Agri-science Resources
for High School Sciences

Soil Erosion

Physics

Science

Grade 10-12

Physics Classroom

Individual reading

DESCRIPTION

Soil erosion is a major problem in Agriculture. Tonnes of soil are lost from fields every year. This not only reduces crop production, the soil acts as a pollutant to rivers, lakes, and other water systems. Soil erosion can be controlled with the proper techniques. This article describes soil erosion and some methods of prevention.

LEARNING OUTCOMES

Students will:

- learn how damaging soil erosion can be to agriculture and the environment
- learn how to estimate the rate of soil loss in a field

READINESS ACTIVITIES

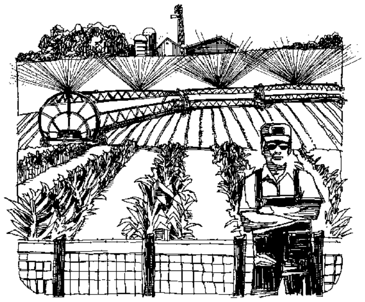
Students should:

- find any fields in their area that are highly prone to soil erosion and determine the cause

MATERIALS

- Copy of article
- calculator

Soil Erosion



Introduction

Soil is the top layer of the earth's surface that is capable of sustaining life. Therefore, soil is very important to farmers, who depend on soil to provide abundant, healthy crops each year. One major problem in agriculture is soil erosion. **Soil erosion** is the deterioration of soil by the physical movement of soil particles from a given site. Wind, water, ice, animals, and the use of tools by man are usually the main causes of soil erosion. It is a natural process which usually does not cause any major problems. It becomes a problem when human activity causes it to occur much faster than under normal conditions.

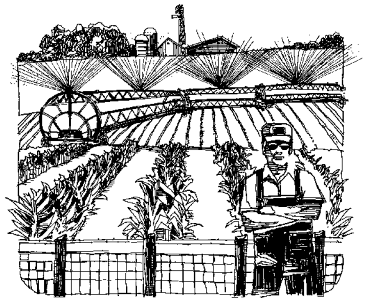
Facts and Figures

Worldwide, farmers are losing an estimated 24 billion tonnes of topsoil each year. In developing countries erosion rates per acre are twice as high as the standard, partly because population pressure forces land to be more intensively farmed. Although soil erosion is a physical process, it also affects productivity and growth. Reductions in yield of up to 50% have been documented on severely eroded soils in Ontario. When soils are **depleted** and crops receive poor **nourishment** from the soil, the food provides poor nourishment to people. Losses of soil take place much faster than new soil can be created. It takes thousands of years to form just a few centimetres of soil. The difference between creation and loss represents an annual loss of 7.5 to 10 tonnes per acre worldwide.

Soil

Topsoil contains most of the soil's **nutrients**, **organic matter**, and **pesticides**. Soil erosion causes these substances to move also. What is left behind is soil with poorer structure, lower water-holding capacity, different pH values, and low nutrient levels. Therefore, fertilizers and organic matter must be added in an attempt to restore the soil to its original composition. The soil also has a lower resistance to **drought**.

Soil Erosion



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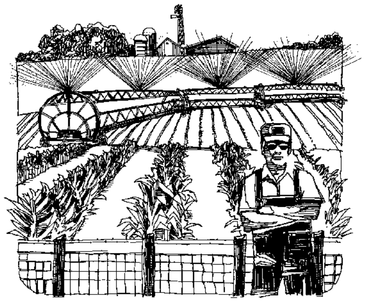
Where does it go?

Much of the eroded soil is deposited either in low areas of the field or it moves off the farm and eventually enters drainage ditches, streams or rivers. Soil that enters a watercourse reduces water quality, reduces the efficiency of drainage systems and the storage capacity of lakes. Soil that settles in water systems is called **sediment**. Accumulation of sediment often requires that it be cleared out manually, which costs money. Sediment fills rivers and reservoirs and reduces their capacity to hold flood waters. Sediment is considered to be a major pollutant. It can inhibit fish spawning and block the sunlight necessary to plant life. Increased runoff of chemical and nutrients from farmers fields must be removed in order for water to be safe to drink.

Geographic Location

The severity of soil erosion can vary from place to place. Wind and water are the main causes of soil erosion. The faster either moves and the amount of plant cover available for protection are two main factors associated with erosion. Wind erosion is a more common problem in dry, windy regions, with a smooth, flat terrain. Water erosion is a problem in wet regions with a sloping or hilly terrain. A significant portion of land used for potato production in Atlantic Canada is vulnerable to erosion.

