In the Name of God

Unit 4: Wind Erosion

Introduction to Wind Erosion

Wind erosion is a serious problem in many parts of the world. It is worse in **arid and semiarid regions**. Areas most susceptible to wind erosion on agricultural land include much of North Africa and the Near East; parts of southern, central, and eastern Asia; the Siberian Plains; Australia; northwest China; southern South America; and North America.

During the 1930's, a prolonged **dry spell** culminated in **dust storms** and **soil destruction** of disastrous proportions. The "**black blizzards**" of the resulting **Dust Bowl** inflicted great hardships on the people and the land. Nearly seventy years after the Dust Bowl ended, wind erosion continues to threaten the sustainability of our nations' natural resources. As recently as the spring of 1996, wind erosion severely damaged agricultural land throughout the Great Plains. On **cropland**, about 70 million hectares (171.8 million acres) are eroded by wind and water at rates that exceed twice the **tolerance level** for sustainable production. On average, wind erosion is responsible for about 40 percent of this loss, and can increase markedly in **drought** years. In the United States, wind erosion is the dominant problem on about 30 million hectares (73.6 million acres) and moderately to severely damage approximately 2 million hectares (4.9 million acres) annually. According to the 1992 National Resources **Inventory** (NRI), the estimated annual soil loss from wind erosion on nonfederal rural land in the United States was 2.5 tons per acre per year. This number is a decrease from 3.3 tons per acre per year in the 1982 NRI. However much of this reduction was a result of enrollment of land classified as highly erodible in the **Conservation** Reserve Program (CRP). The CRP enrollment for much of this acreage is scheduled to retire within the next few years.

Wind erosion physically removes the lighter, less **dense soil constituents** such as organic matter, clays, and silts. Thus it removes the most fertile part of the soil and lowers **soil productivity**. Lyles (1975) estimated that top soil loss from wind erosion causes **annual yield** reductions of 339,000 bushels of wheat and 543,000 bushels of grain sorghum on 0.5 million hectares (1.2 million acres) of **sandy soils** in southwestern Kansas. This loss in productivity has been masked or compensated for over the years by improved crop varieties and increased

fertilization. Thus wind erosion reduces potential soil productivity and increases **economic costs**. Blowing soil impacting plants can also reduce **seedling survival and growth**, depress crop yields, lower the marketability of **vegetable crops**, increase the susceptibility of plants to certain types of **stress**, including diseases, and contribute to transmission to some plant pathogens. In the long run, the cost of wind erosion control practices can offset the cost of replanting a blown out crop. Some soil from damaged land enters **suspension** and becomes part of the atmospheric dust load. Dust obscures visibility and pollutes the air, it fills **road ditches** where it can impact water quality, it causes automobile accidents, fouls machinery, and imperils animal and human health. In Seward County Kansas alone the state highway department spent over $15,000 in 1996 to remove 965 tons of sand from 500 feet of highway and ditch. Wind erosion is a threat to the sustainability of the land as well as the viability and quality of life for rural as well as urban communities. Figure 1 illustrates the magnitude of wind erosion.

Fig. 1: The magnitude of wind erosion

Wind erosion in the United States is most widespread on agricultural land in the Great Plains states. Wind erosion is also a serious problem on **cultivated organic soils**, sandy **coastal areas**, **alluvial soils** along **river bottoms**, and other areas in the United States. In addition it is a major cause of **soil degradation** in arid and semiarid areas worldwide.

Impacts of Wind Erosion

Effect of wind erosion can be on-site as well as off-site. The on-site effects are loss of **topsoil** and plant nutrients, which have direct impact on crop growth. Soils become less productive because they contain less nutrients and less capacity to retain water. A field experiment conducted in the effect of wind erosion and **sand accumulation** in inner Mongolia shows that long term wind erosion could result in significant **soil coarseness**, infertility and dryness. **Abrasion** caused by flying soil particles does considerable damage to crops and to young plants in particular. In addition to this, evaporation from plant leaves is accelerated by wind, restricting wheat growth. The off-site effects are due to sand cover on fertile agricultural areas which affects crop growth and eventual decrease of **harvest**. In number of situations there will be soil textural changes resulting in decrease of clay particles and reduction in the ability of soil to conserve water. In a study of the effect of wind erosion on **soil properties** in China, similar results are reported: decrease of clay content and nutrient reduction in the soil e.g. decrease of organic matter, nitrogen and phosphorus contents. Also **infrastructures** can be covered by over-blown sand which will be very nuisance (Fig. 2). In extreme cases the land becomes useless because of thick sand cover (Fig. 3). Fine dust in the atmosphere will have environmental problem causing health **hazard** to human beings.

