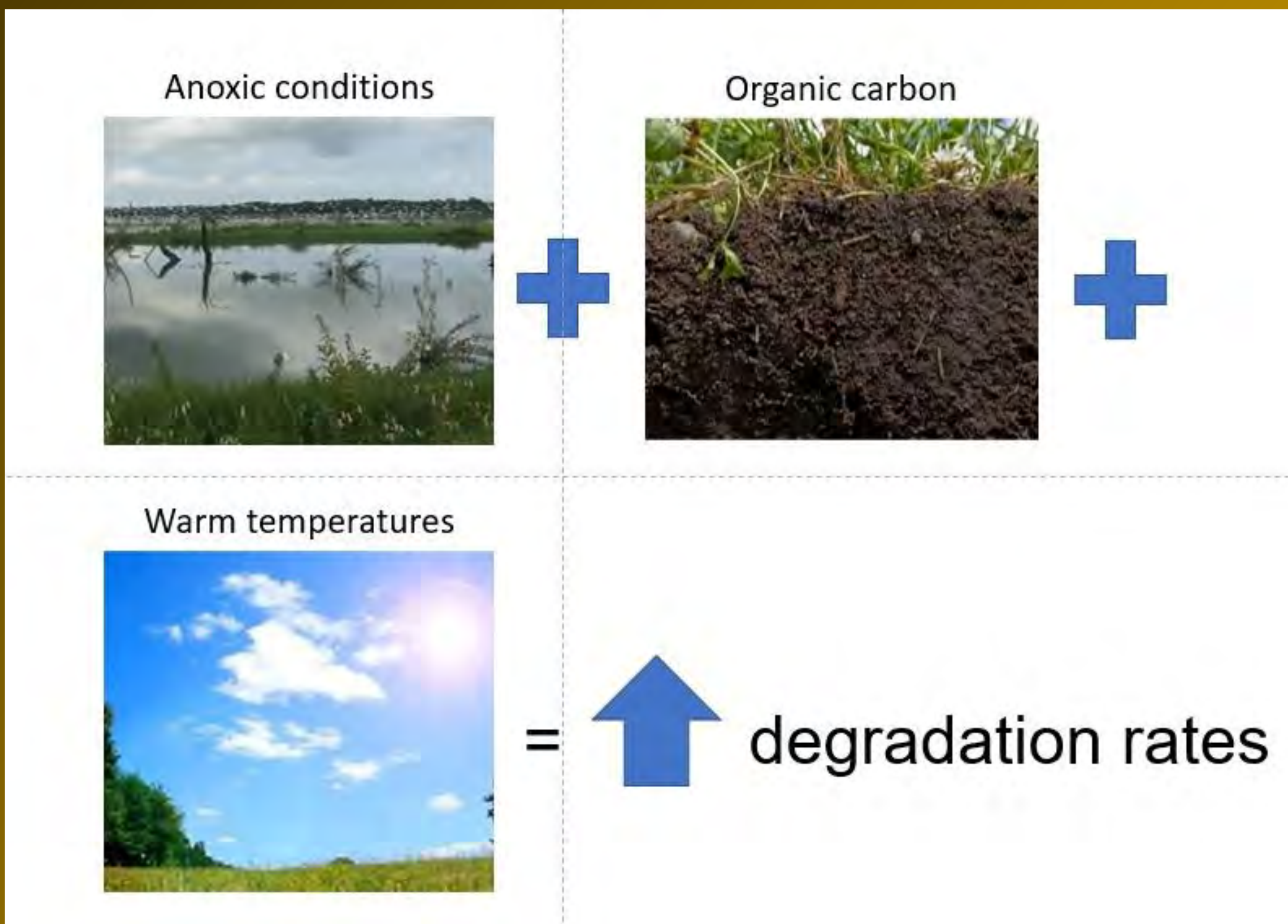
MDC Resource Science

Clothianidin Decomposition in Missouri Wetland Soils

Science Notes



Clothianidin Decomposition in Missouri Wetland Soils

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BACKGROUND INFORMATION

Detections of neonicotinoids in surface waters, including wetlands, has raised concern regarding whether these insecticides might negatively influence non-target aquatic insect communities and, as a result, potentially disrupt aquatic food webs. Clothianidin (CTN), introduced in 2003, is currently one of the most widely applied neonicotinoid active ingredients. Clothianidin or thiamethoxam (which degrades to clothianidin) are components of seed dressings routinely applied to >80% of corn seed planted in North America. Clothianidin is moderately soluble and, while it has high leaching potential in soil, it can also accumulate and persist in the environment. Various studies have reported CTN half-life values that range from 277 to 1386 days. Although some studies have found that soil microbes play an important role in neonicotinoid degradation, anoxic (i.e., absence of oxygen) conditions also appear to be a primary factor affecting CTN half-life in certain soils. Inundating wetland soils, a common wetland management practice, can promote anoxic conditions whereas the opposing action of removing water (i.e., conducting a drawdown) encourages oxic (oxygen-rich) conditions. Understanding the effects anoxic and oxic conditions have on CTN degradation in wetland soils can help inform whether wetland management decisions result in conditions which may lead to reduced CTN concentrations. Our objective was to evaluate the influence of wetland soil saturation on CTN decomposition in soils of different textures collected from Missouri Department of Conservation (MDC) intensively-managed wetlands.

