7 Soil Pollution Caused by Agricultural Practices and Strategies to Manage It

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Abstract

Soil has a role of 'mother' for all living beings present on Earth, including plants, animals, humans and microorganisms. It is source of water and nutrients that are required for suitable growth and development of plants. 'Soil pollution' is the contamination of soil with harmful contents or substances that have poisonous effects on growth and health of plants and all creatures. Since soil pollution cannot be directly assessed or visually perceived generally, it has become a hidden danger. Soil can be polluted in many ways, including precipitation deposits of acidic compounds, human developmental and mining activities, industrial activities, various agricultural activities such as use of pesticides and over-fertilization. All these affect soil pH, presence and activities of microorganisms in soil, occurrence of toxic metals in soil. The plants grown in such soil can uptake harmful components and pass these through various physiological pathways within the food chain. These soil contaminations ultimately affect the whole vegetation of an area and finally will pollute our future. The present chapter summarizes current knowledge on the effects of different soil contaminations on the development of crop plants and their channelization in food chain with effect on human health. This chapter suggests new perspectives and future challenges on the proposed topic.

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7.1 Introduction of Soil Pollution and Scenario Due to Agricultural Practices

Soil pollution primarily refers to the presence of a chemical or substance out of place and/or present at a higher-than-normal concentration that exerts adverse effects on its chemical, biological and physical properties. This cannot be directly assessed or visually perceived, and this makes it a hidden danger. Soil pollution has gradually become a major challenge for agriculture that we need to overcome for establishing a healthy environment assisting in growth of plants. The soil is the home for a large part of bacterial biodiversity and other microscopic and macroscopic living organisms that play a role in various pathways related to nutrient uptake by plants.

Agricultural pollution denotes addition of biotic or/and abiotic by-products of farming practices that result in contamination/degradation of the environment and surrounding ecosystems, and/or cause injury to humans and their economic interests. Such soil pollution may come from a variety of sources ranging from irrigation to management practices such as pesticides, herbicides, fertilizers and other chemicals. There is no doubt that these chemicals, used in agriculture, have made food security possible for increasing population by protecting crops and enhancing the production. Soil pollution by chemical uses during agriculture has become an increasing problem throughout the world as whole crop management practices mainly rely on the chemicals and change in the soil microflora (Fig. 7.1).

7.2 Effect of Fertilization on Soil Health and Crop Productivity

Healthy soil is the basic need for flourishing agriculture. From preparation of field to harvesting the produce, there are several activities that are practised in the field that creates harmful effect on soil health and ultimately cause soil pollution. These adversely affect the soil properties, both chemical and physical and micro-organisms residing in it. Chemical fertilizers can maintain or improve crop yields, but their application can directly or indirectly cause changes in soil chemical, physical and biological properties (Arévalo-Gardini et al. 2015). Long-term application of chemical fertilizer reduced the soil pH, which directed a modification in microbial biomass, activity and bacterial community structure. Long-term fertilization greatly increases soil microbial biomass C and dehydrogenase activity that eventually affect production of crop and health of soil. It has been observed that usage of chemical fertilizers for three decades worsened the soil health and produced similar effect as stated earlier on microorganisms residing in soil.

Many studies concluded that for better presence of soil microbe, a balanced augmentation with organic manure should be applied (Lori et al. 2017; Bargaz

