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THE MEASUREMENT AND FIELD EXPERIMENT DESIGN OF SOIL EROSION.

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ABSTRACT

Soil erosion is one of the critical problems in Southeast Asia, mainly due to high rainfall intensities, poor soil condition, improper land use management and practice, particularly in upland agriculture. Soil loss creates environmental impact to the point where soil particles detached (on-site) and sediment deposited (off-site). Erodibility varies with the soil texture, aggregate stability, shear strength, infiltration, and organic and chemical content. Climate, soil, topography and vegetation are the contributing factors to the soil erosion. The geological and accelerated are two general forms of soil erosion. Surface erosion may be classified according to the mechanism, which cause erosion. There are splash, sheet, rill and gully erosions. Soil erosion can be quantified using several techniques such as pin erosion, rill and gully, sediment yield, stream and channel, erosion plot (using soil erosion gauge) and universal soil loss equation methods.

Keywords: *Soil erosion, Rainfall Intensities, Erodibility, Sediment Yield, Soil Erosion Gauge, Soil Loss Equation*

INTRODUCTION

Soil erosion is the detachment, entrainment and transport of soil particles form their place to origin by the agents of erosion, such as water, wind and gravity. It is a form of land degradation and can be categorized as either geological or accelerated erosion. The former is a part of the natural wearing down of the earth's land surface and occurs at rates ranging from virtually imperceptible soil creep to dramatic sudden landslides. The latter results from human activities exposing the soil surface and thus enabling erosive agents such as rain to wash away topsoil and the underlying weathered rock. In the tropics this agent is mainly water. Soil erosion is one of the critical problems in Southeast Asia, mainly due to high rainfall intensities, poor soil condition, improper land use management and practice, particularly in upland agriculture.

Soil erosion creates environmental impact to the point where soil particles detached (on-site) and sediment deposited (off-site). The on-site effects are the loss of productivity due to reduction on soil fertility, water holding capacity, organic matter content matter and depth of soil. On the other hand, the off-site effects may include siltation of reservoirs, lakes, rivers, flood plains and highways. Although soil resistance to erosion depends in the part on topographic position, slope steepness and the amount of disturbance created by man, for example during tillage, the properties of the soil are the most important determinants. Erodibility varies with the soil texture, aggregate stability, shear strength, infiltration, organic and chemical content (Morgan 1995).

FACTORS INFLUENCING SOIL EROSION

There are four factors contributing to the extent and magnitude of soil erosion (Baver, et al, 1972). These factors are climate, soil, topography and vegetation.

Climate

Rainfall, temperature, solar energy and wind are the major climatic factors that influence soil erosion; of which rainfall is the most important factors. Rainfall amount, duration, intensity and indices influence the magnitude of soil loss. Rainfall indices are based on kinetic energy of the rain. The rainfall indices such as Wischmeier's, EI_{30}, Hdson's, KE>25 and Lal's, AI have been used in many soil erosion studied in the temperate as well as in Malaysian conditions (Maene and Wan Sulaiman, 1980)

Soil

The effects of soil properties on soil erosion are manifested in two ways. These properties determine the rate of rainfall entering the soil and the magnitude of depression and erosion. The properties related to the former are porosity and organic matters content, while to the latter are aggregate stability and permeability. While properties common to both are soil structure, texture and infiltration capacity. In Malaysia, soil with clay content is exceeding 27% and sand content less than 45% is classified as less erodable. On the other hand soil with less than 27% clay and more than 45% sand is classified as more edorable (Wong, 1970)

Topography

The degree and length of the slope are two essential of topography in relation to runoff and soil erosion. Dunne (1977) observed that topographic steepness is a significant factor affecting sediment yields. The affective slope length is measured from the beginning of overland flow to the point where sediment deposited or channeled. The slope roughness is another feature to be considered in topographic factor.

Vegetation

Vegetation cover helps in reducing erosion by absorbing the energy of raindrops and reducing surface runoff. An unbroken and thick litter layer, forest debris, branches and fibrous roots of the forest floor also functioned to absorb the energy of raindrops. Roots and residue physically restrained soil movement, improved aggregation and soil porosity, increased biological activities and increase storage capacity by decreasing soil moisture through transportation. Equally important in protecting the soil is the density and distribution of plant covers the surface.

There are two other factors that should be considered in soil erosion study, namely human-related and animal-related factors (O, Loughlin, 1985). The former involved land clearing for conversion to other types of land use, such as agriculture, urban development, settlement, highways and forest harvesting activities (logging road construction, tree feeling, log skidding and transportation). The latter involved activities such as over grazing or over browsing by domestic livestock or wild animal populations.

