in some countries and not in other parts of countries. The main pesticide used for corn production in the various parts of US is atrazine, but this pesticide has been banned in the EU because of its heavy toxic effect since 2004 (Official Journal of the European Union 2004/248/CE). Public decisions concerning pesticides effects have long been suspected of regulatory capture. Main reasons for transferring pesticides in 1970 regulatory accountability from the US Department of Agriculture to the Environmental Protection Agency (EPA) was to lessen the influence of farmers and pesticide producers.

But this shift of liability naturally increased the persuade of consumers and environmentalists. Indeed, Cropper *et al.* (1992) showed that both grower and environmental groups' participation played a key role in explaining the EPA decisions to cancel a pesticide in the1970s and 1980s. Risk assessment practices also play a role in pesticides regulation. The zero-risk or" de-minimise risk" target has long been the sophisticated objective of regulators. But this objective is overly ambitious and often not implemented as a result. Some of the evidence for instance that a significant fraction of food samples still exceeds the maximum residue limits set by regulators both in the US and in Europe. Finally, risk perceptions may also persuade pesticide regulation. Slovic (2000) reported the grass root of these challenges, there is the gigantic difficulty of producing more food with the minimum use of pesticide, and the vaguenessa bout health sound effects of pesticides. Given the mounting health concerns over the population, some extreme actions to curb the employ of pesticides have been decided in some countries.

Denmark decided in 1986 to diminish the pesticide treatment rate of recurrence in agriculture. Recently, France also announced in 2008 a lessening by two of pesticide use by 2018 in its "Ecophyto 2018" plan (MAP, 2009). A key problem with such ruthless policy targets is that they need not replicate an appropriate balance of benefits and costs induced by pesticides used in our societies. Also, these policy targets may be difficult, if not impossible, to implement in practice, in part because of the opposition of farmers. However, only a few types of research are available in relation to benefit-cost analysis (BCA) concerning pesticides have been produced so far (Pimentel, 2005).

Aquatic toxicology

Aquatic toxicology is the study of the effects of environmental contaminants on aquatic organisms, such as the effect of pesticides on the health of fish or other aquatic organisms' Figure 9.2. A

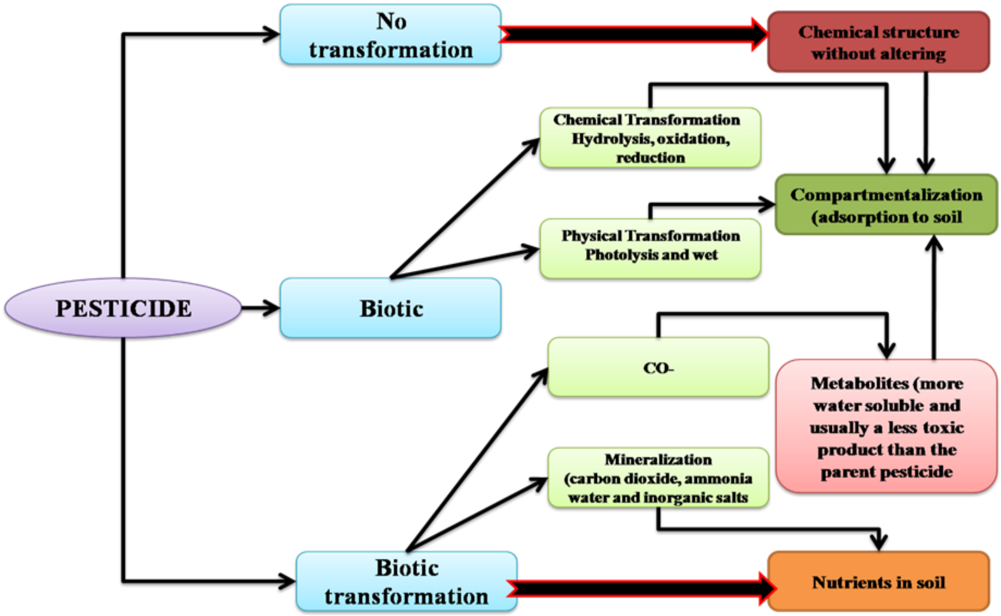

Figure 9.2. *Different route of exposure of pesticides in aquatic system (Adopted from Maurya and Malik 2016b).*

