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UNDERSTANDING SEDIMENTS: PROBLEMS AND SOLUTIONS

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Sediment is the solid organic or mineral material in suspension that is transported or moved from its original site on the earth's surface. While sediment usually represents soil material, it can be other material such as a by-product from a manufacturing process.

Sediment movement is associated with water, wind, gravity and ice. Only that directly related to soil and water is considered here. Sediment is a product of erosion. The types of erosion that produce sediment include: (1) sheet erosion, (2) rill erosion, (3) gully erosion and (4) stream channel erosion. Erosion is common along roadsides and on both rural and urban construction sites.

There is increasing awareness of sedimentation problems because it affects water use in many ways. Suspended solids clog the gills of fish, cover spawning areas and reduce the amount of sunlight available to aquatic plants, therefore adversely affecting fish populations. Recreational uses of water—swimming, boating and fishing—are limited due to the turbidity that sedimentation causes.

Interest in sediments is also increasing because people are now aware of how rapidly sediment can accumulate in streams, ditches and culverts. Many are now aware of the shortened economic life of lake property, farm ponds and water reservoirs. Some have had experiences with plugged filters, damaged pumping equipment and sprinkler nozzles. Many are concerned about the decreased quality of their drinking water.

This publication outlines the nature of sediment materials and describes methods useful in controlling sediment accumulation.

The Sedimentation Process

There are three steps in the sedimentation process. The first is the *detachment* of materials from the earth's surface. Both rain and sprinkler irrigation water drops can detach solid particles of material from the soil surface. The overland flow of water also represents an important detachment process.

The second step is *transport* of detached soil particles. Water movement—velocity, depth, volume, frequency, duration and turbulence—regulates the extent of detachment and the distance that materials can be transported.

The third step is *deposition*. Sediment is deposited when water velocity decreases to such an extent that it can no longer support the suspended material, or when the water depth decreases to such an extent that particle movement is impossible.

Sediment Characteristics

Sediment particles vary greatly in size, shape, density and composition. Light-weight organic materials range in size from macroscopic to submicroscopic colloidal materials. This is also the case with the denser mineral particles.

Large-sized mineral particles such as sand and gravel are not likely to be major sediment problems despite the fact that they are relatively uncohesive and are easily detached from the soil body. Soil aggregates of similar size are less dense than single particles of sand and gravel, but they tend to react in similar ways.

Silt and clay particles and light-weight organic matter resist detachment. When detached, they stay in suspension for longer periods than the larger sand and gravel particles. Silt and clay are easily transported by low-velocity flow and water of shallow depth.

Colloidal clay and organic matter represent unique sediments. They swell and shrink in volume as they become wet or dry. This unstable characteristic increases the number and kinds of problems associated with such materials.

Colloidal clay and organic matter surfaces have electrical charges. Usually, the negative charges outnumber the positive. Because of this, materials with an excess of positive charges are attracted to those with negative charges. Such pollutants as mercury, lead and cadmium, when in a soluble form, have positive charges and are attracted to negatively charged sediment material. Many of the pesticides in common use today react with negatively charged sediments in a similar manner.

Layering of deposited material is usually a conspicuous characteristic of sediments. Layering is the product of several deposit cycles or rates of deposit. Each layer or stratum is separated from the one above or below it by color, particle size or structure.

Examples of stratified sediments are familiar. The common crust seen in field soil or in a flower pot shows stratified sediments. Such char-

The authors are members of the Crop and Soil Sciences Department. They gratefully express their appreciation to Dr. Carter Harrison for assistance in the preparation of this bulletin.

acteristics are important because the stratified sediments restrict air and water movement. A soil crust formed shortly after planting a crop usually retards seed germination as well as plant emergence.

Soil Erosion and Sedimentation

Soil erosion is considered here as the wearing away of land surfaces by water. This is an acceptable definition for many because erosion is related to the loss of soil materials, but it gives little thought to where the eroded materials move.

Others seem to be greatly concerned about what happens to the eroded material and how it affects the environment. They recognize that everyone is affected when sediment increases water treatment and use costs.

Both concepts are incomplete. Without erosion, the sedimentation process is reduced almost to insignificant levels. Erosion, like sedimentation, may be considered a three-step process involving detachment of soil material, transportation of detached materials and the deposition of transported materials.

