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Pesticide Loss in Environment - A Review

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A B S T R A C T

The use of a wide range of chemicals to destroy pests and weeds is an important aspect of agricultural practice in both developed and developing countries. This has increased crop yield and reduced postharvest losses. However, the expanded use of such pesticides expectedly results in residues in foods, which has led to widespread concern over the potential adverse effects of these chemicals on human health. If pesticide residues are transported away from where they are intended to be active they may reach ecosystems such as groundwater or surface waters may harm non-target organisms and impair drinking water quality for human consumption. Pesticides may evaporate, be broken down by sunlight, or be carried away to surface water before reaching their targets. After reaching the soil, they may be taken up by plants, adsorbed to soil particles, broken down by soil microorganisms, or, in some cases, be moved off-target to water resources. The residue of OC pesticide can move thousand kilometers from the point of release through atmosphere as gases and aerosols. Herbicide drift on to non-target areas may affect other crops and wild plants alike, and is a common cause of economic injury to neighbouring farmers, which can reach up to 10% yield losses in the case of canola. Granular formulations of herbicides are otherwise preferred. Irrigation waters containing residues of unwanted herbicides and other pesticides may also affect the performance of rotational crops grown on the same fields.

Introduction

Due to increasing global population and changing diets in developing countries towards meat and milk products, demand for food production is projected to increase by 70 % [7].The use of a wide range of chemicals to destroy pests and weeds is an important aspect of agricultural practice in both developed and developing countries. Undoubtedly, this has increased crop yield and reduced postharvest losses. However, the expanded use of such pesticides expectedly results in residues in foods, which has led to widespread concern over the potential adverse effects of these chemicals on human health. Pesticides are applied to agricultural fields to combat weeds, pests and diseases that reduce crop yields. If pesticide residues are transported away from where they are intended to be active they may

reach ecosystems such as groundwater or surface waters where they may harm non-target organisms [8][17][23][25]; and impair drinking water quality for human consumption [28]. Insecticides, fungicides and herbicides are commonly used for pest control in agriculture. However, insecticides form the highest share in total pesticide use in India.

Pesticide loss in environment and its impact

The primary objective of using pesticides in the fields and the environment in general is to achieve a control of crop pests and disease vectors. This has been a deliberate human effort in a search for increasing agricultural yields and improving public health [12]. Pesticides once released into the environment may have many different fates. The term chemo dynamics of pesticides refers to the study of the movement and transformation of pesticides as well as their fate in various compartments of the environment. The environment can be divided into four major compartments, namely; air, water, soil and biota [13]. Pesticides may evaporate, be broken down by sunlight, or be carried away to surface water before reaching their targets. After reaching the soil, they may be taken up by plants, adsorbed to soil particles, broken down by soil microorganisms, or, in some cases, be moved off-target to water resources [26].

The widespread use and disposal of pesticides by farmers, institutions and the general public provide many possible sources of pesticides in the environment. Pesticides that are sprayed can move through the air and may eventually end up in other parts of the environment, such as in soil or water. Pesticides that are applied directly to the soil may be washed off the soil into nearby bodies of surface water or may percolate through the soil to lower soil layers and groundwater [10]. This incomplete list of possibilities suggests that the movement of pesticides in the environment is very complex with transfers occurring continually among different environmental compartments. In some cases, these exchanges occur not only between areas that are close together (such as a local pond receiving some of the herbicides applied on adjacent land) but also may involve transportation of pesticides over long distances. The worldwide distribution of DDT and the presence of pesticides in bodies of water such as the Great Lakes far from their primary use areas are good examples of the vast potential of such movement.

Pesticides applied to cropping systems can be degraded by microbial action and chemical reactions in the soil. Pesticides can also be immobilized through sorption onto soil organic matter and clay minerals. Pesticides can also be lost to the atmosphere through volatilization. Pesticides that are taken up by pests or crop plants either can be transformed to degradation products (which are often less toxic than the original compound) or, in some cases, can accumulate in plant or animal tissues. A certain portion of the pesticides applied are also removed when the crop is harvested [1].