pesticide's capacity to accelerate the harmful effect of fish and aquatic animals are large. It toxicity always depend upon exposure time, dose rate, persistence time in the environment. Toxicity of the pesticide refers to how poisonous it is. Brief exposure to some chemicals may have little effect on fish, whereas longer exposure may cause harm (Arbuekal and Server, 1998; Barone *et al*., 2000). Bio-concentration is the accumulation of pesticides in animal tissue at stages more than the ones in the water or soil to which they have been carried out. The poisonous substance inters into the aquatic animal body and effected on the idea of attention of toxicant. The sediment and soil are ecologically important for aquatic habitat, which plays a significant role in nutrients hooding capacity. Highly polluted sediments or accumulation of nutrients are adversely affecting the ecological functioning of rivers due to persistence in the environment and longrange transport. Repeated exposure to certain insecticides can result in decreased fish egg production and hatching, nest and brood abandonment, decrease resistance to disease, reduced body weight, hormonal modifications, and reduced avoidance of predators. The general effects of sub-lethal doses of insecticides can be decreased adult survival and reduced population abundance (Hoppin *et al*., 2002; Kamel and Hoppin, 2004; Gupta, 2004).

Different aquatic animals exposed to a pesticide, its survival relies upon on its biological availability (bioavailability), bioconcentration, biomagnification, and persistence inside the surroundings. Bioavailability refers to the amount of pesticide within the environment to be had to fish and flora and fauna. Some insecticides swiftly breakdown after utility. Some bind tightly to soil debris suspended in the water column or to stream bottoms, thereby reducing their availability.

Challenges of the global pesticide market

Fast increase in globalization are affecting pest management practices on and off the farm. The decline in the trade barriers also increases the competitive pressures and provides extra incentives for farmers to reduce costs and increase crop yields. Former participation and input markets, often branded as successful marketplace reform, can lead to incompetent pesticide use and high external costs (FAO, 2009). Other types of forms of trade barriers create a disincentive for adopting new technology such as the unwillingness of the EU to accept (GMO) genetically modified organisms. It may be imperative to indicate that it is not only the big multinational that are an important group of parties in pesticide policy but also the many new based companies in the developing countries who manufacture generics. An increases trend in the agrichemical industries is the big movement of many chemical pesticides off patent. As a result of these chemicals become generic pesticides, manufacturers lose their monopolies on them. Overall, generic type companies make up about 30 % of total sales. Mounting sales of generic pesticides, especially in some countries not only in Africa and Latin America but also in some of the Asian countries, is often facilitated by weak authoritarian control and the lack of an IPM oriented national policy framework (FAO, 2009). Around 30 to 35% of pesticides marketed in the developing countries with an estimated market value of USD 900 million manually do not get together internationally accepted quality standards. They preteens a serious threat to human health and also on their associated environment. Such types of pesticides often put into the accumulation of outdated pesticide stocks in developing countries (FAO, 2009).

Crop losses to pests

Crop productivity may be greater than before in many regions in various parts by high-yielding varieties, enhanced water quality and soil supervision, fertilization and other cultivation modern techniques. As a result of increased in the yield potential of crops, still, it is often linked with high insusceptibility to pest attack leading to increasing absolute losses and loss rates (Oerke *et al*., 1994). An average ofabout35to 35 % of potential crop yield is lost to pre-harvest pests worldwide (Oerke, 2005).In adding together to the pre-harvest losses transport, pre-processing, storage space, dispensation, packaging, promotion, and plate waste losses along with the whole food chain account foranother30 to 35 %. In adding together to lessen crop losses due to pests, avoiding squander along with the whole distance end to end of the foodstuff chain is also a key (Popp, 2011). Evolutionary communications between pests and farmers predate predictable pesticides by thousands of years. Various levels of loss may be differentiated, e.g. direct and indirect level of losses or in the ways of primary and secondary losses, indicating that pests not only imperil crop yield and reduce the farmer's net income but may also affect the contribution of food and feed as well as the economy of different rural areas and even countries (Zadoks and Schein, 1979). Weeds affect crop efficiency particularly due to the antagonism for inorganic nutrients (Boote *et al*., 1983). Crop fortification has been residential for the prevention and control of yield losses due to pests in the field (pre-harvest losses) and during storage space (post-harvest losses). This paper concentrates on pre-harvest losses, i.e. the effect of pests on crop production in the field and the effect of control measures applied by farmers in order to minimize losses to an acceptable level (Oerke, 2005).