The Universal Soil Loss Equation

Scientists and engineers have studied soil erosion for decades and now understand the process well enough to estimate, with the use of mathematical equations, soil losses from a specific site on a long-term basis.

The equation involving accelerated water erosion is referred to as the "USLE," or the universal soil loss equation. The USLE is still being refined as new research results become available. Soil losses are reported from a unit area for a unit time. Thus losses or sediment material availability are usually reported as *tons per acre per year*.

The equation is $A = R \cdot K \cdot LS \cdot C \cdot P$

where:

"A" represents soil loss, erosion rate or the total source of sediment material.

"R" represents rainfall and runoff factors; these represent the number of rainfall erosion index units per year.

"K" represents the soil erodibility factor and recognizes that the physical properties of soil are closely related to erosion rates.

"L" is the slope length factor; in general, the longer the slope the greater the erosion.

"S" is the slope steepness factor; in general, the steeper the slope, the greater the erosion.

"C" represents the soil cover and the cropping management factors as related to soil loss.

"P" represents the conservation practices used in the management process to "keep the soil at home."

In the equation, the factors are multiplied together to estimate soil losses or the availability of sediment materials. Admittedly, the mathematical relationships between the several factors are complicated by interactions. More details on the USLE are available in several of the standard textbooks on soil erosion and soil conservation and from the Soil Conservation Service of the USDA.

Methods of Sediment Control

Sediment can be controlled in all three phases of the erosion process—detachment, transport and deposit. Control is usually most effective in the early stages of the process.

In general, there are three broad groups of sediment control methods: tillage, cropping and mechanical.

Tillage

The most recent innovation in sediment control involves "conservation tillage." This involves the use of primary or secondary tillage implements that leave a protective layer of crop residue on the soil's surface. The residue, if sufficient in quantity, conserves the soil from harvest-time until the next crop produces a good canopy.

"No-till" is a conservation tillage method slowly increasing in popularity across the nation. This method involves the use of herbicides for vegetation control and a special planter that places seed in undisturbed soil with an existing cover crop, sod or crop residues. In most instances the method does not involve previous or subsequent tillage.

Cropping

Cropping concepts for regulating sedimentation involve a number of methods. "Conservation cropping" is talked about more than it is practiced. It represents a planned system of cropping and includes the necessary measures to maintain or improve soil, water and air quality. The most effective systems of conservation cropping involve the use of grass, leguminous sod crops and small grains. Crop residues are left in the field after harvest. Such systems recognize that insect, disease, plant nutrient and soil pH level control are important.

"Strip-cropping" has potential in Michigan as a sediment control method, but is not extensively used. This system involves a systematic arrangement of straight or contour strips to reduce sediment transport. Close-growing or sod crops are alternated with strips of clean-tilled row crops. Where sod crops are grown, sediments are controlled both in the detachment and transport phases.

"Contour farming" is a method of erosion and sediment control that is not used extensively in Michigan. Many areas are not well-suited due to short and variable slopes. As the name implies, all plowing, secondary tillage, planting, cultivation, etc., is done on the contour, which is time-consuming. The use of new and large farm implements creates space problems when implements are wider than the contour strips. Some farmers have therefore discarded the concept as unacceptable as were terraces. This is likely the situation in most parts of the state, especially where contour strip-cropping has been used.

"Green manure" and "cover crops" are close-growing legume or grass crops grown for nitrogen fixation purposes, soil improvement and/or seasonal protection of the soil. Green manure crops improve the structure of soil, thus making soil more erosion-resistant. Such crops also tend to conserve plant nutrients and keep them in available forms. Cover crops protect soil from wind and water erosion during times when the major crop does not provide good soil cover.

Other crop management systems are used for sediment control under specific conditions. Some authorities consider the establishment of a "permanent vegetative cover" as a special conservation method. Others consider "Critical area plantings" especially when managing surface-mined areas, construction areas or severely gullied areas. Still others mention "forest land erosion control" as a special method. The method involves maintaining a good tree cover and forest floor by controlling fires and not overgrazing.

Mechanical

The third group of sediment control methods involves land treatments and mechanical devices to keep soil in place.

"Irrigation water management" as well as the design of the system may influence sedimentation. From a soil erosion control viewpoint, the system should be suitable for specific soils, topography and crops grown. For details on irrigation and sedimentation, consult with professional design engineers as well as some of the handbooks published by the Soil Conservation Service of the USDA.

