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Fate of Herbicide in Soil

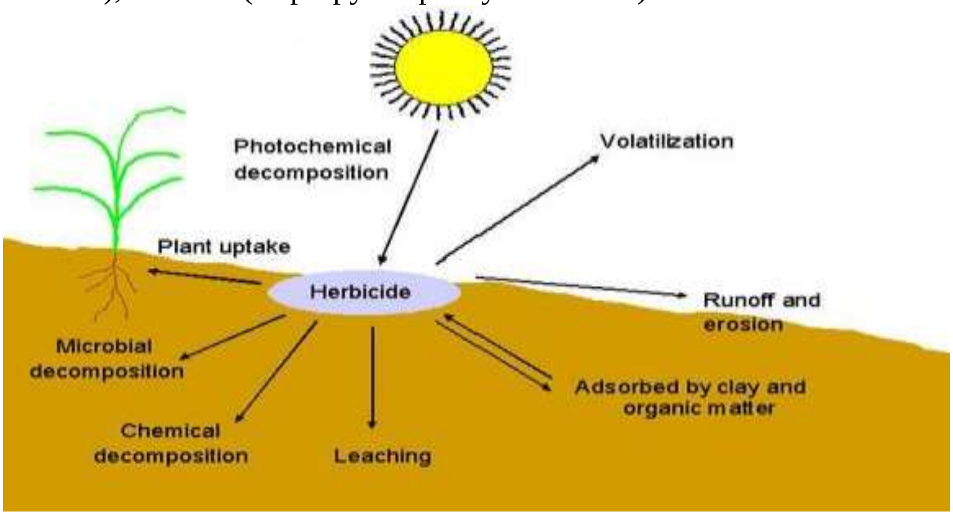
Srinivasa Prasad L.[1] and Chetana Banasode[2]
[1]Ph.D. Scholar, Department of Soil science, UAS, Dharwad
[2]Ph.D. Scholar, Department of Soil science, GKVK, Bengaluru

SUMMARY

Herbicides are either applied directly to the soil (pre-emergence) or on to the foliage of weeds and crops (post-emergence). A part of the post-emergence herbicide also reaches the soil. Upon contact with the soil, herbicides are subjected to various processes. The various processes and reactions that take place between herbicides and soil are important because they can affect the activity and behaviour of the herbicide. It is important to understand herbicide behaviour in the soil because it, determines success or failure in weed control, determines whether or not crop injury occurs, affects persistence of the herbicide, which in turn determines the length of weed control and whether or not there is carryover to the following crop, and ultimately determine the environmental fate of the herbicide.

INTRODUCTION

Herbicides, an agent, usually chemical for killing or inhibiting the growth of unwanted plants such as residential or agricultural weeds and invasive species. A great advantage of chemical herbicides over mechanical weed control is the ease of application which often saves cost of labour. The first major organic herbicide, was developed in France in 1896. The year 1945 was key to the development of selective chemical weed control. Introduced then were 2,4-D (2,4-dichlorophenoxyacetic acid), 2,4,5-T (2,4,5-trichlorophenoxyacetic acid), and IPC (isopropyl-N-phenylcarbamate).



Classification of herbicides:

Sl. No.	Group	Herbicides
1	Aliphatic acids	Dalapon, TCA, Glyphosate, Methyl bromide, Cacodylic acid, MSMA, DSMA
2	Amides	Alchlor, Butachlor, Propachlor, Metalachlor, Diphenamide, Propanil
3	Benzoics	2,3,6, TBA, Dicamba, tricamba, Chloramben
4	By Pyridillums	Paraquat, Diquat
5	Carbamates	Propham, Chlorpropham, Barban, Dichlormate, Asulam
6	Thiocarbamates	Butylate, Diallate, EPTC, Molinate, Triallate, Benthiocarb, Metham
7	Dithiocarbamates	CDEC, Metham
8	Nitriles	Bromoxynil, Ioxynil, Dichlobenil
9	Dintroanilins	Fluchloralin, Trifluralin, Pendimethalin, Nitralin Isoproturan
10	Phenols	Dinoseb, DNOC,PCP
11	Phynoxy acids	2,4-D, 2,4,5-T, MCPA, MCPB, 2,4-DB, Dichlorprop

12	Traizines	Atrazine, Simazine, Metribuzine, Amytrin, Terbutrin
13	Ureas	Monuron, Diuron, Linuron, Metoxuron, Isoproturon, Methabenz thiozuron
14	Uracils	Bromacil, Terbacil, Lenacil
15	Diphenyl ethers	Nitrofen, Oxyfluorfen, Nitrofluorfen
16	Aryloxyphenoxy propionate	Diclopop , Fenoxaprop-p, Quizalofop-p, Haloxyfop-p Fluazifop-p
17	Imidazolines	Imazapyr, Imazamethabenz, Imazaquin, Imazamax imazethapyr
18	Isoxazolidinones	Clomazone
19	Oxadiazoles	Oxadiazon
20	Oxadiazolides	Methazole
21	Cyclohexanedione	Sethoxydim, Clethodim Tralkoxydim, Cycloxidim
22	N-phenylphthalamides	Flumiclorac
23	Phenylpyridazones	Sulfentrazone
24	Phthalamates	Naptalam
25	Pyrazoliums	Difenzoquat, Metflurazone
26	Picolinic acids Pyridine	Picloram , Dithiopyr, Pyrithiobac, Fluridone, Thiazopyr
27	Quinolines	Quinclorac
28	Sulfonylureas	Bensulfuron, Chlorimuron, Metsulfuron, Sulfosulfuron, Triasulfuron
29	Triazolinones	Pyridates
30	Cineoles	Cinmethylin
31	Others	Pichloram, Pyrazon, Endothal, Oxadiazon, Amitrole, Anilofos

