Agricultural Organic Soil Subsidence

Organic soils used in agricultural production are subject to a loss of volume and depth of organic material due to oxidation caused by above normal microbial activity resulting from excessive water drainage, soil disturbance, or extended drought. Microbial mediated oxidation is the primary driver of volume reduction once water is removed. Soil shrinkage and compaction due to dewatering is considered to be secondary. Any drawdown resulting in water levels below soil surface can result in increased subsidence rates. The subsidence rate can also be influenced by agricultural practices. The type of tillage operation, such as plowing, disc harrowing and switch plowing, moldboard plowing increase the oxidation rate. The use of no-till practice is recommended to slow the subsidence. Any aggressive tillage measure increases microbiological activity and decreases carbon sequestration. Drainage water management can be implemented to control water tables to help slow the subsidence rate.

Climate

Organic soils occur in temperate lowlands and cool mountain areas; only one-tenth of all Histosols are found in the tropics. Organic soils that formed in plant material under the permanent influence of groundwater (“low moor peat”) occupy the lower parts of fluvial, lacustrine and marine landscapes, mainly in temperate regions. Organic soils in lacustrine landforms are commonly associated with Vertisols. Rain-dependent organic soils are found in environments with sufficiently high and evenly spread rainfall, e.g. in raised “dome” peat formations (`high moor peat') in lowland areas and in upland areas with blanket peat, where a paucity of nutrient elements, acidity and near-permanent wetness retard decay of organic debris. Organic soil materials in northern regions could accumulate there because decay of organic debris is retarded by frost in the cold season and by prolonged water-saturation of the thawed surface soil during summer. Permafrost-affected organic soils are associated with Cryosols and with soils that have gleyic or stagnic properties, e.g. Gleysols in Alaska and in the northern part of the former USSR.

Hydrology

The surface 10 cm of the soil most reactive. The loss of soil material due to oxidation is directly related to depth of drainage. The rate of loss of drained organic soils (up to a few inches per year) can be 100 times greater than the natural rate of accumulation (a few inches per 100 years) of organic soils. The direction of water movement is also important because of the dissolved materials that move with the water. A rain-fed fen has more oxygen available than bog, which is saturated by groundwater. However, fens have more cations in solution and generally have a more basic pH. Bogs are typically more acidic. Maintaining the water table (water saturation to exclude oxygen) in the soil profile slows the rate of decomposition since anaerobic decomposition is slower than aerobic decomposition.

Material

Histosols are unlike all other soils in that they are formed in organic soil material with physical, chemical and mechanical properties that differ strongly from those of mineral soil materials. Morphological characteristics includes large pore volume typically greater than 85 percent. They contain at least 20-30 percent organic matter by weight and are more than 40 cm thick. Bulk densities are quite low, often less than 0.3 g cm3. Organic soil material accumulates in conditions where plant matter is produced by an adapted ("climax") vegetation, and where decomposition of plant debris is slowed by low temperatures, persistent water saturation of the soil body, extreme acidity or paucity of nutrient elements ("oligotrophy"), and/or high levels of electrolytes or organic toxins. The existing degree of decomposition influences the rate of further decomposition, since the remaining organic material becomes more resistant to decomposition.

References

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Criteria Table

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Degree of Limitation | | |  |
| Soil or Site Feature | Less limiting | Somewhat limiting | Limiting | Impact |
| Organic layer thickness (cm) | Less than 40 | 40 to 130 | Greater than 130 | Thicker organic layer allows more subsidence |
| Mineral layer thickness (percent) | More than 50 | 1 to 50 | 0 | Mineral layers retard oxidation |
| Decay resistance | Highly decomposed plant material, muck | Moderately decomposed plant material, partially decomposed plant material, mucky peat | Undecomposed plant material, slightly decomposed plant material, peat | Humified organic matter is more difficult to oxidize |
| Frost-free days | Less than 90 | 90 to 270 | Greater than 270 | More heat for a longer time favors decomposition |
| Flooding frequency and duration | "long" duration and "frequent" frequency or "very long" duration | "long" duration, "rare" or "occasional" frequency | none | Flooding excludes oxygen |
| Ponding frequency and duration | "long" duration and "frequent" frequency or "very long" duration | "long" duration, "rare" or "occasional" frequency | none | Ponding excludes oxygen |
| Electrical conductivity (dS/m) | Greater than 8 | 4 to 8 | Less than 4 | Saltiness lowers the activity of water |
| Depth to saturation (cm) | Less than 30 | 30 to 100 | Greater than 100 | Saturation excludes oxygen |
| pH | Less than 3.5  Greater than 9.5 | Between 3.5 and 5.0 or between 7 and 9.5 | Between 5.0 and 7.0 | There is an optimal pH for microbial activity |

Criteria

1. Cumulative organic layer thickness - The thickness of the organic layer over any mineral material ultimately determines the amount of subsidence that can occur.

