

# Soil Challenges by Pesticide: An Illustrated Concept for Environmental Awareness

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## Abstract

Majority of pesticides applied to the soils are not specifically targeting the pest only but also taking another dimension of environmental concern. Typically, when pesticides are sprayed to the plants, they dissolve speedily and enter various components of soil medium. This situation brings into existence a relationship between soil and chemicals contained in the pesticides. This relationship creates abnormal condition in soil and makes it to behave contrary to its natural stage of formation. This paper has taken into account an illustrated concept of pesticides behaviour under this condition as a challenge to four major soil components namely: soil quality, water quality, air quality and human quality. However, complex activities of soil challenges by pesticides as affecting these soil components include the agricultural activities, waste disposal, industrial environmental issues such as mining, chemical disposals, and accidental oil spills and occurrence of acid rain. These combined issues are discussed in this paper primarily to contribute with some basic ideas regarding the environmental aspect of pesticides consequences in agriculture.

**Keywords:** Soil; Air; Water; Soil challenges; Pesticides

## Introduction

In the US 1957 Yearbook of Agriculture entitled "Soil", three definitions are presented, and each being a little more involved than the preceding and 21st Century one. These definitions are as follows: (a) the natural medium for the growth of land plants; (b) a dynamic natural body on the surface of the earth, in which plants grow, composed of mineral and organic materials and living forms; and (c) the collections of natural bodies occupying parts of the earth's surface that support plants and that have properties due to the integrated effect of climate and living matter acting upon parent material, as conditioned by relief over periods of time [1].

These definitions revealed that the term 'Soil' is the unconsolidated mineral or organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants [2]. It is the unconsolidated mineral or organic matter on the surface of the earth that has been subjected to and shows effects of genetic and environmental factors of: climate (including water and temperature effects), and macro and microorganisms, conditioned by relief, acting on parent material over a period of time [3]. These entailed the particular need to protect soil and also to manage and improve its important components- the physical, biological and chemical properties for diverse economic development particularly in Sub-Saharan Africa [4]. This possibly will not be ensured if there is no awareness and a specific consideration to the understanding of the challenges facing the soil particularly with regard to pesticide chemicals [5,6]. These pesticide chemicals are considered the major global concern that caused many environmental contaminations in various components of ecosystem: Soil, water, forest, vegetation and biological habitat [7,8]. They pollute all components of soil namely: Air, water bodies, organisms and agronomic resources [9].

The term 'pesticide' is a generic name that includes all chemicals used to kill or control pests either in agricultural field or in other environments such as store rooms, human houses and gardens as noted by the Food and Agricultural Organization (FAO) of the United Nation [10]. These chemicals are classified into herbicides (control of weeds), insecticides (control of insects), fungicides (control of fungi), nematocides (control of nematodes), and rodenticides (control of rodents and their kinds). They also include sanitizer, predacide, bactericide, insect repellent, animal repellent, antimicrobial, disinfectant, molluscicide and avicide [11]. Soil challenges by these pesticides are combination of environmental soil issues, which are of high concern at national and international levels. This viewpoint has led to the joint FAO/WHO meeting on pesticide residues (JMPS) and the joint FAO/WHO meeting on pesticide specifications (JMPS) [12]. The outcome of the meeting provides an improved understanding of the broad lists of pesticides and their specification. This information has further entails the need to understand soil challenges caused by pesticides. However, the most challenged aspects of pesticides in soil have been related to contamination and pollution [13-15]. These two soil challenges affect almost all the components of surface and subsurface soils- the plant root zones and below profile horizons particularly the microbial activity [16-18]. This entails that the soil, water, plant and diverse microorganisms are directly/indirectly involved in these challenges.

Soil contamination and pollution by pesticides can be related to the concentration of chemicals pesticides and chemical elements in the soil in such a situation whereby they become more than normal. This implies that the concentration of a substance (e.g. pesticide chemicals, organic chemicals acidic or saline compound) in soil might be higher than would naturally occur [5]. However, the continuity of this contamination in soil could result to what is called 'soil pollution'- the situation that can be related to an accumulation and build-up of toxic chemical compounds resulted from the activities of man and caused

adverse effect on soil properties, human, animal health, plants and soil biota [10]. The term has been also regarded as a situation whereby harmful objects and chemicals are applied to soils directly or indirectly in a way that cause harm to other living things or even destroys soil mineral particles or water ecosystem [19].

Tools such as herbicides, insecticides, and fungicides protect crops both before and after harvest by increasing crop productivity, reducing yield losses, controlling pest and diseases, and improving crop quality [15]. Unfortunately, pesticides are poisons and can be hazardous when misused in the farm or garden. Many problems are attributed to this misused of pesticides. These include the following: Fish kills, reproductive failure in birds, and acute illnesses in people and animals [20]. Besides, they are non-biodegradable, persistent and get accumulated in the environmental soil component as well as into the human food chain [14]. Therefore, this short communication was initiated to take into consideration the aspect of some challenges created by pesticides in soil, and also to build an awareness regarding pesticides behaviour in soil. This information is important because of the need to further understand the negative relationship between pesticides, soil, plant, microorganism and environment.