Costs and benefits of pesticide use

The profitable analyses of pesticide remuneration are hindered by the lack of pesticide use data and fiscal models for minor and crops as well as non-agricultural pesticides. Cost–benefit analysis of pesticides use is increasingly used to measure resource supervision and environmental policies. This approach monetizes all costs as well as benefits so that they are deliberate in currencies and its full functioning might be constrained by data limitations factor and difficulties in monetizing human and environmental health risks. Further economic impacts are complicated by the various government programmes that support pesticide users, such as price and cost supports system and deficit payments.

The most usually economic incentives are based on the "polluter pays" principle, including the use of licensing fees, user fees or taxes. Denmark, Sweden, and Norway are some of the countries which experience the introduced taxes in such a way of reducing pesticide use. However, the price elasticity of this chemical is estimated very low and can suggest comparatively very little effect in terms of quantity reductions, unless they may set very high rates relative to price. Some suggestions in regard to pesticides are to revenue and recycling may have been more effectual, with revenues redirected to research and information. Using further research or to encourage various changes in farming activities would appear to make more sense (Pearce and Koundouri, 2003).

Pesticides may vary in their toxicity by design, by concentration and also according to the conditions in which they are receiving environment. The main theoretical solution is to articulate the tax as an absolute sum per unit of toxicity-weighted ingredient. The overall stipulate for pesticides and insecticides are not reduced drastically by a tax, a toxicity-differentiated tax may be more effective if the exchange between pesticides will occur in a way that the all over the toxic force of pesticides will be abridged. This means that the pesticide and its use, as well as toxicity, could be "decoupled" by a pesticide tax. The various problems with pesticide tax studies are few of them simulate the "cross-price effects" of such a policy, i.e. they do not look directly at the changeover between different types of pesticides (or between pesticides and other inputs such as fertilizers and land). Simulations of such type of toxicity-weighted taxes for the UK show that overall cost price elasticity is demand for pesticides was consistently low and may never greater than −0.39. Nevertheless, cross-price elasticities in between the "banded" pesticides (banded according to toxicity) were greater than the "own" price elasticity, telltale that farmers might be switch between various types of pesticide (Pearce and Koundouri, 2003). Nonetheless, the "polluter pays" principle (i.e. adding the environmental and public health costs to the price paid by consumers) can be an efficient loom toward internalizing the social costs of pesticide use. The fees, as well as taxes generated, can be used to enhance (sustainable) pest management system. In instruct to place the right level of levies and taxes, it may be obligatory to estimate the positive and negative impacts of pesticides. Various attempts have been made to establish the costs price related to public health (risks to farm workers and consumers and drift risk) and spoil to favourable species, and also to the ecosystem (Pimentel *et al*., 1992; Pimentel and Greiner, 1997; Pimentel, 2005). However, the result of the use of the pesticides can in a range of benefits including wider public outcomes with benefits being manifested in increased income and reduced risk, plus the aptitude to hire manual labour and provide the employment opportunities and other services. Some other outcomes were also the evolution of more multipart hamlet facilities, such as educational institutes, schools, and shops in such a way to improved health structure (Bennett *et al*., 2010). Some of the sub-lethal effects include:

- Loss of attention.
- Low diseases resistance.
- Low predator avoidance.
- Reduced egg production.
- Sterility.
- Weight loss.

Exposure of pesticides to aquatic animals

Both in fish species, as well as aquatic flora and fauna, are exposed to a variety of pesticides in three common ways as dermal, direct absorption all the way through integument by swimming in contaminated surface water with pesticide as well as subordinate surfaces of waters in form of lentic and lotic water bodies, direct or indirect uptake of pesticides through inhalation by the way of gills during respiration, and directly throughout, drinking pesticides contaminated water or feed pesticide contaminated prey as in Figure 9.3. The sources of pesticides in the aquatic system through the agricultural runoff and industrial effluents, the entire foreign toxic compound mixed in the aquatic ecosystem and disturbed all aquatic life.

