

Harmful Impacts of Chemicals on Biological Organisms

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Abstract—Now-a-days, chemicals are excessively used in agricultural industry to increase the production by protecting the crops from various pathogens. As these chemicals are non-biodegradable, they enter into human body through food chain causing biological magnification. Man is deteriorating nature by injudicious use of chemicals to overcome the problems of controlling insects, diseases etc. It is well known that these chemicals are major reason for various diseases in human beings. Indiscriminate use of pesticides leads to soil degradation. These pesticides degrade the soil quality by targeting the beneficial soil microorganisms. Microbes play an important role in soil ecosystem. These chemicals not only affect the human beings and microorganisms but also adversely affect the beneficial insects which play an important role in maintaining the ecosystem by pollinating the plants. Most of the angiosperms depend heavily on pollinators for cross-pollination. Over usage of pesticides have had a devastating effect on the pollinator around the world and it directly affects the plant production. Serious concerns about human health and biodiversity are rising due to overuse of pesticides.

Introduction

India is an agricultural country. The Indian economy is chiefly dependent on agriculture. Even though Indian economy has improved due to development and industrialization, agriculture is still considered the backbone. Nearly two-third of Indian population depends directly on agriculture for their livelihood. In spite of the fact that large area in India is associated with agriculture sector still there is problem of food scarcity. It is widely accepted that a number of diseases caused from pathogens results in higher yield losses. Loss of crop from these plant pathogens result in hunger and starvation. To prevent this devastation, growers often rely on synthetic chemicals (insecticides, pesticides, herbicides and fungicides). These chemicals are well known for their effectiveness. No doubt these chemicals have helped in increasing yields per hectare as well as total production but it also has resulted in environmental pollution, ill health to biotic community, and are hazardous to the ecological systems. Their impact on soil and environment, and accumulation in the food chain are the matters of serious concern [1]. Chemical pesticides not only diminish the nutritional value of our food, but they also contaminate it. Population of some insects (bees, wasps, butterflies and beetles) which are beneficial for human kind,

can drastically reduce by the application of these insecticides and pesticides. Approximately 88% of angiosperms are dependent on pollinators for pollination services [2]. Around \$220 billion annually is provided by the pollinators as a result of the pollination [3]. Absence of pollinators can adversely affect the yield in many plant species. *Anacardium occidentale*, an entomophilous tree species, is pollinated by honey bees. Limitation of pollinators is identified as one of the major constraints in cashew nut production [4]. Spraying of insecticides, herbicides and fungicide in soil have also been associated with the reduction in the number of soil microbes which are essential for maintaining the soil quality. Their excessive and long term uses are degrading the soil fertility. Consumption of these pesticides has been a major cause for various diseases in human beings. The paper presents an overview of how the various chemicals have an effect on pollinators, soil microorganisms and human beings.

Effects on pollinators

Pollinators represent a key ecosystem service that is essential for the maintenance of wild plant communities and agricultural productivity [5-7]. A survey of literature confirms that the numbers of pollinators are declining all over the world because of many reasons such as deforestation, habitat fragmentation, pollution by industrial effluents, forest fire, and global climate change [8-9]. Another significant reason is the excessive use of insecticides, pesticides and herbicides which is responsible for decreasing the pollinator's population.

In most of the angiosperms, pollination is mediated by insects. Pollinators play an important role in the maintenance of plant communities. Therefore, protection and management of these biotic agents are required for successful reproduction as well as to increase the genetic diversity of the plant species. A study conducted on *Rhus aculeatus*, an evergreen shrub, reported that the plant is facing threat of extinction because of unsuccessful pollination. Reduction in the number of pollinators visiting the flowers is found to be the main reason for plant's vulnerability [10]. In the scarcity of pollinators, seeds are set through self-pollination, which increases homozygosity and also increases the expression of deleterious traits associated with inbreeding [11]. Therefore, these

pollinators are directly involved with the plant production and economical value of about 153 billion euros in around the world [12]. Therefore, scarcity of pollinators can directly reduce the crop yield as well as the economy throughout the world.

