# Soil Erosion
# Getting Washed Away: How bad is it?
## Grades 9-12
## Orvil L. White

**RATIONALE:**

We are losing our valuable lands to the agents of erosion. The agents of soil erosion are water and wind, each contributing to a significant amount of soil loss each year. Soil erosion is a major environmental threat to the sustainability and productive capacity of agriculture. Soil erosion is a naturally occurring process on all land of the world. Soil erosion is one form of soil degradation along with soil compaction, low organic matter, loss of soil structure, poor internal drainage, salinisation, and soil acidity problems. These other forms of soil degradation, which are serious in themselves, usually contribute to and accelerated soil erosion. Soil erosion is a very widespread phenomenon, and is usually irreversible. Once the nutrient-rich surface soil has been lost the ability to sustain plant growth is severely reduced and increased runoff from the more impermeable subsoil results in a decrease in plant-available water

Erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing serious loss of topsoil. The loss of soil from farmland may be reflected in reduced crop production potential, lower surface water quality and damaged drainage networks. One of the most widespread threats to soil quality is wind and water erosion, an ever-occurring process that impacts our lives in numerous ways, the lost of food production has the most direct impact.

Since the late 1960's, nearly one-third of the world's arable land has been lost by erosion and continues to be lost at a rate of more than 10 million hectares (25 million acres) per year. With the addition of a quarter of a million people each day, the world population's food demand is increasing at a time when per capita food productivity is beginning to decline. It is estimated that soil erosion is damaging the productivity of 29% (112 million acres) of U.S. cropland and is adversely affecting the ecological health of 39% (145 million acres) of rangeland.

In the United States, an estimated $4 \times 10^9$ tons of soil and $1.3 \times 10^{11}$ tons of water are lost from the $1.6 \times 10^8$ hectares of cropland each year. This translates into an on-site economic loss of more than $27 billion each year, of which $20 billion is for replacement of nutrients and $7 billion for lost water and soil depth. Furthermore, erosion brings various associated "off-site" problems, including reduced water quality from increased sediment loads and poorer air quality due to dust. The total estimated on and off-site costs of damages by wind and water erosion and the cost of erosion prevention each year is 44 billion dollars per year. These costs are passed along to consumers in higher food and other costs.

A major misconception to overcome is the belief that weathering and erosion are synonymous processes. Weathering is the processes whereby rock is broken down (by chemical and or mechanical means) into soil. Weathering creates the soils of the world. Erosion is the transportation of soil from one place to another, usually by running water or wind.

“They're making people every day,
but they ain't makin' any more dirt."
Will Rogers

## BACKGROUND

A major misconception to overcome is the belief that weathering and erosion are synonymous processes. Weathering is the processes whereby rock is broken down (by chemical and or mechanical means) into soil. Weathering creates the soils of the world. Erosion is the transportation of soil from one place to another, usually by running water or wind.

### I. SOIL EROSION

Each year much of our country is being washed away. Soil is the thin layer of loose or unconsolidated material that covers most of the Earth's land surface. Weathering is the processes whereby rock is broken down (by chemical and or mechanical means) into soil. Weathering creates the soils of the world. It is important because it provides a medium in which plants can take root, and the materials found in soil sustain plant growth. Soil also is a natural storage and purification area for water. Loss of soil by erosion results in loss of agricultural land, reduced crop yields, and impacts to other resources. Soil erosion by water, wind and tillage affects both agriculture and the natural environment, and is one of the most important (yet probably the least well-known) of today's environmental problems. Erosion is the process of physically removing material from its place of formation or temporary residence, usually by running water or wind.

Because particles comprising soil are generally very small, they can be easily eroded by wind and running water. Loss of soil by erosion results in loss of agricultural land, reduced crop yields, and impacts to other resources. Soil erosion is a natural process. It becomes a problem when human activity causes it to occur much faster than under natural conditions.

Soil erosion is a naturally occurring process on all land. Soil erosion is one form of soil degradation along with soil compaction, low organic matter, loss of soil structure, poor internal drainage, salinisation, and soil acidity problems. These other forms of soil degradation, serious in themselves, usually contribute to accelerated soil erosion. The agents of soil erosion are water and wind, each contributing a significant amount of soil loss each year. Soil erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing serious loss of topsoil. The loss of soil from farmland may be reflected in reduced crop production potential, lower surface water quality and damaged drainage networks.

However, erosion is the beginning process that develops the channels for streams that in turn allows water to move freely across the landscape to the sea. To a geologist or hydrologist, any water moving in a channel is call a stream regardless of its size.

#### SOIL ERODIBILITY

Soil erodibility is an estimate of the ability of soils to resist erosion, based on the physical characteristics of each soil. Generally, soils with faster infiltration rates, higher levels of organic matter and improved soil structure have a greater resistance to erosion. Sand, sandy loam and loam-textured soils tend to be less erodible than silt, very fine sand, and certain clay textured soils.

**FORMS OF EROSION**

Awareness usually occurs only when property is damaged and productive areas of soil are lost. The common forms of soil erosion are:

- Sheet erosion (water), which is almost invisible
- Lighter colored soils are a sign that over many years erosion has taken its toll.
- Wind erosion is highly visible. Although wind erosion is a problem, water erosion is generally much more severe.
- Rill erosion occurs during heavy rains, when small rills form over an entire hillside, making farming difficult.
- Gully erosion makes gullies, some of them huge, impossible to cross with farm machinery.
- Ephemeral erosion occurs in natural depressions. It differs from gully erosion in that the area can be crossed by farm equipment.