There are also some minor causes that affect the attention of fish species and aquatic flora and fauna to pesticides and resulted in toxicity. By the utilization of pesticide contaminated animal and their by-products also transfer toxicity to consumer's i.e. various carnivorous fish species feed upon the variety of aquatic insects already killed due to the toxicity of pesticide may transfer effect to next tropic level. Mainly surface water of the riverine ecosystem generally comes first with pesticides contact, and various organic substances like algae, mosses, vascular hydrophytes, leaf litter, and branches, etc. may also behave as secondary causes of toxicity. The revelation of any fish species and other aquatic community to pesticide may be widespread problem realized by the people. Most of the case related to the pesticide toxicity in fish species goes unreported and also in some known cases, the quantity of fish species mortality is often underestimating.

The scientific knowledge regarding possible pesticides affect fish species and other aquatic living organism depend mainly upon seven factors i.e. category of pesticide and its by-product, concentration rates, climate conditions, type of aquatic species concerned, degree of the dilemma (number of fish mortality), place and dimension of water body affected. Acute effect of toxicity with different types of pesticides mainly depends upon the fish species and duration of exposure as in Tables 9.1-9.3.

Various steps to reduce the effect of pesticides: Before using any pesticide, think about the following:

- Only use the pesticide whenever necessary.
- Use another ways of treating the predicament. Landowners should think about the expenses and consequences of pesticide cure relative to the problem.
- Use pesticides having less toxicity.

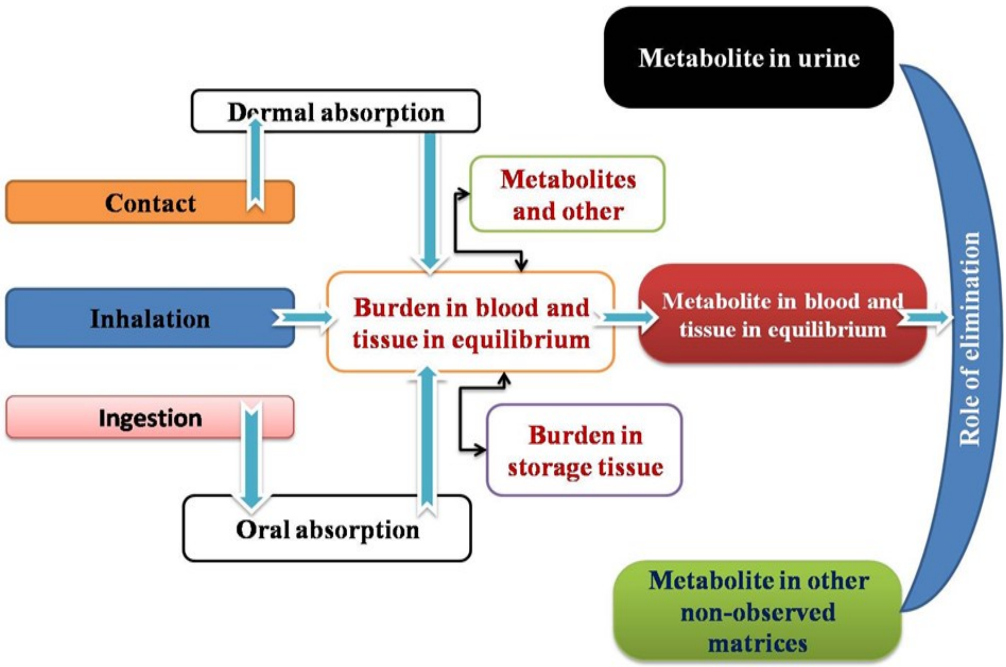

Figure 9.3. *Distribution toxicant by route of exposure in the animal body and representation of the toxic kinetic model (Source: Maurya and Malik, 2016a).*

