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# A REVIEW OF APPLICATION OF CHEMICALS FOR ENHANCED AGRICULTURAL PRODUCTIVITY: PROBLEMS AND PERSPECTIVES

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## ABSTRACT

This review article puts into perspective the benefits of the use of chemicals for enhanced agricultural productivity in relation to the hazards that affect the environment and the human populace. The desire to meet global food security has led to diverse methods and means of improving agricultural productivity. Chemicals in different forms are used as fertilizer for soil or growth boosters of plants, pesticides are used to control pests, and herbicides for weeds. Many chemicals remain as persistent organic pollutants (POP). These have resulted in various environmental pollution as well as diverse health conditions. Many diseases have been associated with use of some of these chemicals. The world is struggling to meet its challenge of food security and also confronted with the adverse impact of use of chemicals for improved agricultural productivity. The way forward is to encourage researches on healthy and environmentally friendly substitute and alternatives. Also, attention should be given to slow release compounds that reduces the amount of chemicals applied in a farming season.

**Key words:** Agricultural productivity, pesticides, herbicide, fertilizers

## INTRODUCTION

Agriculture has been constantly evolving. In the evolution process, plants and animals have been massively domesticated to enhance national food security [1]. Equally significant is the increase in consumption rate due to population growth which poses a major threat to global food security. In order to ensure food sufficiency globally, different scientific and innovative approaches were employed to enhance agricultural productivity. These include application of nutrients and fertilizers (chemical and organics) for improved crops and animal production, pesticides for pest control, and for healthier yields. However, with the increase in the use of these chemicals came the attendant risks and side effects of the enhancement techniques.

As global focus is on environmental protection, natural resources and public health management as well as food security for a fast-growing world population which is currently estimated to be about 7.4 billion [2], the scientific applications of chemical substances for enhanced agricultural productivity is also evolving [3].

In Nigeria, agriculture is the most important user of natural resources including water, forests, pastures and soil nutrients. Sustainable agriculture has been defined as one that over a long term enhances environmental quality and public health as well as provides for basic human food and enhances the quality of life of farmers and society as a whole [4]. The high vulnerability of the agricultural landscape to degradation and loss of nutrients make augmentation through the use of chemicals necessary to realize improved food production.

Therefore, the thrust of this paper is that without a scientific and strategic control scheme for the applications of chemicals in the enhancement of agricultural productivity, food security and the environment will not only be threatened in the foreseeable future, it will be a recipe for public health disaster. In view of the foregoing definitions, this paper deals with the identification of the risks and problems associated with the employment of different chemical materials and processes, particularly the synthetic ones, for crops and livestock production with the sole intent of improving fertility and efficiency in farming outputs. Additionally, the paper is aimed at compelling new research thinking in the management and application of chemicals in the enhancement of agricultural productivity.

This article is divided into five sections. Section one addresses conceptual and contextual perspectives. Section two provides an overview of different methods of chemical applications for agricultural productivity enhancement as well as pertinent fundamental concepts. The attendant risks and challenges of application of chemicals in agricultural practices are examined in Section three. Section four presents perspectives on possible research areas for the development of scientific methods for chemical applications control in agriculture. Concluding remarks and recommendations on the way forward are presented in Section five.

## Conceptual and Contextual Perspectives

Chemical is defined as ‘material produced by or used in a reaction involving changes in atoms or molecules; or material made from or made of substances produced by or used in reactions involving atomic or molecular changes [5]. Agriculture on the other hand, is defined as the art or

science of cultivating the ground, including the harvesting of crops; and the rearing and management of livestock [5].

## Types and classes of chemicals used in agriculture for enhanced productivity

### Fertilizers

Fertilizers are classified into organic and inorganic fertilizers. Organic fertilizers are those gotten from plant and animal source. Urea is considered a synthetic organic fertilizer; while inorganic fertilizers are chemical compounds such as mixture of nitrate, potassium, sulphur, phosphate calcium, magnesium (macro nutrients) and micronutrient blends (Fe, Zn, Cu etc). They are used in crop production and sometimes in aquaculture

In poultry the use of artificial chemical nutrient and steroids such as Testosterone, Progesterone and Zeranol is a common practice in order to enhance growth and bulk size of the animals. Antibiotic for disease control is also widely practiced [6, 7].