Soil Erosion



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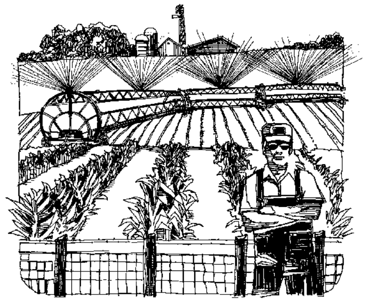
Erosion Factors

The vulnerability of a field to soil erosion is dependent on a number of factors:

- The climatic conditions of the area
- the proportion of sand, **silt** and **clay** sized particles in a particular soil
- the organic matter level
- the **water permeability** of the soil
- the length and slope of the field
- amount of **crop rotation**
- direction of cultivation

Protection

It is vegetation that keeps soil from eroding. This is because soil is usually covered with shrubs and trees, by dead and decaying matter or by a thick mat of grass. The root systems of plants is able to hold the soil together. Plants slow down water as it flows over the land and it allows much of the rain to soak into the ground. Plants also break the impact of a raindrop before it hits the soil. This reduces water erosion. When this covering is stripped away through deforestation, over-grazing, ploughing and fire, soil erosion is greatly accelerated. Over-cultivation and compaction cause the soil to lose its structure and cohesion and it becomes more easily eroded. Soils with high clay content are more cohesive and allow soil particles to stick together. Soil with more clay are less vulnerable to erosion than soil with high sand or silt content.



Prevention

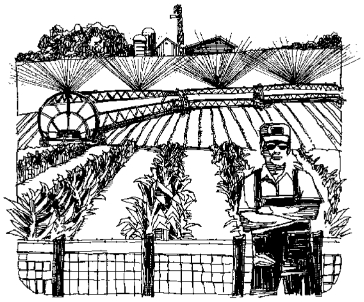
There are a number of other conservation practices which can be used by farmers. Any single conservation practice can significantly decrease soil erosion rates. Combining a number of soil conservation practices is often more effective. The ideal goal would be to achieve a soil loss rate of 6.7 tonnes/ha/year. This is roughly the rate at which soil can rejuvenate itself. Making sure there are always plants growing on the soil and that the soil is rich in organic matter are two key methods in prevention. Organic matter binds soil particles together which reduces erosion. Organic matter in soil can be increased with crop rotation or by incorporating organic fertilizers. Crop rotation is also effective at enhancing soil structure. There are also many other methods used by farmers to reduce soil erosion. Mulching is one example. It involves spreading hay or straw over a field as a substitute for a cover crop.

Exercise: Calculation of Erosion Rates

Soil conservationists around the world use the Universal Soil Loss Equation to estimate soil erosion rates by water. The equation provides an estimate of the Soil Loss Rate in Tonnes/hectare/year. This estimate can be used for soil conservation planning. The Universal Soil Loss Equation is:

$$A = KR(LS)CP$$

where A = Estimate of the Soil Loss Rate in Tons/ha/year
K = Soil erodibility factor
R = Rainfall factor
LS = Length/Slope Factor
C = Crop management Factor
P = Support Practice Factor



K

The soil erodibility factor varies according to soil type and geographic location. The K factor for a particular soil does not change.

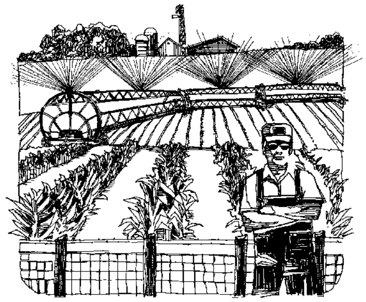
Table 1. Soil Erodibility Factor determined by soil texture and organic matter content

	Organic Matter Content (%)		
Soil Texture	0.5	2	4
Fine Sand	0.16	0.14	0.10
Very Fine Sand	0.42	0.36	0.28
Loamy Sand	0.12	0.10	0.08
Loamy very fine sand	0.44	0.38	0.30
Sandy loam	0.27	0.24	0.19
Very fine sandy loam	0.47	0.41	0.33
Silt loam	0.48	0.42	0.33
Clay loam	0.28	0.25	0.21
Silt clay loam	0.37	0.32	0.26
Silty clay	0.25	0.23	0.19

For the purposes of this example, the Charlottetown soil type in P.E.I. (K=.38) will be used to calculate the soil loss rate.