- To reduce the sound effects of pesticides on aquatic ecosystems, use only those least toxic pesticides to the aquatic organism. Some relative toxicity lists of pesticides used in various agricultural activities are presented in tables at the end of this booklet.
- Application methods must be safe and sensible
- The initial tenet of accountable in the use of pesticide is to understand and then go through the pesticide label and follow the guidelines precisely. Label information sometimes can be mystifying. Contact extension agent, supplier in a case if don't recognize the directions or the company of pesticide for more information.
- Give meticulous awareness to the word of warning about ecological hazards on the sticky label. Look the label to confirm that: "These manufactured goods are toxic to fish species." think about supplementary pesticide or any other alternative control technique.
- Certify that equipment is working in fine proviso. Check for any leakage, reinstate worn out parts, and vigilantly standardize your equipment.
- While preparing the pesticides for relevance, subsist that you are assimilation them accurately.
- Never rinse spray tools in lakes, ponds, or rivers. If you use water directly from the natural ponds, lakes, or streams, use an anti-siphon device to avoid backflow.
- In some case applying pesticides near surface water, ensure the sticky label to locate the suggested buffer zone. Buffer strip widths varied between the water and the treatment areas. Depart a broad buffer zone to shun contaminating fish species and aquatic flora and fauna.
- Store up and dispose of unused pesticides and their containers according to the label directions.
- Avoid the use of pesticide waft into no target areas, or applications for the period of wet, turbulent weather that may endorse runoff to non-target streams, ponds, or lakes. Mist on cool days or in the early hours or evening when it is less windy.
- Pesticide applicators are legally responsible for downstream fish mortality and pesticide contamination.

Table 9.1.*The toxicity of pesticides on the basis of concentration.*

Hazard rating	Dose (mg/L)
Toxicity	LC50
Minimal	>100
Slight	10-100
Moderate	1-10
High	0.01-0.1
Extreme	0.01-0.1
Super	<0.01

Table 9.2. *The acute toxicity (LC50) of some pesticides against certain fish species.*

Name of pesticide	Fish species	Duration of exposure
DDT	*Rainbow trout*	96 hrs-8.7 µg/l
Akton	Channel catfish	96 hrs-400 µg/l
Acephate	Feathed M.	96hrs>1000 µg/l
Alachlor	*Rainbow trout*	96hrs 2.4 µg/l
Endosulfan	*Channel catfish*	96hrs 1.5 µg/l
Malathion	*Labeorohita*	96hrs 15 µg/l
Malathion	*Heteropneustesfossilis*	96hrs 0.98 ppm
Methyl parathion	*Catlacatla*	96hrs 4.8 ppm
Roger	*Pontius stigma*	96hrs 7.1 and 7.8 ppm

Table 9.3. *Acute toxicity of some insecticides against certain fish species (Source: Hanazato, 2011).*

Insecticides	Fish species	96hLC50
Azodrin	Rainbow trout(RT), bluegill (BG), Channel catfish, Feathered minnows (FM)	4.9-50 ppm
Aldrin	FM, Chinook Salmon, RT, blue head, bluegill	2.5-53 ppm
Carbaryl	Coho salmon, Chinook salmon, RT, green sunfish, largemouth bass, yellow perch, and black crappie	0.9-39 ppm
Carbofuran	Walked catfish, Chubs	0.22-23 ppm
Chlordane	Coho salmon, cutthroat, RT, FM, Channel catfish	0.72-11.9 ppm
Chlorpyrifos	Nile tilapia (NT), Bluegill , FM, RT, Goldfish	0.72-11.9 ppm
DDT	Coho salmon, cutthroat, RT, FM, Channel catfish	1.5-21.5 ppb
Diazinon	Guppies, Channapunctatus	0.9-2.6 ppm
Dieldrin	Coho salmon, Chinook salmon, RT, green sunfish, largemouth bass, yellow perch and black crappie, Cutthroat	1.2-19 ppb
Diflubenzuron	FM, Brook trout, Yellow perch, RT and Cutthroat	25-240 ppm
Dinitroceresol	RT and bluegill	66-360 ppb
Dioxathion	Cutthroat, Largemouth bass	22-110 ppb
Disulfoton	Coho salmon, Chinook salmon, RT, green sunfish, largemouth bass, yellow perch, and black crappie, Cutthroat	60-4700 ppb
Fenthion	Coho salmon, Chinook salmon, RT, green sunfish, largemouth bass, yellow perch and black crappie, Cutthroat	1.1-3.4 ppm
Trichlorfon	Eel, RT, Cutthroat, Brown trout, bluegill, Largemouth bass	1.1-3.4 ppm

Modification in habitat

Increase in pesticides concentration can diminish the accessibility of aquatic plants and insects that in order to serve as food for fish species and another aquatic organism. Use of pesticides in various agricultural practices can affect the food chain of insect eating birds and also for fish species. An unexpected, insufficient availability of insect's food can force fish species to migrate in search of food, where they might found the availability of greater revelation to predation. Similar to pesticides, herbicides can also trim down the reproductive success of fish species and other aquatic flora and fauna (Malik *et al*., 2015; Maurya *et al*., 2016c; Maurya *et al*., 2019).