Fish farmers use fertilizers such as NPK, and superphosphate in feed in order to enhance the growth of the fishes [6, 8].

### Pesticides

Pesticides are chemicals designed to kill, reduce or repel pests. They are classified as insecticides, herbicides, fungicides, rodenticides fumigant and insect repellants.

Pesticides have different distribution and persistence patterns in the environment, even though all of them are distributed in some way through air, soil and water. This should be addressed to gain an understanding of how acute and chronic exposure may occur because air, water and soil are the media of exposure. The scheme below illustrates the routes followed by an agricultural chemical (spray, granulate or seed treatment) that is applied to a given site, representing a risk to applicators, bystanders and wildlife. When a pesticide is applied directly to a target pest (plant or animal) the whole site is affected including crop plants, soil organisms and, potentially, humans and wildlife in the immediate area. In addition, part of it goes to the air or to surface waters, due to emission (1 in Fig. 1) or drift (2 in Fig. 1). Once on the target site, the pesticide may "drain"(6 in Fig. 1) into surface waters or volatilize (7 in Fig. 1) into the air. From the air it may deposit (3 in Fig. 1) on humans, wildlife or plants or on the soil. From the animals or plants where it was applied the pesticide may leak (5 in Fig. 1) into groundwater. Pesticides in surface water may go into aquatic organisms, and by sedimentation (4 in Fig. 1) into other

organisms that remain in the sediment. The persistence of the pesticide depends on its physical and chemical properties (partition coefficients, degradation rates, deposition rates) and the characteristics of the environment. Climate characteristics also play a role in persistence. Studies in the Arctic have shown that insecticides and herbicides persist 3 to 8 times longer in cold climates than in temperate ones. The most persistent pesticides are termed "persistent organic pollutants" (POPs).

