MAJOR CAUSES & EFFECTIVE SOLUTIONS OF EROSION AND MITIGATION MEASURES

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Abstract-Soil erosion by water is a natural process that cannot be avoided. Soil erosion depends on many factors, and a distinction should be made between humanly unchangeable (e.g., rainfall) and modifiable (e.g., length of the field) soil erosion factors. Soil erosion has both on-site and off-site effects. Soil conservation tries to combine modifiable factors so as to maintain erosion in an area of interest to an acceptable level. Strategies to control soil erosion have to be adapted to the desired land use. Knowledge of soil loss tolerance, *T*, i.e., the maximum admissible erosion from a given field, allows technicians or farmers to establish whether soil conservation practices need to be applied to a certain area or not. Accurate evaluation of the tolerable soil erosion level for an area of interest is crucial for choosing effective practices to mitigate this phenomenon. Excessively stringent standards for *T* would imply over expenditure of natural, financial, and labor resources. Excessively high *T* values may lead to excessive soil erosion and hence decline of soil fertility and productivity and to soil degradation. In this last case, less money is probably spent for soil conservation, but ineffectively. Basic principles to control erosion for different land uses include maintaining vegetative and ground cover, incorporating biomass into the soil, minimizing soil disturbance, increasing infiltration, and avoiding long field lengths. Preference is generally given to agronomic measures as compared with mechanical measures since the former ones reduce raindrop impact, increase infiltration, and reduce runoff volumes and water velocities. Agronomic measures for soil erosion control include choice of crops and crop rotation, applied tillage practices, and use of fertilizers and amendments. Mechanical measures include contour, ridging, and terracing. These measures cannot prevent detachment of soil particles, but they counter sediment transport downhill and can be unavoidable in certain circumstances, at least to supplement agronomic measures. Simple methods can be applied to approximately predict the effect of a given soil conservation measure on soil loss for an area of interest. In particular, the simplest way to quantitatively predict mitigation of soil erosion due to a particular conservation method makes use of the Universal Soil Loss Equation (USLE). Despite its empirical nature, this model still appears to represent the best compromise between reliability of the predictions and simplicity in terms of input data, which are generally very difficult to obtain for other soil erosion prediction models. Soil erosion must be controlled soon after burning.

Keywords- *soil erosion, soil loss tolerance; on-site and off-site erosion impacts ; burned areas; erosion modeling for soil conservation.*

What is Soil Erosion?

Soil erosion is, at its core, a natural process. Put simply, it is when topsoil, which is the upper-most layer of the ground, is moved from one spot to another. Why this matters is because topsoil is the part of the land that is highest in organic matter and best suited for farming and other fertile activities, which is why soil erosion can have the greatest impact on farmers and agricultural land. In other words, soil erosion is a naturally occurring and slow process that refers to loss of field's top soil by water and wind or through conversion of natural vegetation to agricultural land.

When farming activities are carried out, the top soil is exposed and is often blown away by wind or washed away by rain. When soil erosion occurs, the movement of the detached topsoil is typically facilitated by either a natural process – such as wind or water movement – or by the impact of man, such as through tilling farmland.

The process of soil erosion is made up of three parts:

- Detachment: This is when the topsoil is actually "detached" from the rest of the ground.
- Movement: This is when the topsoil is relocated to another area.
- Deposition: Where the topsoil ends up after this process.

Fig.1

"*Soil erosion is one form of soil degradation. Soil erosion is a naturally occurring process on all land. 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.*"

When it comes to our planet, natural resources are typically affected by two things – either naturally-occurring ones such as weather, or from man-made influence. Soil erosion, or the gradual reduction of topsoil in a geographic area, can be caused by both natural and unnatural processes, but it can also have great effects on inhabitants of an affected area. One of the major concerns regarding soil erosion is that it can permanently affect the land, which can be devastating for farmers or those with agricultural pursuits.

Unfortunately, many people are still uneducated about soil erosion, which is leading to the occurrence in greater amounts around the world. Soil erosion contributes to pollution in adjacent water sources and reduces cropland productivity. Major crops that cause soil erosion include coffee, cotton, tea, tobacco, palm oil, soybean and wheat that can increase soil erosion beyond the soil's ability to maintain itself.

Causes of Soil Erosion

As mentioned, the predominant causes of soil erosion are either related to naturally-occurring events or influenced by the presence of human activity. Some of the principal causes of soil erosion include:

- Rain and rainwater runoff: In a particular heavy rain, soil erosion is common. First of all, the water starts to break down the soil, dispersing the materials it is made of. Typically, rainwater runoff will impact lighter materials like silt, organic matter, and finer sand particles, but in heavy rainfall, this can also include the larger material components as well.
- Farming: When land is worked through crops or other agricultural processes, it reduces the overall structure of the soil, in addition to reducing the levels of organic matter, making it more susceptible to the effects of rain and water. Tilling in particular, because it often breaks up and softens the structure of soil, can be a major contributor to erosion. Farming practices that reduce this activity tend to have far less issues with soil erosion.