Property evaluated: THICKNESS OF O HORIZONS IN DEPTH 0-150CM

Restrictive limits:

Less limiting Less than 40cm total of organic thickness

Somewhat limiting 40 to 130cm total of organic thickness

Limiting Thicker than 130cm of organic material

2. Cumulative mineral layer thickness - Some soils that are primarily organic have layers of mineral material interbedded in them. These mineral layers act to slow the decomposition of the underlying organic material.

Property evaluated: PERCENTAGE OF MINERAL HORIZONS IN DEPTH 0-150CM

Restrictive limits:

Less limiting More than 50 percent of mineral material

Somewhat limiting 1 to 50 percent of mineral material

Limiting 0 percent of mineral material

3. Organic decay resistance - The degree of decay influences the rate of further decay of the organic matter because the material becomes more difficult for the microorganisms to attack as it humifies.

Property evaluated: USDA TEXTURE CLASS DOMINANT CONDITION IN DEPTH 0-150CM

Restrictive limits:

Less limiting Highly decomposed plant material, muck

Somewhat limiting Moderately decomposed plant material, partially decomposed plant material, mucky peat

Limiting Undecomposed plant material, slightly decomposed plant material, peat

4. Organic soil subsidence, frost-free Days - The rate of microbial activity in soils is temperature dependent. The amount of oxidation that can occur is also dependent upon the length of time the temperature is suitable for microbial activity. A useful metric of these parameters is the frost-free days or length of the growing season.

Property evaluated: FROST-FREE DAYS

Restrictive limits:

Less limiting Less than 90 frost-free days

Somewhat limiting Between 90 and 270 frost-free days

Limiting Greater than 270 frost-free days

5. Flooding and ponding - Flooding and ponding of the soil surface tend to exclude oxygen and decrease the rate of microbial decomposition of organic matter.

A. Properties evaluated: FLOODING DURATION CLASS, FLOODING FREQUENCY CLASS

Restrictive limits:

Less limiting "long" duration and "frequent" frequency or "very long" duration

Somewhat limiting "long" duration, "rare" or "occasional" frequency

Limiting "none"

B. Properties evaluated: PONDING DURATION CLASS, PONDING FREQUENCY CLASS

Restrictive limits:

Less limiting "long" duration and "frequent" frequency or "very long" duration

Somewhat limiting "long" duration, "rare" or "occasional" frequency

Limiting "none"

6. Salinity - The degree of saltiness in the soil water has an influence on the rate of microbial activity in soil because of the impact of salinity on the activity of water.

Property evaluated: SOIL SALINITY THICKEST LAYER IN DEPTH 0-100cm

Restrictive limits:

Less limiting Greater than 8 dS/m

Somewhat limiting 4 to 8 dS/m

Limiting Less than 4 dS/m

7. Depth to air exclusion - Microbial decomposition of organic matter is slower under anaerobic conditions. Thus, saturation tends to preserve organic soils.

Property evaluated: DEPTH TO HIGH WATER TABLE MINIMUM

Restrictive limits:

Less limiting Less than 30cm to saturation

Somewhat limiting 30 to 100cm to saturation

Limiting Greater than 100cm to saturation

8. Subsidence pH - The degree of acidity or alkalinity of the soil environment has an impact on the rate of microbial activity.

Property evaluated: WTD\_AVG PH 0-150cm OR ABOVE RESTRICTION

Restrictive limits:

Less limiting Less than 3.5 or Greater than 9.5

Somewhat limiting Between 3.5 and 5.0 or between 7 and 9.5

Limiting Between 5.0 and 7.0

All of the above criteria are evaluated and a membership value is derived for each. The average membership value is returned as the rating for that soil. An initial criterion is applied to determine if the soil is organic or not.

Logic Diagram

