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Applied systems approach to wind erosion control engineering model

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Abstract

This study deals with the supplied systems approach to wind erosion and control engineering. Many humid regions of the world are damaged by wind erosion, wind distribution with height; wind erosion types, mechanics and control engineering, estimation of wind have been treated.

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Introduction

Stanhill 1969, Tannest Pelton 1960, and Chepil 1945, have conducted research studies relevant to wind erosion control engineering model. Similarly Chepil, et al 1962, Hagen 1991 and Hailsted et al 1936 did studies on planet factor for estimating wind erosion in farn, wind erosion prediction system and soil moisture respectively in the same vain Bagnold 1941, Chepil 1944 and 1941 work on the physics of blown sand utilization of crop residues and wind erosion of soil accordingly. Wind erosion not only removes soil, but also damages crops, fences, buildings, and highways. Fine soil particles are lost along with nutrients, which can result in reduced crop yields the areas most subject to damage are the sandy soils along streams, lakes, and coastal plains and the organic soils.

Materials and Method

Wind velocities are measured at a height at major airports and first – order weather stations. For other heights, such as required for predicting evapo transpiration, velocities can be estimated since they vary approximately as the logarithm of the height. A mean wind velocity – profile equation over stable surface is

$$U_z = \frac{u^*}{K} \text{In} \frac{(z-d)}{z_0} \quad \text{equt (1)}$$

where u_{z} = wind velocity at z height (L/t),

U_* = friction velocity (L/T) = $(t_{o/p})$ ½

To = shear stress at the boundary (F/L2),

p = air density (M/L3),

k = von Karman's constant, usually taken as 0.4,

z = height above a reference surface (L),

d = an effective surface roughness height (L),

z_0 = a roughness parameter (L)

The friction velocity u_* is a characteristic velocity in a turbulent boundary layer. The equation is valid only in the first few meters of height above the surface under neutral temperature conditions. These conditions exist when no heat is added or subtracted from the surface. Over short crops and smooth surfaces, the effective roughness height *d* is small or nearly zero. Both *d* and the roughness parameter z_0 are subject to considerable variation as crops bend and weave with the wind. For a wide range of crops, Stanhill (1969) found the equation.

$$d = 0.7h \quad \text{equt (2)}$$

Applies where *d* is the effective roughness height and *h* is the crop height. The roughness parameter z_0, as defined in equ 2, is the height above d where the velocity profile extrapolates to zero. It can be estimated (Tanner and Pelton, 1960) from

$$z_0 = 0.13h \quad \text{equt (3)}$$

Saltation is the process where fine particles (0.1 to 0.5 mm in diameter) are lifted from the surface and follow distinct trajectories under the influence of air resistance and gravity. When the particles return to the surface, they may rebound or become embedded when impacting the surface, but in either case, they initiate movement of other particles to create an "avalanching" effect of additional soil movement. Most saltation occurs within 0.3m of the surface.

Suspended finer aloft for an extended period. Suspended particles are often abraded by saltating particles and represent 3 to 10 percent of eroding particles. Sand-sized particles or aggregates (0.5 to 2mm in diameter) are set in motion by the impact of saltating particles, and tend to roll or creep along the surface. Creep has been shown to account for 7 to 25 percent of soil movement (Chepil, 1945).

For a precise understanding of the mechanics of wind erosion engineering model, an analysis .must be made of the nature and magnitude of the forces as they react on soil particles. The wind erosion process may be divided into the three simple but distinct phases: (1) initiation 'of movement (2) transportation and (3) deposition.

Soil movement is initiated as a result of turbulence and velocity of the wind. The fluid threshold velocity is defined as the minimum velocity required producing soil movement by direct action of the wind, whereas the impact threshold velocity is the minimum velocity required to initiate movement from the impact of soil particles carried in saltation. Except very near the surface and at low velocities (less than about 1 m/s), the surface wind is always turbulent. Wind speed of 5 m/s or less at 0.3-m height are usually considered nonerosive for mineral soils.

The quantity of soil moved is influenced by the particle size, gradation of particles, wind velocity, and distance across the eroding area. Winds, being variable in velocity and direction, produce gusts with eddies and cross currents that life and transport soil. The quantity of soil moved varies as the cube of the particle diameter, and the constant threshold velocity, the square root of the particle diameter, and the gradation of the soil.

The rate of soil movement increases with the distance from the windward edge of the field or eroded area. Fine particle drift and accumulate on the leeward side of the area or pile up in dunes. Increased rates of soil movement with distance from the windward edge of the field or eroded area. Fine particles drift and accumulate on the leeward side of the area or pille up in dunes. Increased rates of soil movement with distance from the windward edge of the area of the area subject to erosion are the result of increasing amounts of erosive particles, thus causing greater abrasion and a gradual decrease in surface roughness.