FORMS OF EROSION

There are two forms of soil erosion:

Geological Erosion

Geological erosion or natural erosion that results from the force of nature occurs under undisturbed and vegetated conditions. The rate of soil formation is equal to the rate of topsoil loss by erosion. Under forest condition the rate of natural erosion is usually less than 1 t/ha/y (Baharuddin, 1992).

Accelerated Erosion

Accelerated Erosion is due to fire or human disturbances such as forest clearing, agriculture and urban development. In this type of erosion, soil is exposed to the influence of erosion agent. In forest harvesting operations, the main activities affecting soil erosion are road construction, river crossing, and construction of bridge and log skidding.

Surface erosion may be classified according to the mechanism, which cause erosion.

Splash erosion

Splash erosion results from the impact of water, which drops directly on moist soil. The splash can be muddy or turbid. When the turbid water enters the soil, it plugs the pore spaces and as raindrops continue to fall, the soil surfaces become compacted and reduced the infiltration rate. Splash erosion during an intense storm on bare and unvegetated surface could be identified by the formation of pedestals beneath protecting materials such as stones, stems, shells and roots.

Sheet Erosion

Sheet erosion occurs on a surface soil when overland flow transports the detached soil material. This is the most widespread and probably the most damaging form of erosion by water. Essentially, it refers to the uniform removal of a thin layer or "sheet" of soil from a given area of land. Normally, the soil is detached by the impact of falling raindrops and then removed by surface runoff. Besides the removal of soil, sheet erosion also results in soil compaction and the formation o an impervious layer, 2 to 6 cm below the soil surface (Bennet, 1947).

Rill Erosion

Rill erosion occurs when soil removed by water from small well-defined channel during concentration of overflow. Detachment of soil particles is primarily initiated by the energy of the flowing water, not by the raindrop impact as in sheet erosion. The amount of soil particles detached by moving water is proportional to the square of its velocity and its transporting power varies as the fifth of its velocity (Govers, 1989). .

Gully Erosion

Gully erosion produces channels bigger than rill erosion. There is a wide range a gully size, depending on where the gullies are located, their age and the many conditions contributing to their development. They may be narrow and only 1 m deep or they may range to enormous sizes from 12 m to 15 m deep and 30 m to 40 m wide (FAO, 1965).

Landslides

Landslide is the movement of soil body which includes rocks due to gravitational pull. They occur on steep sloped where a large amount of soils slide downhill, uprooting trees and burying others. Landslide has been identified one of main erosion processes and sediment source in tropical forests.

MEASUREMENT OF SURFACE EROSION

There are various ways to quantify surface erosion.

Pin Erosion

This is a simple way to measure sheet erosion on hill slopes. In this technique, a 40 cm iron rod with half of its length is embedded into the ground. The difference in the length of the iron rod exposed indicates the amount of soil loss. The pin erosion may be installed either in a specified grid pattern on a hill slope or in transacts down slope.

Rill and Gully Erosion

The amount of soil loss from rill or gully erosion can be quantified by measuring the cross section areas of rill or gully. At selected study sites, horizontal measurement of transacts will be dome at a minimum of three transacts located at the base, middle and upper slopes. These transacts are at equal intervals with no measurements done at the top of the slope.

Sediment Yield

The rate of soil erosion can also be measured in terms of sediment yield from a watershed. Sediment yield is referred to as the total suspended and bedload sediments discharged at the lower end of a measuring station of a catchment. Suspended sediment is the sediment that is supported by upward components of turbulent current and stays in suspension for an appreciable length of time. Bedload sediment is the sediment that moves along the bottom of stream in a tolling, sliding or saltating mode. It refers to coarser materials such as gravel, stones and boulders.