## II. CAUSES OF SOIL EROSION

Wind and water are the main agents of soil erosion. The amount of soil they can carry away is influenced by two related factors; speed - the faster either moves, the more soil it can erode away, and plant cover - plants protect the soil and in their absence wind and water can do much more damage. The occurrence and rates of soil erosion depend primarily on amount and type of vegetation, slope, amount of rainfall, soil type, and any human activities.

**AMOUNT AND TYPE OF VEGETATION**

The presence of vegetation prevents or reduces the likelihood of soil erosion. Plant roots form a network in the O- and A-horizons that bind soil particles together. Where vegetation is sparse or absent, such as in arid or cleared areas, this binding agent is absent. Wind or running water easily erodes soils under these conditions. Additionally, the canopy of leaves provided by vegetation lessens the erosive force of rain impacting on soil. Plants also reduce wind velocity near the ground surface, thereby lessening the ability of winds to erode and transport soil particles.

### The importance of plants;

Plants provide protective cover on the land and prevent soil erosion for the following reasons: plants slow down water as it flows over the land (runoff) and this allows much of the rain to soak into the ground; plant roots hold the soil in position and prevent it from being washed away; plants break the impact of a raindrop before it hits the soil, thus reducing its ability to erode; plants in wetlands and on the banks of rivers are of particular importance as they slow down the flow of the water and their roots bind the soil, thus preventing erosion.

The loss of protective vegetation through deforestation, over-grazing, plowing, and fire makes soil vulnerable to being swept away by wind and water. In addition, over-cultivation and compaction cause the soil to lose its structure and cohesion and it becomes more easily eroded. Erosion will remove the topsoil first. Once this nutrient-rich layer of soil is gone, few plants will grow in the soil again. Without soil and plants the land becomes desert-like and unable to support life - this process is called desertification. It is very difficult and often impossible to restore desertified land.

Soil erosion potential is increased if the soil has no or very little vegetative cover of plants and/or crop residues. Plant and residue cover protects the soil from raindrop impact and splash, tends to slow down the movement of surface runoff and allows excess surface water to infiltrate.

The erosion-reducing effectiveness of plant and/or residue covers depends on the type, extent and quantity of cover. Vegetation and residue combinations that completely cover the soil, and which intercept all falling raindrops at and close to the surface are the most efficient in controlling soil (e.g. forests, permanent grasses). Partially incorporated residues and residual roots are also important as these provide channels that allow surface water to move into the soil.

The effectiveness of any crop, management system or protective cover also depends on how much protection is available at various periods during the year, relative to the amount of erosive rainfall that falls during these periods. In this respect, crops which provide a food, protective cover for a major portion of the year (for example, alfalfa or winter cover crops) can reduce erosion much more than can crops which leave the soil bare for a longer period of time (e.g. row crops) and particularly during periods of high erosive rainfall (spring and summer). However, most of the erosion on annual row cropland can be reduced by leaving a residue cover greater than 30% after harvest and over the winter months, or by inter-seeding a forage crop (e.g. red clover). Soil erosion potential is affected by tillage operations, depending on the depth, direction and timing of plowing, the type of tillage equipment and the number of passes. Generally, the less the disturbance of the vegetation or residue cover at or near the surface, the more effective the tillage practice in reducing erosion.

**SLOPE**

The likelihood of soil erosion is directly related to the slope of the land. In flat or gently sloping areas, water infiltrates into pore space in the soil before beginning to run off at the surface. For short duration rainfall events, there may be little or no runoff, and therefore little or no soil erosion. In addition, the velocity of surface water movement is slower on gentle slopes, so that running water has less ability to erode and transport soil particles. On steeper slopes, water begins to run off at the surface before all of the pore spaces are full. Running water also has a greater velocity on steeper slopes and therefore a greater ability to remove and transport particles. Both slope gradient and length will have an effect on the amount of erosion. Naturally, the steeper the slope of a field, the greater the amount of soil loss will be from erosion by water. Soil erosion by water also increases as the slope length increases due to the greater accumulation of runoff. Consolidation of small fields into larger ones often results in longer slope lengths with increased erosion potential, due to increased velocity of water which permits a greater degree of scouring (carrying capacity for sediment).

**RAINFALL**

Soil erosion is influenced by the amount of rainfall in a given amount of time. Gentle rain falling over a long period of time permits the rainwater to infiltrate the soil and percolate downward. Organic material in the O-horizon can also absorb much of the moisture. Under these conditions, surface runoff of water may be minimal or absent. When rain falls rapidly the water cannot enter the pores in the soil fast enough and surface runoff occurs. If rain falls over an extended period of time, all of the pore space may become filled with water, and any additional moisture will run off at the surface. Under these conditions, the presence of running water at the surface increases the likelihood of soil erosion.

**Erosion by Water**

The rate and magnitude of soil erosion by water is controlled by rainfall intensity and runoff. Both rainfall and runoff factors must be considered in assessing a water erosion problem. The impact of raindrops on the soil surface can break down soil aggregates and then disperses the aggregate material. Lighter aggregate materials such as very fine sand, silt, clay and organic matter can be easily removed by the raindrop splash and runoff water; greater raindrop energy or runoff amounts might be required to move the larger sand and gravel particles.