- Slope of the land: The physical characteristics of the land can also contribute to soil erosion. For example, land with a high hill slope will perpetuate the process of rainwater or runoff saturation in the area, particularly due to the faster movement of the water down a slope.
- Lack of vegetation: Plants and crops help maintain the structure of soils, reducing the amount of soil erosion. Areas with less naturally-occurring flora may be a hint that the soil is prone to erosion.
- Wind: Wind can be a major factor in reducing soil quality and promotion erosion, particularly if the soil's structure has already been loosened up. However, lighter winds will typically not cause too much damage, if any. The most susceptible soil to this type of erosion is sandy or lighter soil that can easily be transported through the air.

Effects of Soil Erosion

A major problem with soil erosion is that there is no telling how quickly or slowly it will occur. If largely impacted by ongoing weather or climate events, it may be a slow-developing process that is never even noticed. However, a severe weather occurrence or other experience can contribute to rapid-moving erosion, which can cause great harm to the area and its inhabitants.

Some of the greatest effects of soil erosion include:

- Loss of topsoil: Obviously, this is the biggest effect of soil erosion. Because topsoil is so fertile, if it is removed, this can cause serious harm to farmer's crops or the ability to effectively work their land.
- Soil compaction: When soil under the topsoil becomes compacted and stiff, it reduces the ability for water to infiltrate these deeper levels, keeping runoff at greater levels, which increases the risk of more serious erosion.
- Reduced organic and fertile matter: As mentioned, removing topsoil that is heavy with organic matter will reduce the ability for the land to regenerate new flora or crops. When new crops or plants can't be placed successfully in the area, this perpetuates a cycle of reduced levels of organic nutrients.
- Poor drainage: Sometimes too much compaction with sand can lead to an effective crust that seals in the surface layer, making it even harder for water to pass through to deeper layers. In some ways, this can help erosion because of the densely packed soil, but if it perpetuates greater levels of runoff from rainwater or flooding, it can negatively impact the crucial topsoil.
- Issues with plant reproduction: When soil is eroded in an active cropland, wind in particular makes lighter soil properties such as new seeds and seedlings to be buried or destroyed. This, in turn, impacts future crop production.
- Soil acidity levels: When the structure of the soil becomes compromised, and organic matter is greatly reduced, there is a higher chance of increased soil acidity, which will significantly impact the ability for plants and crops to grow.
- Long term erosion: Unfortunately, if an area is prone to erosion or has a history of it, it becomes even harder to protect it in the future. The process has already reduced the soil structure and organic matter of the area, meaning that it will be harder to recover in the long run.
- Water pollution: A major problem with runoff from soils – particularly those used for agricultural processes – is that there is a greater likelihood that sediment and contamination like the use of fertilizer or pesticide. This can have significant damage on fish and water quality.

Fig.2 Solutions for Soil Erosion

When it comes to finding solutions for soil erosion, the most useful techniques found tend to be those that emphasize reinforcing the structure of the soil, and reducing processes that affect it.

- Careful tilling: Because tilling activity breaks up the structure of soil, doing less tilling with fewer passes will preserve more of the crucial topsoil.
- Crop rotation: Plenty of crop rotation is crucial for keeping land happy and healthy. This allows organic matter to build up, making future plantings more fertile.
- Increased structure for plants: Introducing terraces or other means of stabilizing plant life or even the soil around them can help reduce the chance that the soil loosens and erodes. Boosting areas that are prone to erosion with sturdy plant life can be a great way to stave off future effects.
- Water control: For those areas where soil erosion is predominantly caused by water – whether natural or man-made – specialized chutes and runoff pipes can help to direct these water sources away from the susceptible areas, helping stave off excess erosion. Having these filters in particular areas rather than leading to natural bodies of water is a focus to reduce pollution.
- Increased knowledge: A major factor for preventing soil erosion is educating more and more people who work with the land on why it is a concern, and what they can do to help reduce it. This means outreach to farmers in susceptible areas for ways that they can help protect crops from inclement weather, or ways that they can help make sure their soil remains compact without restricting their plant growing activities.

Experiment: the importance of cover

The importance of cover was shown in an experiment at Mt Mort, near Ipswich (see table below). In treatment C, where the land was almost bare, 70% of rainfall from a 54mm storm was lost as runoff. The soil loss from this one event was 22 tonnes per hectare. Treatments A and B with higher cover levels had much less runoff, soil and nutrient loss.

It can take thousands of years to form an inch of soil. The depth of soil lost from treatment C from this one storm event may take hundreds of years to replace, provided no further erosion occurs.

Table 1. Results from a 54mm storm at Mt Mort.

