Erosion and Sedimentation

Erosion in the context of soil and **watershed** conservation is the detachment and movement of soil particles by natural forces, primarily water and wind. More broadly, erosion is the process of wearing away rocks, geologic, and soil material via water, wind, or ice (e.g., glaciers). Erosion will transport materials after mechanical **weathering** has broken rock and geologic materials down into smaller, moveable pieces.

Sedimentation is the process in which particulate matter carried from its point of origin by either natural or human-enhanced processes is deposited elsewhere on land surfaces or in waterbodies. Sediment is a natural product of stream erosion; however, the sediment load may be increased by human practices. Such enhanced sources of sediment in a watershed include unvegetated streambanks and uncovered soil regions, including construction sites, deforested areas, and croplands.

Erosive Forces

Through different types of erosion, the Earth's surface is continually being reshaped. Landmasses are altered as waves and tides erode old lands while **silt** and other sediments deposited in waterbodies build up new lands. Over geologic time, some gullies become ravines and eventually valleys. More than 1,500 meters (5,000 feet) deep, the Grand Canyon in Arizona was produced by erosion over a 5-million-year timeframe.

Ice.

Glaciers are important means of erosion over long periods of time. Although a glacier moves slowly, it eventually removes material from the surface over which it travels through processes such as plucking, abrasion, crushing, and fracturing. Rock fragments, located at the bottom and sides of moving ice masses, will grind and scour bedrock to eventually form the walls and floors of mountain valleys.

Wind.

Wind can move sediment grains over long distances when they are carried through the air. Sediments also can be blown along expanses of land, such as beaches, mudflats, unvegetated cropland, or construction areas. Obstructions help reduce the wind's erosive capacity; hence, windblown sediment often is deposited at these locations.

Water.

Flowing water plays a major role in erosion by carrying away soils and other materials on the land surface. In general, there is a potential for water erosion where the land slope is at least 2 percent. The four types of water erosion of soil are sheet, rill, gully, and tunnel

Sheet erosion is the uniform removal of soil without the development of visible water channels. It is the least apparent of the four erosion types. Rill erosion is soil removal through the cutting of many small, but conspicuous, channels. Gully erosion is the consequence of water that cuts down into the soil along the line of flow. Gullies develop more quickly in places like animal trails, plow furrows, and vehicle ruts. * Tunnel erosion may occur in soils with sublayers that have a greater tendency to transport flowing water than does the surface layer.

Along the seacoast, erosion of rocky coastal cliffs and sandy beaches results from the strong, unceasing action of currents and waves. Severe storms

Over geologic time, mass wasting and erosion by flowing water can produce well-defined ridges and valleys, such as this water-carved hillside in Hawaii. On a water-shed scale and over short periods of time, erosion carries soil particles (plus any adsorbed nutrients or pollutants) from one location to another.

exacerbate the problem of sandy beach erosion. In many world regions, land and economic losses due to coastal erosion represents a serious problem. *

Stream Sedimentation

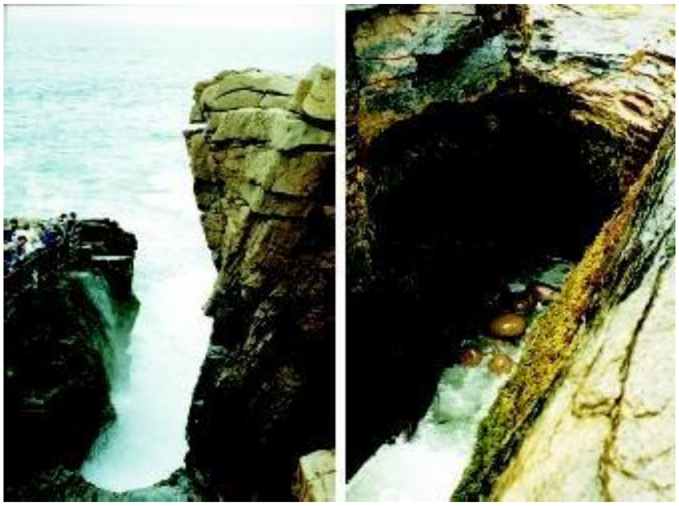
In the context of stream hydrology, sediment is **inorganic** and **organic** material that is transported by, suspended in, or deposited by streams. Sediment load, which is the quantity of sediment transported by a stream, is a function of stream discharge, soil and land-cover features, weather conditions, land-use activities, and many other factors. Sediment load carried by streams and rivers can be composed either of fine materials, mostly silts and clays, or larger materials such as sand.