Soil movement by rainfall (raindrop splash) is usually greatest and most noticeable during short-duration, high-intensity thunderstorms. Although the erosion caused by long-lasting and less-intense storms is not as spectacular or noticeable as that produced during thunderstorms, the amount of soil loss can be significant, especially when compounded over time. Runoff can occur whenever there is excess water on a slope that cannot be absorbed into the soil or trapped on the surface. The amount of runoff can be increased if infiltration is reduced due to soil compaction, crusting or freezing. Runoff from the agricultural land may be greatest during spring months when the soils are usually saturated, snow is melting and vegetative cover is minimal.

**SOIL GRAIN SIZE**

The influence of rainfall on soil erosion is closely related to the general grain size of soil. The mineral particles comprising the soil can range from sand and small gravel (greater than 1/16 mm) to clay-sized (less than 1/256 mm). Soils that have an abundance of coarser grains mixed with organic debris also have a large volume of pore space. The pore space permits a large amount of rainwater to infiltrate into the soil before it begins to run off at the surface. A low amount of runoff lessens the likelihood of erosion on these coarser soils. Soils dominated by clay-sized particles have a smaller volume of connected pore spaces. Less rainfall is likely to be absorbed by these finer-grained soils before surface runoff of the water begins. Because runoff occurs sooner, finer-grained soils are more susceptible to erosion than coarser-grained soils.

**HUMAN ACTIVITIES**

Human activities that reduce the amount of vegetation, increase land slope, or prevent soil from soaking up water serve to increase soil erosion. Some agricultural practices, such as land clearing for crops or clear-cutting of forests, remove the leaf canopy and permit direct impact of rain on bare soil. These practices also reduce or eliminate the network of plant roots that bind soil together. In addition to removal of vegetation, the land slope is often increased during construction of roads and buildings. Rainfall runoff on the exposed slopes will result in soil erosion and formation of gullies. Construction projects can also compress the soil and reduce pore space, thereby reducing the soil's capacity to absorb water before runoff occurs.

## III. EFFECTS OF EROSION.

### Erosion by Water

Sheet and Rill Erosion:

Sheet erosion is soil movement from raindrop splash resulting in the breakdown of soil surface structure and surface runoff; it occurs rather uniformly over the slope and may go unnoticed until most of the productive topsoil has been lost. Rill erosion results when surface runoff concentrates forming small yet well-defined channels. These channels are called rills when they are small enough to not interfere with field machinery operations. The same eroded channels are known as gullies when they become a nuisance factor in normal tillage.

Gully Erosion:

There are many farms that are losing large quantities of topsoil and subsoil each year due to gully erosion. Surface runoff, causing gully formation or the enlarging of existing gullies, is usually the result of improper outlet design for local surface and subsurface drainage systems. The soil instability of fully banks, usually associated with seepage of ground water, leads to sloughing and slumping (caving-in) of bank slopes. Such failures usually occur during spring months when the soil water conditions are most conducive to the problem. Gully formations can be difficult to control if remedial measures are not designed and properly constructed. Control measures have to consider the initial cause of the increased flow of water across the landscape. This is where combinations of the many of the conservation measures can come into play to reduce soil loss due to running water. Operations with farm machinery adjacent to gullies can be quite hazardous when cropping or attempting to reclaim lost land.

Stream and Ditch Bank Erosion:

Poor construction, or inadequate maintenance, of surface drainage systems, uncontrolled livestock access, and cropping too close to both stream banks has led to bank erosion problems. The direct damages from bank erosion include:

- The loss of productive farmland.
- The undermining of structures such as bridges.
- The washing out of lanes, roads and fencerows.
- Poorly constructed tile outlets may also contribute to stream and ditch bank erosion. Some do not function properly because they have no rigid outlet pipe, or have outlet pipes that have been damaged by erosion, machinery, inadequate or no splash pads, and bank cave-ins.

Failure to clean clogged or blocked drainage intake/outlets can also significantly contribute to stream bank erosion and damage.

**Erosion by Wind**

The rate and magnitude of soil erosion by wind is controlled by the following factors

- Erodibility of Soil:

  Very fine particles can be suspended by the wind and then transported great distances. Fine and medium size particles can be lifted and deposited, while coarse particles can be blown along the surface (commonly known as the saltation effect). The abrasion that results can reduce soil particle size and further increase the soil erodibility.
- Soil Surface; Roughness

  Soil surfaces that are not rough or ridged offer little resistance to the wind. However, over time, ridges can be filled in and the roughness broken down by abrasion to produce a smoother surface susceptible to the wind. Excess tillage can contribute to soil structure breakdown and increased erosion.
- Climate

  The speed and duration of the wind have direct relationship to the extent of soil erosion. Soil moisture levels can be very low at the surface of excessively drained soils or during periods of drought, thus releasing the particles for transport by wind. This effect also occurs in freeze-drying of the surface during winter months.
- Unsheltered Distance

  The lack of windbreaks (trees, shrubs, residue, etc.) allows the wind to put soil particles into motion for greater distances thus increasing the abrasion and soil erosion. Knolls are usually exposed and suffer the most.
- Vegetative Cover

The lack of permanent vegetation cover in certain locations has resulted in extensive erosion by wind. Loose, dry, bare soil is the most susceptible; however, crops that produce low levels of residue also may not provide enough resistance. As well, crops that produce a lot of residue also may not protect the soil in severe cases. The most effective vegetative cover for protection should include an adequate network of living windbreaks combined with good tillage, residue management, and crop selection.

**Resulting Effect**

Wind erosion may create adverse operating conditions in the field. Crops can be totally ruined so that costly delay and reseeding is necessary - or the plants may be sandblasted and set back with a resulting decrease in yield, loss of quality, and market value.

