Hazardous side effects of Pesticides on rhizospheric soil organisms, birds, honeybees and human health

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Abstract

Pesticides, including herbicide and insecticide are the most dangerous environmental pollutant. The term pesticide covers a wide range of compounds including insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and others. Persistent pesticide residue in agricultural field affects crop yield. Application of pesticides causes deleterious effects on soils, beneficial soils organisms and environment. The presence of herbicide residues in soil could have direct impacts on soil microorganisms is a matter of great concern. Ideally a pesticide must be lethal to the targeted pests, but not to non-target species, beneficial rhizobateria. The present study is aimed to review the effect of pesticides on soil, honeybee, amphibians and arthopods population, earthworms, birds, and human health. Pesticides have contaminated almost every part of our environment and pesticide residues are found in soil, air and in surface and groundwater. Pesticide contamination poses a significant risk to the environment and non-target organisms ranging from beneficial soil microorganisms to insects, plants, fish, birds and human beings. The environmental deterioration due to pesticides is endangering the situation of future.

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Introduction

Over the last decade, a significant research interest has been generated around pesticides and herbicides, because of it`s significant potential to kill the pests, as a result crop yield increase. India is now the largest manufacturer of pesticides in Asia after China and ranks twelfth globally (Abhilash and Nandita 2009). India consumes only 1% of pesticides of the total pesticide consumption of the world. However, Indian average consumption of pesticide is far lower than many other developed economies. Consumption of persistent organic pesticides, their maximum residual limit (MRL) and the presence of persistent organic pesticides in multicomponent environmental samples (air, water and soil) from India modeling simulations has been well documented (Yadav et al., 2015). Pesticide and herbicide, when administered to the soils cause various degradative activities within the soils environment. The overall degradation of these hazardous compounds results to soils degradation by a combination of mechanisms such as microbial degradation, chemical hydrolysis, photolysis, volatility, leaching and surface runoff. Moreover, the degree of overall soils degradation depend on its physiochemical properties, such as water solubility, sorptive affinity, characteristics of soils, such as pH, organic matter content, microbial biomass, redox status, environmental conditions, such as temperature moisture and management practices, such as application rate, formulation type. There are various complex interactions take place within the soils, after the application of pesticides and herbicides which is poorly understood (Sitaramaraju *et al*., 2014). The degradation of pesticides in soil systems depends on their physico-chemical properties and how they interact with the biotic and abiotic soil components (Beigel *et al.,* 1999; Sannino *et al*., 1999). Soil fungi often make up at least 75-90% of the soil microbial biomass and together with bacteria are responsible for about 90% of total energy flux of organic matter decomposition in soil (Paul and Clark 1996).

At normal field recommended rates, herbicides are considered to have no major or long-term effect on microbial populations. It has been reported that some microorganisms were able to degrade the herbicide, while some others were adversely affected depending on the application rates and the type of herbicide used (Sebiomo *et al*., 2011). Therefore, effects of herbicides on microbial growth, either stimulating or depressive, depend on the chemicals (type and concentration), microbial species and environmental conditions (Zain *et al*., 2013). India is one of the few remaining countries still producing and using some of the chlorinated pesticides such as DDT and lindane (Abhilash and Singh, 2009; Vijgen *et al*., 2011). Among the various states, Uttar Pradesh is the largest consumer of pesticides and herbicides followed by Punjab, Haryana and Maharashtra (Gupta, 2004; Abhilash and Singh, 2009). Many of the