METHOD

Soil samples were collected from five randomly selected wetland pools that contained hydric soil and were > 2 acres on five MDC Conservation Areas (BK Leach, Eagle Bluffs, Four Rivers, Otter Slough, and Ted Shanks) between mid-August and mid-October 2016. Anoxic and oxic incubation experiments were conducted to determine the rate at which CTN degrades in wetland study soils. Triplicate samples of each soil and three replicates that did not contain soil but served as controls were destructively sampled on days 0, 2, 5, 10, 30, and 60. Study soils were not sterilized so as to not destroy the soil microbial community. Anoxic experiments were conducted in an oxygen-free anaerobic chamber maintained at a constant temperature of 25ºC (77ºF). Soil samples were treated with CTN solution to achieve an initial concentration of 500 µg kg^{-1} and deoxygenated water was added to reach a 4 cm layer of standing water above the soil surface. This water depth was maintained throughout the incubation experiment and is referred to as the flood layer. The oxic incubation experiment was like the anoxic incubation except it was conducted under ambient atmospheric conditions and soil samples were maintained at 60% water-filled pore space. Oxic incubation bottles were opened weekly to introduce oxygen into the 70 cm^3 of headspace. Clothianidin decomposition was analyzed by considering soil phase only (oxic and anoxic incubations), and total CTN within the soil phase plus flood layer.

RESULTS

Degradation kinetics involves determining the rate or speed at which chemicals decompose by calculating half-life values ($t_{0.5}$). Half-life is the time it takes for an initial concentration of a chemical to be reduced by half. Typically, a chemical or pesticide will breakdown to 50% of the original concentration after one half-life. About 25% will remain after two half-lives and approximately 12% after three half-lives. We used two models (zero-order and first-order) to calculate half-life values for CTN. The data fit both models fairly well; however, for our discussion, we focus on results from the first-order analysis which suggests CTN degradation in soils occurs significantly faster under anoxic conditions (Table 1). Average half-life for the soils under anoxic conditions was ***27.2*** days compared to ***149.1*** days for soils under oxic conditions. All soils in the anoxic incubations exhibited a similar trend, reaching anoxic conditions at approximately day 10. Clothianidin half-life values were also negatively correlated with organic carbon (OC) content under anoxic conditions meaning that greater soil OC content increases CTN degradation.

Table 1*. Half-live values of wetland soils collected from five MDC intensively-managed wetland areas which were treated with clothianidin and incubated under anoxic and oxic conditions. Clothianidin degraded significantly faster under anoxic conditions.* ***-k****=reaction, or rate, constant and* $t_{0.5}$*=days required for one-half of the initial concentration of clothianidin to degrade by 50%.*

Area	Anoxic Soil		Total Anoxic (Soil + Flood Layer)		Oxic Soil	
	-k (day^{-1})	$t_{0.5}$ (day)	-k (day^{-1})	$t_{0.5}$ (day)	-k (day^{-1})	$t_{0.5}$ (day)
BK Leach	0.024	28.7	0.023	30.8	0.006	121.2
Eagle Bluff	0.016	44.5	0.018	39.6	0.004	176.8
Four Rivers	0.027	25.9	0.031	22.0	0.003	203.8
Otter Slough	0.025	27.4	0.024	28.6	0.005	128.3
Ted Shanks	0.044	15.8	0.047	14.8	0.006	115.5
Average:	0.027	28.5	0.029	27.2	0.005	149.1

MANAGEMENT IMPLICATIONS

Findings from this project indicate that CTN degrades more rapidly in anoxic soil conditions and that greater soil OC increases CTN degradation rate. Although anoxic conditions were reached at day 10 for this laboratory-based study, various factors affect the amount of time required to reach reducing, or anoxic, conditions in a wetland or field setting (e.g., water depth, temperature, vegetation). Typically, MDC intensively-managed wetland pools are inundated throughout winter months, when microbial activity is lowest. Promoting anoxic conditions for 30-60 days by maintaining water depth ≥ 20 cm (a condition in which Kuechle (Science Note 2019 Vol 14 No 6) found neonicotinoids to be less prevalent), especially when temperatures are >60ºF (greater microbial activity) could be a beneficial strategy to augment the effectiveness of anoxic conditions on neonicotinoid degradation. Management strategies that increase and/or retain soil organic matter (e.g., no-till planting) may also result in more rapid CTN decomposition.

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