Soil drifting is a fertility-depleting process that can lead to poor crop growth and yield reductions in areas of fields where wind erosion is a recurring problem. Continual drifting of an area gradually causes a textural change in the soil. Loss of fine sand, silt, clay and organic particles from sandy soils serves to lower the moisture holding capacity of the soil. This, in turn, increases the erodibility of the soil and compounds the problem.

The removal of wind blown soils from fencerows, ditches, roads and from around buildings is a costly process

**ON-SITE EFFECTS:**

The implications of soil erosion extend beyond the removal of valuable topsoil. Crop emergence, growth and yield are directly affected through the loss of natural nutrients and applied fertilizers with the soil. Seeds and plants can be disturbed or completely removed from the eroded site. Organic matter from the soil, residues and any applied manure is relatively lightweight and can be readily transported off the field, particularly during spring thaw conditions. Pesticides may also be carried off the site with the eroded soil.

Soil quality, structure, stability and texture can be affected by the loss of soil. The breakdown of aggregates and the removal of smaller particles or entire layers of soil or organic matter can weaken the structure and even change the texture. Textural changes can in turn affect the water-holding capacity of the soil, making it more susceptible to extreme condition such a drought.

**OFF-SITE EFFECTS:**

Off-site impacts of soil erosion are not always as apparent as the on-site effects. Eroded soil, deposited down slope can inhibit or delay the emergence of seeds, bury small seedling and necessitate replanting in the affected areas. Sediment can be deposited on down slope properties and can contribute to road damage.

Sediment, which reaches streams or watercourses, can accelerate bank erosion, clog drainage ditches and stream channels, deposit silt in reservoirs, cover fish spawning grounds and reduce downstream water quality. Silt in large quantities, deposited into waterways, can contribute to the flooding of many low-lying areas and increase the chances of flooding in other areas. Pesticides and fertilizers, frequently transported along with the eroding soil can contaminate or pollute downstream water sources and recreational areas. Because of the potential seriousness of some of the off-site impacts, the control of "non-point" pollution from agricultural land has become of increasing importance.

## IV. SOIL EROSION IN AGRICULTURAL SYSTEMS

Soil erosion in agricultural systems is a very important problem to manage. The productive layer of dirt is called the humus or topsoil. If this layer is eroded away, then the ground is very unproductive in producing crops. High winds can blow away loose soils from flat or hilly terrain. Water erosion generally occurs only on slopes, and its severity increases with the severity of the slope. In the Midwest much of the wind erosion occurs in winter when the ground is frozen, but the upper most soil layer is dry and loose. Water erosion occurs during the spring with the thawing and melting action of the snow.

There are a number of different methods of reducing soil erosion. Contour tillage reduces water erosion. On hilly areas plowing is done across the hill rather than straight up and down. One problem with this is that some fields' shape makes this method impractical. Terraces can also be constructed so to reduce water erosion. Strong proponents of soil protection also advocate no-till agriculture.

No-till is actually a misnomer. Traditional plowing cuts down and overturns up to 8" of soil. The coulter disks on traditional plows are straight disks. No-till only stirs up to 2" in creating crop rows. No-till coulter disks are waved which creates the stirring action. Traditional plowing is utilized to break up dirt clogs in heavy clay soils and to kill competing weeds. No-till reduces soil erosion by keeping crop and plant residue on the surface longer. The major problem with no-till is that weed growth can only be stopped by heavier herbicide applications than with traditional tillage methods. In this case, farmers must make the hard choice between soil conservation and heavier applications of herbicides. No-till also does not work as well in all soil types. No-till works best in sandy soils, but in the heavier clay soils, fall traditional plowing is required to break the soil up enough for adequate crop yields. No-till also does not work in compacted soils. The only way to break down soil compaction is through traditional moldboard plowing or the use of a sub-soiler.

One method designed to reduce to wind erosion is the establishment of windbreaks. Windbreaks work well in reducing wind velocities over fields, but they have one serious drawback to farmers. For every quarter mile of windbreak approximately one acre is taken out of crop production. Windbreaks take out not only their physical width, but they shade out crops to the side of them as well. Farmers must pay taxes, rent, and the maintenance for windbreaks that produce no short-term benefit in return.

Another method of reducing soil erosion is to leave crop residue on the field after harvesting. For example, after the corn is harvested, the stalks are left on the field all winter to reduce erosion and soil fertility decline. The major problem with this is that the crop residue offers habitat for pests. If crop rotation is unfeasible then heavier amounts of pesticides are required to eliminate the pest problem. Again farmers must decide between soil conservation and chemical applications.

As this shows, there are some hard decisions for farmers to make in preserving soil from erosion. Soil conservation is critical to creating sustainable agriculture, but it also creates the need for heavier doses of pesticides and herbicides. Long-term soil conservation practices must also be balanced with farmers' short-term economic needs. Farmers need to earn a healthy living just as much as any non-food producer does.

Tillage and cropping practices which lower soil organic matter levels, cause poor soil structure, and result of compacted contribute to increases in soil erodibility. Decreased infiltration and increased runoff can be a result of compacted subsurface soil layers. A decrease in infiltration can also be caused by a formation of a soil crust, which tends to "seal" the surface.

On some sites, a soil crust might decrease the amount of soil loss from sheet or rain splash erosion; however, a corresponding increase in the amount of runoff water can contribute to greater rill erosion problems.

