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Abstract. Sediment is the principal pollutant resulting from soil erosion on agricultural lands. Soil erosion also contributes to the delivery of other agricultural related pollutants to surface waters. Application of practices which control erosion on agricultural lands can be effective in reducing sediment and related pollutants in surface waters. Intensive application of terraces and other practices at critical locations will have the greatest effect on sediment reduction.

Agricultural Pollutants of Surface Waters

Pollution of the nation's surface waters is now a national concern. "Clean Water" is a popular and, under certain circumstances, a reasonable demand. All pollution sources are suspect and agriculture is no exception.

Four principal agricultural sources of surface water pollution are usually recognized:

1. Sediment
2. Plant nutrients
3. Pesticides, herbicides, fungicides, etc.
4. Animal wastes

All of these require a means of transport to the stream or other waters if they are to become pollutants. Surface runoff from agricultural land is the primary agent for transport.

Soil erosion, a source of sediment pollution, also contributes to the movement of the other agricultural pollutants to surface waters. Therefore, reduction or control of both surface runoff and soil erosion is needed to reduce agricultural pollution of streams and lakes.

Sediment Pollution

By far the greatest pollutant in volume in surface waters is sediment. No surface waters are or ever have been completely free from sediment, but current sediment yield rates are staggering. It is estimated that four billion tons of sediment are washed into rivers, lakes, reservoirs, estuaries, streams, and other bodies of water annually. Of this amount over one billion tons reach the sea. The Mississippi River Basin produces about one-half billion tons annually.

Sediment yield is particularly high in parts of Iowa. The Missouri River deep loess hills area of western Iowa, comprising about

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20% of the State, is one of the largest sediment yielding areas in this country. Sheet and rill erosion are severe on the deep loess soils when poorly managed. Gully erosion is also a major problem.

Recent Comprehensive River Basin studies by the Missouri Basin Inter-Agency Committee estimate sediment yields for drainage areas in excess of 100 square miles range from 6,000 to 10,000 tons per square mile per year in much of Woodbury, Monona, and Harrison Counties, with 3,000 to 6,000 tons from most of the remainder of this area.

Recorded sediment yield from small drainage areas have been even larger, with some in the range of 20,000 tons per square mile or 30 tons per acre per year. Current estimates for soil loss from unterraced cropland farmed to corn and soybeans in this area is about 20 tons per acre.

Maximum recorded concentration of sediment in the runoff water from streams in this area is also spectacularly high. The Soldier River in Harrison County, with a drainage area of 417 square miles, has recorded sediment concentrations in floodwater of 23.6% by weight. Waubonsie Creek in Mills County, with a drainage area of 30 square miles has recorded a maximum concentration of 27.6%. This is contrasted with maximum recorded concentration of 0.67% for Hardin Creek with a drainage area of 24 square miles in the level area of north central Iowa and of 4.76% for the Des Moines River with a drainage area of 5,841 square miles.

Sediment yields in other sections of Iowa average much lower than in the western Iowa loess hills, but locally, rates can be high and extensive sediment damage can result.

Sediment Damages. The high yield of sediment in this country causes correspondingly high damages as it is deposited or remains in suspension in water.

First, the sediment impairs the quality of water for municipal, industrial, agricultural and recreational uses. Removal of sediment from municipal and industrial water supplies is costly. Colloid size particles are particularly difficult to remove.

Recreational use of water is particularly affected by sediment content. Clear water is naturally more desirable for all types of recreational use than is muddy water. Sediment in the water and on the bottom also affects the number and species of water plants, fish, and other organisms. Sediment covering spawning beds may reduce reproduction, and natural foods may be eliminated because of sediments.

Sediment, while in itself damaging, may act as a carrier for more dangerous pollutants. Some pesticides and herbicides may enter our water attached to sediment particles. Plant nutrients may also enter water attached to sediment. Phosphorus from agricultural sources in particular is present in surface waters primarily attached to sediment particles.