Chemicals modify the flight and homing behaviour of the bees [13]. Studies reveal that, Neonicotinoids insecticides such as clothianidin and imidacloprid are toxic to bees. It is a serious matter of concern because a large number of crops are pollinated by bees. Bees feeding on neonicotinoid contaminated pollen and nectar produces less offspring. Some of these pesticides can destroy cells in the gut, brain, or other tissues, and therefore affect their behavior. These pesticides directly affect the reproductive potential of the bees by reducing sperm viability in drones that causes poor mating for queens, and disruption of ovary activation in the developing queen [12]. Honey and wax obtained from commercial hives were reported to contain a mixture of pesticides in which neonicotinoids have a significant proportion. Since 2006, each year, honey bee populations have reduced by 29-36% [14]. It was also reported that the use of pesticides like imidacloprid and clothianidin could lead to a considerable reduction in foraging activity [15-17]. Reports also revealed that exposure of thiamethoxam to honey bees was the major reason of high levels of mortality due to homing failure and putting colonies at risk of collapse [18]. Similarly, Bumblebee colonies when exposed to imidacloprid significantly reduced growth rate after 8 weeks by 8% and 85% reduction in queens [19].

Accumulation of pesticides in the bird species also lead to their death. In USA, Bald eagle populations were drastically reduced due to the exposure to DDT and its metabolites [20]. It is an indirect relation since birds and mammals feed on earthworms which are killed by fungicides. Granular forms of pesticides have been found in the food grains in birds. Organophosphate insecticides are highly poisonous for the birds and sub lethal quantities of pesticides can affect the nervous system, causing behavioral changes [21].

Effect on soil (soil microorganisms)

The use of pesticides more than the recommended concentration is a major concern as these chemicals leach into the soil, which affects the microbes present inside the soil. Treatment of soil with these synthetic chemicals adversely affects the population of naturally occurring soil microorganisms by disturbing the soil pH. The changing levels of pH in the soil reduce the microorganisms which are beneficial for the plant and soil as these microbes provide natural defense to plants against pests and diseases. Moreover, Soil microbes increases soil fertility. Any adverse effect of chemicals on soil characteristics and microorganism may lead to loss of soil fertility. These microbes also help in nutrient uptake, nutrient recycling and breakdown of organic matter [22]. Unfortunately, overuse of pesticides may have drastic consequences as these chemicals affect non-target microorganism.

As we know there are several soil microbes which help in the fixation of atmospheric nitrogen. Chlorothalonil and dinitrophenyl fungicides have been shown to disrupt nitrification and de-nitrification bacterial dependent processes [23]. Glyphosate and triclopyr both are herbicides which are applied to the leaves of plants to kill both broadleaf plants and grasses. It has been observed that glyphosate reduces the growth and activity of free-living nitrogen-fixing bacteria *Azotobacter vinelandii* [24] whereas triclopyr reduced the number of mycorrhizal fungi [25]. Similarly oryzalin and trifluralin both herbicides inhibited the growth of certain species of mycorrhizal fungi, which help in nutrient uptake [26]. Oxadiazon has been known to reduce the number of fungal spores [27]. Experiments conducted by [28] on paraquat, one of the organophosphates reported that it could inhibit a great number of cellulolytic microflora, and cause adverse effects to symbiotic, anaerobic and nitrogen fixing bacteria.

Earthworms play an important role in the soil ecosystem by contributing towards the soil fertility. It has been reported that insecticides and fungicides produce neurotoxic effects in earthworms and after a long term exposure they are physiologically damaged [29]. At the cellular level DNA can also get damaged in earthworms because of usage of glyphosate and chlorpyrifos. Glyphosates affect feeding activity and viability of earthworms [30-31]. A field study conducted in South Africa has also reported that population of earthworms were drastically decreased due to exposures of chlorpyrifos and azinphos methyl. [32]. Studies revealed that as neonicotinoids have a tendency to accumulate in the soil, therefore, they can kill *Eisenia foetida*, one of the species of earthworm [33].