Past erosion has an effect on the soils erodibility for a number of reasons. Many exposed subsurface soils on eroded sites tend to be more erodible than the original soils were, because of their poorer structure and lower organic matter. The lower nutrient levels often associated with sub soils contribute to lower crop yields and generally poorer crop cover, which in turn provides less crop protection for the soil.

**A brief history Lesson**

A severe drought combined with poor soil conservation practices can lead to extreme topsoil erosion, with devastating effects on the land. This is just what happened in the Great Plains region of the U.S. during the 1930s Dust Bowl years. In 1931 one of these cyclical droughts struck Texas, the Oklahoma Panhandle, Kansas and the Eastern parts of Colorado and New Mexico. This time, it struck a changed landscape. In the 1920s, technological advances had made more land available to the wheat farmer. Increased production drove down prices, which led to more intensive cultivation of more land in wheat, including some regions where the land could barely support wheat under the best of conditions. Disk plows; pulled in long rows by newly available tractors, cut the soil shallowly but more thoroughly, making it drier and more vulnerable. The combination proved disastrous when the usual spring winds came in 1932.

The most visible evidence of how dry the 1930s became was the dust storm. Tons of topsoil were blown off barren fields and carried in storm clouds for hundreds of miles. Technically, the driest region of the Plains – southeastern Colorado, southwest Kansas and the panhandles of Oklahoma and Texas – became known as the Dust Bowl, and many dust storms started there. But the entire region, and eventually the entire country, was affected.

In May 1934, a cloud of topsoil from the Great Plains blanketed the eastern U.S. as far as 2,400 km (1,500 miles) away. In 1935, the U.S. established the Soil Conservation Service to promote good soil management practices. But according to some experts, this is not enough. Human-accelerated soil erosion continues to occur because much of the Great Plains is suited to moderate grazing rather than farming. And in 1975, the Council of Agricultural Science and Technology warned that severe drought in the Great Plains could trigger another Dust Bowl.

The Dust Bowl got its name after Black Sunday, April 14, 1935. More and more dust storms had been blowing up in the years leading up to that day. In 1932, 14 dust storms were recorded on the Plains. In 1933, there were 38 storms. By 1934, it was estimated that 100 million acres of farmland had lost all or most of the topsoil to the winds. By April 1935, there had been weeks of dust storms, but the cloud that appeared on the horizon that Sunday was the worst with the winds clocked at 60 mph.

## V. PREVENTING SOIL EROSION:

Preventing soil erosion requires political, economic and technical changes. Political and economic changes need to address the distribution of land as well as the possibility of incentives to encourage farmers to manage their land in a sustainable manner. Aspects of technical changes include:

- The use of contour plowing and wind breaks.
- Leaving unplowed grass strips between plowed land;

- Making sure that there are always plants growing on the soil, and that the soil is rich in humus (decaying plant and animal remains). This organic matter is the "glue" that binds the soil particles together and plays an important part in preventing erosion.
- Avoiding overgrazing and the over-use of croplands.
- Allowing indigenous plants to grow along the riverbanks instead of plowing and planting crops right up to the water's edge.
- Encouraging biological diversity by planting several different types of plants together.
- Conservation of wetlands.

**CONSERVATION MEASURES**

Certain conservation measures can reduce soil erosion by both water and wind. Tillage and cropping practices, as well a land management practices, directly affect the overall soil erosion problem and solutions on a farm. When crop rotations or changing tillage practices are not enough to control erosion on a field, a combination of approaches or more extreme measures might be necessary. For example, contour plowing, strip cropping, or terracing may be considered.

Many farmers have already made significant progress in dealing with soil erosion problems in their farms. However, because of continued advances in soil management and crop production technology that have maintained or increased yields in spite of soil erosion, others have not been aware of the increasing problem on farmland.

**STANDARDS**

| Indiana Science Standards (Science) | |
|---|---|
| **Earth Science** | |
| ES.1.25 | Investigate and discuss the origin of various landforms, such as mountains and rivers, and how they affect and are affected by human activities |
| ES.1.26 | Differentiate among the processes of weathering, erosion, transportation of materials, deposition, and soil formation. |
| ES.1.27 | Illustrate the various processes that are involved in the rock cycle and discuss how the total amount of material stays the same through formation, weathering, sedimentation, and reformation. |
| **Environmental Science** | |
| Env.1.33 | Identify natural Earth hazards, such as earthquakes and hurricanes, and identify the regions in which they occur as well as the short-term and long-term effects on the environment and on people. |
| **Indiana Science Standards (US History)** | |
| USH.2.3 | Explain the economic problems facing farmers during the late nineteenth century. (Economics) |
| USH.2.4 | Explain how industrialization affected the environment and the emergence of a conservation movement. (Economics; Individuals, Society, and Culture) |

| National Science Standards | | |
|---|---|---|
| **A** | Science as Inquiry | Abilities necessary to do scientific inquiry<br>Understanding about scientific inquiry |
| **D** | Earth and Space Science | Properties of earth materials<br>Changes in earth and sky |
| **F** | Science in Personal and Social Perspectives | Types of resources<br>Changes in environments<br>Science and technology in local challenges |
| **G** | History and Nature of Science | Science as a human endeavor<br>Nature of scientific knowledge<br>Historical perspectives |