Solid sediment load can be divided into two components on the basis of the mode of sediment transport: suspended sediment, and bedload sediment, each of which is produced by mechanical weathering processes, is clearly visible, and is able to settle out of water. Suspended sediment consists of silt-sized and clay-sized particles held in suspension by turbulence in flowing water. Bedload sediment consists of larger particles which slide, roll, or bounce along the streambed by the force of moving water. Dissolved load consists of inconspicuous material in solution moving downstream. It is produced by chemical weathering processes, and does not settle out of water.

Sediment yield is the total quantity of sediment transported from a watershed (drainage basin) at a given location in a given period of time. Low suspended sediment yields can be attributed to, among other factors, a region's low erosion rate. Permeable soils and low topographic relief, in general, help limit the availability of eroded material from within a watershed. Conversely, relatively impermeable soils and steep topography can yield high erosion rates and therefore greater sediment yield.

Accelerated Sedimentation.

Changes in land use, streamflow characteristics, and drainage patterns can alter the natural sedimentation rate. Historically, agriculture has been a main source of human-enhanced sediments in waterbodies. U.S. farming, for instance, accounts for an annual erosion loss of over 3 billion metric tons of soil.



The pounding surf at Acadia National Park, Maine illustrates the erosive power of water. At Thunder Hole, a popular tourist location, waves gradually carve away the coastal bedrock (left), deepening the narrow cut and polishing the rocks on its floor (right).

The conversion of **wetlands** or woodlands to cropland can increase soil erosion and the associated sedimentation in streams, particularly when bare soil is exposed. * Windblown particles from bare soils also contribute to sedimentation problems. Activities such as dredging and **channelization** that increase stream slope and velocity can increase the stream's erosive capacity and sediment-transport capability. Construction projects within or adjacent to streams can contribute to sedimentation problems as they dislodge or expose soils and sediments.

Ecological and Economic Impacts

Excessive erosion can reduce the soil's inherent productivity, whereas the associated sedimentation can damage young plants and fill drainage ditches, lakes, and streams. Erosive processes can reduce farm income by decreasing crop yields and increasing maintenance costs for drainage systems. Additional erosion damages in both rural and urban areas include reduced property values, deteriorated water quality, and increased costs of removing sediment from roadways, roadside ditches, and surface-water supplies.

One of the principal causes of degraded water quality and aquatic **habitat** is the depositing of eroded soil sediment in waterbodies. Excessive amounts of sediment resulting from natural or human-induced causes can result in the destruction of aquatic habitat and a reduction in the diversity and abundance of aquatic life. Diversity and population size of fish species, mussels, and benthic (bottom-dwelling) macroinvertebrates associated with coarse substrates can be greatly reduced if the substrates are covered with sand and silt. Where sand or silt substrates have historically predominated, however, increased deposition may have little detrimental impact on benthic aquatic life.

Suspended sediment causes the water to be cloudy (turbid). Increased turbidity reduces light transmission (and hence **photosynthesis**), thereby

Contrasting side-by-side ditches show the impacts of human-induced sedimentation. The heavily silted ditch carries its load into the coastal waters of San Juan, Puerto Rico.

reducing the growth of algae and aquatic plants, which can adversely affect the entire aquatic **ecosystem** . Moreover, increased turbidity decreases the water's aesthetic appeal and the human enjoyment of recreational activities. If the river cross-section is sufficiently reduced by sediment buildup, sedimentation can increase downstream flooding. In addition, some metal **ions** , **pesticides** , and nutrients may adhere to sediment particles and be transported downstream.

Increased sediment in surface-water bodies (e.g., rivers, lakes, and reservoirs) may have an economic impact on public water systems that use them as a source of drinking water. High turbidity not only is aesthetically displeasing, but also interferes with disinfection of the water prior to it being pumped to customers. Communities whose water-supply source has become more turbid often invest millions of dollars to upgrade their treatment facilities in order to remove the increased sediment load.