chemicals used in pesticides are persistent soil contaminants, whose impact may endure for decades and adversely affect soil conservation. The transport, persistence or degradation of pesticides in soil depends on their chemical properties as well as physical, chemical and biological properties of the soil. All these factors affect sorption/ desorption, volatilisation, degradation, uptake by plants, run-off, and leaching of pesticides. Pesticide with halogen or alkyl substituent of benzene ring tends to make the molecule more resistant to biodegradation (cork and Krueger 1991). Chlorinated hydrocarbons such as DDT, pentalene and dieldrin are insoluble in water, sorb tightly to soil and are thus relatively unavailable for biodegradation (Chakraborty *et al*., 2006). Pesticide with low water solubility tends to be more resistant to microbial degradation than compounds of higher water solubility. The persistence of organochlorine pesticides in soils upto several years has been well documented (Jiang *et al*., 2009; Ferencz and Balog 2010). Persistence is due to bonding between pesticides and soil organic matter or clay particles that are less mobile and less accessible to microbial degradation. Sorption limits soil degradation and transport in soil. Soil organic matter is the most important factor influencing sorption and leaching of pesticides in soil. Addition of organic matter to soil can enhance sorption and reduce risk to water pollution. It has been demonstrated that amount and composition of organic matter had large impact on pesticides sorption. For example soil rich on humus content are more chemically reactive with pesticides than nonhumified soil (Farenhorst 2006). This paper briefly reviews the current state of knowledge on pesticides and herbicides and its deleterious effects on the environment, soil, soil organism and human being. The present study is aimed to review the effect of pesticides and herbicides on rhizospheric soil and rhizospheic organisms.

Results and Discussion

Effect of pesticides on soil

Study of Mada *et al*., (2010) showed the negative impacts as drastic decline of micro organic activities, soil degradation and reduction of water retention in soil and decrease of organic matter after continuous application of pesticides with high percentage. The activity of biomass is drastically affected in the soil. On the other hand Adhikary *et al*., (2014) assessed the reduction of soil microbial population and size of chilli fruiting body with the application of three commonly used herbicides namely pendimethalin, oxyfluorfen and propaquiza.

Studies show that some organochlorine pesticides suppress symbiotic nitrogen fixation resulting in lower crop yields. It was observed that pesticide pentachlorphenol, DDT and Methyl parathion interfered signaling from leguminous plant such as alfalfa, peas, and soybeans to symbiotic soil bacteria. Sebiomo *et al*., (2011) reported the significant drastic decrease in percent organic matter of the soil when treated with four herbicides namely atrazine, primeextra, paraquat and glyphosate.

Soil microorganisms play a key role in soil. They are essential for maintenance of soil structure, transformation and mineralization of organic matter, making nutrients available for plants. Soil microorganisms are also able to metabolise and degrade a lot of pollutants and pesticides. Although soil microbial population is characterized by fast flexibility and adaptability to changed environmental condition, the application of pesticides (especially long-term) can cause significant irreversible changes in their population (Fox *et al*., 2007; Potera 2007).

Effect of pesticides on earthworms

Earthworms represent the greatest part of biomass of terrestrial invertebrates (>80 %) and play an important role in soil ecosystem. They are used as bioindicator of soil contamination providing an early warning of decline in soil quality. Continuous application of herbicides leads to destruction of earthworm cast and burrowing micro organism and their complete disappearance. A review of pesticides effects on earthworms showed on negative effects on growth and reproduction by many pesticides (Shahla and D'Souza 2010). Glyphosate, nonselective herbicide, and chlorpyrifos, insecticide, belong to the most worldwide used pesticides, especially on transgenic resistant crops. Mohasin *et al*., (2005) reported the inhibitory effect of Earthpod formation by the earthworm *(Metaphire pa.rthuma)*, when applied with herbicide such as paraquat and Glyphosate with 2-4D at recommended dose. Toxic effect of 2,4D on mammal has been well documented (Ville *et al*., 1997). Repeated application of pesticides in agricultural ecosystem has threatened the ability of survival of different nontarget soil fauna and earthworm is one group of soil dwelling and fertility improver invertebrate. An integrated study on a Roundoup resistant soya field showed deleterious effect of these pesticides on earthworm population (Casabé *et al*., 2007). Garcia *et al.,* (2008) reported avoidance behavior of three pesticides namely Benomyl, Carbendazim and lambda-cyhalothrin of earthworm *Eisenia fetida*. Reinecke and Reinecke (2007) reported adverse effects of spraying by pesticides (Chlorpyrifos and Azinphos methyl) on earthworm's biomass and cholinesterase activity.

