The Benefits of Vegetative Barriers on Erosion and Environment Pollution

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Abstract: Vegetative barriers are a simple and cost-effective way to reduce the dangers associated with erosion. They perform a variety of functions, including reducing and delaying surface runoff through the encouragement of retention and infiltration. Vegetative barriers inhibit the formation of ephemeral gullies by effectively dispersing concentrated flow. These barriers are also important in retaining sediment-borne and soluble pollutants, promoting their transformation and reducing their environmental impact. They also provide great habitat for wildlife. The purpose of this research is to delve into the mechanics of this technology, investigating the numerous modes of action used by vegetative barriers and their tremendous impact on erosion management and pollution reduction. Extensive study has shown that vegetative barriers are adaptable, making them suited for use in eroding areas such as cropland, pastureland, feedlots, mined land, gullies, and ditches. The success of these barriers can be ascribed to four distinct sorts of behaviour. For starters, sedimentation and filtration occur as water passes through vegetative barriers, settling suspended materials and decreasing downstream movement. This method contributes to the preservation of water bodies' ecological equilibrium by minimising excessive silt buildup. Second, chemicals are retained on the grassy surfaces of vegetative barriers. When runoff comes into contact with these barriers, the plant functions as a physical filter, collecting and retaining pollutants and inhibiting their further movement. This retention mechanism considerably minimises the chance of pollutants reaching water bodies, hence protecting water quality overall.

Furthermore, vegetative barriers allow chemicals located above the grass layer to be absorbed. The vegetation's extensive root system improves soil permeability, allowing water and related pollutants to penetrate into the soil. This infiltration process prevents pollutants from being transferred to deeper waters, conserving the quality and integrity of groundwater supplies. Finally, vegetal barriers aid in degrading processes. Certain pollutants undergo changes due to the activity of soil microorganisms, resulting in their breakdown or conversion into less hazardous compounds. Aside from these methods, the creation of an edge along cultivated plots is critical in controlling element escape from the plots, successfully lowering edge impacts and erosion. Furthermore, vegetal barriers absorb water that flows into the fields like a sponge. This capacity for absorption aids in the prevention of soil particle displacement, the spread of diverse contaminants, and eventual contamination. The advantages of vegetative barriers go beyond erosion management and pollutant reduction. They provide a variety of benefits, including great wildlife habitat. The existence of vegetative barriers promotes biodiversity and ecological balance by creating a favourable environment for numerous species. Finally, vegetative barriers are a realistic and cost-effective way to mitigate erosion threats. Because of their abilities to slow and minimise surface runoff, distribute concentrated flow, entrap toxins, and provide wildlife habitat, they are a diverse erosion control and pollution mitigation option. These barriers successfully minimise erosion and inhibit the spread of pollutants through sedimentation, filtration, retention, infiltration, degradation, and edge development. Furthermore, the use of vegetative barriers in a variety of environments demonstrates their versatility and broad-scale usefulness

Key words: erosion, vegetative barriers, pollution, soil productivity, environmental impacts

Erosion is one of the five soil degradation processes listed in the proposed Soil Directive of the European Union (Environment, 2006). In Worldwide, agricultural production occupies about 50% of the terrestrial environment. Soil degradation, which includes erosion, has been an ongoing issue since the advent of agriculture. However, its impact on human food production and the environment becoming more serious than ever before due to its widespread occurrence and intensified effects. Soil erosion, in particular, has far-reaching implications. It exacerbates the loss of essential soil nutrients and water, leading to decreased agricultural productivity. Moreover, eroded soil particles often find their way into surface waterways, causing pollution and impacting aquatic ecosystems. Erosion also plays a pivotal role in deforestation, serving as a primary catalyst for land degradation. Furthermore, it contributes to global environmental changes, such as climate change, through the release of stored carbon and disruption of natural ecosystems. Each year, about 75 billion tons of soil is eroded from the world's terrestrial ecosystems, most from agricultural land at rates ranging from 13 Mg ha−1 yr−1 to 40 Mg ha−1 yr−1 (Pimentel D., 1998). According to Lal R. (R., 1990) and Wen and Pimentel. (Wen D., 1998) about 6.6 billion tons of soil per year is lost in India and 5.5 billion tons are lost annually in China, while in the USA, soil loss is more than 4 billion tons per year. These statistics underscore the urgent need to address soil erosion comprehensively. Mitigating its detrimental effects on soil health, water quality, biodiversity, and agricultural productivity is of paramount importance for sustainable land management and ensuring food security in the face of a growing global population. Recognizing the magnitude of the problem and implementing effective erosion control measures will be crucial in safeguarding our environment and preserving the Earth's invaluable soil resources.

