Managing Organic Soils to Reduce Nonpoint Pollution
Michigan State University Cooperative Extension Service
Water Quality Extension Publications
Robert Lucas, Darryl Warncke, Crop and Soil Sciences
August 1985
4 pages

Cooperative Extension Service Michigan State University August 1985 Extension Bulletin WQ03

MANAGING ORGANIC SOILS TO REDUCE NONPOINT POLLUTION

Robert Lucas
and Darryl Warncke

Department of Crop Soil Sciences

Michigan has about 4.5 million acres of land classified as organic soils. These soils in their natural state are commonly associated with wetlands, but their ecosystem can be quite diverse. They were formed by the accumulation of plant residues under water or in poorly drained areas with low oxygen content. The goal of this bulletin is to emphasize how organic soils relate to nonpoint pollution both in the natural and managed state, and to bring out ways to manage these soils for maintaining water quality.

Organic Soil Defined

Soil scientists describe organic soils as "histosols." These soils are commonly referred to as *peat* when undeveloped and fibrous in texture. When peat soils are drained and developed for crop production, the fibrous plant residues decompose into finely divided organic particles. These soils are then referred to as *muck* soils.

To be classified as organic, a soil must exceed 20% organic matter. Many tilled organic soils exceed 50%, and undeveloped sites exceed 70%. Organic soils were formed in former pot holes, lakes and glacial river valleys: examples of "eutrophication" under natural environments.

Only 125,000 acres of Michigan's extensive organic soils are used in agriculture. Of this acreage, about 35,000 acres are intensely farmed with such crops as sod, potatoes, onions, carrots, mint, celery and radishes. The gross agricultural value in recent years of the intensely farmed crops is about $90 million.

Organic soils in their natural state are very low in mineral elements essential for plant growth. Deficiencies are particularly high in acid peats, which depend upon fallout from airborne sediments and rainwater for minerals.

With the above information, we can better understand what management practices are needed to reduce nonpoint sources of chemical contamination in our waters.

Nitrogen (N)

Nitrogen, a constituent of soil organic matter, usually ranges from 1.0 to 1.7% for acid peats and 1.8 to 2.5% for nonacid organic soils. When organic matter decays, nitrogen is mineralized and eventually forms nitrate-nitrogen (NO_3-N). Studies on cultivated vegetable mucklands in New York showed the annual mineralized rate varied from 320 to 530 lb of N per acre. Of this amount, only about 10% of the mineralized form was found in drainage water. The remainder was found to be denitrified to form gaseous nitrous oxide (N_2O). Investigations on the mucklands of Florida, likewise, showed high levels of denitrification. In the New York study the maximum observed concentration of NO_3-N in the drainage water was 35 ppm (mg/liter) and the average was 15 ppm. At the Michigan Muck Experimental Farm in 1969, it was found that 17 lb of NO_3-N per acre per year were transported in the drainage water. The content in the water was always less than 7 ppm. Both the New York and Michigan studies showed high NO_3-N in the March-April drainage water when the discharge rate was highest.

Both wind and water erosion can also be major contributors to organic nitrogen added to lakes. (This source is discussed later.)

Suggestions for reducing NO_3-N in the leachable and drainage water:

1. Do not apply nitrogen fertilizer in the fall or winter season.

2. Reduce nitrogen rates in preplant fertilizer, and apply the balance when plants are actively growing.

3. Because of a high organic-matter decomposition rate when the soil temperature is high, nitrogen fertilization for muckland crops is seldom needed during July and early August.

4. Grow cover crops to utilize

available nitrogen remaining after harvest rather than leave the field without plants.

5. Keep the soil water level at sufficient depth to obtain good crop yields and yet allow for the least amount of soil decay. For most cropping situations this depth is 24 to 30 inches.

6. Promote denitrification of NO_3-N in drainage water:

- Where possible, submerge the tile drains below the water table.
- Pond or slow down the movement of water in the drainage ditches before it enters the main streams.