Estimating wind erosion

The wind erosion is not a simple product of erodibility parameters, but is a set of complex relationships among that parameter that effects erosion. Currently monograph solutions are available and widely used. Computer model are being developed that will eventually replace the graphical solutions (Skidmore et al., 1970; Hagen, 1991). The wind erosion model is denoted as

$E=f(I,K,C,L,V)$ equt (4)

Where E = the estimated average annual soil loss (Mg/ha-year),

I = the soil erodibility index (Mg/ha-year),

K = the ridge roughness factor,

C = climate factor,

L = unsheltered length of eroding field in meters,

V = vegetative cover factor,

The above factor are not independent, but must be combined to estimate wind erosion. The wind erodibility I is a function of the soil aggregates greater than 0.84mm in diameter. The following regression equation was developed from estimates of I given in Woodruff and Siddoway (1965),

$I = 525 \times (2.718)^{(-0.04F)}$

Where I is the wind erodibility, and F is the percentage of dry soil fraction greater than 0.84mm. The fraction of dry soil can vary during the season and can also be altered with changes in soil water content and organic matter.

Results

Table 1 revealed soil erodibility values for different textures of soil. Increased wind erosion has also been observed on knolls, and table .2 denoted adjustment factors.

Computer models will have the ability to include tillage effects on soil roughness and edibility (Hagen, 1991). The roughness factor K is a measure of the effect of ridges made by tillage and planting implements on erosion rate. Ridges absorb and deflect wind energy, and trap moving soil particles. Too much roughness, however, causes turbulence which may accelerate particles movement. Ridge roughness can be estimated from the equation

$K = 4 \frac{H^2}{D}$ equt (5)

Where k = ridge roughness in mm

H = ridge height in mm

D = ridge spacing in mm

Table 1. Wind erodibility indices for different soil textures.

Predominant Soil Texture	Erodibility Group	Soil Erodibility Index I[a] (Mg/ha-year)
Loamy sands and sapric organic material	1	360-700
Loamy sands	2	300
Sandy loams	3	200
Clay and clay loams	4	200
Calcareous loams	4L	200
Noncalcareous loams, silt loam<20 percent clay, and hemic organic soils	5	125
noncalcareous silty clay loam>20 percent clay	6	100
Silt, noncalcareous silty clay loam and fabric organic soils	7	85
Wet or rocky soil not susceptible to erosion	8	-

The I factor for group 1 vary from 360 coarse to 70 for very fine sands. Use 500 for an average.

Table 2. Knoll erodibility adjustment factors.

Slope Change in Prevailing Wind Erosion Direction (%)	Knoll Adjustment to 1 (factor)	Increase at Crest Area Where Erosion is Most Severe (factor)
3	1.3	2.5
4	1.6	1.9
5	1.9	2.5
6	2.3	3.2
8	3.0	4.8
10	3.6	6.8

Source SCS (1988)

Be multiplied by 1 to account for the increased erosion on windward sides and tops of knolls.

From the ridge roughness K. factor K can be calculated by the regression relationship rive from woodruff and Siddway (1965):

$$K = 0.34 + 12 + 6.2 * \frac{10 - 6k2}{(k + 18)} \quad \text{equt (6)}$$

If there is a dominant wind direction, and are normal to that direction then K is assumed to equal regardless of the soil roughness.

Discussion

Woodruff and Zigg (1952) found that the distance of full protection from a windbreak is

d = 17h (vm/v)cos

where d = distance of full protection (L),

h = height of the barrier in the same units as d (L),

vm = minimum wind velocity at 15-m height required to more the most erodible soil fraction (L/T),

v = actual wind velocity at 15-m height (L/M),

O = the angle of deviation of prevailing wind direction from the perpendicular to the windbreak.

The Chief Advantages of Strip Cropping are

(1) physical protection against blowing, provided by the vegetation

(2) Soil erosion limited for a distance equal to the width of strip

(3) Greater conservation of water particular from snowfall and

(4) The possibility of earlier harvest.

The chief disadvantages are machine problem in arming narrow strip and greater number of edge to protect in case of insect infestation.

Conclusion

From the researched study findings it is noted that close- growing crops are more effective for erosion control than are interfiled crops. The effectiveness of crops is dependent on stage of growth, density of cover, row direction, width of rows, kind of crop, and climatic conditions.

The study involving applied systems approach to wind erosion control engineering is analyzed. The study suggested several methods of adopted for control measures or wind erosion as indicated above

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