Soil erosion

Soil erosion results in soil being detached, carried away, and eventually deposited elsewhere. It is a natural process, and rivers and creeks naturally hold soil, deposit it in some places and pick it up in other places. In the Huron River Watershed, soil erosion is a problem when it is accelerated because of high water flow and human disturbance (i.e. farming, construction) of the land surrounding our streams. When the amount of soil in the creek exceeds the ability of the water to transport it downstream, the excess soil can clog rocks and gravel beds, which are important habitat for fish, insects, and other river life. When excess soil drops out of the water and remains in the stream, the process is known as **sedimentation.**

Erosion and sedimentation can also have these affects:

- Loss of fertile top soil
- Flooding from clogged ditches, culverts, and storm sewers
- Muddy or turbid streams
- Damaged plant and animal life
- Clogged ponds, lakes, and reservoirs
- Damaged aquatic and other habitats
- Decreased recreational value and use
- Structural damage to buildings and roads

Naturally occurring factors also influence both the rate and the amount of erosion and deposition into streams.

1) **Vegetation** is the most important physical factor influencing soil erosion. A good vegetative cover binds the soil together, infuses it with organic matter, shields it from rain, makes it resistant to runoff, and filters sediment. A robust vegetative cover is one of the best protections against erosion.

2) **Climatic conditions** influencing erosion include the amount, intensity, and frequency of rainfall, and hot and cold temperatures. For example, during periods of frequent rainfall there is a greater percentage of runoff. And, while frozen soil is highly resistant to erosion, rapidly thawing soil can lead to increased erosion.

3) **Soil characteristics** also determine erodibility. One of these characteristics is texture – the size or combination of sizes of soil particles. They fall into three broad classifications ranging across small (clay), medium (silt), and large (sand). Soils most susceptible to erosion are those with the largest amount of medium (silt)-size particles. Clay and sandy soils are less prone to erosion.

4) **Ground slope** – its combined length, grade, and surface quality (rough or smooth) – affects erodibility. The longer the slope, the steeper the grade, and the smoother the surface, the larger is the potential for erosion. Along with quantity of rainfall, slope characteristics determine the speed of flow. The faster the water flows, the greater the potential for erosion and sedimentation.

Environmental scientists estimate that, from all sources, more than 4.5 billion tons of sediment pollute the rivers of this country each year. This volume is equivalent to 25,000 100-yard football fields stacked 100 feet high. Experts also estimate that we spend somewhere between $6 and $13 billion in the United States each year to correct the effects of erosion and sedimentation.

Preventive Measures and Erosion Control

During the last 40 years of the twentieth century, nearly one-third of the world's **arable** land was lost to erosion, and topsoils continue to be lost at a nonsustainable rate (i.e., faster than it can be naturally restored). In the United States, the Midwest experiences some of the highest erosion rates, with some states losing between 7 and 10 tons of soil per acre annually.

Water quality can be protected by controlling and minimizing erosion. State and federal laws provide some consideration of erosion and sedimentation control along streams and lakes during flood control, drainage, highway, bridge, and other stream-related construction projects. A variety of programs administered by public and private agencies encompass research projects, education programs, technical assistance, regulatory measures, and cost-share financial assistance for erosion control.

Coordinated efforts by federal and state agricultural programs have been helping reduce the amount of soil erosion and sedimentation. Farmers now utilize a variety of **conservation** practices to reduce erosion and limit sedimentation, such as conservation tillage methods, use of conservation buffers and **riparian** habitat, and establishment of conservation easements. The Natural Resource Conservation Service, state and local conservation districts, and other organizations play critical roles in preserving cropland productivity and limiting adverse water quality impacts.

Preventive measure for reducing excessive sediment load in streams include:

- Proper repair and maintenance of drainage ditches and levees;
- Minimal disturbance of the streambanks;
- Avoidance of structural disturbance of the river;
- Reduction of sediment excesses arising from construction activities;
- Application of artificial and natural means for preventing erosion; and
- Use of proper land and water management practices on the water-shed.

These preventive measures are preferred over remedial measures, which include:

- Construction of detention reservoirs, sedimentation ponds, or settling basins;
- Development of side-channel flood-retention basins; and
- Removal of deposited sediment by dredging.