**<u>Principles for School Mathematics</u>**

| **Instructional programs from pre-kindergarten through grade 12 should enable all students to—** | **Expectations**<br>**In grades 9–12 all students should—** |
|---|---|
| **Algebra Standard for Grades 9–12** | |
| Analyze change in various contexts | • Approximate and interpret rates of change from graphical and numerical data. |
| **Geometry Standard for Grades 9–12** | |
| Use visualization, spatial reasoning, and geometric modeling to solve problems | • Draw and construct representations of two- and three-dimensional geometric objects using a variety of tools;<br>• Visualize three-dimensional objects and spaces from different perspectives and analyze their cross sections;<br>• Use geometric models to gain insights into, and answer questions in, other areas of mathematics;<br>• Use geometric ideas to solve problems in, and gain insights into, other disciplines. |
| **MEASUREMENT STANDARD FOR GRADES 9–12** | |
| Understand measurable attributes of objects and the units, systems, and processes of measurement | • Make decisions about units and scales that are appropriate for problem situations involving measurement |
| Apply appropriate techniques, tools, and formulas to determine measurements | • Analyze precision, accuracy, and approximate error in measurement situations;<br>• Apply informal concepts of successive approximation, upper and lower bounds, and limit in measurement situations;<br>• Use unit analysis to check measurement computations. |
| Connections Standard for Grades 9–12 | |
| Recognize and use connections among mathematical ideas | • Understand how mathematical ideas interconnect and build on one another to produce a coherent whole;<br>• Recognize and apply mathematics in contexts outside of mathematics. |

## NAAEE Strands

| Strand # | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| **1** | Questioning | | Collection Information | Evaluating Accuracy/Reliability | Organization Information | Models / Simulations | Conclusions Explanations |
| **2.1** | Shaping the Earth | | | | | | |
| **2.3** | Individuals / Groups | | | | | | |
| **2.4** | Human/Environment Interactions | | | | Environmental Issues | | |
| **3.1** | ID / Investigate Issues | Consequences of Issues | Alt. Solutions / Actions | | | | |
| **3.2** | Personal Views | Citizen Action | Planning, Taking Action | Evaluating Results of Actions | | | |
| **4** | | Citizen's Rights & Responsibilities | Recognizing Efficacy | Accepting Personal Responsibility | | | |

**GOALS AND OBJECTIVES:**

**At the end of this lesson the student will be able to:**

Explain the origins of rivers, how they change over time, and how they are affected by human activities.

List the causes of weathering and erosion and describe the differences.

Using drawings to illustrate the processes and extent of erosion (the transportation of soil material, a part of the rock cycle)

Identify and describe how erosion can lead to natural hazards such as floods and its long and short-term effects on the environment and people.

| **Time line of Erosion unit lessons** | | |
|---|---|---|
| **Day 1** | **2 hours** | **Engage, Explore & Explain #'s I, II A-C** |
| **Day 2** | **2 hours** | **Explore & Explain #'s III – IV and final Explanation** |
| **Day 3** | **2-4 hours** | **Extend and start research for reports** |
| **Day 4** | **2 hours** | **Research & Report writing** |
| **Day 5** | **2 hours** | **Oral reports** |

**NOTE:** Added time may be needed to complete all of the different 'Extend' activities. Plan and adjust the classroom schedule accordingly.

**NOTES:**
Teachers: This work can be done individually, in pairs, or in corporative groups.
Students: For all of the following experiments you will keep records of your data tables and drawings in your science journal for comparison and reporting.

**<u>Engage:</u>**

Engage the students by asking questions, checking for prior knowledge and uncovering misconceptions. The questions should include; what is erosion, what are examples of erosion, what causes erosion, where does erosion happen, is erosion a natural process or is it a man-made problem, is erosion a problem for our school, community, state, nation, or world, can we control erosion, and should we control erosion.

Accept all student responses, without explanation, and make a list or chart of the answers. This will be used at a later time during the explanation and extension parts of the lesson.
The students should fully explain their answers and give examples where appropriate. Students should be encouraged to use examples from their personal experiences.

**<u>I. Explore</u>**: (***What happens to the material that is carried away by rivers?)***

Raise the end of the molded tray opposite the drain to approximately four inches. Do not allow the tray to sag along its length. Clear an eight to ten inch area of sand from around the drain and form a gentle slope towards the raised end of tray. Using your index finger cut a narrow straight groove into the sand from the top of the tray to the bottom. Position the inlet water source just above the beginning of the groove at the raised end. Start the water flowing and adjust until a light flow is achieved. Allow the water to run for approximately three minutes. In your science journal make a scaled drawing of the stream channel and the delta formed. Using your protractor measure the angle of repose of the material. Remove the delta material and weigh it. Repeat the above steps while varying the elevations and/or flow rates. Make a data table showing the length, width and weight of the deltas as you vary the parameters. Compare your sketches and data tables to those of other students. Do they look different? List the similarities and differences in your science journal and develop a hypothesis to explain those similarities and differences.

**<u>I. Explain:</u>**

Deltas are formed at the mouths of many large rivers. They come in various sizes and shapes. The primary factor that affects the formation of a delta is the river's carrying capacity. Carrying capacity is directly related to the stream's volume. As a stream's volume increases so does its carrying capacity.

**<u>II A. Explore:</u>** ***(Does a stream change over time? What are the factors that may lead to this change?)***

Raise the stream table to approximately eight inches. Smooth the sand and cut a groove, on center, the length of the table. Place a meter stick along side the groove. Locate the inlet water over the head of the groove and adjust the flow rate to heavy. Place a float, such as, a small cork at the upper end of the groove. Measure and record the time it takes the float to run the length of the meter stick. Calculate the average velocity in centimeters/second (cm/sec). Measure the width and depth of the stream at three points, its head, middle and mouth. Place the information into a data table, using this data; determine the form ratio (depth/width) for each point of measurement. Sketch an overhead view of the stream. Repeat the above exercise three times and compare the data and sketches that you have developed from each trial.

