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Mechanism of Wind Eroson and Soil Loss Estimation

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SUMMARY

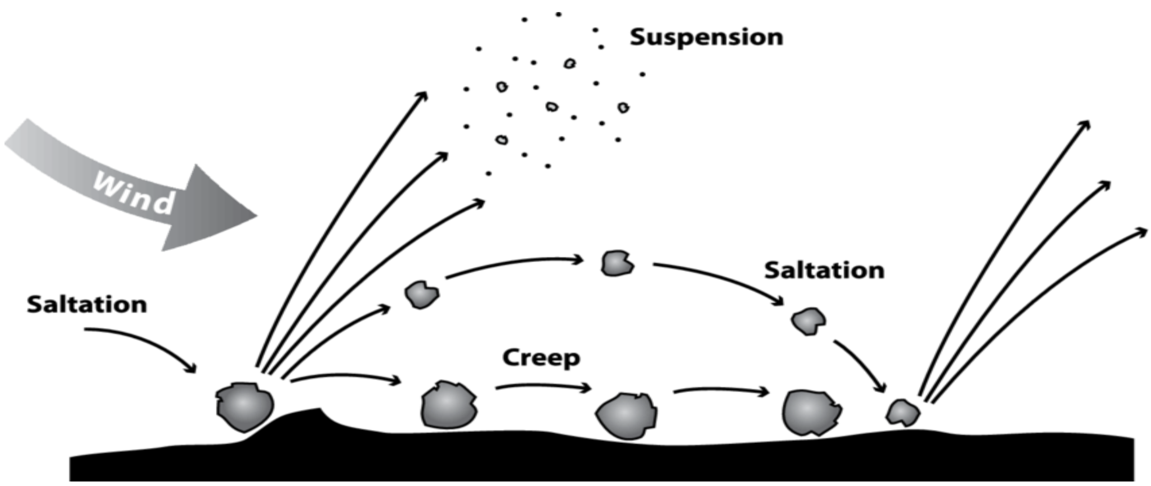
Erosion of soil by the action of wind is known as wind erosion. It is a serious problem on lands devoid of vegetation. It is more common in arid and semiarid regions. It is essentially a dry weather phenomenon stimulated by soil moisture deficiency.

INTRODUCTION

The process of wind erosion consists of three phases initiation of movement, transportation and deposition. About 33 M ha in India is affected by wind erosion. This includes'23.49 M ha of desert and about 6.5 M ha of coastal sands.

Mechanism of Wind Erosion

Lifting and abrasive action of wind results in some detachment of tiny soil particles from the granules or clods. The impact of these rapidly moving particles dislodge other particles from clods and aggregates. These dislodged particles are ready for movement. Movement of soil particles in wind erosion is initiated when the pressure by the wind against the surface soil grains overcomes the force of gravity on the grains. Certain minimum wind velocity is needed to initiate movement of soil particles. The velocity at which movement of most erodable soil particles is initiated is known as minimum fluid threshold velocity, It depends on the size and weight of soil particles arid the friction provided by neigbhouring particles. This threshold velocity is the lowest for grains of 0.1 - 0.15 mm dia. Velocities exceeding about 3 km hr1 are turbulent and are responsible for initiating the process of wind erosion. As the wind velocity increases beyond this minimum, bigger particles start moving till the movement of almost all the size of particles in a soil containing only erodable fractions is initiated. This critical velocity is known as maximum fluid threshold velocity. In practice, no maximum fluid threshold velocity exists as the soils contain both erodable and non-erodable fractions together. Minimum wind velocity necessary for initiating the movement of most erodable soil particles (about 0.1 mm dia) is about 16 km hr-1 at a height of 30.5 cm. Most practical limit under field conditions, where a mixture of sizes of single grained material present is about 21 km hrl at a height of 30.5 cm. Particles of about 0.1 mm dia. have a size-weight relationship which is most conducive to initiate the movement. In general, transportation of soil particles by wind takes place in three stages: saltation, suspension and surface creep.



Mechanism of Wind Erosion

Saltation

It is the movement of soil particles by a short series of bounces along the ground surface. It is due to the direct pressure of wind on soil particles and their collision with other particles. After being rolled by the wind, soil particles suddenly leap almost vertically to form the initial stage of movement in saltation. Some grains rise only a short distance, others leap 30 cm or more, depending directly on the initial velocity of rise from the ground. They also gain considerable forward momentum from the pressure of wind acting upon them and acceleration of horizontal velocity continued from the time grains began to rise to the time they struck the ground. Inspite of this acceleration, the grains descend in almost straight line. On striking the surface, they either rebound and continue their movement in saltation or loose most of their energy by striking other grains, causing them to rise and sinking themselves into the surface or forming part of the movement in surface creep. Particles less than 0.5 mm in diameter are usually moved by saltation. This process may account for 50-70 per cent of total movement.

Suspension

Movement of fine dust particles, smaller than 0.1 mm diameter by floating in the air is known as suspension. Turbulent erosive wind a velocity more than 3.0 km/hr are capable of lifting silt and very fine sand particles to heights greater than 3 to 4.5 km. Soil particles carried in suspension are deposited when the sedimentation force is greater than the force holding the particles in suspension. This occurs with decrease in wind velocity resulting in decrease in the drag velocity gradient. The particles are also deposited in the depressions and behind ridges and other obstructions. Suspension usually may not account for more than 15 per cent of total movement.

Surface Creep

Rolling and sliding of soil particles along the ground surface due to impact of particles descending and hitting during saltation is called surface creep. Movement of particles by surface creep causes an abrasion of soil surface leading to breakdown of non erodable soil aggregates due to impact of moving particles. Coarse particles larger than 0.5-2.0 mm diameter are moved by surface creep. This process may account for 5-25 per cent of the total movement.