R

The R value in the equation takes climatic conditions into consideration. The rainfall factor can vary from year to year, so an average over a number of years is usually used. For this example, the value 60.6 will be used to calculate the soil loss rate.



LS

The length and slope factors vary according to the size and shape of different fields. The standard factor is calculated based on a standard length of 22 m and a 9 percent slope.

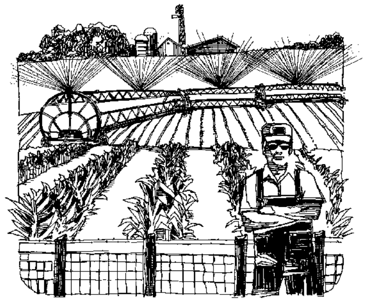
Table 2. Approximate LS soil loss factor determined by the length and steepness of slope.

Slope length (m)	Degree of Slope (%)	LS - Soil loss factor
250	2	0.2
200	4	0.4
150	6	1.5
125	8	2
110	10	2.5
100	6	1.2
90	14	4
60	16	4
50	18	4.5
45	20	5

This table gives the LS values which can be used in the universal soil loss equation.

C

The cropping-management factor can vary according to farming practices. This value includes the effects of cover, crop sequence, productivity level, length of growing season, tillage practices, residue management, and the expected time distribution of erosive rainstorms. For example, the approximate C value for a rotation with corn-corn-oats-meadow is 0.18 if good management is used.



P

Another variable that can be altered is the conservation practice factor. This is the ratio of soil loss for a given practice compared to simple up and down the slope farming. Contouring is one practice which involves field operations such as plowing, planting, cultivating, and harvesting approximately on the contour. The P values obtained using contouring vary according to the slope of the field

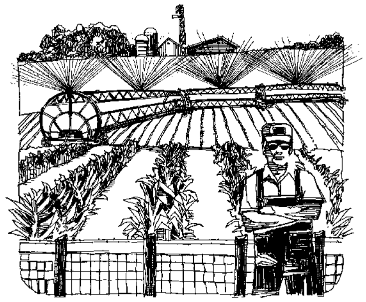
Table 3. Conservation practice factor values for contouring.

Percent Slope	P value for Contouring (with maximum allowable slope length in metres)
1.1-2	0.6 (150)
2.1-7	0.5 (100)
7.1-12	0.6 (60)
12.1-18	0.8 (20)
18.1-24	0.9 (18)

Calculation

Determine the average annual soil loss (tons/hectare) of a field with the following parameters: The field is located in Prince Edward Island and has a Charlottetown soil type.
The rainfall factor is 60.6
The slope length is 100 m and the slope is 6 percent
The crop management factor is a corn-corn-oats-meadow rotation
The field is to be contoured

Is the average annual soil loss below the Tolerable Soil Loss Rate?



Solution

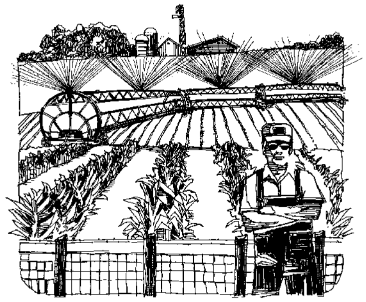
Use tables 1 through 3 to get the following values:

$$
\begin{aligned}
A &= KR\,(LS)\,CP \\
&= (.38)(60.6)(1.2)(0.18)(0.5) \\
&= 2.5 \text{ tons/hectare}
\end{aligned}
$$

Because the Tolerable Soil Loss Rate is 6.7 tons/hectare, this soil loss of this field is occurring under the appropriate levels.

Glossary of Terms

crop rotation	planting of different crops in a given field every year or every several years
depleted	soil that has valuable resources exhausted or used up
drought	continued absence of rain or moisture
nourishment	providing something with the material to keep it alive and make it grow
nutrients	substances necessary for the functioning of an organism
organic matter	dead plant or animal tissue that originates from living sources
pesticides	chemicals used to control pests.
sediment	sand, gravel, or mud which settles at the bottom of a liquid
soil	top layer of the earth's surface capable of sustaining life
soil erosion	wearing away of soil
water permeability	the rate at which water can pass through the soil profile



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