The deep, weedy nursery areas for various fish species supply rich food and protection for fry and fingerlings. Spraying pesticides along weedy nurseries can diminish the quantity of cover and protection that fry and fingerlings need in order to hide from predators and to feed. Most fry and fingerlings depend on aquatic plants as a refuge in their nursery areas (Schreinemachers *et al*., 1999). Aquatic flora contributed about 80% of the total dissolved oxygen essential for aquatic organism present in different ponds and lakes. Pesticides kill all aquatic organisms due to the low oxygen levels and the suffocation mainly in fish species. Future use of herbicides to utterly "clean up" a pond will drastically reduce fish habit and habitat, food supply, dissolved oxygen, and fish yield.

Control of pests

Chemical control

The remedial technique for pest control with noxious chemicals has been proved the major prevailing pest control approach about an average of 50 years. Security exertion and environmental disruptions go on to ensure (Wright, 1996) and renewed appeals for efficient, safe, and cost-effectively adequate alternatives (Benbrook, 1996).

Pesticides carry synthetic chemical are the most extensively used scheme of pest management. Mainly four problems are encountered with toxic pesticides are its residues, pest resistance, pests as secondary form, and pest resurrection (Lewis, 1997). Many pesticides, as well as organophosphates that are eco-friendly, must be preferred and synthetic form pesticides should only be preferred as the last option as to use only when required.

Biological control

From time to time, the word ''biological control'' has been used in a broad perspective to include a full scale of biological organisms and products based biologically including some i.e. phero-110 Weed and Pest Control - Conventional and New Challenges mones, resistant plant varieties, and autocidal techniques such as sterile insects. IPM is mostly intended at developing systems based on the use of various biological and non-chemical methods as much as possible.

Mechanical control

By the help of machinery and other modern tools as well as advanced technique are used now a day to control pests in any agricultural practices. It involves some farming practices like tillage, slash and burn, and also by manual hand weeding. The pruning of infected parts of various fruits, forest trees and defoliation in certain standing crops help to reduce the population of the pest. Chaffing of sorghum/maize part of stalks and blazing of stubbles to kills maize borer is also used.

Sanitary control

Sanitary control comprises cleaning field equipment (tillage equipment, haying equipment, etc.), certified seeds should be planting and quarantine of infected crops from farmlands. These are some methods which help to prevent the introduction of a pest into the agricultural field.

Natural control

Certain techniques which only involve the improvement of naturally occurring pest management methods to conflict with pests like using valuable insects. Here only insecticides are applied to efficiently realistic and it is obvious that natural predators will help to control the pests.

Resistance in the host plant

This method involves various breeding strategies with enviable financial traits, but a smaller amount of attractive for pests, egg laying and consequent progress of insect, disease as well as a nematode. It also involves the infestation/infection or the lessening of pests to some level that they are not in huge figures during the growth period of an aquatic plant (Sharma, 2007).

Cultural measures

The developments of cultural control are the oldest methods that have been used to manage pest populations. However, with the development of synthetic pesticides, these controls were rapidly de-emphasized and research on them was largely discontinued. The involves practices that suppress pest problems by minimizing the conditions that favour their existence of life (water, shelter, food). The selection of an appropriate site for the cultivation of field crops and fruit trees can reduce future infestation from insect pests. The culture should be selected in such a manner that it should be suitable for growing in the area and tolerant of important pests diseases of the area.