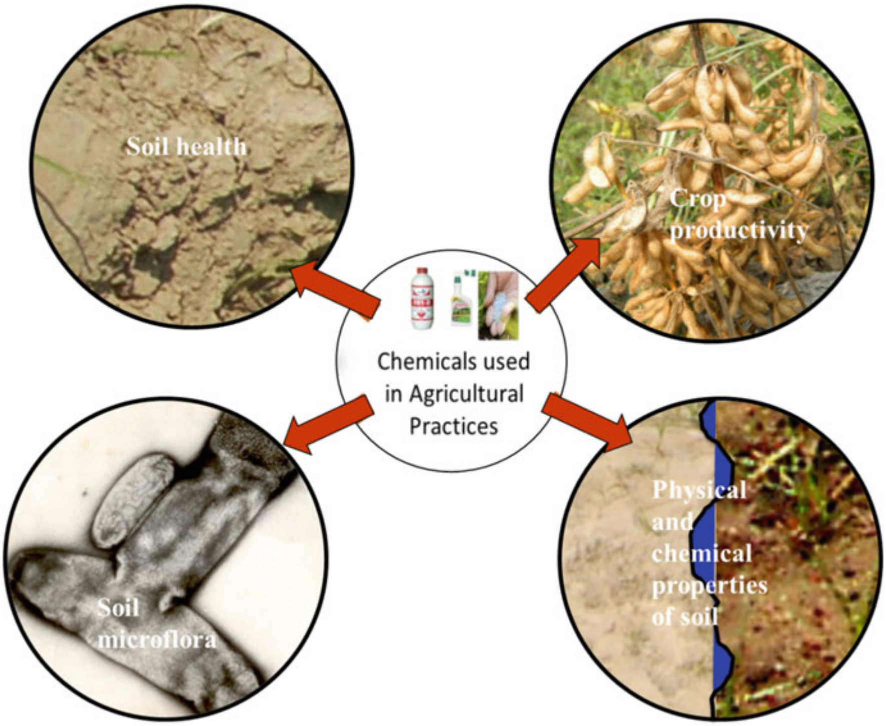

Fig. 7.1 Chemicals used in agriculture and their effect

et al. 2018). In the early 1900s, organic manures (mainly animal manures) containing large amount of organic materials and legume crops were used as the major source of N for the crops. Introduction of chemical nitrogen fertilizers and use of fertilizer-sensitive crops boomed the production, but they created a reduction in use of organic manures that affected the volume of soil organic matter and ultimately its health. The use of N fertilizers, i.e., urea, exerts profound influence on the chemical, physical, and biological properties of the soil. Rate of decomposition of 'low-quality' or high C:N ratio organic inputs and SOM (soil organic matter) increases when fertilizers, particularly N, are applied to the soil (Recous et al. 1995). Fertilizer application increases microbial decomposer activity, which has been limited due to low nutrient concentrations in the organic materials. Thus, application of fertilizer N may lead to accelerated decomposition of SOM and adversely affect the soil health.

Presence of soil microbiomes constitutes an important soil health parameter that is adversely affected due to application of chemical fertilizers. While net primary production in agricultural ecosystems is generally nitrogen limited, activity of soil microorganisms may be carbon and/or nitrogen limited (Wardle 1992; Singh et al. 2011; Das et al. 2017). Use of fertilizer application produces harmful effect on the soil and is one of the notions that have been put forth many times to support the argument against fertilizers. Chemical sources of nitrogen may lead to increased acidity that adversely affects many soil functions. A very recent study by Poffenbarger et al. (2017) evaluated the impact of N fertilizer in Midwest U.S. maize fields and observed a site-to-site variability on soil health and crop yield. Similarly, a study by Wang et al. (2018) observed the influence of N and/or P inputs on below-ground microbial communities in subtropical forests using quantitative polymerase chain reaction and Illumina Miseq sequencing of the bacterial 16S rRNA gene to investigate bacterial abundance, diversity, and community composition in a Chinese fir plantation. The results depicted a decrease in bacterial richness and diversity with N addition (N and NP) input. *It also concluded that* addition of P fertilizers did not significantly affect soil bacterial communities.

Heavy metals are naturally present in the soil and needed by plant in a very small quantity, but at higher concentration in soils, they are harmful to both plants and animals. An experiment was designed to investigate the variability of chemical applications of cadmium, lead and arsenic concentrations on wheat-cultivated soils (Atafar et al. 2010). Soil sampling was done from 40 locations of a field and measured for heavy metal concentration, soil texture, pH, electrical conductivity, cationic exchange capacity, organic matter, and carbonate contents. It was indicated by this study that cadmium, lead and arsenic concentrations were increased in the cultivated soils due to fertilizer application. Soil scientists Lambert et al. (2007) investigated the solubility of cadmium and zinc in soils after the application of phosphate fertilizers containing those two metals and concluded that phosphate fertilizers increased the concentration of Cd in soil extracts compared to control in 87% and 80% of the treatments in field and laboratory experiments, respectively. Increase in heavy metal concentration may have manipulating effect on soil properties, including both physical and biological (Friedlová 2010). Heavy metals that get channelized in food chain will produce fatal effects in humans and animal too (Iheanacho et al. 2017). Various studies reflected that use of fertilizer positively affected the crop productivity, but over-application of fertilizers as well as the other agrochemicals that are used against insects, herbs, and rats had adversely affected soil and its properties.