### Soil Challenges by Pesticides

The theoretical and practical concept of soil challenges by pesticides can be described as 'pesticides transmission in soil'. This concept can be explained as a situation whereby the pesticide chemicals enter the soil via spray drift during foliage treatment, wash-off from treated foliage, release from granulates or from treated seeds in soil [21]. The same problem may exist when pesticides such as soil fumigants and nematocides are applied directly into soil to control pests and plant diseases [22]. However, the transport, persistence or degradation of pesticides in this circumstance, depend on the chemical, physical and biological properties of the soils involved [7,23,24]. This is particularly true because of the relation between soil factors and sorption/desorption, volatilisation, degradation, uptake by plants, run-off, and leaching of pesticides in soil medium [10,23].

Sorption is the most important interaction between soil and pesticides and limits degradation as well as transport in soil [25]. Pesticides bound to soil organic matter or clay particles are less mobile, bio available but also less accessible to microbial degradation and thus more persistent [7]. Soil organic matter is the most important factor influencing sorption and leaching of pesticides in soil [26]. Practically, addition of 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 non-humified soil [27]. Fast sorption usually occurs in short time after pesticide application, and with time it becomes much slower [25]; although repeated application may also increase the sorption and formation of bound, non-extractable residues. This transformation and degradation system of pesticides has created many entrances for the occurrence of contamination and pollution in soil [7]. The results of these caused tremendous effects on soil and water quality, biological system in soil and human diseases [9].

Generally, the ecosystem aspects of these implications include the soil quality, the air quality, the water quality, and the human health issues. The following explanation is generalized as it must be noted that pesticides affects almost all the major components of soil interaction systems [3]: the biosphere (organisms), lithosphere (rocks), hydrosphere (water), atmosphere and pedosphere (soil). These five

components of ecosystem are fully describing the soil, air, water and human qualities in detailed concept of soil science as a scientific discipline.

### 1. Soil quality

Soil quality has been defined by Karlen and co-workers as: 'the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation' [28]. This potential meaning of soil in this context may be affected when soil becomes contaminated or polluted. The surface and subsurface soil components may be disturbed by concentration of chemicals, deposition of unfamiliar molecules and transmission of high artificial or unnatural substances [29,30]. These actions could result in a wide range of possible soil consequences, which may include surface soil turbidity, soil profile concentration, soil biological changes, and soil structural damage [5]. This contamination may also affect surface soil types even from the viewpoint of visual soil assessment [31,32]. Additionally, the pore-spaces in soil might become implicated and turbid. This may finally affect the physical, chemical and biological properties, processes and systems in soil medium. In some cases, the plants, forest trees, vegetation shrubs, pasture grasses and animals and wildlife at nearby could be affected by the concentration of the pesticide chemicals in soil.

### 2. Air quality

Air quality is a general term related to an environment where air is absolutely healthy- free from polluted compounds at any measure (slight, low, high, very high or even extremely high). The environmental aspect of air can be affected by the pollution transmitted by pesticide chemical through a combination of environmental factors [23]. Typically, the emissions of those groups of pesticides, which are in powder form such as dust, affect the surrounding air quality, greatly [33]. Volatilization and evapo-transmission of pesticides also affect the air quality [7]. Dust containing particles of pesticides is a serious problem to both environmental water quality and human quality. This is a serious health issues to global soil environment- the aspects of physical, chemical and biological.

### 3. Water quality

Water quality is a multifunctional concept with varieties of special qualities primarily related to physical, biological, chemical and ecological characteristics of water suitable for management and protection of human lives, animal growth and biological cycle. This perspective may be absolutely nought when water is contaminated by pesticide molecules. The physical fitness may be changed, biological taste/flavour may be altered, and natural chemical composition may be destructed. This happened as a result of the release of chemicals and contaminants into process water [20]. The water bodies perhaps could be contaminated by for example, erosion of fine soil particles from the contaminated soil site, the release or leakages of disposed containers, the transformation of the affect soil through runoff, snow-melt and over-flow or flooding [10]. The underground water can be affected through infiltration, leaching, rainfall, percolation and in-flow.

#### 4. Human quality

Human quality can be related to the concept of health and wellbeing of human population from childhood to adulthood. This dynamic system of human growth requires protection and management for its success in all aspects of agronomic practices. When soil, air and water polluted and contaminated, the human quality is also affected. Human population used soil for food security, water for drinking and related purposes, and air for breath. These three components of human ecosystem are affected by pesticides through contamination and pollution. The problems have also led to multiple and complicated human diseases including cancers, inability to speak fluently, hormonal imbalances leading to infertility, breast pain, menstrual disturbances, adrenal gland exhaustions, early menopause, immune system dysfunction leading to immune suppression that cause potentially serious health risks and also subject to malnutrition [34]. Understanding the broad complexities of the pesticides residues and pesticides specification would help minimize the impact. The joint FAO/WHO meetings as indicated earlier are part of the efforts to achieve this development. Awareness through workshops and teaching particularly in a great part of sub-Saharan African's rural areas may be an added advantage.