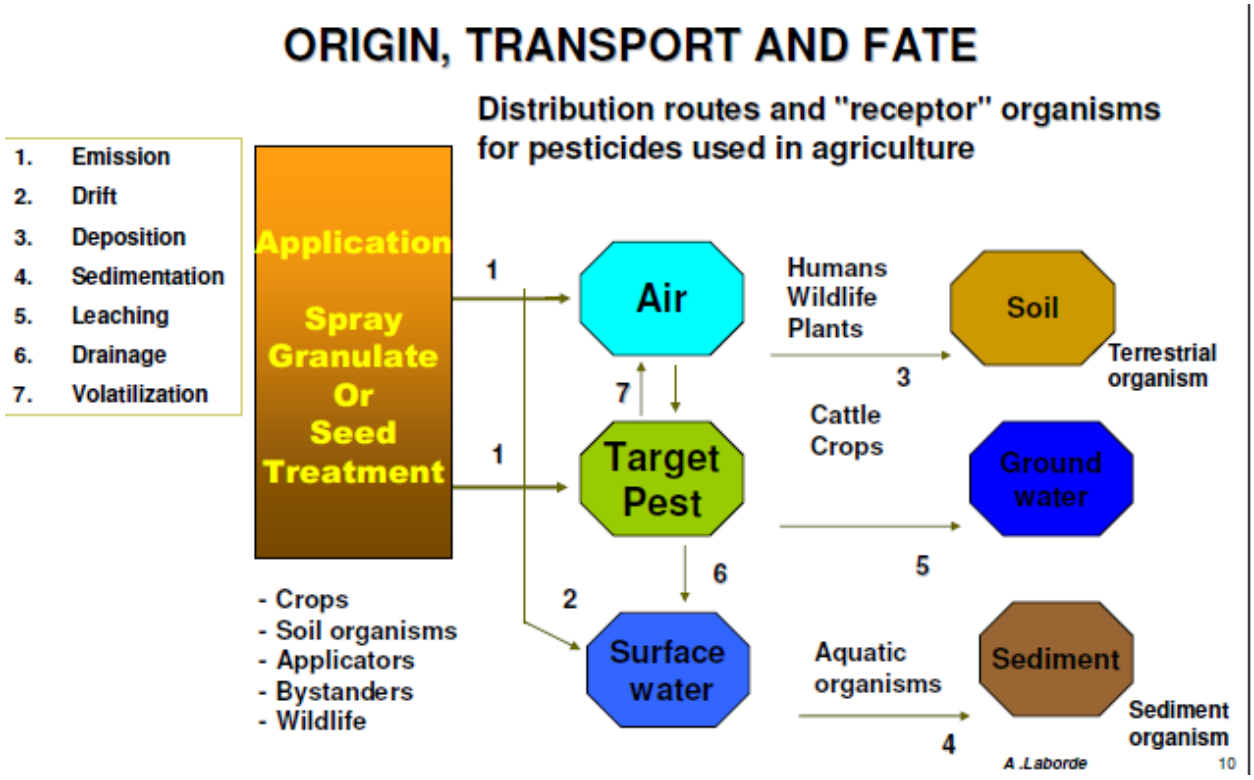



Figure1: Distributor routes and "receptor" organism for pesticides used in agriculture
Source: Children's health and the environment WHO training package for health sector. www.who.int/ceh [11]

Other chemicals used are steroid, antibiotics etc.

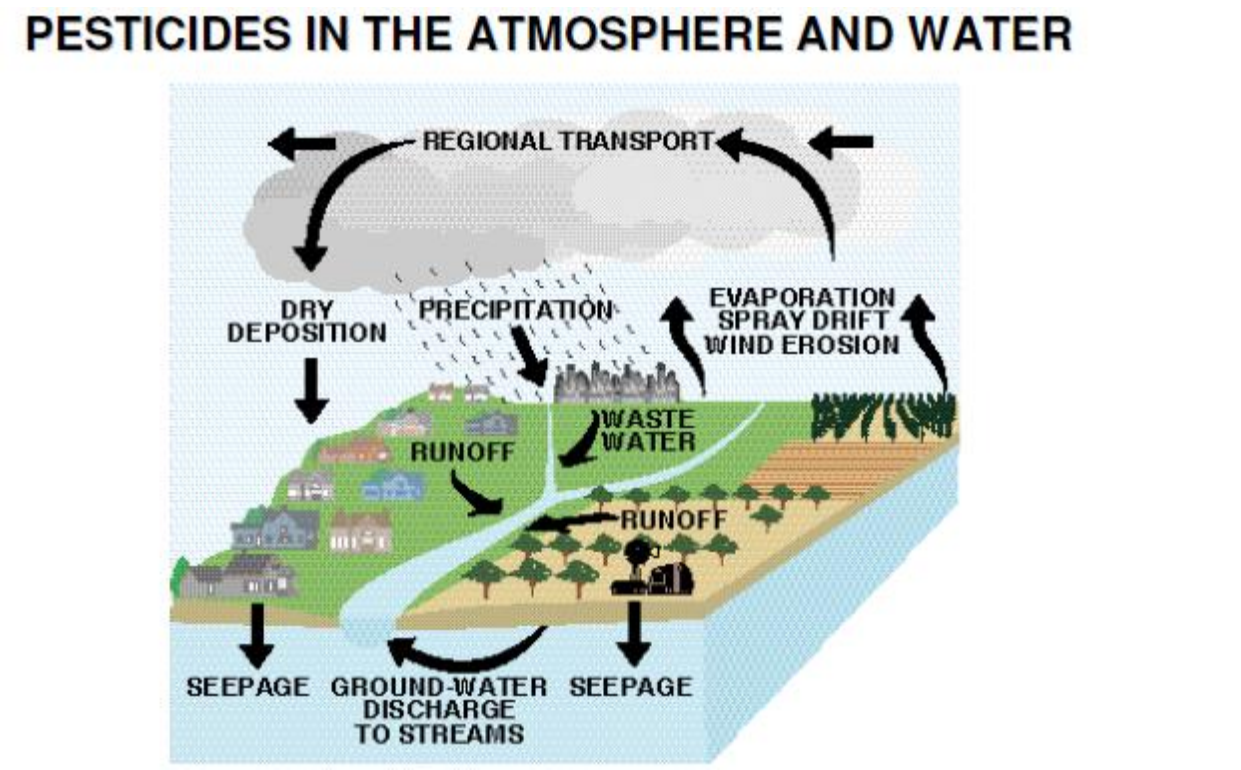



Figure 2: Pesticides in the atmosphere and water

Source: Children's health and the environment WHO training package for health sector. www.who.int/ceh [11]