1 Impact of Erosion on Soil Productivity

The loss of soil from land surfaces by erosion is widespread globally and adversely impacts the productivity of all natural, agricultural, forest, and rangeland ecosystems, seriously decreasing water availability, energy, and biodiversity throughout the world. Future world populations will require ever increasing food supplies, considering that more than 99.7% of human food comes from the land (FAO., 1998), while less than 0.3% comes from the oceans and other aquatic ecosystems. Maintaining and augmenting the world food supply depends basically on the productivity and quality of all soils.

Soil erosion and runoff reduce the soil productivity decreasing rainfall water infiltration, and water-storage capacity. In this sense, the effect of plant cover on soil represents a sustainable measure for improving productivity, given their many environmental benefits. Since water is the prime limiting factor of productivity in all terrestrial ecosystems, when soil-water availability for agriculture is reduced, productivity is depressed. Particularly, in semiarid areas vegetation suffers longer periods of water deficit, determining the vegetation structure and complexity, and thus soil protection and water conservation. During precipitation, some water is intercepted by the plant covers, and a new spatial distribution of rainfall takes place due to the through-fall and stem-flow pathways (Bellot J., 1998).

Planting grass strips along the contour can be one simple and cheap method of reducing the erosion hazard. Grass strips absorb-part of the runoff and trap part of the sediment transported from the upper partof a field and may gradually develop into a series of terraces stabilized by permanent vegetation. Ministryof Agriculture Annual Reports show, in Kiambu District, for the years 1975-1979, 436 km. of grass strips were established while in Machakos District, 950 km. of grass strips were planted in the years 1978-1980 The reports show that grass strips are being used widely in the semi-arid areas as well as the humid, high potential, areas and that they have become a common conservation measure in recent years.

2 Purpose of Vegetative Barriers

Vegetative barriers or grass hedges are currently being evaluated as an alternative conservation practice. Vegetative barriers are narrow strips (1-3 feet wide) of stiff, erect densely growing plants, usually grasses, planted across the slope perpendicular to the dominant slope. Over forty years ago, the USDA-Soil Conservation Service referenced the use of vegetative barriers in an agriculture handbook on conservation (USDA, 1954). More recently, the World Bank has promoted the use of vetiver grass (Vetiveria zizanioides (L) Nash) as a hedge against erosion. The main purpose of vegetative barriers is to:

1. Retard and reduce surface runoff by promoting detention and infiltration.
2. Disperse concentrated flow and prevent ephemeral gully development.
3. Entrap sediment-borne and soluble contaminants and facilitate their transformations.
4. Reduce soil loss by causing deposition of eroded sediment on hill slopes.
5. Facilitate benching of sloping topography.
6. Provide valuable wildlife habitat.

3 Concept of Erosion

Whether caused by wind or water, accounts for the loss of tons of soil every year. Gully erosion is the most obvious form of erosion with the deep down cutting of the soil profile. However, sheet erosion is the most insidious form of erosion. Raindrops pound the ground dislodging soil particles which are carried away by the surface runoff. Sheet erosion is a slow but steady form of erosion that covers vast amounts of acreage. It is difficult to see since it takes small amounts of soil over a long period of time.

Erosion can be controlled in two different ways. The first way, the surface can be protected or reinforced by residue or through vegetation such as pastureland or a grass waterway. The second way, the surface or slopecan be flattened through benching or terracing. Earthen terraces or vegetative barriers stair-step water down the hillside. These barriers inhibit surface runoff, slowing and ponding water and capturing and preventing sediment from flowing downhill (figure 1). Vegetative barriers inhibit the flow of water because of their dense concentration of thick stems, thusslowing and ponding water and causing sediment to deposit in back of them (Meyer, 1995). Over timethese deposits can develop into benched terraces (Aase, 1995). These barriers function to diffuse and spread the water runoff so that it slowly flows through them without erosion. Vegetative barriers are resilient to failure because water passes over a broad area secured with perennial root reinforcement.