Phosphorus (P)

Phosphorus is the essential plant nutrient most likely to be limiting in plant growth. It is especially critical for aquatic micro-organisms and plants because of the low solubility of most phosphorus compounds. These are usually combinations of calcium, iron, aluminum, silicon, fluorine and other metals. Thus, any situation that can enhance phosphorus solubility helps promote plant growth, including algae production. Excess growth leads to algal blooms, oxygen depletion and eventually faster eutrophication of ponds and lakes.

Organic soils are normally low in phosphorus, containing less than 0.1%. Most of the phosphorus in virgin deposits is in the organic form. As with nitrogen, phosphorus must be mineralized before plants can utilize it. Organic soils differ greatly in their ability to hold or adsorb phosphates, where the source is soluble fertilizers or soil organic matter decomposition products. Virgin peats low in clays, iron and/or aluminum show high mobility of soluble phosphorus.

Upon drainage of a peat bog, the phosphorus content of the drainage water increases greatly because of increased microbial decomposition and high phosphorus mobility. A Florida study showed the phosphorus content in the drainage water increased 10-fold after drainage. Tests made on a Houghton muck, commonly found in Michigan, showed soluble phosphorus applied to a virgin soil to be 25 times more mobile than in a nearby site which had been well fertilized and farmed for over 20 years. Similar results have been obtained in other states. Because most of the 125,000 acres now in crops in Michigan have been under cultivation for over 40 years, the mobility of phosphorus is quite low and follows movement patterns similar to those of inorganic soils.

Typical drainage ditch through a production muck soil area. Only a small amount of algal growth is present indicating relatively low nutrient levels in the drainage water. An onion field is in the background.

Studies on cultivated mucklands in New York showed about 45 lb P/acre are mineralized annually from organic material decay and an additional 35 lb P/acre were added annually as fertilizer. The yearly leaching loss was less than 27 lb P/acre. The maximum observed concentration for PO_4^{-3}–P in the drainage water was 10 ppm, and the average was about 4 ppm. These values are considerably greater than those found at the Michigan Muck Research Farm, which showed less than 0.3 ppm P in the drainage water. The annual leaching loss amounted to 1.3 lb/acre where the average application rate of phosphorus was 15 lb/acre. Similar values were reported for the Holland Marsh area in Ontario, Canada.

Studies made on nutrient sources for Lake Apopka, Florida, showed that drainage waters from nearby mucklands contributed to faster eutrophication rates in the lake. Interestingly, however, it was *not* the applied phosphorus fertilizer that caused the condition but the phosphorus released from the organic matter decomposition following drainage.

Drainage and leaching losses of phosphorus are sources of nonpoint pollution of our water, but probably far more important are wind and water erosion losses.

Suggestions for reducing PO_4^{-3}–P in drainage and surface waters are:

1. Test soils to determine appropriate phosphorus fertilizer rates.

2. Apply starter fertilizer near the seed or plant to help reduce total rate.

3. Do not drain virgin deposits if they are not to be used for high-value crop production.

4. Because of leaching losses with water-soluble phosphates, use low-soluble products such as high-grade rock phosphate when trees and woody shrubs are planted on virgin organic soils.

5. Salvage or properly dispose of drainage water obtained in bedding or greenhouse plant production when using peats without mineral soils.

6. Consider a drainage reservoir so as to have a closed water management system. A suggested ratio of cropland to reservoir area is about 20 to 1.

A natural wetland area showing aquatic vegetation, which contributes to natural eutrophication and organic matter accumulation. Peat deposits formed this way over thousands of years.

Other Nutrients

Potassium, sodium and ammonium are held rather weakly in organic soils. Studies in Michigan have shown 25% of the available potassium may be leached out from late fall to early spring. Similar observations have been made in Ohio. These elements, however, contribute only mildly to eutrophication of lakes. They are, however, major elements that can account for increased salinity in lake waters.