**3.0 Problems associated with current realities of chemical application for agricultural productivity**

Some risks or problems associated with the use of nutritional chemicals for crop fish production and poultry enhancement are listed below:

1. Waterways and nearby water bodies can be adversely affected by use of excessive chemical fertilizers from chemical run off through rain water. As a result, the amount of oxygen is reduced in the water leading to hypertrophication to the aquatic system. The living organisms existing in the water use up the oxygen which leads to depletion of oxygen level in the water body. Such depletion of oxygen can cause death of majority of aquatic organisms including fishes.
2. Carbon dioxide and nitrous oxide, which are greenhouse gases, can be released in the atmosphere by over and repetitive application of nitrogenous fertilizer beyond the crop's assimilation capacity contributing to global warming and erratic climatic conditions.

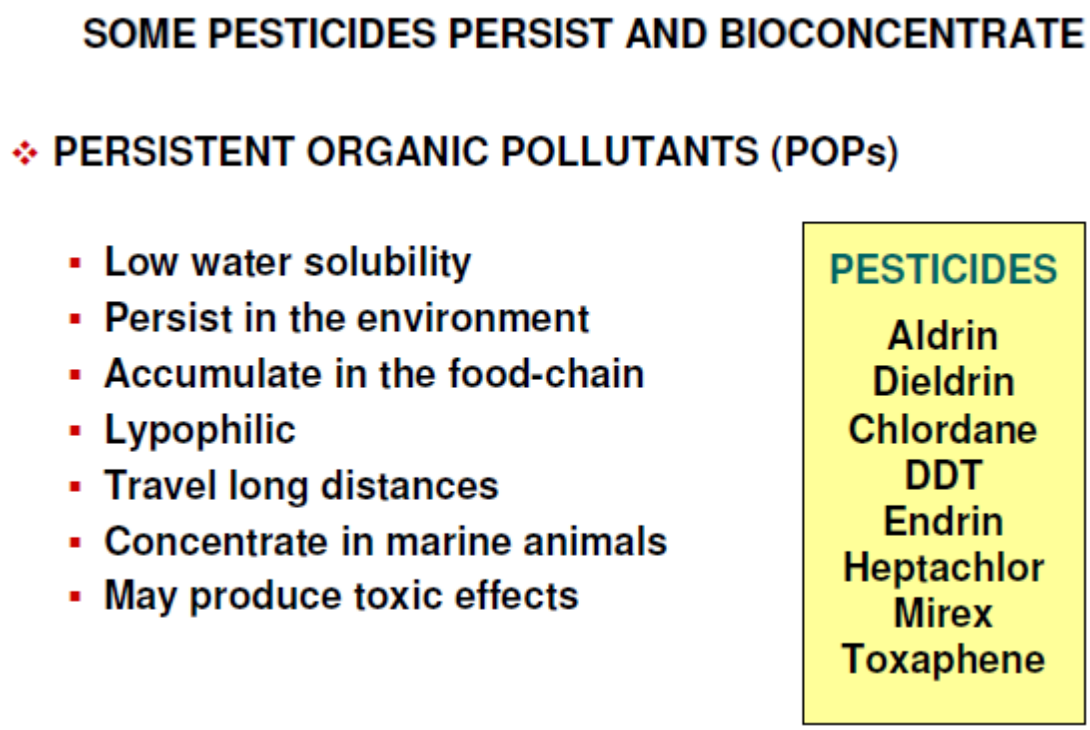
3. Acidification of soil can take place due to decrease of organic matter in the soil by excessive use of chemical fertilizers causing threats to survival of plants.
4. Application of chemical fertilizers in imbalanced ratio consumes the indispensable part of the nutrients in soil reducing the amount of minerals and vitamins in the food items.

When high concentrations of fertilizers are applied to the soil, the natural nutrients of the soil are imbalanced. Usage of nitrogen containing fertilizers reduces stability in the system and causes soil acidification [6].