The vegetative barrier concept should not be confused with vegetative filter strips. Vegetative filter strips are a broad area of vegetation ranging from 15 to 30 feet wide whose purpose is to remove nutrients, pesticides and sediment from surface runoff. Vegetative barriers, on the other hand, are narrow strips of vegetation which are designed primarily to slow runoff, capture sediment and resist gully development. However, the two practices can be very complimentary. Research has reported that vegetated filter strips can be effective at nutrient removal and trapping sediment where water flows are shallow and uniform (Magette, 1989). Meyer et al. (Meyer, 1995) documented that stiff erect grasses such as vetiver (Vetiver zizanioides (L) Nash) and switchgrass (Panicum virgatum L.) can retard runoff and capture sediment from concentrated flow. Thus, asa vegetative barrier matures it reduces water velocities and establishes a broad uniform vegetative surface for the uptake of nutrients. Vegetative barriers have potential to not only reduce erosion but can enhance vegetated filter strips in the uptake of nutrients.

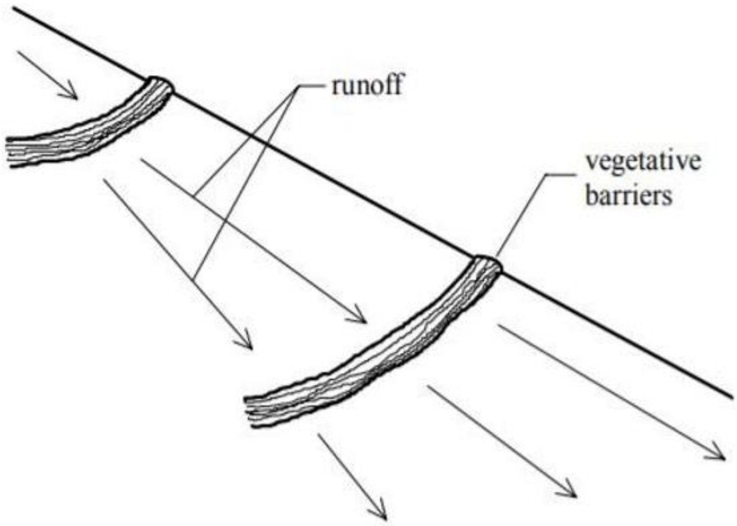

Figure 1: Vegetative Barriers preventing sediment from flowing downhill

4 Practice Application

Vegetative barriers can be applied to eroding sites on areas of cropland, pastureland, feedlots, minedland, gullies, and ditches. This practice should be used in conjunction with other conservation practices in a conservation management system. Management practices such as conservation cropping rotation and residue management must be considered in designing the conservation management system on cropland. Associated structural practices such as water and sediment control basins, subsurface drainage, and underground outlets may need to be considered to adequately handle surface and subsurface water. This practice may improve the efficiency of other practices such as strip-cropping, filter strips, riparian buffer zones, grassed waterways, diversions, and terraces.

Vegetative barriers have their greatest potential in use as a method for controlling ephemeral gully development in concentrated flow areas, and as water detention barriers with buffer strips and filter strips toensure more uniform entry of runoff and nutrient uptake.

5 Modes of Action of Vegetative Barriers

The experiments show four types of action of Vegetative barriers:

Sedimentation and filtration

The slowing of the flow caused by the high hydraulic roughness of the grass causes the solid particles to settle. The coarser particles are trapped first. The finer ones, more loaded with adsorbed pollutants, are retained if the device has a sufficient size. The effectiveness of filtration depends on many factors: in particular, the flow rate of the runoff, as well as the slope and the specific characteristics of the grass surface.

Retention of substances on the grassy surface

The humus rich surface film and plant debris have a certain but difficult to quantify ability to fix substances.