Factors affect an herbicide's fate are;

- Environmental factors
- Wind
- Rainfall – activation, runoff
- Microbial population
- Humidity
- Soil - pH, moisture, compaction, OM, texture,fertility, slope of soil
- Vegetation

Process that affect herbicide activity

Adsorption:

The extent of adsorption determines how much herbicide is available to plants (available to control weeds or injure crops). Adsorption also affects other environmental processes such as leaching, volatilization, and microbial degradation.

Soil Organic Matter:

Soil organic matter (humic matter) has a high capacity to adsorb herbicides, and it is the single greatest factor affecting herbicide adsorption. Herbicide adsorption increases as the organic matter content increases. Application rate of most soil-applied herbicides increases, as the organic matter content increases. Organic matter (humic matter) has many negatively charged sites that can attract positively charged herbicides. That is referred to as ionic bonding. Organic matter (humic matter) also has many organophillic, non-charged sites on the surface that lead to non-ionic bonding of herbicides.

Soil clay type and content:

Clay carries a negative charge, which contributes to the soils CEC. Herbicides with a positive charge are ionically bound to clay particles. 2:1 type clays (such as montmorillonite), which have expanding lattices, have more surface area and more negatively charged sites than 1:1 type or non-expanding, clays (such as kaolinite). Hence, soils with 2:1 clays will adsorb more herbicide than soils with 1:1 type clays. Herbicide adsorption and therefore application rates of most soil applied herbicides increases with increase in the clay content of a soil.

Soil moisture:

Herbicides are more tightly bound to drier soil due to less competition with water for binding sites under dry conditions. Plants absorb herbicide that is dissolved in the aqueous phase, or the soil solution. With good soil moisture, some of the binding sites on colloids are occupied by water and more of the herbicide is in the soil solution. As the soil becomes drier, there is less water present to compete with the herbicide for binding sites on the colloid, hence more of the binding sites are occupied by herbicide.

Herbicide chemistry and soil pH:

Soil pH can affect the amount of adsorption. The term sorption coefficient, or KOC, is used to describe the tendency for herbicides to adsorb to soil. Partition coefficient, Kd, is the ratio of herbicide bound to soil particles compared to the amount left in the soil solution. Sorption coefficient, KOC, measures the tendency for adsorption adjusted for organic carbon content. The smaller the KOC value, the smaller the amount of herbicide bound to the soil. Paraquat is very tightly and irreversibly bound to soil. Alachlor and imazaquin are weakly bound to soil.

Nonionizable herbicides: These remain uncharged regardless of soil pH. Hence, soil pH does not affect adsorption of such herbicides.

Cationic herbicides: Paraquat exists only in the cationic form (positively charged). It is strongly (irreversibly) bound to negatively charged clay particles.

Degradation process

a) Biological decomposition or degradation
1) Soil microorganisms
2) Plants
b) Chemical decomposition
1) Hydrolysis in the soil or even spray tank
2) Oxidation, etc.
c) Photodecomposition
1) Breakdown by sunlight

Biological decomposition or degradation

- Algae, fungi, actinomycetes and bacteria may use herbicide for N, C, S sources
- Fungi--smaller number than bacteria, but larger in size
- Bacteria- large number, but small size
- Herbicides have generally not caused damage to fungi or bacteria however, these organisms have caused herbicides to degrade

Chemical decomposition

- The breakdown of a herbicide by a chemical process or reaction in the absence of a living organism.
- Example:
- Oxidation, reduction and hydrolysis – these are heavily influenced by soil pH changes
- Sometimes hydrolysis can occur while the herbicides in the spray tank mixed with water

Photodecomposition

- Breakdown of herbicides by light. Breakage of chemical bonds
- Incorporation of herbicides helps reduce this with soil applied herbicides
- Can also occur with some post applied herbicides.
- Can also occur in the spray tank

CONCLUSION:

Soil organic matter greatly facilitated degradation of herbicides. Decreasing temperature and moisture resulted in prolonging the half-life of herbicides in soil. Microbial degradation played a role in the persistence of herbicides in soil. The influence of soil pH on the degradation rate of herbicides, the rate of degradation and process involved in highly alkaline soils. The sorption coefficient is decreased as pH is increased and the half life of herbicide is correlated with soil pH. Higher the rate of degradation of herbicides is directly related to the moisture.

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