7.3 Effect of Agrochemicals on Physico-Chemical Properties of Soil

Soil is a dynamic living system and considered as mother earth as lives of all living beings depend on it. It is habitat for variety of micro- and macro-flora and fauna, including bacteria, actinomycetes, fungi, nematodes, arthropods, crustaceans, and earthworms that play a crucial role in the degradation of plant and animal residues and other organic matter in the environment as well as in nitrogen fixation, nitrification and the release of nutrients from soil minerals. Any of our activity during agriculture with prolonged use of chemicals can adversely affect soil properties and activities of living nexus that will result in changed function of soils not only in crop production but also in the global C and N cycles and in the removal of a range of environmental pollutants. The consequences could thus be serious. Evaluation of long-term effects of pesticides and chemical fertilizer usage on soil properties and heavy metal accumulation depicted that soil physical characteristics such as bulk density were changed in long term and it was increased, compared to control soil (Yargholi and Azarneshan 2014). Besides heavy metal, inorganic fertilizers may have harmful effect on soil organic carbon (SOC), soil physical properties, and crop yields in a maize (*Zea mays*)–wheat (*Triticum aestivum*) rotation by prolonged use (Brar et al. 2015).

Prolonged fertilization badly impacts on soil physicochemical properties, microbial biomass carbon, microbial quotient, enzyme activities, and cypermethrin dissipation. By experimenting with five fertilization treatments, i.e., organic manure, NPK fertilizer, PK fertilizer, NK fertilizer, and no fertilizer (control), it was concluded that higher soil organic C, N, P contents and enzymatic activities occurred in soils with balanced fertilization as opposed to those with unbalanced fertilization, especially fertilization with organic manure (Xie and Zhou 2008). The studies also indicate that during agricultural practices, oversupplying N should be stopped as it is the major fertilizer that changes the pH, thus creating subsequent changes in physical and biological properties. Application of P fertilizer may be an efficient way to decrease N/P ratio and enhance cypermethrin dissipation in soil with high available N content. Application of chemical fertilizers alone or chemical fertilizers combined with organic amendments is commonly practiced to improve physicochemical properties and fertility of red soils (Wang and Zhang 2016). The microbes present in soil have specific requirements of pH and temperature for their enzymatic activities. Change in any of it can alter the activities and soil fertility in turn. Total N and total P content of soil significantly increased during the long-term fertilization. In contrast, total K contents in soil significantly decreased by the long-term fertilization.

Several other studies were done for enhancing the understanding of effect of fertilization on soil properties. A field experiment was conducted during 2010–2011 and 2011–2012 to investigate the effect of optimal (100% NPK) to super-optimal doses (200% NPK) of mineral fertilizers on soil enzymes such as dehydrogenase, acid phosphatase, alkaline phosphatase, fluorescien diacetate hydrolysis, urease, and nitrate reductase (NRA) at three physiological stages (CRI, anthesis and maturity) of wheat crop on an Inceptisol (Rakshit et al. 2016). The study illustrated a reduction in dehydrogenase activity by 28–37% with induction in urease and NRA positively by 43–44% and 213–231%, respectively. A significant positive interaction between fertilizer treatments and physiological stages of wheat growth was observed on soil enzyme activities (except urease and NRA), highest being at the anthesis stage of wheat. These studies produce evidence for avoiding over-application of fertilizers because they hinder the enzyme activities and vis-à-vis sustainable nutrient enrichment under rhizosphere that is prerequisite for growth and production.

The information for effects of long-term fertilization, use of pesticides and its persistence is limited. The discussed studies gave comprehensive information with consideration of soil fertility, crop yield, and environment. These observations suggest that a mixed application of organic manure and inorganic fertilizers is recommended to avoid reduction in soil fertility, change in chemical and biological properties of soil (Singh and Ghoshal 2010). Soil contamination and pollution by pesticides can be related to the concentration of chemical pesticides and chemical elements in the soil. This is the reason why state of the soil–managed application of pesticides and fertilizers is essential, and it requires planning to reduce or replace pesticide and fertilizer usage in order to keep the soil problem free.