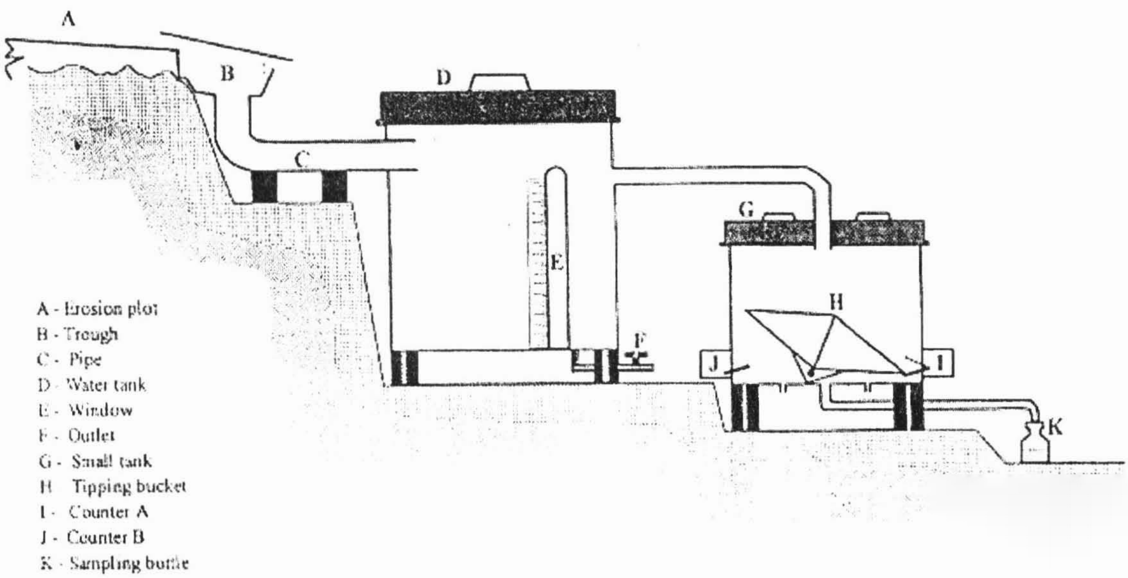
Suspended sediment concentration is determined from the stream water collected on weekly or monthly basis during storm flow and baseflow period. Bedload sediment is measured monthly or six monthly or using bed load sampler or by measuring the volume of sediment accumulated un the sediment trap. The total sediment yields indicate the amount of soil loss from the catchments. It can be expressed in kg/ ha by dividing the sediment yield value with catchments area. The sources of these eroded materials are from rill, gully, streambank and streambed erosion.

Stream-channel Erosion

The simplest way to monitor changed in stream-channel morphology is by cross-section survey. A permanent benchmark is established at each end of a survey line. The information gathered from channel cross-section survey includes aggradation and degradation of the bed and channel width. Resurvey may be made at yearly interval to observe long-term changes or after highflows to observe the effects of individual floods on the channel. Measurement of streambank erosion can be accomplished by driving a series of pin erosion horizontally into the bank. As the bank is eroded greater part of the pin is exposed. This additional amount of pin exposure represents the bank erosion.

Erosion plot

An erosion plot is another way to measure surface erosion. The plot is defined on three sides by metal sheeting inserted to a depth of about 10cm with its long axis in the downslope direction. The lower is connected to through used to collect surface runoff and erosion products from the plot during rainfall. The size of the plot varies according to the objective of the study. For example, in a study to estimate soil loss from different surface conditions under mature oil plantation, a plot size 4 x 22.1m was used (Maene et.al.1979). The amount of surface runoff and eroded materials from plot is measured using equipment called " soil erosion gauge". The main components of the gauge are trough, water tank, small tank equipped with tipping-bucket, counter and sample bottle. The components are arranged as shown in Diagram 1.



Daigram 1: The Soil Erosion Gauge

The surface runoff generated from the plot flows into the trough and collects in the water tank. The water level in the tank is read from the vertical scale fixed at the window of the water tank. If overflow occurred due to heavy rainfall, it will be measured by tipping-bucket system in the small tank. Every tip will be counted by the number of tips are recorded by counters A and B which are fixed at both sides of the small tank. At the same time water samples are collected using sampling bottle.

The total surface runoff from the plot is the sum of water accumulated in the water tank and number of tips shown in counters A and B. For this equipment 1 tip is equivalent to 1 liter. The runoff samples from water tank and sampling bottle are collected for sediment concentration analyses. The sediment analyses will be done in the laboratory by gravimetric method. Data collection could be done after every rainfall event or on weekly basis. This depends on accessibility available at the research site. Bedload sediment (if any), which settled in the tank, is also measured.

Universal Soil Loss Equation (USLE)

Empirical equations have been used extensively in United States to estimate soil loss from a cropped field under specific combination of soil slope, cropping system and management. These soil-loss equations undergo continuous modification with the availability of more research data. At present a new equation has been developed which has universal application. The new equation improves localized soil-loss predictions without drastically changing basic concepts and application procedure of the older equation. The equation is as follows (Agricultural Research Service, 1961):

$$A=RKLSCP$$

Where

A- soil loss in tone per unit area and time interval
K- soil credibility factor
R- rainfall factor
L- length slope factor
S- slope gradient factor
C- crop management factor and,
P- conservation practice factor

The above equation provides an estimate of surface erosion that can be applied not only for agricultural land but also for non- agricultural situations, such as construction sites and undisturbed lands. Since this equation is not universally applicable for forest environmental conditions, attempts have been made to develop a Modified Soil Loss Equation (MSLE). To adapt the USLE to forest conditions, the crop management factor (C) and conservation practice factor (P) have been replaced by a vegetation management factor (VM) in the MSLE. The Modified Soil Loss Equation is given as:

$$A=R\ K\ LS\ VM$$

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