Increased use of fertilizers along with continued soil erosion has increased the amount of plant nutrients entering our reservoirs and lakes. This has hastened the eutrophication process of these bodies of water, seriously impairing their recreational value.

The second area of damage from sediment is to water transportation facilities through the silting of rivers, harbors and canals. Over 380 million cubic yards of sediment are dredged annually from the nation's rivers and harbors. This volume exceeds that excavated for the construction of the Panama Canal.

Another area of sediment damage is the reduction in capacity of our lakes and reservoirs. In the reservoirs of this country, annual sediment deposits are estimated to be 850,000 acre-feet. The volume occupied by sediment cannot be used to store water for other purposes. In addition to loss of capacity, progressive sedimentation reduces the depth of the reservoir. During prolonged drought, losses from evaporation are much greater in proportion to total storage in a shallow reservoir than in a deeper one. Sediment may also reduce the flood storage capacity of the reservoir. As flood storage is replaced with accumulated sediment, the effectiveness is reduced for larger storms, causing more frequent use of emergency spillways and more probability of overtopping the dam.

The cost of providing adequate sediment storage is often a significant part of the total cost of a reservoir. Dredging out or altering existing reservoirs to provide additional sediment storage is usually even more costly, and in most cases, prohibitive.

The most favorable reservoir sites have usually been selected for existing reservoirs. If excessive sedimentation reduces their effectiveness to a point that another reservoir is needed, a less favorable and more costly site will have to be selected. The number of good reservoir sites in an area is usually limited. This is a compelling reason to plan adequate sediment storage in new reservoirs and to minimize sedimentation through erosion control measures on new and existing reservoirs.

Sediment also interferes with the functioning of drainage, irrigation, and flood control works. Reduced capacity of natural and constructed channels due to sediment deposits increase flood peaks. Damages to crops as well as to buildings, roads, and other installations are often the result.

Sediment deposition in drainage channels and natural streams may result in swamping out many acres of productive land. Where the land is not permanently swamped out, costs of maintaining drainage channels are high.

Sediments deposited on floodplains may be extremely infertile and the productive capacity of floodplain lands permanently reduced.

Flooding as a result of silted channels can also create a nuisance and health hazard by providing breeding places for mosquitoes.

Soil Erosion

Sediment is produced as a result of soil erosion including sheet erosion, gully erosion, streambank erosion and other types. The problems of soil erosion and sedimentation are inseparable. The damages associated with sedimentation are multiplied when the damage to land through erosion is considered.

Soil erosion is a natural geologic process, but the accelerated erosion of the present age is caused by man and his actions. Removal of natural vegetation is the largest single cause of soil erosion under most conditions.

In the United States, over three billion tons of soil are washed from cultivated or idle fields or from overgrazed pastures or ranges annually. In the Midwest, sheet and rill erosion from cultivated fields is the largest single source of erosion, although, in some areas of western Iowa, gully erosion has contributed over 50 percent of the sediment yield at times.

Wind erosion also contributes to sediment in our reservoirs, lakes, and streams. Much of these wind-blown sediments are not deposited directly in surface waters, but the wind-blown deposits in road ditches, drainage channels, and small watercourses are subsequently moved by runoff water into streams, lakes, and reservoirs.

Stream channel erosion is estimated to move 500 million tons of sediment into our streams annually.

Non-agricultural sources also contribute substantial amounts of sediment to this nation's waters. Roadside erosion is estimated to produce 56 million tons of sediment annually. Suburban developments also contribute heavily. Reports from the Potomac River Basin show that sediment from suburban developments ran as high as 50 times that produced from agricultural lands in the area.

Erosion Control

Control of erosion is necessary if sediment damages are to be reduced. Each source of erosion is a separate problem, but since sheet erosion is the largest single source, it is most important that sheet erosion be controlled. In sheet erosion the energy required for detachment of soil particles is supplied by the raindrops and for transport of these detached particles by the elevation of the land. Sheet erosion can therefore be reduced by reducing the impact force of the raindrops by maintaining a vegetative or mulch cover, or by reducing the volume or velocity of the surface runoff water.