7.4 Effect of Agrochemicals on the Soil Microflora

The quality of life is undistinguishably related to environmental health. The balance between livings and environment can be disturbed by biosphere contamination with fungicides and herbicides that are considered to be effective crop protection chemicals in modern agriculture. Such enhancement in crop production and crop protectants poses a serious problem for food safety and sustainable soil use. They can also employ toxic effects on non-target organisms, including soil-dwelling microbes. Therefore, there is need to monitor the environmental fate of fungicides or any chemical that changes microflora of soil as it affects the soil fertility in turn (Handa et al. 1999).

Microbes that reside in soil help plants to obtain nutrient from soil and degrade the organic matter. Fertilization and other chemicals that are used in various practices during agriculture can cause harm to these (Singh and Prasad 2019). Influence of the Falcon 460 EC fungicide on microbial diversity, enzyme activity and resistance, and plant growth was observed and found differences in the values of the colony development index and the eco-physiological index, which indicated that the mixture of spiroxamine, tebuconazole and triadimenol modified the biological diversity of the analysed groups of soil microorganisms (Baćmaga et al. 2016). The fungicides inhibit the activity of dehydrogenases, catalase, urease, acid phosphatase and alkaline phosphatase of microbes, thus reducing their ability to perform their function. Dehydrogenases, i.e. most resistant enzyme to soil contamination, were highly induced with the highest fungicide dose (300-fold higher than control). The phytotoxic test can reveal that the fungicide can inhibit seed germination capacity and root elongation by changing the nutrient availability in soil. It was also indicated by studies that excessive doses of the fungicide can induce changes in the biological activity of soil that help plants to grow and flourish. The analysed microbiological and biochemical parameters are reliable indicators of the fungicide's toxic effects on soil quality. Effect of multiple herbicides Alister Grande 190 OD, Fuego 500 SC and Lumax 537.5 SE on counts of actinomycetes as well as the activity of enzymes and their resistance to herbicides was investigated (Baćmaga et al. 2016) and found that soil contamination with herbicides contributed to elevated counts of actinomycetes. In case of enzymatic activities, urease was the most tolerant to soil contamination with the herbicides, while others got affected by herbicide contamination in soil. A study by Wyszkowska et al. (2016) analysed the effect of a mixture of pethoxamid (P) and terbuthylazine (T) contained in the herbicide Successor T 550 SE on organotrophic bacteria, total oligotrophic bacteria, *Azotobacter* and Actinomycetes, oligotrophic-sporulating bacteria, fungi and on the activities of dehydrogenases, catalase, urease, alkaline phosphatase, acid phosphatase, arylsulphatase and glucosidase in soil. The study also analysed phytotoxic effect of this pesticide on maize. The P + T mixture disturbed soil homeostasis and altered soil stability, resulting in a succession of K-strategy organotrophic bacteria. It also negatively affected bacteria of the genus *Azotobacter*, oligotrophic sporulating bacteria, actinomycetes and fungi, and a positive effect on oligotrophic bacteria. P + T in doses greater than 0.73 mg kg^{-1} of soil resulted in a strong inhibition of dehydrogenases, catalase, urease, acid phosphatase, alkaline phosphatase, arylsulphatase and β-glucosidase and significantly inhibited the growth and development of maize.