Pesticides that are not degraded, immobilized, detoxified, or removed with the harvested crop are subject to movement away from the point of application. The major loss pathways of pesticides to the environment are volatilization into the atmosphere and aerial drift, runoff to surface water bodies in dissolved and particulate forms, and leaching into groundwater basins.

The fate of pesticides in the environment depends upon a number of factors, including site characteristics, pesticide properties, and pesticide use practices [11] [26].

Environmentalists, scientists and agriculturalists are all too aware of the long-

term effects of pesticides as they seep away to pollute streams and watercourses. Air in field margins may be contaminated with pesticides because of application drift, post-application vapor loss and wind erosion of treated soil. Soil, vegetation and water bodies within field margins may become contaminated through wet and dry atmospheric deposition of pesticides and through surface runoff from pesticide-treated agricultural land [3]. Movement of pesticides from the sites of application to non target regions creates three problems. It represents an economic loss to farmers, inefficient control of pests, and possible environmental contamination [4] [27]. Pesticides are lost to water resources through (i) surface loss (runoff and erosion) to streams, lakes, and estuaries, and (ii) leaching through the soil to groundwater. For example, Organochlorine pesticides (technical HCH and DDT) have extensively used in India due to their wide spectrum application. The residue of OC pesticide can move thousand kilometers from the point of release through atmosphere as gases and aerosols. Water can provide a means of transporting from one place to another. Water and soil becomes the ultimate sink for most of the contaminants. The indiscriminate use, and due persistent properties, these compounds were found in water and sediment of Ramgarh reservoir [5]. The seasonal variation in the distribution of residues of OC pesticide reflected their use. The behaviour of residues in water and sediment is of great concern, since disappearance, persistence or partial transformation of such compounds may helpful in determining the target affectivity and the non-target effects.

Pesticides also may volatilize or be blown away by the wind. In general, pesticides with vapor pressure index values of less than 10 have a low potential to volatilize. Pesticides with vapor pressure index values greater than 1000 have a high potential to volatilize [14]. As much as 80–90% of an applied pesticide can be volatilized within a few days of application [15].

Heavy treatment of soil with pesticides can cause populations of beneficial soil microorganisms to decline. For example, plants depend on a variety of soil microorganisms to transform atmospheric nitrogen into nitrates, which plants can use. Common landscape herbicides disrupt this process: triclopyr inhibits soil bacteria that transform ammonia into nitrite [18]; glyphosate reduces the growth and activity of free-living nitrogen-fixing bacteria in soil [20] and 2,4-D reduces nitrogen fixation by the bacteria that live on the roots of bean plants [2] [6], reduces the growth and activity of nitrogen-fixing blue-green algae [22] [24], and inhibits the transformation of ammonia into nitrates by soil bacteria [9] [16]. Mycorrhizal fungi grow with the roots of many plants and aid in nutrient uptake. These fungi can also be damaged by herbicides in the soil.

Herbicide drift on to non-target areas may affect other crops and wild plants alike, and is a common cause of economic injury to neighbouring farmers, which can reach up to 10% yield losses in the case of canola [19]. For this reason, aerial sprays of 2,4-D on fields of cereal crops must be carefully planned to avoid drift onto nearby sensitive crops like cotton [21]. Granular formulations of herbicides are otherwise preferred. Irrigation waters containing residues of unwanted herbicides and other pesticides may also affect the performance of rotational crops grown on the same fields. However, water-borne residues of herbicides in runoff are more likely to affect aquatic plant communities growing along streams, rivers and marshes since their levels are at most sub lethal to animals. The management practices that can be used to reduce loss of pesticide use in agro ecosystems [1].

Selection of proper pesticides and formulations;

Improvement in pesticide application methods to minimize drift and volatile losses;

Use of erosion and runoff control measures to reduce losses through runoff and leaching;

Use of nonchemical pest control measures such as crop rotations and management; and

Integrated pest management, which embodies most of the recommended practices cited earlier

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