Factors Affecting Wind Erosion

Major factors that affect the amount of erosion from a given field are soil clodiness, surface roughness, water stable aggregates and soil crust, wind and soil moisture, field length, organic matter, vegetative cover, topography and soil.

Soil Clodiness

Soil clods resist wind erosion as they are large enough to resist the forces of wind, besides acting as barrier to other erodable materials. Coarse textured sandy loams, loamy sands and sands are most susceptible to erosion and break down. These soils form clods only when cultivated while moist and firm. Such clods are readily broken down by rain. The clodiest and least erodable soils are the loams, silt loams, clay loams and silty clay loams if they have 20-30 per cent clay and silt ranging from 0.005 to 0.01 mm in size. The proportion of soil aggregates that are more than 0.84 mm diameter can be used as a simple index of wind erodability of soils.

Surface Roughness

In addition to clods, soil aggregates and ridges, depressions formed Sy tillage also alter the wind speed by absorbing and deflecting part of the wind energy away from the erodable soil. Rough surface also trap saltating particles. A smooth soil surface is generally more erodable by wind than a rough one because of being less effective in slowing the wind velocity near the ground. Although, a smooth surface reduces wind turbulence, its effect in reducing wind erodability is not compensated by the increased surface velocity. In general, greater the surface roughness, lower the wind velocity against the ground and lower is the rate of erosion.

Water Stable Aggregates and Surface Crust

Greater the quantity of fine particles dispersible by water, greater the degree of cementation among the structural units and greater is the mechanical stability. Mechanical stability tends to reduce wind erosion by resisting the break down of nonerodable units to smaller erodable particles. Soil crust formed by dispersion of surface soil are more compact and mechanically stable against wind action than soil below.

Wind and Soil Moisture

Wind velocity and turbulence influence wind erosion. Wind speed of about 12 km hr " is necessary to initiate soil movement. At higher speed, soil movement is proportional to the cube of wind velocity. Wind velocity of 8-10 ms^{-1} can carry 490 Mt of soil ha' on a 100 m front. Turbulence of wind influences the capacity of atmosphere to transport soil particles. In general, wind erosion can only happen when the soil surface is dry or only slightly moist, because surface tension holds the soil particles together when wet. Moisture film between individual particles provides the cohesive force to hold them together.)amp and moist soil particles are, therefore, virtually stable. Wind velocities must create a force in excess of these film forces to cause soil movement. Force of cohesion between erodable soil particles varies directly with moisture content.

Field Length

Erosive winds vary highly in direction and seldom follow field boundaries. Hence, the amount of soil lost from a given field cannot be determined by the width and length of field alone. Distance across the field along the direction of prevailing wind must be known. Fields with their broad sides at right angels to, and their narrow sides parallel with, the prevailing wind direction will have the minimum overall rate of erosion. Field orientation is of little consequence where erosive winds blow equally from all directions. If a barrier is present on the windward side of the field, the distance it fully shelters from the wind must be substracted from the total distance across the field along the prevailing direction when computing the soil loss.

Vegetative Cover

Living or dead vegetative matter protects the soil surface from wind action by reducing wind speed and by preventing much of the direct wind force from reaching erodable soil particles. It also reduces erosion by trapping soil particles. The finer and denser the residue, the more it slows the wind and the more it reduces wind erosion. Soil loss by wind erosion varies inversely as the 0.8 power of the weight of surface residue.

Organic Matter

Numerous cementing substances responsible for binding soil particles together are produced in the initial stage of organic residues decomposition by soil microorganisms. These cementing products are not easily water soluble and hence increase the size of aggregates or clods large enough to resist wind erosion.

Topography

Level land is usually more liable to wind erosion than rolling land as the wind encounters less resistance. However, erosion on knolls and ridges is more as wind presses against such areas instead of parallel to the surface. Small depressions catch salating particles and reduce wind erosion.

Soil Loss Estimation

Soil loss due to wind erosion can be predicted by a numerical equation combining the factors influencing Wind erosion. As in the case of water erosion, the soil loss due to wind erosion can be estimated with the equation

$$E = I \times R \times K \times F \times C \times W \times D \times B$$

Where, E = soil loss per unit area, I = soil clodiness factor, R = surface cover factor, K = surface roughness factor, F = soil textural class factor, C = local wind factor, W = field width factor, D = wind direction factor, B = wind barrier factor.

Several studies are necessary to evaluate the above factors. Studies using wind tunnel is useful in studying wind erosion phenomenon and to establish required relations for use in the equation for estimating soil loss by wind.

Losses Due to Wind Erosion

The USSR and subsaharian Africa have been subjected to severe damage by wind erosion. Fertile Indo-Gangetic alluvial plains have been converted into sandy desert. Important losses due to wind erosion are:

- Fertile top soil is lost.
- Fertile soils are converted into unproductive sandy soils due to drifting sand
- Yield losses due to• abrasive action of wind driven soil particles, especially on broad leaved crops.

CONCLUSION

Greatest damage by wind erosion occurs during summer months in dry regions, where soil surface is bare and wind velocity is at its peak. Basic principles of wind erosion control are reducing wind velocity at ground surface, sufficient to prevent it being able to pickup soil particles, increasing the size of soil aggregates or covering the soil with a nonerodable surface. traping the saltating soil particles and keeping the soil moist so that soil particles moving by saltation loose their momentum at the surface. Practices such as stubble mulching and minimum tillage, cover crops, striperopping, crop rotation, wind barriers and shelterbelts and mulches can be practiced to minimise wind erosion.

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