SOIL QUALITY – URBAN TECHNICAL NOTE No. 1

Erosion and Sedimentation on Construction Sites

USDA NRCS

United States
Department of
Agriculture

Natural
Resources
Conservation
Service

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Urban Technical
Note No. 1

March, 2000

This is the first note in a series of Soil Quality-Urban technical notes on the effects of land management on soil quality.

Introduction

Soil is a crucial component of rural and urban environments, and in both places land management is the key to soil quality. This series of technical notes examines the urban activities causing soil degradation and sedimentation, and the management practices that protect the functions that urban societies demand from soil. This technical note will focus on soil erosion and sedimentation from construction sites.

Off site damage from sediment is the most critical problem facing construction sites. Erosion, which produces this sediment, is accelerated when soil is disturbed, left bare, and exposed to the abrasive action of wind and water. Unless adequate measures are taken to prevent this abnormal, highly accelerated soil removal, it becomes the most visible and damaging factor in the deterioration of soil quality and the environmental quality of urban areas.

Construction Erosion

Although erosion on construction sites often affects only a relatively small acreage of land in a watershed, it is a major source of sediment because the potential for erosion on highly disturbed land is commonly 100 times greater than on agricultural land (Brady and Weil, 1999). Erosion and sediment damages occur both on and off the construction site, and all of society pays for the destructive impacts.

Erosion Impacts

Construction activities, such as grading and filling, drastically reduce soil quality on construction sites. Left unprotected, sites will be further degraded by erosion and begin to adversely affect the surrounding environment. The goal of soil quality management on construction sites is to revegetate for protection against off-site damage and increase soil organic matter levels to remedy the on-site damage caused by site preparation.

On-site impacts: The loss of topsoil, either by actual removal with heavy equipment or erosion by wind and water, is the worst on-site damage in urban areas. This layer of soil has the highest biological activity, organic matter, and plant nutrients—all key components of healthy soil. The on-site loss of this upper layer of soil nearly eliminates the soil's natural ability to provide nutrients, regulate water flow, and combat pests and disease.

- Loss of nutrients and nutrient holding capacity, results in a less fertile environment for lawns and landscape plants. The organic matter and finer soil particles are responsible for soil fertility and are washed away first, leaving larger, less reactive particles such as sand and gravel.
- As organic matter is lost, soil density increases and compaction occurs. Compaction lowers the infiltration rate of water and reduces the available water holding capacity. This results in poorer growth of lawns, gardens, flowerbeds, shrubs, and trees, as well as making the site more susceptible to drought and requiring more frequent watering. Additionally, soil amendments such as fertilizer and pesticides cannot move into the soil and, instead, run off into nearby lakes and streams. Lower organic matter levels are also associated with weaker soil aggregates and therefore greater risk of further erosion and soil crusting.
- The surface organic matter is also the food source and habitat for beneficial microorganisms and insects. The loss of this material drastically reduces the soils natural ability to control disease and pest outbreaks, increasing the need for pesticides. These microorganisms are also key to removing or buffering toxic elements or contaminants.

Off-site impacts: Erosion from construction sites has off-site environmental and economic impacts. Erosion creates two major water quality problems in surface waters and drainage ways: excess nutrients and excess sediment. These problems adversely impact the health and biological diversity of water bodies. More specifically:

- Excess nutrients impact water quality through eutrophication, a process whereby excess nitrogen and phosphorus causes unwanted biological growth.
- Sediment reduces water quality by making the water turbid (cloudy). Turbidity prevents sunlight from penetrating the water and thus reduces photosynthesis and underwater vegetation. Oxygen levels are reduced in turbid waters, further degrading habitat for fish and other aquatic organisms.
- Sediment can build up in stream channels, lowering flow capacity. The problem of low stream capacity is compounded as runoff increases from newly built-up or paved areas and causes stream channels to receive larger amounts of water in shorter periods of time. This leads to more frequent flooding in areas that never or only rarely flooded in the past. In flood-prone areas, levees may need to be built or enlarged to better protect public safety.
- A financial burden results from clean up of sediment-damaged areas. Taxpayers often bear the cost of removing sediment from public roads, road ditches, culverts or streams; not to mention damage to homes and the safety hazards associated with flooding. Other costs of erosion that are borne by the public are degraded soils, a polluted environment, more runoff, greater need for irrigation, and aesthetically unpleasing sites.

Many local governments enforce regulations to control or prevent erosion from construction sites. State and local laws and the Clean Water Act of 1992 can require contractors to develop detailed erosion and sediment control plans before beginning construction projects over approximately 2.5 acres.

Tool for Estimating Erosion on Construction Sites

Soil loss from sheet and rill erosion on construction sites, mined lands, reclaimed lands, and other highly disturbed areas can be estimated using the Revised Universal Soil Loss Equation (RUSLE) version 1.06. A handbook is available to help the user estimate factor values and apply the computer model (Toy and Foster, 1998).

The person in each NRCS State or Basin Area Office with responsibility for RUSLE (typically the state agronomist) should be contacted for assistance with estimating soil loss on construction sites using RUSLE.