Effect of pesticides on honeybee, amphibians and arthropods population

Wild bees are the major crop pollination. Brittain *et al*., (2010) reported decline of wild bees after repeated application of insecticide fenitrothion. Tapparo *et al*., (2012) shown the aerial dust of neonicotinoids, sprayed during sowing, can be sufficient to cause direct mortality in honeybees flying nearby (Marzaro *et al*., 2011). Negative impact of pesticides on butterflies population, butterflies wing, pupa weight and their survival has been well documented (Adamski *et al*., 2009; Russell and Schultz 2009). Toxic effect of Carbaryl on amphibian species has been well documented (Relyea and Hoverman 2008). Also herbicide Roundup, glyphosate, caused high mortality of tadpoles and juvenile frogs (Relyea 2005). Impact of commonly applied, Malathion, a broad spectrum insecticide, to control mosquitoes on aquatic ecosystem has been well documented. There are direct and also indirect effects of malathion on aquatic food web. It changes in plankton and periphyton abundance and composition consequently affected growing of frog tadpoles and reduced predation rates on amphibians (Relyea and Hoverman 2008). On the other hand effect of glyphosate on the predatory arthropods such as spiders and ground beetle, in agricultural field, caused behavioral changes (Evans *et al*., 2010). Decrease in number of spiders and diversity after application of insecticide chlorpyrifos has been reported (Fountain *et al*., 2007). Nematodes, springtails, mites and further micro-arthropods, earthworms, spiders and insects make up the soil food web and enable decomposition of organic compounds such as leaves; manure, plant residues and they also prey on crop pests. Soil organisms enhance soil aggregation and porosity and thus increasing infiltration and reducing runoff.

Effect of pesticides on environment and human health

Pesticides may increase water toxicity via drift during pesticide spraying, by runoff from treated area, leaching through the soil. However, water toxicity depends on nature of pesticides such as water solubility, hydrophobicity. Recent studies also reported presence of pesticides in surface water and groundwater close to agriculture lands over the world (Añasco *et al*., 2010). In general, the compounds most frequently detected were currently used pesticides (herbicides Atrazine, Simazine, Alachlor, Metolachlor and Trifluralin, insecticides Diazinon, Parathion methyl, and organochlorine compounds due to their long persistence (lindane, endosulfan, aldrin, and other organochlorine pesticides. Mada *et al*., (2010) reported the impact on farm workers and operators with related cases of 35 acute poisoning 50 deaths and 57 contacted diseases from 2001–2011(Mada *et al.,* 2010). Field survey and study 2012 unveiled most of contacted disease farmers are complaining include, heart pain, skin rash,

eyes problems, nervous disorder and respiratory condition. Field report and studies have showed that herbicide is in human breast milk. Excessive use of toxic synthetic pesticides damaged not only environment and agriculture but has also entered into the food chain thereby affecting all living beings. Pesticides and their degraded products would flow into the atmosphere, soils and rivers, resulting in the accumulation of toxic substances and thus threatening human health and the environment. World health organization estimated that at least 3 million cases of acute poisoning and 20,000 deaths occurs annually due to exposure to pesticide (Orhii 2010). Other soil species are also often affected by pesticides application and non-target soil community structure can be strongly affected.

Conclusion

Pesticides and herbicides contamination poses significant risks to the environment and non-target organisms ranging from beneficial soil microorganisms to earthworms, tadpole, plants, fish, and birds. Recent studies have indicated that our environment ischronically polluted by pesticides and levels of biocidal contamination have increased tremendously. Our study showed that the pesticide treatments significantly cause undesirable effects on soil, earthworm, honey bees, amphibian and on human.

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