Effect on Humans

If human beings are exposed continuously to lethal quantities of pesticides for a very long period of time, it results in various diseases. The symptoms are not immediately visible but its side effects can be seen in the later stages. These health effects are dependent upon the nature of the substance, the quantity of dose, route of exposure such as inhalation or ingestion but in most of the cases people get affected due to the intake of pesticide contaminated food. Many pesticides including organophosphates, organochlorine and carbamates affect central and peripheral nervous system by their toxic effects [34]. Several studies have revealed that use of pesticides lead to occurrence of chronic health hazards, e.g., cancer, diabetes, depression, neurological defects, respiratory diseases, and fertility problems [35]. According to a survey of epidemiological studies in humans, it was observed that there is a possible association between pesticide exposure and infertility, breast, prostate and ovarian cancer, and nervous system cancer [36]. A study conducted in the United Arab Emirates, revealed that due to unawareness or illiteracy, farmers used more than the recommended amount of pesticides which resulted in pesticide-induced dermorespiratory

symptoms like cough, pharyngitis, bronchitis, asthma, respiratory insufficiency, pneumonia, dyspnea, nasal catarrh, sinusitis, pharyngeal irritation, nasal irritation (dryness, sneezing, and secretions), ocular irritations, cutaneous pruritis and contact dermatitis [37]. Pesticides induced oxidative stress also causes several health problems such as Parkinson's disease and disruption of glucose homeostasis [38].

It has been observed that insecticide and fungicides act as neurotoxin and they effect by altering the synaptic neurotransmission. Exposure with Organophosphates (OP) show symptoms like headache, nausea, vomiting, pupillary constriction, dizziness and excessive sweating, tearing, and salivation and in case of severe effects muscle weakness and twitches, bronchospasm, and changes in heart rate has been observed which may lead to convulsions and coma. It also leads to a disorder called OP-induced delayed polyneuropathy, in which axonal region of neuron is affected badly and is unable to produce the neuropathy target esterase enzyme. Organophosphate and organochlorine pesticides effects acetylcholine esterase regulation and the consequences may lead to the Alzheimer disease in the late life of exposed humans [39]. Alzheimer disease has also been associated with the use of some herbicides (rotenone and paraquat) which disrupts the bioenergetical activities of mitochondria, oxygen metabolism and redox function [40].

Pesticides also cause leukemia in children whose pregnant mothers are exposed to them. Moreover, small children less than one year have seven times more chances of leukemia if they are exposed to permethrin pesticide [34].

Conclusions

Although these synthetic chemicals are helpful in the effective mitigation of pathogens, but unfortunately, the risks coupled with their use have exceeded their positive effects. Non-regulated application of these chemicals has led the environment into disastrous consequences. Hazardous chemicals should be deregistered to avoid adverse impacts. For the sustainable agriculture, biological control promises to be a useful alternative approach in the controlling of plant pathogens. These biological insecticides have been proved to be a potential source of eco-friendly and safe antimicrobial agents. Chemicals derived from plants sources such as nicotine, quassin, veratrine, anabasine, rotenone, ryan, tephrosia, pyrethrins are considered to be safe pesticides, because these pesticides do not exhibit large negative influence on pollinators [41]. Similarly some bacterial strains belonging to the genera *Pseudomonas*, *Bacillus*, *Xanthomonas* and *Rhodococcus* as well as some fungi have been proven to display high degradation capacity of a wide range of pesticides [42-45]. So, we can conclude that the application of biological controls using antagonistic microorganisms has proved to be successful for controlling various plant diseases. Practicing Integrated Pest Management (IPM) also helps in maintaining the pollinator population and the diversity of the ecosystem.

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