Calcium and magnesium are held moderately tight to organic matter. For example, soils with about 30 times more exchangeable calcium than potassium may only show about twice the amount in the soil solution and drainage water. Calcium and magnesium contribute to the hardness of water but are not usually considered as contributing to ecological problems.

The heavy metals such as aluminum, copper, zinc and manganese are found in very low quantities in soil solution because of strong adsorption to organic matter. Iron, which averages about 1% of the soil, can become mobile under reducing conditions (low oxygen content) when soils are saturated. The iron then can be toxic to plants. It can also move out with the drainage water. When exposed to the air, the iron then precipitates out of solution and causes reddish-brown-ocherous sediments and rusty-colored water.

Wind and Water Erosion

Organic soils are lightweight; they are easily moved by wind and water. Wind erosion is particularly hazardous and can contribute to large amounts of sediments in open drains. These sediments may contain pesticides and normally have a high-nutrient content. Common bottom-rooted water plants can thrive on these rich deposits. The increased plant growth can result in oxygen depletion when the plants mature and decay. Under such anaerobic conditions, phosphate minerals are more soluble than in aerated soils. Thus, sediments can be a contributing factor in the phosphorus levels of drainage water for many years.

To help reduce wind and water erosion, consider some of the following practices:

1. Keep fields rough, such as ridging and planting on a 3- or 4-ft wide seed bed.

2. Use shrubs and windbreaks wherever possible.

3. Use irrigation water so as to keep the soil surface moist.

4. Use small grains between each vegetable row.

5. Do not leave fields smooth after secondary tillage.

6. Use cover crops to protect the field after harvesting.

7. Use primary tillage immediately before planting.

8. Use herbicides to help reduce field tillage.

9. Consider a management operation whereby the seed row is worked and planted, but leave a no-till plant-residue strip between rows.

10. Plant crops in a north-south direction.

Climatic Conditions

Temperatures for organic soils can differ from those of mineral soils because organic soils are usually found in low areas. Organic soil also is a poor conductor of heat, and thus can show rapid loss of heat by radiation at night and have a high surface temperature during bright sunny days. The high surface temperature can result in rapid volatilization or breakdown of pesticides. Urea-nitrogen applied topdress can be lost by volatilization of ammonia, especially if the soil surface is dry and has a high pH.

On calm, clear nights an air temperature inversion may develop over organic soils; that is, the air next to the soil surface is colder than the air above. Pesticide applications, particularly with aircraft, made under such weather conditions can result in poor plant coverage and more drift.

To help reduce nonpoint pollution:

1. Incorporate urea into the soil, especially if the soil surface is dry.

2. If a pesticide has potential for contaminating waters in drainage ditches and other sites, use ground equipment that directs the spray toward the soil or plant and has a droplet size of about 100 micrometers.

3. Avoid spraying in winds above 8 to 10 mph.

4. Avoid aerial spraying when there is an inversion temperature.

5. Use chemical drift retardants.

Because their absorption rates are higher, organic soils often require chemical rates that are two or three times greater than those of mineral soils. These increased amounts can mean longer residual effects. Some pesticides are not effective when applied to organic soils. Before using any chemical, make certain label instructions include their proper use for application to organic soils.

Managing organic soils to obtain the maximum efficiency of crop production inputs will also result in a minimum impact on the quality of water in the streams and lakes of Michigan.

O-15782

MICHIGAN STATE UNIVERSITY CES COOPERATIVE EXTENSION SERVICE

MSU is an Affirmative Action/Equal Opportunity Institution. Cooperative Extension Service programs are open to all without regard to race, color, national origin, sex, or handicap.
Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8, and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Gordon E. Guyer, Director, Cooperative Extension Service, Michigan State University, E. Lansing, MI 48824.

New-8:85-5M-KMF-UP, Price 20¢, Single Copy Free to Michigan Residents