Treatment	A	B	C
Per cent cover	87	69	6
Total runoff from storm (mm)	1.5	14	38
Per cent of rainfall that ran off	3	26	70
Soil loss (t/ha)	0.03	0.3	22
Depth of soil lost (mm)	0.002	0.02	1.7
Sediment concentration (g/L)	1.5	1.9	63
Nitrogen removed (kg/ha)	0.14	1.9	15.3
Phosphorous removed (kg/ha)	0.02	0.26	4.3

Using trees to control erosion

Trees are often considered to be the universal answer to control soil erosion. Tree roots help prevent landslides on steep slopes and stream bank erosion but they don't stop erosion on moderately sloping hillslopes.

In forests, the soil surface is usually protected by a layer of mulch from decaying vegetation as well as a variety of surface growing plants. If the soil is bare under the tree canopy from over grazing, vehicles or pedestrians, soil erosion will still occur.

Fig.3 Bare soil under trees is susceptible to erosion

Erosion control in cropping lands

Tillage

Conservation cropping practices that maintain cover on soils include minimum and zero tillage practices. Nowadays during the fallow period, farmers use tillage implements that kill weeds without burying stubble and herbicides to minimise the frequency of tillage.

Contour banks and strip cropping

Runoff concentration is managed by structural measures such as contour banks in upland areas, or strip cropping on floodplains. These systems involve a total change in the way a farm is managed.

Runoff systems must be carefully planned. Flow between properties and across roads and railway lines must be coordinated and suit those affected by the changes.

Fig.4 Conservation cropping practices—a soybean crop planted directly into wheat stubble without any prior tillage

When runoff water can impact neighbouring properties or infrastructure, land owners are encouraged to discuss with their neighbours and seek professional advice.

Approximately 80% of soil lost as a result of poor cover can be trapped in the paddock by contour banks. The banks channel the runoff at low speed into grassed waterways. Good surface cover between contour banks and in waterways will ensure their stability and dramatically reduce the amount of soil deposited in waterways.

Fig.5 Strip cropping over a floodplain on the Darling Downs

On flood plains, strip cropping is used to spread flood flows rather than allowing it to concentrate.

Green cane harvesting

Another measure that maintains soil cover is green cane harvesting or 'trash blanketing'. When a cane crop is harvested, the leaves and tops of the cane are left on the ground as a 'trash blanket'. This protects the soil from erosion by raindrop impact. This practice has been widely adopted in many Queensland cane growing districts.

Fig. 6 Well-maintained contour banks (left) and grassed waterways (right)

Fig.7 Green cane harvesting on a paddock in North Queensland

Erosion control in grazing lands

Surface cover

Surface cover is the key to erosion control in grazing lands. It prevents erosion by maintaining the soil so it can absorb rainfall.A well-managed pasture with good cover will ensure that runoff spreads rather than concentrates. Bore drains, tracks, roads, cattle pads and fences concentrate runoff, so careful planning is required to ensure that property improvements are located where they will not contribute to erosion.The critical level of cover for pastures in tussock grasslands is about 40% cover and 1000 kilograms per hectare of dry grass. Ideally, this level of cover will exist at the beginning of the summer storm season.

The ideal stocking rate is flexible, and stock numbers should match available feed. Regular monitoring of pastures is necessary to achieve this. Long-term weather forecasting, using predictive tools such as the Southern Oscillation Index (SOI), has improved the options available for predicting droughts.

Opportunistic spelling

Opportunistic spelling should also be part of a grazing strategy. A total spell in a good year may be required to allow desirable grasses to recover from past grazing. Grazing pressure can also be managed by locating watering points away from areas vulnerable to erosion.

Fire

Fire is useful for controlling woody weeds but it needs to be managed carefully. Regular burning of pastures will further reduce ground cover and promote runoff and erosion.

Fig.8 Use of a sediment fence and grassed strips on a development near Sinnamon Park, Brisbane

Managing erosion in urban areas

Queensland’s rapidly increasing population and continued economic development require numerous construction projects and activities that expose soils to erosion.

The following approaches will help reduce erosion on development sites:

- disturb minimal area when excavating
- where possible, divert upslope stormwater around the work site and other disturbed areas
- install sediment barriers (e.g. sediment fences or turf buffer strips) downslope of the building site to filter coarse sediments
- restrict vehicle access to one entry point where possible. Gravelling the access point will allow all weather access and minimise erosion.
- connect a temporary or permanent downpipe to a stormwater system before laying the roof

- place all stockpiles on the construction site and behind a sediment barrier
- landscape all bare areas as soon as possible after construction is completed.

Concluding remarks

Much progress has been made in developing techniques tominimize the impact of landslides, although new, moreefficient, quicker and cheaper methods could well emerge inthe future. There are a number of levels of effectiveness andlevels of acceptability that may be applied in the use of thesemeasures, for while one slide may require an immediate andabsolute long-term correction, another may only requireminimal control for a short period.

Whatever the measure chosen, and whatever the level ofeffectiveness required, the geotechnical engineer andengineering geologist have to combine their talents andenergies to solve the problem. Solving landslide relatedproblems is changing from what has been predominantly anart to what may be termed an art-science. The continualcollaboration and sharing of experience by engineers andgeologists will no doubt move the field as a whole closertoward the science end of the art-science spectrum than it is atpresent.

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