This contact zone plays a physicochemical role with respect to runoff, similar to that of the passage ofa layer of soil in the case of infiltration. The ability of grassy strips to reduce the concentration of solution products is probably explained by this phenomenon.

5.3 Infiltration

Some of the runoff seeps in because a grassy surface is generally more permeable than a worked soil.However, this infiltration capacity can be reduced by compaction (trampling by animals) or by water saturation (hydromorphic grasslands). This infiltration leads to the substances transported by the runoff in the formof molecules in solution. The root zone under a grassy surface of more than one year is a particularly well- structured medium without micro-cracks. This promotes the retention and subsequent degradation of the substances present at this level and thus limits their transfer to the deep waters.

5.4 Degradation

The surface layer of the soil containing the roots of the herbaceous brood and more or less evolved organic matter constitutes an aerobic medium favorable to biological activity. These conditions allow for degradation of plant protection product residues along pathways and at speeds similar to those observed in the plot. The scrubbing power of the grassed device and the small amounts of intercepted residues compared to those applied to the plot suggest that the risk of long-term accumulation is not significant.

6 Direct impact on erosion and diffuse pollution

6.1 Edges and erosion

Particles of soil and organic matter move from one plot to another or are transferred down slopes and streams, resulting in sometimes considerable material losses, due to the action of water and wind. When the edge of the cultivated plots is formed, it acts as a brake on the escape of the elements from the plots, and this thanks to the two phenomena seen above: sedimentation and infiltration.

6.2 Field edges and diffuse pollution

In sufficiently heavy rains, the water flowing into the field causes soil particles and various substances, in particular a fraction of fertilizers or applied plant protection products. By following a natural flow, rainwater will reach water reserves, surface or underground. The polluting materials can do the same if they are not degraded in the medium, strongly fixed or adsorbed by the plants during their transfer. The combination of the four phenomena of action of the edges of the fields will contribute to the purification of the runoff waters and ttherefore limit the diffuse pollution.

Field edges also have an indirect action: reducing the effect of spray drifts. Their location on the banks of the river or water provides protection against the entrainment of spray droplets by the wind, by moving the crops away from the shore.

7 Other Environmental Impacts

7.1 Field edges and flora

The edges of the fields represent a space on which the natural flora develops as a function of the seed potential of the soil and the fertility of the medium. Faced with the regular infestation of weeds in his crops, the farmer distrusts this grassland, which contains many species against which he must fight and which he fears will invade from the edges of fields. The flora of the edges of the fields therefore constitutes a potential risk for neighboring crops. However, it also has beneficial aspects: it is a direct source of food for game, it is a privileged space for the formation of pairs and nesting, it is also a shelter of choice for prey species that protect themselves from their predators. Finally, the composite flora of the edges of the fields contributes to biodiversity.

7.2 Field edges and wildlife

First of all, the edges of the fields can be designed as a reserve of lumbricals. They play an importantrole both from the environmental point of view and from the agricultural point of view. Earthworm improve soil porosity, promoting air and water circulation. By incorporating litter into the soil and forming stable aggregates, they also contribute to the creation of the granular structure of the soil. All this acts on limiting runoff. The activity of burying litter favors soil fertility, this has a not negligible impact on agricultureyields. Finally, earthworms are an important food resource for many animals.

Next, the edges of the fields constitute an important reservoir of arthropods. Most of these species arenot harmful to crops, and knowledge of the plant species to which they are subordinate makes it possible to control their transfers. Transfer accommodation is a largely positive property with a view to the rational protection of crops. Finally, these arthropods are prey whose abundance is essential for the maintenance and development of bird populations.

Finally, the setting of the edges of the fields is an effective solution to promote the development ofsmall game. By providing a protective cover, a nesting area, food resources, it makes it possible to overcome the gaps created by the areas of field crops.

Conclusion

Soil erosion is a natural process which has been greatly accelerated by human action. But withVegetative barriers can reduce erosion. It can revitalize and support waterways by capturing and spreading eroded sediment. It can enhance nutrient uptake of filter areas. Vegetative barriers can provide a cost effective technique for water and sediment control basins. Furthermore, vegetative barriers can provide critical wildlife habitat when annual crops deteriorate.