Again, in your science journal make a scaled drawing of the stream channel and the delta formed. Compare your sketches and data tables to those of other students. Do they look different? List the similarities and differences in your science journal and develop a hypothesis to explain those similarities and differences.

**<u>II A. Explain:</u>**

A stream undergoes a sequence of changes as it passes from youth to maturity and finally to old age. In its youth, it tends to flow swiftly with great velocity that gives it a greater erosive capability. Over time the river's velocity begins to slow down, which affects its ability to erode land and carry away sediment. Landforms tend to get in the river's way and without the energy required to change the land, the river begins meandering around obstacles. This and the following experiments are characteristic changes that occur during the life cycle of a stream.

***Youth:*** In its youth, the stream tends to flow swiftly and cut a deep, straight, narrow channel in the land.

**<u>II B. Explore:</u>**

Lower the height of the stream table to four inches and smooth the sand. Cut a groove in the sand from top to bottom with two or three gentle curves. Set the flow rate to moderate and repeat the procedures used to develop comparative data in the Youth experiment. Compare your sketches and data tables to those of other students. Do they look different? List the similarities and differences in your science journal and develop a hypothesis to explain those similarities and differences.

**<u>II B. Explain:</u>**

***Maturity:*** During this stage in the life of a stream, it begins to lose its velocity and erosive capacity. It begins to meander and to form flood plains.

**<u>II C. Explore:</u>**

Set the height of the stream table to two inches and smooth the sand. Cut a sharply meandering narrow groove in the sand from top to bottom. Set the flow rate to moderate and repeat the procedures used to develop comparative data in the Youth demonstration. Compare your sketches and data tables to those of other students. Do they look different? List the similarities and differences in your science journal and develop a hypothesis to explain those similarities and differences.

**<u>II C. Explain:</u>**

***Old Age:*** Very few rivers ever reach the Old Age stage of life because land and sea and other conditions must be stable for very long periods. This seldom occurs in nature.

**<u>III. Explore:</u>** ***(What other landforms are the results of the erosion of soil?)***

**A.** Set the height of the stream table to four inches. Scrape all of the sand to the upper end and form a cliff 2 to 2-1/2 inches high and 18 inches from the upper end of table. Make a groove in the cliff to a depth of one inch, which extends all the way back to the upper end. Hold the inlet water source above this groove with the flow rate set to moderate for approximately two minutes.

**B.** Now pour a cup of fine sand into a pile and measure the angle of repose with a protractor.

**<u>III. Explain:</u>**

**A.** The formation found at the bottom of the cliff is an alluvial fan. Using a protractor, determine the angle of repose of sedimentary material.

**B.** This represents a talus cone. Which has the greatest angle of repose the alluvial fan or the talus cone?

**<u>IV. Explore:</u>** ***(Water need not be running to lead to soil erosion. What other factor(s) can contribute to the movement of earth materials?)***

***Mudflow:***

Clear all sand from the lower end of table. Place a pile of sand approximately 12 inches from the upper end of the table. Tilt the table 30 degrees and slowly pour water onto the base of the pile. Note the resting angle of the sand as it slides down the table.

***Soil Slumping***:

Smooth the sand and form a dam 18 inches from the upper end that runs the entire width of the table and is two inches in height and three inches in depth (wide). Clear the sand from the base of the ridge on its lower side. Space 10 to 15 toothpicks upright across the ridge. Adjust the inlet hose to a moderate flow and allow a pool to form behind the ridge. After three minutes, turn off the water. Wait several minutes until slumping begins, then record the sequence of events that are observed such as the angle of the toothpicks and the width of the remaining ridge

**<u>IV. Explain:</u>**

***Erosion and Gravity***

Erosion is not the only factor that changes landscapes. Whenever the force of gravity is great enough to overcome the internal force of friction and cohesion, that holds a material together, the material will begin to move. This movement can result in the rapid movement of landslides or the gradual movement of mudslides, etc.

**<u>Explain Continued:</u>**

Using the information collected and recorded in the ‘Engage” phase, the background information, and the data collected lead a class discussion about erosion. This discussion should be mostly student input with factual information being added and corrected by the teacher. Include the historical perspectives and the outcomes of uncontrolled erosion.

**Extend:**

**1 A. Surveying your schoolyard & Measuring an erosional feature:**

Conduct a survey of your schoolyard and the surrounding area to locate any erosion features. If any are located use the survey drawings (attached), as a guide, measure the feature several times over the course of the year to determine if the feature is increasing in size and scope. Prepare a report of your findings to be presented to your school's administrators to explain the problems of erosion found in the area.

**1 B.**

Research and plan ways to solve these problems. Carry out your plan and follow up and evaluate the results. Modify the solutions as necessary to improve the results and report the findings to your school's administrators.

**2 A. Map surveys:**

Conduct a map survey of your local area using both topographic maps and the Internet resources to locate and identify any streams that are in the various stages of development.

**2 B.**

Extend the above search to a national and global level. List the number of streams found for each developmental stage and prepare a report of your findings for both A & B.

**Evaluate:**

Evaluation will be an ongoing process and will include:

- Active participation.
- Accuracy and completeness of information recorded in the science journal, including the drawings used to illustrate the processes and extent of erosion.
- Accuracy and completeness of information presented in both oral and written reports.
    - ✓ Explaining the origins of rivers and how they change over time.
    - ✓ How they are affected by human activities.
    - ✓ List the causes of weathering and erosion, describing the differences.
    - ✓ How erosion can lead to natural hazards such as floods and its long and short-term effects on the environment and people.

