

Assessing soil contamination: A reference manual

FAO PESTICIDE DISPOSAL SERIES 8

APPENDIX 2

Parameters of pesticides that influence processes in the soil

The parameters used to characterize the properties of pesticides are:

Degradation

- persistence
- half-life time DT_{50}
- biodegradation
- hydrolysis
- photolysis

Mobility

- water solubility
- soil-water partition coefficient K_{oc}
- retardation factor R

Bioaccumulation

- octanol-water partition coefficient K_{ow}

DEGRADATION

The organic compounds in soil undergo a lot of change. Most pesticides break down or degrade over time as a result of several chemical and microbiological reactions in soils. Some are broken down by sunlight. These processes result in the final degradation of the compound into the mineral compounds CO_2 , H_2O , HCl , SO_2 , etc. As they degrade, some pesticides produce intermediate substances (metabolites) whose biological activity may also have environmental significance.

Compounds with an extremely long degradation time are considered *persistent*. Persistent compounds disperse into the environment without undergoing any changes.

The value of the degradation is given by half-life DT_{50} . Half-life DT_{50} is a measure of the amount of time it takes for 50 percent of the parent compound to disappear from soil or water by transformation. The important degradation processes are biological processes (*biodegradation*) and physicochemical processes (*hydrolysis*, *photolysis*, etc.).

The major degradation products are listed in Appendix 3. Additional remarks are made for the degradation products that are expected to have a significant influence on the environment.

Biodegradation

Biodegradation is the transformation of a substance by micro-organisms. Under environmental conditions, biodegradation can be affected by a number of factors, including the presence of oxygen (aerobic/anaerobic conditions) and nutrients, the population size of the required microorganisms, and the micro-organisms' adaptation.

Hydrolysis

During hydrolysis a compound is split by contact with water, undergoing a chemical reaction in which a part of the molecule of the reacting substance is replaced by an OH group. This process is strongly affected by the acidity of the environment (pH).

Photolysis

Photolysis is the breaking down of a compound as a direct result of irradiation.

MOBILITY

The mobility of a pesticide in water indicates the water's solubility and pesticide sorption (K_{oc}), or retardation factor. When a pesticide enters soil, some of it adheres to soil particles (particularly organic matter) through a process called sorption, and some dissolves and mixes with the soil water.

TABLE A

Classification of degradability in soil (biological and physicochemical transformations)

DT ₅₀	Classification
<20	Readily degradable
20–60	Fairly degradable
60–180	Slightly degradable
>180	Very slightly degradable

The organic compounds that dissolve in groundwater move more slowly than groundwater because of sorption to the soil particles. The solubility of a pesticide and its sorption in soil are inversely related: i.e. increased solubility results in less sorption.

Water solubility

Pesticide solubility is an important factor in waste disposal. Solubility can indicate the maximum amount of pesticide in solution in any accidentally contaminated water. The solubility of a compound in water is given in mg/L at 20°C. Compounds with high degrees of solubility are expected to leach into groundwater.

Soil-water partition coefficient K_{oc}

The partition coefficient K_{OC} is defined as the ratio of pesticide concentration in a state of sorption (i.e. adhered to soil particles) and the solution phase (i.e. dissolved in the soil water). Thus, for a given amount of pesticide, the smaller the K_{OC} value, the greater the concentration of the pesticide in solution. Pesticides with a small K_{OC} value are more likely to leach into groundwater than those with a large K_{OC} value.

Sorption for a given pesticide is greater in soils with a higher organic matter content. Thus, pesticide leaching is thought to be slower in those soils than in soils lower in organic matter.

Because of the large range of K_{OC} values, use the logarithm of K_{OC} . A compound's mobility in soil is classified according to Table C.

Retardation factor

The K_{OC} value is used to determine the parameter known as *retardation factor R*. This factor indicates the delay of the pesticide transport rate in comparison with the water rate.

TABLE B

Classification of solubility in water

Solubility	Classification
<0.10	Not soluble
0.1–1	Slightly soluble
1–10	Moderately soluble
10–100	Readily soluble
>100	Highly soluble

TABLE C

Classification of mobility

Log K_{OC}	Classification
<1	Highly mobile
1–2	Mobile
2–3	Moderately mobile
3–4	Slightly mobile
4–5	Hardly mobile
>5	Immobile

BIOACCUMULATION

Bioaccumulation indicates the tendency of a compound to accumulate in organisms. The most useful index for quantifying pesticide bioaccumulation is the partition coefficient K_{OW} .

Octanol-water partition coefficient K_{OW}

The octanol-water partition coefficient K_{OW} is defined as the ratio of the pesticide concentration in two unmixed liquids, octanol and water. The compounds with a high K_{OW} value (i.e. readily soluble in octanol and less soluble in water) accumulate in organisms.

TABLE D

Pesticide categories

Pesticide	Category
	Impact mainly because of high mobility in groundwater (risks owing to spreading)
1,2-dibromoethane(EDB)	
Paraquat	
Pentachlorophenol	
2,4,5-T	
Warfarin	
	Impact mainly because of bioaccumulation, toxicity, high persistency and immobile character (risks owing to direct contact with pesticide or consumption of contaminated fruits or vegetables)
Chlordane	
DDT	
Dieldrin	
Dioxins	
Furans	
Heptachlor	
Hexabromobiphenyl	
Hexachlorobenzene	
Hexachlorobiphenyl	
Polyaromatic Hydrocarbons (PAHs)	
Polybrominated biphenyls (PBB)	
	Impact because of degradation products
Carbaryl	
Endosulfan	
Malathion	
Mancozeb	
Methamidophos	
Monocrotophos	
	No dominant impact
Aldrin	
Atrazine	
Captafol	
Carbofuran	
Chlorfenvinphos	
Chlorobenzilate	
Diazinon	
Dimethoate	
Dinoseb and dinoseb salts	
Fenitrothion	
Methyl-parathion	
Parathion	

Phosphamidon	
Propoxur	
	Insufficient information
Chlordimeform	
Crocidolite	
Endrin	
Fluoroacetamide	
HCH(mixed isomers)	
Mercuric chloride	
Mirex	
Polychlorinated biphenyls (PCB)	
Polychlorinated terphenyls (PCT)	
Toxaphene	
Tris(2,3-dibromopropyl) phosphate	

The full version of this document can be found at:
<https://www.fao.org/3/X2570E/X2570E00.htm#TOC>

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