If the land were maintained in meadow or hay for a large percent of the time, both impact forces of the raindrops and velocity of surface runoff could be reduced, and effective sheet erosion control maintained. Such meadow based rotations have successfully controlled erosion in the past. But with increased pressure to produce more high value row crops and a decreased need for hay, other methods for erosion control are needed.

One of the more effective methods of controlling sheet erosion on gently rolling lands is the use of mulch tillage systems for row crops. The conventional plow-disc-harrow system of preparing a seedbed for corn leaves the ground vulnerable to erosion from the time of plowing until the crop is large enough to provide a ground canopy. Using a mulch tillage system, the preceding year's crop residue is managed so that it remains as a protective cover until the new crop is large enough to protect the ground.

Research in Illinois has shown that mulch rates of one ton per acre reduces average runoff velocity by at least 60% and soil loss by at least 50% on a 6% slope 100 feet long. On flatter slopes and when used with contouring or terracing, mulch tillage is even more effective. Mulch tillage has the added advantage for controlling wind erosion, which is a serious problem in some years.

Other conservation practices can be used to control sheet erosion. Contouring will reduce sheet erosion by 50% on moderate slopes but loses its effect on steeper slopes. Controur strip cropping is twice as effective as contouring alone.

The most effective method of sheet erosion control is by use of terraces. Research at Treynor, Iowa, by the Agricultural Research Service has shown that average sheet erosion loss from contoured watersheds was about 20 tons per acre, while losses on level terraced watersheds were less than one ton per acre when farmed to continuous corn. Preliminary results of research on graded terraces using tile outlets indicate similar effectiveness in reducing soil loss.

Gully Erosion. Gully erosion can also be reduced by conservation practices. The advance of a gully head can be slowed or stopped by diverting runoff water away from it with terraces or diversions. Closed-end terrace systems on a watershed at the Treynor research farm has completely stopped the advance of a downstream gully head.

Grade stabilization structures either alone or in conjunction with grassed waterways are frequently used to stop gully erosion. These grade stabilization structures include drop spillways, risers on existing road culverts, chute spillways, and drop inlets. Water impounding structures with a drop inlet spillway are frequently used as a grade stabilization structure to flood out the overfall at gully heads and prevent further advance. This type of structure also acts as a trap for sediment from sheet erosion from the watershed. In western Iowa, with silt sized sediment particles, about 95% of the sediment delivered to these structures is trapped in the sediment pools.

Sediment Reduction by Conservation Measures

Plot and small watershed research has demonstrated the value of conservation practices in controlling erosion and resultant sedimentation. There is some evidence that concentrated treatment with conservation measures has reduced sediment production from larger watersheds. The average suspended sediment discharge of 880 tons per square mile per year for the period 1960-1963, inclusive of the Little Sioux River at Turin, Iowa, as compared to an indicated value of 1,777 tons per square mile per year for the period 1940-1951, inclusive, reflects the influence of conservation measures becoming effective during the intervening period, along with other factors. The estimated sediment yield of over 20 tons per acre from Mule Creek in Mills County was reduced to a measured 3.5 tons per acre after grade stabilization structures and other conservation measures were installed.

For the maximum reduction of sediment damage at any location, concentrated application of erosion control measures on the sediment source areas causing the damage will be required. The average suspended sediment discharge of the Little Sioux River at Correctionville is 244 tons per square mile per year from a drainage area of 2500 square miles. At Kennebec where the drainage area has increased to 2738 square miles, the suspended sediment discharge increases to 719 tons per square mile per year. The indicated pick-up from the 238 square miles of intervening drainage, however, is 5,700 tons per square mile per year. Obviously, treatment of the intervening high sediment source area would have more effect on reducing sediment at Kennebec than would treating the area above Correctionville.

Excessive sediment accumulations threaten to reduce the effective life of each existing and future lake and reservoir in Iowa. Location of the critical sediment source areas in the watershed and concentrated treatment of those areas with applicable conservation measures will be needed to preserve our lakes and reservoirs.

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