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DEFINITION OF PERSISTENCE IN PESTICIDE CHEMISTRY

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Commission on Pesticide Chemistry*

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1. INTRODUCTION

The term persistence was introduced into the pesticide scientific literature to describe the continuing existence of certain insecticides in the environment and is now applied to any organic chemical that has biological activity. Terms such as stable or inert, commonly encountered in chemistry and physics, are not appropriate since they do not properly characterize the nature of persistent chemicals. Some degradation almost always occurs and in fact some persistence is desirable.

Ideally, a pesticide should effectively control the target organism for a critical period of time during its growth and then be degraded to products harmless to man and other organisms. In practice, this situation rarely occurs and some uses may lead to the continued existence of the parent compound and/or biologically active metabolites over prolonged periods. These unwanted residues or contaminants may directly or indirectly endanger some phase of life. Based on these considerations, it is necessary to know how long any given pesticide persists after its regular application (good agricultural practices) and what the implications of its persistence might be, i.e. its potential for bioaccumulation or selective toxicity.

With increased concern over the long term effects of pesticides in various environments, the idea has arisen that persistence is a measurable property of a chemical and represents its resistance to changes of its chemical structure. This is an oversimplification, since the period over which a compound exerts an effect will depend on its chemical properties, the characteristics of the specific environment and the organisms concerned. Hence persistence does not denote an absolute characteristic of a chemical, but is a variable which is a function of many interactions.

The term persistence is employed by scientists in many disciplines. An agronomist must consider whether a pesticide will survive long enough to control a problem, be it weed or insect, and also whether it will leave toxic residues that may adversely affect future use of soil or crop. The analytical chemist determines the measurable presence of a substance in a medium at a specific period of time, regardless of its bioavailability or effect. The toxicologist examines the effects of food-stuffs containing residues of the parent compound or relevant metabolic products for human safety. The ecologist is interested in the even wider environmental problems caused by pesticide dispersal such as adverse effects in non-target organisms.

In addition, the term persistence appears in numerous scientific and popular publications, where the actual meaning with respect to the limits prescribing its use are not described. Because of the varied use of the word, a precise definition is lacking. The objective of this discussion is to develop a rationale to define the term "persistence" as applied in pesticide chemistry.

2. DEFINITION

PERSISTENCE IS THE RESIDENCE TIME OF A CHEMICAL SPECIES IN A SPECIFICALLY DEFINED COMPARTMENT OF THE ENVIRONMENT

Chemical species - is a specific chemical, which may be the parent compound or a derivative, but not both.

Residence time - is the period in which the specific chemical species remains in one compartment, regardless of the means by which it is quantified. It is measured in units of time, day, year, etc. When (pseudo) first order processes occur, it is simply (1/k) where k is the first order rate constant. If the order is unknown, the time for 50% disappearance (DT 50) at specific initial concentrations can be used.

Compartment - is one phase of the environment, i.e. soil, water, air, animal or plant tissues and its description must include all the environmental factors which affect persistence.

This definition is concerned only with the chemical and physical properties of the chemical species in its immediate compartment of the environment. The dispersal (translocation and bioaccumulation) of the chemical from its primary compartment will necessitate a further determination of persistence. Consequently, a chemical will have a specific persistence in each compartment where it is present. The consequences of persistence, as related to the toxicity and bioavailability of the chemical are not considered.

3. FACTORS AFFECTING PERSISTENCE

The persistence of a compound should be defined after consideration of a number of factors that affect its behavior. The primary factors are the inherent properties of the compound and its environment. These are, -

(a) Chemical properties of pesticide, such as its susceptibility to oxidation, reduction, hydrolysis, photolysis and substitution.

(b) Physical properties of pesticide, such as vapour pressure, solubility in water dissociation constant, partition coefficient, sorption to soil, and volatility from water and soil.

(c) Composition and characteristics of relevant environmental compartment, for soil this includes the clay/silt/sand ratio, water content, organic matter, pH, microbial biomass and temperature.

(d) Climatic conditions, such as the light intensity, energy and duration, temperature, wind and humidity.

In addition, secondary factors which must be recognized include the analytical methodology employed, formulation and method of application and the use pattern.

4. DETERMINATION OF PERSISTENCE

Measurement of the overall degradation rate of a pesticide and all the various processes affecting its disappearance from the relevant compartment defines persistence in either specific or comparative terms. The establishment of fundamental data on pesticide dynamics, however, could provide a more basic understanding of persistence. Kinetic and equilibrium data would allow the evaluation of persistence by determining the critical factors affecting the stability of a compound in a given situation.

Persistence can be expressed either in units of time or in terms relative to another compound. In the former case, half-life or residence times may be used, but they relate only to a specific condition and environment. In this sense they are not absolute values, but variables. It is not feasible to assemble kinetic data for each pesticide, and comparison with "benchmark" pesticides is a viable alternative. Normally, benchmarks should be of the same class as the chemical under investigation and have similar sorption characteristics. In certain cases, benchmarks may be used from different classes when the same disappearance pattern is followed. The relative persistence could be determined in model systems and the level of validation established against results obtained in field studies. The persistence of new compounds would then be expressed relative to the benchmark for that particular class in a specific environment.

5. SUMMARY

Persistence is defined on the basis of the inherent properties of an individual chemical and the nature of its immediate environment. It can be expressed in units of time or dimension-less units relative to a benchmark.