Wind Erosion Processes

Wind erosion occurs in three processes. The first process is called the **entrainment of soil particles**. In this process, the wind energy has to outweigh the weight of soil particles. Wind erosion occurs when strong winds blow over a **smooth, exposed, loose, and dry soil surface**. Depending on conditions, the wind speeds required to initiate erosion of **mineral soils** vary between 25 and 50 km/hour measured at 30 cm above the soil surface. Soil particles between 0.1and 0.5 mm diameter are first to move. The **wind pressure** causes them to vibrate and, if their resonant frequency is achieved, they are ejected into the **wind stream**. **Gravity** quickly brings

Fig. 2: Sand covering part of a main road in Priai, Cape Verde

Fig. 3: Over blowing with dune formation, case of extreme wind action

these particles back to earth but meanwhile they have gained considerable energy from the wind and they collide into the soil surface **dislodging other particles**. The process is called **transportation** (**saltation**) and is very like an atomic chain reaction. Once a few soil particles are in motion the erosion process spreads very rapidly. Small soil particles and aggregates dislodged by these collisions are carried aloft by **eddies in the wind**, where they form dust clouds and may be transported for thousands of kilometers. **Soil aggregates** between 0.5 and 1 mm diameter generally do not travel far. They are rolled by impacts of saltating particles and the pressure of the wind. Saltation is just like **sandblasting** and can be very damaging to the soil and to growing crops. The last process is named **deposition**. It occurs when the wind dies down and losses its energy.

Transport Modes of Soil Particles

Wind erosion occurs when the forces exerted by the wind overcome the gravitational and **cohesive forces** of soil particles on the surface of the ground. The wind transports these particles in three ways, depending on their size.

1- Particles greater than 0.5 mm diameter are generally too heavy to be lifted by the wind, so they are rolled along the surface by wind drag or moved by bombardment by other moving particles. This mode of wind transport is called **creep**. 7 to 25 percent of particles move by this mode of transportation.

2- Particles in the range 0.1-0.5 mm diameter are lifted by the wind, and then fall back to the ground, so they move in a hopping or bouncing fashion. These particles cause **abrasion** of the soil surface and as they hit other particles they break into smaller particles, a process called **attrition**. This bouncing mode of wind transport is called **saltation** and is the main process forming the suspension fraction of soil particles in the air. The bulk of total transport, roughly 50 to 80 percent, is by saltation.

3- Once small particles less than 0.1 mm in diameter have been ejected into the air by saltation they remain suspended as dust and are carried away from the erosion site by the wind. This mode of wind transport is called **suspension**. The majority of particles > 0.02 mm will settle back to the ground within 100 km of the erosion site but finer particles can be carried long distances, even as far as New Zealand.

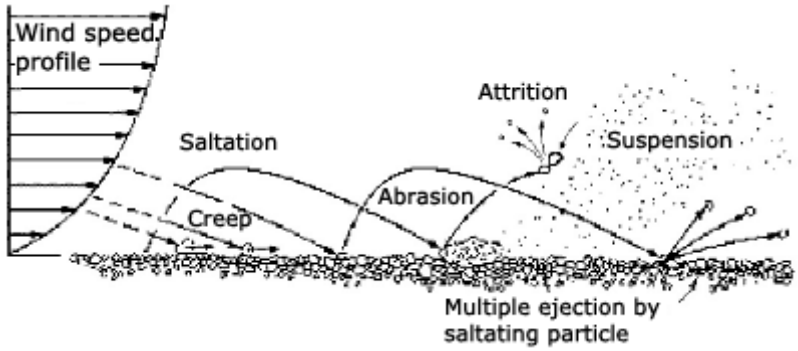

Fig. 4: Transportation modes of soil particles by wind

Wind Erosion Control Measures

1- **Windbreaks:** A **windbreak** or **shelterbelt** is a **plantation** usually made up of one or more rows of trees or shrubs (Fig. 5) planted in such a manner as to provide shelter from the wind and to protect soil from erosion. They are commonly planted around the **edges of fields** on farms. If designed properly, windbreaks around a home can reduce the cost of heating and cooling and save energy. Windbreaks are also planted to help keep snow from drifting onto roadways and even yards. Other benefits include providing **habitat** for wildlife and in some regions the trees are harvested for **wood products**. A further use for a shelterbelt is to screen a farm from a main road or motorway. This improves the farm **landscape** by reducing the visual incursion of the motorway, mitigating noise from the traffic and providing a safe barrier between farm animals and the road.

   A further use for 'windbreaks' is for a retail item used on the beach and camping to prevent wind from disturbing social enjoyment. Americans tend to use the term windbreaker whereas Europeans favour the term 'windbreak'. Normally made from cotton, nylon, canvas and recycled sails, windbreaks tend to have three or more panels, held in place with poles that slide into pockets sewn into the panel. The poles are then hammered into the ground and a windbreak is formed.

2- **Mulching:** Mulching is a very good way of protecting the top soil from washing and blowing away. You can cover the soil with any kind of mulch like newspaper, bark chips, dead leaves or pine needles. Mulching not only helps control erosion, but also increases water penetration of the soil, keeps it cool and increases the organic nutrient of the soil.

Fig. 5: Windbreak for controlling wind erosion

Top 10 Scientific Journals publishing wind erosion-related papers

1- ***Aeolian Research***
2- ***Journal of Arid Environments***
3- ***Geomorphology***
4- ***Natural Hazards***
5- ***Natural Hazards and Earth System Sciences***
6- ***Land Degradation and Rehabilitation***
7- ***Journal of Soil and Water Conservation***
8- ***Earth Surface Processes and Landforms***
9- ***Professional Geographer***
10- ***Geographical Review***