5. Animal manure rarely contains the entire essential nutrient needed for plant's growth and productivity. Some types of manure application frequently lead to imbalances and accumulation of nutrient in soil that can pose environmental risk. Also, the mineralization of compost and manures depends on complex interaction between of both soil and environmental factors that are not easily predicted which commonly result in lower efficiency of the fertilizer.
6. The process of fish farming releases nutrients such as nitrogen and phosphorus, from fish feed into the marine environment in a soluble form. These nutrients can enhance the growth of marine plants and algae [7, 9]
7. When nitrate fertilizers are applied to soil a fraction of this is reduced to nitrite. This is leached into the water body or absorbed by the plant itself especially vegetables. If ingested in excess quantity it may be involved in the formation of carcinogenic substances such as nitrosamine and nitosamide. Also, excess nitrate leached into water from either manure or chemical fertilizer poses a high risk to infants and pregnant women. This leads to a disease condition known as methenoglobinemia. A condition caused by inability of the hemoglobin to transport oxygen in the blood [10].
8. Many endogenous steroids, including their semi-synthetic and synthetic analogues, have been produced and administered to animals to improve growth of animals for food production, as well as to regulate and enhance fertility. Some scientific reports stated their possible carcinogenicity, genotoxicity and interfere with human and animal natural physiological function. Also, it has been found that the highest rates of hormone relatedcancer, including cancer of breast, ovary, prostate, testes and colon were found where hormone treated meat is consumed [8].

**Risks associated with pesticides**

1. Some pesticides are characterized as being very persistent in the environment. They may represent long-term dangers as they bio-accumulate up the food-chain. Humans, and particularly breastfed babies, are at the top of the food-chain. POPs and PTSs (Persistent Toxic Substances) are typically lypophilic compounds, with low water solubility, that are resistant to environmental breakdown and accumulate in adipose tissue. They bio-concentrate in fish, wildlife and human tissues, the highest levels are found in marine mammals. There is concern about potential endocrine and developmental effects of the POPs and PTSs, especially in children [11].
2. Many of the herbicides are known to be toxic to human and the mode of action of some of them immobilizes the nutrient in the soil and makes them unavailable for plant up-take. Paraquat for instance is known to cause tissue damage by setting off a redox reaction that generates the toxic super oxides free radicals. In acute exposure it kills by damaging the lungs. It is also link with the Parkinson disease [12].
3. They immobilize the essential minerals needed by plants for growth. For example, studies have shown that glyphosate forms stable complexes with metals essential for plant development. It forms complexes with transition metals by means of amino, carboxyl and phosphonate groups [13].




Source: Children's health and the environment WHO training package for health sector. www.who.int/ceh [11]

**4.0 Perspectives on way forward**

The obvious investigatory questions would be: What should be the perspectives of concerned chemical researcher on the way forward? These include

1. Encourage inter/multidisciplinary research in the search for new bio-compatible and non-hazardous compounds.
2. Funding of research on healthy substitutes and alternatives to the current products. For example, paraquat has been banned in many European countries but they are in different product names all over Nigeria. Also, most POPs (these will soon be considered as persistent toxic substances or PTS) like organochlorine pesticides, namely, aldrin, endrin, clordane, DDT, heptachlor, mirex, toxaphene and hexachlorobenzene. have been banned for agricultural or domestic uses in Europe, North America and many countries of South America in accordance with the Stockholm Convention (ratified in 2004) [11].
3. Encourage research in the area of slow release compounds to reduce the rate of application of the nutrients.

## 5.0 RECOMMENDATIONS AND CONCLUSION

1. Intensifying food production must be done in an environmentally safe and health conscious manner. Therefore, the need to encourage and ensure best management among users.
2. Curbing processes that introduce toxin into the environment, such as proper decomposition of manure before application on farm land or open disposal. Application of right nutrient ratio to the soil and animal feeds.
3. Design appropriate policies on the use of chemicals for agricultural product enhancement. For example, the need for regulation for the use of drugs in the poultry industry as well as the inspection of broilers for residues and analysis of imported poultry and fish products for residual chemicals prior to marketing.
4. Training and re-training of farmers on proper method of application of these chemicals.
5. Establish monitoring procedures and data base for the level of agricultural chemical contaminant in crops and animal products. This will help solve the problem of rejection of our agricultural products in international markets.

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