Pesticides, the most cost-effective means of pest and weed control, allow the maintenance of current yields and so contribute to economic viability. But when it comes to concern about the environmental impact of repeated pesticide use and their fate in the environment, it emerges as a great problem, which can emigrate from treated fields to air, other land and water bodies. Pateiro-Moure (2007) reviewed many studies based on the influence of the physical and chemical characteristics of the soil system such as moisture content, organic matter and clay contents and pH on the sorption/desorption and degradation of pesticides and their access to groundwater and surface waters. There is evidence that chemicals applied to the soil surface may be transported rapidly to groundwater, bypassing the unsaturated soil zone (Johnson et al. 1995). The hypotheses proposed to explain this rapid transport include preferential flow (Elliott et al. 2000; Roulier and Jarvis 2003), co-transport with colloidal matter (Worrall et al. 1999; Hesketh et al. 2001) and a combination of both processes (Williams et al. 2000). Pesticides form large number of transformation products (TPs) (Barcelo and Hennion 1997) that are very harmful for both plant and environment. The parameters that provide information regarding its persistency, movement and their TPs are water solubility, soil-sorption constant (K_{oc}), the octanol/water partition coefficient (K_{ow}), and half-life in soil (DT_{50}). Pesticides and TPs could be grouped into: (a) Hydrophobic, persistent and bioaccumulable pesticides that are strongly bound to soil. Pesticides that exhibit such behaviour include the organochlorine DDT, endosulfan, endrin, heptachlor, lindane and their TPs. Most of them are now banned in agriculture, but their residues are still present. (b) Polar pesticides are represented mainly by herbicides in general, but they include also carbamates, fungicides and some organophosphorus insecticide TPs. They can be moved from soil by runoff and leaching, thereby constituting a problem for the supply of drinking water to the population. The most researched pesticide TPs in soil are undoubtedly those from herbicides. Several metabolic pathways have been suggested, involving transformation through hydrolysis, methylation and ring cleavage that produce several toxic phenolic compounds. The pesticides and their TPs are retained by soils to different degrees, depending on the interactions between soil and pesticide properties. The most influential soil characteristic is the organic matter content. The larger the organic matter content, the greater the adsorption of pesticides and TPs. The capacity of the soil to hold positively charged ions in an exchangeable form is important with paraquat and other pesticides that are positively charged. Strong mineral acid is required for extracting these chemicals without any analytical improvement or study reported in recent years.

Soil pH is also altered greatly by pesticide and herbicide application. Adsorption increases with decreasing soil pH for ionizable pesticides (e.g. 2,4-D, 2,4,5-T, picloram and atrazine) (Andreu and Picó 2004). Intensive treatment of soil with pesticides/herbicides can cause populations of beneficial soil microorganisms to decline that causes changes in physical properties of soil. Overuse of chemical fertilizers and pesticides has effects on the soil organisms that are similar to human overuse of antibiotics. A prolonged use of chemicals creates a non-significant change in the plants' response, organisms' reactions towards that chemical (Savonen 1997). 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. For example oryzalin, triclopyr and trifluralin inhibit the growth of certain species of mycorrhizal fungi (Kelley and South 1978; Chakravarty and Sidhu 1987). Oxadiazon reduces the number of mycorrhizal fungal spores (Moorman 1989). Abd-Alla et al. (2000) observed the effect of afugan, brominal, gramoxone, selecron and sumi oil herbicides on growth, nodulation and root colonization by arbuscular mycorrhizal (AM) fungi of the legumes. The results indicated that all five pesticides when used at field application not only changes the soil environment but also rates, reduced growth and related microbial activity in cowpea, common bean and lupin.

The experiments and ideas suggest that an understanding of the fate of pesticides/herbicides is essential for rational decision taking regarding their authorization. To reach an adequate understanding will require the concourse of soil science, clay mineralogy, physical chemistry, surface chemistry, environmental microbiology, plant physiology, and, no doubt, other disciplines also. By applying multidisciplinary approach to environmental research, it will be possible to plan, manage, pursue and integrate the results of the studies that will be necessary for the development of tools and techniques allowing effective environmental decision making.

7.5 Effect of Irrigation on Soil Properties

Irrigation is the application of water to the soil for the purpose of supplying moisture essential for plant growth. Throughout world, agriculture is dependent on the soil moisture as it is required for germination till grain filling. This demonstrates that irrigated agriculture is the backbone and plays an important role as a significant contributor to the world's food and fibre production. Irrigation has an important role in maintaining soil's physical and biological properties. To examine the effects of irrigation practices on some soil chemical properties, Adejumobi et al. (2014) took soil samples at variable depths from two operating lands of the study area. The samples were analysed for chemical parameters (pH, CEC, ESP, Mg2+, Ca2+, OM, and OC). The soil pH, which was in the neutral range (pH = 6.65–7.00) at inception of scheme, has become slightly acidic (pH = 6.53–6.60). Cation exchange capacity (CEC) levels have also increased from 10cmol.kg^{-1} to 35cmol.kg^{-1}, while organic matter (OM) and organic carbon (OC) also have marked increase in their levels (baseline as 0.93 to 1.08; for year 2013 as 9.52 to 9.79). Generally, the analysis indicated a need for proper monitoring of the scheme soil to prevent further deterioration. In each and every field, it is suggested that proper irrigation scheduling is required since soil water content is critical to supply the water needs of the crop and to dissolve nutrients, which make them available to the plant. Excess water in the soil, however, depletes oxygen (O_2) and builds up carbon dioxide (CO_2) levels, so there is need for proper water exits in field. Field experiments for three growing seasons (2007–2009) at five different sites of soil types and salinity levels were conducted to monitor the effect of irrigation water quality on soil properties in Saudi Arabia (Al-Ghobari 2011). It was concluded that all irrigated fields have differed in salt concentration as indicated by soil electrical conductivity (ECe) values of the saturated paste extracts. The study indicated that salt accumulation in soil of fields was closely related to the salt concentration of irrigation water, and there was a progressive and significant increase in soil salinity values as the salinity of irrigation water increases. Also, the obtained results showed that the decrease or increase in soil salinity through the soil profiles for all fields occurred mainly at first season and slight increase in the following two seasons and not with the increase of the number of seasons, and the soil salinity values remains closely the same and does not get influenced by the prolonged use of low- or high-salinity waters for a number of years for all fields during the study. These observations directly linked soil pollution with quality of water used in irrigation.