#### Complex Activities of Soil Contamination

The complex activities of the pesticides in farm, garden, industrial developments, waste disposal and overall environmental protection programmes remained the most important components of soil contamination. These complex activities need to be understood for possible rehabilitation and management.

#### 1. Agricultural Activities

Farm and garden activities related to pesticide application contribute in many ways to soil contamination and soil pollution. This application of pesticide chemicals has gone up greatly since the advancement of technology in the aspects of soil protection (pesticides) and soil fertility management (fertilizers). These pesticides and fertilizers are chemicals that are produced artificially and degraded into the various component of soil; they slowly reduce the fertility and quality of the soil [35]. Possible solution through an integrated soil fertility management and insect control may help harmonize soil and plant health in a more proper way [36].

#### 2. Waste Disposal

This is another serious activity that causes soil contamination and soil pollution. Large volume of chemicals and packages are waste that could cause a variety of diverse environmental effect if not managed and disposed sustainably. The most affected components of environmental ecosystem include the soils, land surfaces, surfaces and ground water, and biota. The soil bodies might become polluted and full of concentrated chemicals. This affects the physical, chemical and biological systems at the surface and subsurface zones. The results include soil structural disturbances and soil profile damage. Solution is always needed to control the impacts and unsustainable waste disposal activities and other related environmental problems [37]. There are varieties of methods to achieve this [38]; however, it is believed that the following concept may be useful particularly in the circumstance of Nigeria and other sub-Saharan African countries.

(a) Discharge of wastes to a safe and very restricted areas far away from township premises, and also far away from water bodies and wildlife zones.

(b) Stacking wastes in piles and disposing them in a restricted environment as in the case of (a)

(c) Creating and providing safe and restricted bin for immediate disposal of the wastes, which may be checked by the authority or environmental protection agency at least daily for possible disposal at the restricted areas as in the case of (a).

(d) Creating awareness through special lessons and lectures in the urban and rural areas might help people understand the true impacts of unsustainable wastes disposal in town areas. This might also help to dispose the wastes in an appropriate manner as in the case of (a).

#### 3. Other Activities

Other activities although, not directly related to the incidents of pesticides chemicals, may also lead to soil contamination and soil pollution. These activities include industrial environmental businesses such as mining, chemical disposals, accidental oil spills and occurrence of acid rain. These complex activities have lingered in the soil surfaces for a long time and created diverse environmental soil problems [6]. Possible solution to these complex activities can be achieved when government policies are functioned. The government owned the environment and the responsibilities for the management at all cost. Therefore, the policies must always be sustainable to achieve better environmental protection at local and national level.

#### Conclusion and Recommendations

This paper has taken into consideration the aspect of soil challenges caused by pesticides. The adverse ecological effects from pesticides occur as a result of complex issues, which include the agricultural activities, waste disposal and related industrial issues. These activities have led to various contaminations that affect soil quality, air quality, water quality and human quality. These contaminations can be measured at global and local levels as well as provisional and permanent (i.e. acute or chronic form). However, the most serious contaminations as with regards to the soils include structural disturbances, and soil profile concentration of unhealthy chemicals, which may also affect the underground water system and soil quality development. Therefore, the following can be used as recommendations towards achieving better soil protection and healthy crop yield in agriculture.

For developing countries like Nigeria most of the farmers are poor and illiterate, as such they use these chemicals rampantly. Therefore, government should intervene and educate the farmers on the impact of these chemicals, and how to use them, properly.

Pesticides manufacturers should conduct long-term studies on ecosystem-wide impacts to demonstrate that a pesticide has no adverse effects before allowing it to be registered for use in the local communities. Manufacturers must collaborate with government agencies on this matter.

It is advocated that using a combination of prior gained field experience with the existing pesticides and applying fundamental government principles and policies would help make the safe use of pesticides in farm and garden. Government should persuade this to happen particularly in rural areas where farmers are ignorance.

Most of the global soil's environment has been mapped for various needs, but in many areas soil contamination by pesticides is not yet covered. This study of soil mapping needs to be conducted in all aspects of agronomic soils to help outline the major areas of soil contamination by pesticide.

Surface soil formation is made up of millions of very small drops of pesticide chemicals, which are combined formulations of active and inactive ingredients. Therefore, the need for regular soil analysis that could involve the use of both ex situ and in situ equipments will be an added advantage to help understand the impact of soil contamination by pesticides.

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