"Drainage" is another consideration in sediment control. Well-designed surface and subsurface systems help to safely dispose of excess water so that little or no soil erosion occurs. Certified drainage engineers have both skills and knowledge valuable in reducing or preventing sediments.

"Sediment basins" represent natural or artificial depressions in the land surface used to trap and store sediment, water and sometimes debris. Basins are useful because they collect both macroscopic materials as well as microscopic and submicroscopic silts and clays. They are effective in reducing peak flow rates of water and "on-site" erosion. They have been used extensively on urban construction sites and on forest land especially as related to erosion control along logging roads.

"Terraces" are low embankments or ridges of soil material constructed across a slope. The purpose of terraces is to reduce slope length and steepness, which in turn results in reduced erosion and reduced sediment load of runoff water. Terraces are not extensively used in Michigan because they are expensive to construct and require considerable upkeep. Despite this, they have their place in Michigan, especially where slopes are relatively long and uniform. Terraces should be designed and constructed by qualified engineers.

A "diversion channel" is constructed across a slope to reduce sediment detachment and transport by diverting runoff water to less erosion-susceptible areas. In many ways it is similar to terraces in that it involves not only water transport but also a supporting ridge of soil material on the lower side of the structure. As with previously considered methods, diversion channels should be designed by qualified engineers.

There are two other mechanical devices effective in reducing soil erosion and sedimentation. Both involve the use of plants. One method represents a way to prevent or reduce erosion by reducing the contact between soil and water. The other represents a way of removing sediment, organic matter, etc., from runoff water.

A "grass waterway" may be a natural or a constructed waterway or outlet designed for the safe disposal of runoff water. Grass is used as a soil cover. This reduces the contact between water and soil particles and increases the stability of the soil structure. A very high percentage of the farms in Michigan could be improved with grassed waterways. Care and upkeep costs are relatively low.

A "filter strip" is an area of vegetation, either natural or established, used to remove sediment, organic matter and other pollutants from water that flows across the surface of the soil. Removal of transported materials is by filtration, absorption, decomposition, etc. Especially effective on land adjacent to lakes, ponds and streams, this practice is well adapted to the support of other conservation measures.

Sediment Control Concepts

The methods considered for sediment control may be most effective when used with a high level of soil and crop management. All are most successful where high crop yields, especially residue yields, are produced. The following concepts are closely associated with sediment control methods, especially those related to the production of high residue yields:

1. Be well informed about sediment problems and methods of control.
2. Match the crops to be grown to the use of the land or to the characteristics of the soil.
3. Use the services of research-oriented soil testing laboratories and certified farm advisors.
4. Don't play the averages. Plan for unusual weather every year.
5. Use adapted modern crop varieties.
6. Use high populations and narrow row spacings.
7. Control insects, diseases and weeds.
8. Attack sediment problems early.

Conclusions and Summary

Annual losses associated with sedimentation are now estimated to be in excess of $6 billion. This includes losses associated with water treatment and transport, river and harbor dredging, etc.

A reduction in the amount of sediment produced in Michigan each year would greatly improve the quality of our environment. Active soil conservation programs would result in less erosion, an improved landscape and improved water quality. This would be reflected in lengthened economic life of shoreline and water property, and in increased use of water for fishing, boating and swimming. In addition, economic inputs related to the use of filters, pumps, nozzles, etc., would be reduced.

Accelerated soil erosion and sediment control are closely associated. Both involve a three-step process—soil particle detachment, soil material transport and deposition.

Methods of erosion control are relatively well understood because of extensive research during the last half century. There are three general groups of sediment control methods including tillage and cropping methods and mechanical devices. Conservation tillage and "no-till" are now used with increasing frequency.

Conservation cropping involves planned systems of cropping and management. Other cropping methods include strip cropping, contour farming, contour strip cropping, green manure and cover crops.

The third group of sediment control methods involves land treatments and mechanical devices to keep soil in place. Irrigation, water management, drainage, sediment basins, terraces, diversion channels and grass waterways are methods and devices proven to be effective under specific conditions.

All of the previously mentioned methods are likely to be most effective in controlling sediments when they are used in conjunction with other methods which result in high crop yields, especially crop residue yields.

Sediment control is best achieved when all are aware of a sediment problem and when all participate in the solution.

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