Integrated pest management (IPM)

IPM is a science based on scientific thought and decision-making process that identifies and reduces the risk of pest management related strategies. IPM coordinates the pest biology of the environmental information and available different technology to prevent unacceptable levels of pest damage by the most economical means while minimizing risk to people, property, resources, and the environment. The key to pest control strategies is to determine the extent of the problem. IPM takes benefit of these natural controls and their programs come to mind in numerous places all over the country. They may be applying in several situations from small home gardens to trade water weed administration. IPM involves an array of methods, including pesticides in order to reduce the pest contaminated populations to adequate levels. Due to the overdependence on pesticides, IPM was developed. Many factors i.e. contamination in groundwater, the ever-increasing cost of agricultural pesticides, concerns of the customer regarding pesticide contaminated foods, and also concern about the environment persuade the use of IPM. IPM provides an effective improvement, all encompassing, low risk approach to protect resources and people from pests" (USDA NIFA, 2013). IPM integrates multiple management tactics mostly allow the production system to move away from traditional, chemical-based management in ways that usually allow production systems to move away from traditional management to ecologically sound strategies. IPM practices are typically crop and region-specific and are intended to result in effective, timely and affordable pest control while also reducing the use of pesticides to health and the environment (Biddinger and Rajotte, 2015). IPM can readily evolve to meet new challenges such as food safety. IPM protocols, or collections of practices for specific crops and regions, often include related practices such as irrigation and nutrient management, at least to the extent that they influence pest management. The carefully timing management for irrigation cycles so plant foliage will dry quickly limits the potential for plant disease growth and spread (Waage, 1997). On the other hand, bio-pesticides may be safer comparing to that of conventional pesticides, the manufacturing groups of these bio-pesticides composed mostly of small to average sized enterprises, and it is very difficult for such companies to fulfil and comprehensively subsidize investigate and expansion, marketing and promotion services of such companies required to make a successful way to aware the use and benefits of bio-pesticide. Yet it is a major challenge for anyone to initiate this process due to the lack of innovative bio-pesticide goods impending to the open market and also for their registration (Popp, 2011; Farm Chemical Internationals, 2010). Types of strategies under IPM include:

- Cultural control in the form of crop rotation and planting season to avoid pests.
- Host resistance plants are used and select livestock that is resistant to pests.
- Mechanical control by uprooting, weed harvesting, cultivation, and use of various types of traps to the captured insect)
- Biological control as stocking some carp fish species that feed on water weeds.
- Control of pesticides with chemical
- Proper sanitation

Efficient supervision practices for the protective quality of water

- Preferred only IPM practices in order to avoid the chemical controls methods or will be applied only whenever necessary. Preventive measures should be taken before using any pesticide and can be applied safely and in an effective manner.

- Estimate the concentrations of chemical control in agricultural practices. Separate out the major option that is the slightest adverse impact on water quality. Select those products which reduce waste and applicator exposure.
- Proper care should while incorporation and loading pesticides. Check equipment working correctly and is properly calibrated in advance. Prepare only the required amount of pesticide needed for the urgent application.
- Apply pesticides in short and precise time period. Think about climate as well as the life cycle of pest before planning applications.
- Store pesticides products safely in a ventilated away from sunlight, and protected area free from flooding.
- Disposal of empty containers of pesticides should not rinse in water.
- Keep records about the concentration and timing of all pesticide used in the area. This will help in assessment of pest control efforts and also help to plan future treatments.

Conclusion

Exposure of aquatic as well as terrestrial organisms to pesticides for the long term means an incessant health risk for the inhabitants. So, directly and indirectly, human populace is at elevated risk by consuming the toxicities fish species. This clearly reveals that the individual should take the required preventative measure in the application of pesticides to guard the fish population and also to other aquatic fauna. Thus it is probable that many approaches using according to molecular biology techniques will modernize toxicological applications that are cheaper and do not entail the animals to identify ecological stressors. Different effect of pesticide toxicity in fish species has been premeditated by a number of researchers, who have revealed that at chronic level, may cause different effects i.e. oxidative damage, the reticence of AchE movement, changes in histopathological, embryonic and developmental changes, carcinogenicity and mutagenesis. Usage of pesticide and its undesirable effects on non-target aquatic organisms including fish species, it has befallen crucial to plan rigid rules and regulations against the arbitrary use of this pesticide.

Since pesticide in the environment have some other toxicant compound i.e. compounds of organophosphate, additive responses to organophosphate compounds may bring on poisonous or lethal effects in fish species. Therefore it is an issue of enormous public healthiness consequence to habitually supervise the concentration of pesticide residues in foods material and also supervise the humans in a way to measure the resident's exposure to the pesticide. More experimental effort should be performed to establish the concentration and exposure time of these pesticides and also induce significant lethal and sub-lethal effects on the organism.

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