# Evaluation Rubric

| Objective / Goal | 5 Points | 3 Points | 0 Points |
|---|---|---|---|
| Active participation in all activities | Full participated in all activities | Participated in some bit not all activities | Little or no participation |
| Science Journal all entries (activities) | All information is complete and accurate | Journal entries contain few errors and/or is missing minor information | Journal entries contain many errors or missing major information |
| Written reports | Explains origins of rivers with change over time | Has few errors and/or is missing minor information | Contains many errors or missing major information |
| | How affected by human activities | Has few errors and/or is missing minor information | Contains many errors or missing major information |
| | Includes causes of weathering and erosion, describes the differences. | Has few errors and/or is missing minor information | Contains many errors or missing major information |
| | Explains how erosion can lead floods and long/short-term effects on the environment and people. | Has few errors and/or is missing minor information | Contains many errors or missing major information |
| Oral reports | Explains origins of rivers with change over time | Has few errors and/or is missing minor information | Contains many errors or missing major information |
| | How affected by human activities | Has few errors and/or is missing minor information | Contains many errors or missing major information |
| | Includes causes of weathering and erosion, describes the differences. | Has few errors and/or is missing minor information | Contains many errors or missing major information |
| | Explains how erosion can lead floods and long/short-term effects on the environment and people. | Has few errors and/or is missing minor information | Contains many errors or missing major information |
| Written/ Oral reports connect to other curriculum areas. | Connection to 2 other curriculum areas. | Connection to 1 other curriculum areas. | No connections made |
| | | | |

**REQUIRED MATERIALS**,

Stream Tray (includes), 1 Molded Tray,1 Clamp, Ratchet, 1 Vinyl tube 6 feet, 1 Nipple, Brass 1 Support, Trough, 2Washers, Natural Gum Threaded, 2 Washers, Brass, 1 Trough, 2 Nuts, Brass hex, 1 Siphon, 1 Cork, Small, 3 Buckets, 10 Kilogram of Sand, 1 Timer, 15 Toothpicks, 1 Protractor, Supports.

Stream Table Assembly (if necessary):

Take the nipple and slide one gum and one brass washer onto one end. Thread a hex nut onto the same nipple end as the washers, until it is flush with the end of the nipple. Insert this assembly, from inside the molded tray, through the hole in the end. Slide a gum and a brass washer onto the end of nipple that extends beyond the outside of the tray. Secure in place by tightening the remaining nut onto this end of nipple.

Insert drain tube through ratchet clamp. Use ratchet clamp to adjust flow rate for your inlet water supply

**Other materials:**
Graph paper
20 m. Rope 1
5 m. Rope 5
Clipboard per team
Meter sticks 5
25 m measuring tape 2
Scoops (cups)
Marking Tape & Pens

**SAFETY CONSIDERATIONS:**
**WARNIG: The edges of gullies or other eroded areas are extremely unstable. Use extreme caution and common sense when working near or in these areas!!**

Ensure that while working outside the students take the necessary precautions to protect themselves from the sun, adverse weather, poisonous plants, and insects. While working in or around gullies or other eroded areas proper clothing and footwear must be worn. As always, there can be no horseplay while working out of doors.

**Map View:**

When measuring a gully mark the starting point (sp) for future reference. Stretch a line or rope along the center of the gully at ground level. Be sure to closely follow the slope of the land. From the sp mark the center line (c. l.), at 1 meter intervals. These will be marked A, B, C, etc. This will be where you will take all of your cross section measurements. Sketch the gully with the sp and the c. l., adding any reference points and distances, to aid in assessing continued erosion.

**Cross section view**:

From each of the 1 m marks on the c. l. stretch a line or rope across the gully securing the ends at ground level. From the c. l. mark the cross rope at .5 m intervals. Starting at mark A on the c. l. measure downward to the ground level of the edge of the gully. Sketch and label each of the cross sections, A-A', B-B', C-C', etc. until all of the cross sections are measured and sketched.

NOTE:
Measurement distances may need to be adjusted for small gullies of other eroded features.

## References


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http://chnm.gmu.edu/courses/hist409/dust/dust.html
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http://www.livinghistoryfarm.org/farminginthe30s/water_02.html

*Earth Science* (1995) Prentice Hall A Paramount Communications Co. Englewood Cliffs, New Jersey

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http://www.growbiointensive.org/biointensive/soil.html

Environmental and Economic Costs of Soil Erosion and Conservation Benefits
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http://www.pmac.net/science2.htm

*Managing Lakes and Reservoirs* (2001) 3rd Ed North American Lake Management Society & Terrene Institute

Misconceptions: Weathering and erosion are synonymous
http://www.cst.cmich.edu/users/Franc1M/esc334/lectures/origin.htm

Original Fact sheet Title: *Soil Erosion - Causes and Effects* OMAF Staff; G. Wall - Ontario Institute of Pedology; C.S. Baldwin - Ridgetown College of Agricultural Technology; I.J. Shelton - Ontario Institute of Pedology
http://www.gov.on.ca/omafra/english/engineer/facts/87-040.htm#top#top

Principles for School Mathematics
http://standards.nctm.org/document/

Soil and Sediment
http://cse.cosm.sc.edu/hses/SoilNSed/Soil/pages/erosion.htm

Sustainable Agriculture Educational Project Homepage
http://www.msu.edu/user/dunnjef1/rd491/project.htm