To develop a sustainable agricultural system, limited information regarding the influence of long-term irrigation schedules on soil properties and crop performance is known. Sun et al. (2018) investigated the changes of soil bulk density (BD), saturated hydraulic conductivity (K_{sat}), water-stable aggregate, soil organic matter (SOM), and total nitrogen (TN) at the variable depths of soil with different irrigation amounts based on a 17-year-long experiment in a double-cropping system with crop residue removed and manual tillage in the North China Plain. The study summarized that BD increased as the irrigation amount increased. K_{sat} reached a maximum level at a moderate irrigation level. It also indicated that irrigation timing also affected soil BD and K_{sat}. SOM and TN also got affected and decreasing trends with increased irrigation amount were observed. Soil quality and crop production may benefit from a reasonable irrigation strategy and the return of crop residue to the field. According to Razzaghi et al. (2016), wastewater irrigation can be beneficial or detrimental; it generally depends on the geographic region and the type of wastewater used. In Ghana, effects of four sources of irrigation water (river, canal, tap and well) were examined for chemical and physical properties of tomato-planted soil (Takase et al. 2011). The observations showed that continuous irrigation lowered values of the variables and values of soil nutrient. However, the water quality and soil chemical and physical data suggest that the sodification process and the increased soil erosion risk must be controlled in order to achieve a sustainable high production system. Soil irrigated with river water was most preferred for growing tomato by virtue of their optimum level of pH, EC, Na, Mg and NH_4-N. It is suggested that in case of waste water or water with any combination should not be used directly for irrigation as minerals released from such water create soil pollution. Treated wastewater for agricultural irrigation is common in arid and semi-arid regions as a solution to water scarcity (Keraita and Drechsel 2004; Uzen 2016).

7.6 Strategies to Use Alternatives to Agrochemicals

Fertilizers, Pesticides and herbicides are chemical compounds engaged with enhancing production, controlling pest and weed species in agricultural fields.

Heavy soil treatment with pesticides and herbicides can lead to depletion of populations of beneficial soil microorganisms, which are essential for maintaining soil fertility. Overuse of chemical fertilizers, herbicides and pesticides has effects on the soil organisms that are similar to effects of human overuse of antibiotics. Indiscriminate use of agrochemicals might give better productivity for initial years, but at later years, there aren't enough soil beneficial micro-organisms to hold onto the nutrients present in the soil. For example, to absorb nitrogen from soil, plants rely on a variety of nitrogen-fixing bacteria that are present in soil to convert atmospheric nitrogen into plant available nitrogen in the form of ammonia. Common herbicides disrupt nitrogen fixation: triclopyr inhibits bacteria that transform ammonia into nitrite; glyphosate reduces the growth and activity of free-living nitrogen-fixing bacteria in soil and 2, 4-D reduces nitrogen fixation by the bacteria that live on the roots of bean plants, reduces the growth and activity of nitrogen-fixing blue-green algae, and inhibits the transformation of ammonia into nitrates by soil bacteria (Bhat et al. 2019). Mycorrhizal fungi grow in symbiotic association with the roots of many plants and aid in nutrient uptake. These beneficial fungi can also be damaged by herbicide application. One study found that both oryzalin and trifluralin inhibited the growth of certain species of mycorrhizal fungi (Kelley and South 1978). Roundup has been shown to be toxic to mycorrhizal fungi, Triclopyr was also found to be toxic to several species of mycorrhizal fungi and oxadiazon reduced the number of mycorrhizal fungal spores.