Evaluating Management Practices and Developing Alternative Systems

Erosion control practices and management systems can be evaluated and planned using the RUSLE model. The erosion control benefits of cover and management practices such as adding mulch, seeding, and sod can be estimated with the RUSLE conservation management (C) factor. Structural and vegetative practices such as straw bales, silt fences, gravel bags, narrow grass strips or buffers, vegetative barriers, terraces and diversions can be evaluated with the RUSLE conservation practice (P) factor.

Alternative management systems, consisting of combinations of cover and structural practices, can be developed with the RUSLE program. Ideally, these management systems will reduce or control erosion and sedimentation and improve soil quality. Each site and management system must be evaluated individually, since erosion estimates will vary depending on climate, soils, topography, and cover conditions.

The RUSLE model also estimates the amount of sediment delivered to the base of a slope (sediment yield) using the RUSLE P factor. Some temporary practices used on construction sites such as a silt fence placed at the base of the slope will not reduce erosion on the slope but will trap some of the sediment leaving that slope. The RUSLE model estimates this sediment yield, as displayed in Table 1.

Table 1. Effects of management practices on controlling erosion on a road bank. Estimated sheet and rill erosion and sediment yield using RUSLE during a construction year in Nashville, TN[1].

Site Conditions[2] -1st 6 mo	2nd 6 mo	Soil Loss from Road Bank (t/a/y)	Sediment Yield at Base of Slope (t/a/y)
Bare	Bare	400	400
Bare	Bare, Silt Fence	400	250
Bare	Mulch, Seeded	140	140
Bare	Sod, Diversion	40	5

[1]Effects of management will vary under other climatic conditions. For example, soil loss and sediment yield will be 35 % and 80 % less in Chicago and Denver, respectively, than values shown in table.
[2]Roadside cutbank, 100 ft. long at 30% gradient. Site disturbed from March – June. Soil loss and sediment yield during a single construction season. Soil is a silt loam. Silt fence placed at base of slope. Diversion placed in middle of slope.

Principles of Construction Erosion Control

Prevention of urban erosion is best. Here are some basic principles of erosion control on construction sites (adapted from Brady and Weil, 1999):

1. Divide the project into smaller phases clearing smaller areas of vegetation.
2. Schedule excavation during low-rainfall periods, when possible.
3. Fit development to the terrain.
4. Excavate immediately before construction instead of leaving soils exposed for months or years.
5. Cover disturbed soils as soon as possible with vegetation or other materials (mulch) to reduce erosion potential.
6. Divert water from disturbed areas.
7. Control concentrated flow and runoff to reduce the volume and velocity of water from work sites to prevent formation of rills and gullies.
8. Minimize length and steepness of slopes (e.g. use bench terraces).
9. Prevent sediment movement off-site.
10. Inspect and maintain any structural control measures.
11. Where wind erosion is a concern, plan and install windbreaks.
12. Avoid soil compaction by restricting the use of trucks and heavy equipment to limited areas.
13. Soils compacted by grading need to be broken up or tilled prior to vegetating or placing sod.

It is inevitable that soil will be exposed during construction. However, it is essential that the exposed land is minimized, and cover is established as quickly as possible. Conservation practices that provide immediate permanent cover (sod) or provide intermittent cover (mulches and permanent seeding) drastically reduce soil losses and runoff (Table 2). Other supporting practices such as diversions or terraces change slope lengths, thus reducing runoff and erosion. These supporting practices provide temporary protection for vegetation or sod until they become established and provide permanent protection for the site. There are other conservation practices available for construction and urban erosion (NRCS Watershed Science Institute, 2000).

Table 2. Effectiveness of various groundcovers in reducing runoff and soil erosion for a single simulated rain event (3.78 in/h) at University of Maryland's turf grass research facility[1] (adapted from Brady and Weil, 1999).

Material	Soil loss[2] (tons/acre)	% of Rainfall Runoff	% Ground Cover Established[3]
Bare soil with partial cover	2.97	83	50
Woven mesh	0.18	68	61
Wood shavens in non-woven polyester netting	0.36	74	69
Coconut fiber mat	0.48	76	58
Straw (2 t/a)	0.26	60	76
Grass sod	0.04	28	NA

[1]Effectiveness will vary at other locations because of differences in climate, soils and topography.
[2]Soil from Sassafras loamy sand with a 8 % slope and a Matapeake sandy clay loam with a 15% slope.
[3]Percent vegetation cover established one year after Kentucky 31 fescue grass was seeded and covered by various material.

Conclusion

Soil is important but is often an overlooked component of our urban infrastructure. It is especially important in regulating runoff of storm water and in supporting trees, shrubs, lawns, and gardens. Soil erosion during construction is often a serious problem. Many erosion control practices are available in local soil and water conservation district offices. However, the effects of erosion on construction sites continue to menace society both from on-site and off-site damages. Preventing soil-related problems before they occur is easier and more cost effective than correcting them later. Communities need to work with developers, contractors, and local governments to limit compaction and soil loss during construction operations. The result is a soil functioning properly in the urban landscape.

References

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