There are a relatively few pesticide management tactics that have been proposed risk-free and have a reasonable chance of success under a variety of different circumstances. Prominent among these are monitoring of pest population in field before any pesticide application, alteration of pesticides with different modes of action, restricting number of applications over time and space, creating or exploiting refugia, avoiding unnecessary persistence, targeting pesticide applications against the most vulnerable stages of pest life cycle, using synergists that can enhance the toxicity of given pesticides by inhibiting the detoxification mechanisms in pest gut system.

Apart from reduction in pesticide use, biological control of pest is a more recent approach dealing with pest management in fields. Integrated pest management (IPM) is often intended to encompass the management of plant diseases and insect pests bringing the population of pest below the economic injury levels. IPM practices include monitoring pests and using economic thresholds (ETs), reducing pesticide rates, and diversifying cropping systems and control strategies to prevent pest problems. IPM approaches such as using genetic-crop-resistant varieties and maintaining populations of beneficial pest predator species aid in pest management.

Strategies for reduction in herbicide vary from organic culture practices where no herbicides are used to conventional agriculture systems in which endeavours are made to profit by herbicide use reduction. Organic farming is the most widely recognized form of reduced-pesticide agriculture. Its primary feature is that no synthetically or artificially produced herbicides, pesticides or fertilizers are used. Limited fertilizer application and reduction or elimination of pesticide or herbicide use may appear more feasible to many farmers than organic production in terms of productivity, but organic farming maintains the fertility of soil and gives products with higher monetary value in commercial market. Strategies for diminishing herbicide use can be set along a continuum of progressively devoted management practices: (1) herbicide substitution with other weed management methods, (2) efficiency in the use of herbicides and (3) redesigning the cropping system to prevent herbicides use. While most strategies can be utilized in any of the practices mentioned, the more prominent goal is to lessen herbicide use, the more vital it is to utilize strategies that seem further along the continuum. For instance, farmers who are determined to lessening herbicide utilization must decrease the requirement for herbicides by redesigning the cropping pattern in a way that diminishes interference capacity and size of the weed population. Organic farming must be firmly dedicated to their system since herbicide use is never a choice. Herbicide use can be improved by applying the learning of weed biology and ecology, for example, weed emergence and the critical weed control period. Improved application and comprehension of elements influencing herbicide performance can decrease the amount of herbicide utilized.

Weeds can be constrained by the utilization of living organisms (insects, fungi or bacteria), and this methodology is also referred as bio-herbicide. The utilization of sheep (*Ovisaries* L.) or flea beetles (*Aphthona* spp.) to constrain leafy spurge (*Euphorbia esula* L.) has been fruitful in Manitoba, Canada (Mico and Shay 2002). Building an effective delivery strategy for these bio-herbicides is the focal point of current research. There are a number of constraints to the applications of bio-herbicides, especially the generation of effective formulations. Currently, bioherbicides are frequently increasingly exorbitant, have lower adequacy, and require more thorough handling and capacity necessities than traditional herbicides.

Expulsion of weed seeds by seed pathogens and predators (for example, spineless creatures and rodents) is another type of biological control. However, there is little research with respect to how these biocontrol operators may effectively be controlled. In field crops, weed management is the management strategy of field-cropping systems to decrease weed densities and maintain their population at low levels, thus reducing herbicide necessity. The utilization of single non-synthetic weed management techniques is commonly not adequate for diminishing weed densities or keeping up weed densities at low levels. However, the mix of a few non-compound practices can be powerful.

7.7 Conclusion

Soil pollution is a hidden danger that affects the growth and health of living organisms. An overview of reports presented here in this chapter highlights the causes of soil pollution due to precipitation deposits of acidic compounds, human developmental and mining activities, industrial activities and various agricultural activities. Soil pollution has gradually become a major challenge for agriculture that we need to overcome for establishing a healthy environment assisting in growth of plants. All nations must invest regional survey to get national data of soil problem and take steps to prevent the migration of pollutants. Availability of global map of soil pollution will help to guide policymakers on soil pollution mitigation and soil management strategies.

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