Newsletter

Plants and Pollution

ENVIS-NBRI

Soil Erosion - A Major Concern

Vol. 11 No. 3, July 2015

CSIR - National Botanical Research Institute, Lucknow

Assam loses 4.27 lakh hectares of land due to erosion

Assam has lost 4.27 lakh hectares of land due to erosion and channelization of rivers has become highly necessary to combat the problem. Flood and erosion were major challenges for the state with the Brahmaputra, Barak and their fast-flowing tributaries gobbling up 4.27 lakh hectares of land since 1954. The state government has already initiated steps to constitute a group of national and international experts to advise the government on steps to ensure reduction of erosion including channelization of the rivers. The state government has earmarked Rs 1,201 crore under the annual Plan and Rs 250 crore under non-Plan for flood and erosion management during the financial year 2013-14. During the 11th Five Year Plan, 100 flood management schemes were taken up and out of these, 80 schemes have been completed and 20 schemes was in progress. Rehabilitation of erosion-affected people has been given high priority while innovative methods and technologies for construction of embankments and anti-erosion measures using eco-friendly and geo-synthetic materials have been also adopted to combat the problem.

Source: Press Trust of India

Soil erosion threatens to leave Earth hungry

Within next 40 years, there will be around 2 billion more people on Earth. Food production will have to increase at least 40%, and most of that will have to be grown on the fertile soils that cover just 11% of the global land surface. There is little new land that can be brought into production, and existing land is being lost and degraded. Annually, says the UN's Food and Agricultural Organisation (FAO), 75bn tonnes of soil, the equivalent of nearly 10m hectares of arable land, is lost to erosion, waterlogging and salination; another 20m hectares is abandoned because its soil quality has been degraded. Soil erosion is not a high priority among governments and farmers because it usually occurs so slowly that its cumulative effects may take decades to become apparent, says David Pimentel, Professor of Agricultural Sciences at Cornell University. "The removal of 1 millimetre of soil is so small that it goes undetected. But over a 25-year period the loss would be 25mm, which would take about 500 years to replace by natural processes." The best hope may lie in the global climate change talks, which have recognised that nearly 30% of all carbon is released from deforestation, the conversion of peat lands and degradation of soils. If agreement can be reached to reward reforestation and conservation, there is some hope that the next 2 billion people may be fed.

Source: www.theguardian.com

Contents

From:
The ENVIS Coordinator
NBRI-ENVIS Centre
Centre for "Plants and Pollution"
CSIR-National Botanical Research Institute
Rana Pratap Marg, Lucknow-226001

Soil erosion-A major concern

Soil is a major component of the Earth's ecosystem because most of the biological processes are carried out in the soil. The world's ecosystems are strongly affected by the processes carried out in the soil, from ozone depletion, global warming, destruction of rain forest and water pollution. As the earth heat up, soils will add carbon dioxide to the atmosphere because microorganisms in the soils decompose organic matter more rapidly at higher temperatures. This activity releasing extra carbon dioxide (CO_2) and accelerating climate change. Soil is the largest surficial global carbon reservoir on Earth and it is potentially one of the most reactive to human disturbance and climate change (Powlson 2005).

Soil degradation is any type of problem that removes soil in an area or makes high-quality soil become poor. Careless agricultural practices, pollution and deforestation cause lots of soil degradation in the world. Several types of soil degradation exist and possess threat to natural forests and planted crops.

Types of soil degradation

a) Erosion:

Erosion occurs when the topsoil that many plants need to grow gets blown or washed away. While some erosion is natural, humans often remove plants that cover soil and, therefore, speed up erosion. Topsoil takes so long to build back up through natural processes, erosion damage is almost irreversible. Soil is the most precious gift of nature and most important resource for food, fodder etc. In India, more than 100 million hectares soil degraded, eroded and unproductive. About 17 tones/ha soil detached annually and >20% of this is transported by river to sea 10% deposited in reservoir results 1 to 2% loss off storage capacity (Jain et al 2001).

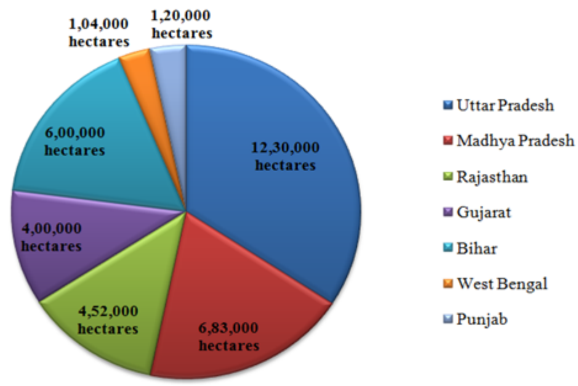

Figure 1: Graph showing degraded soils in India.

Source: www.yourarticlelibrary.com

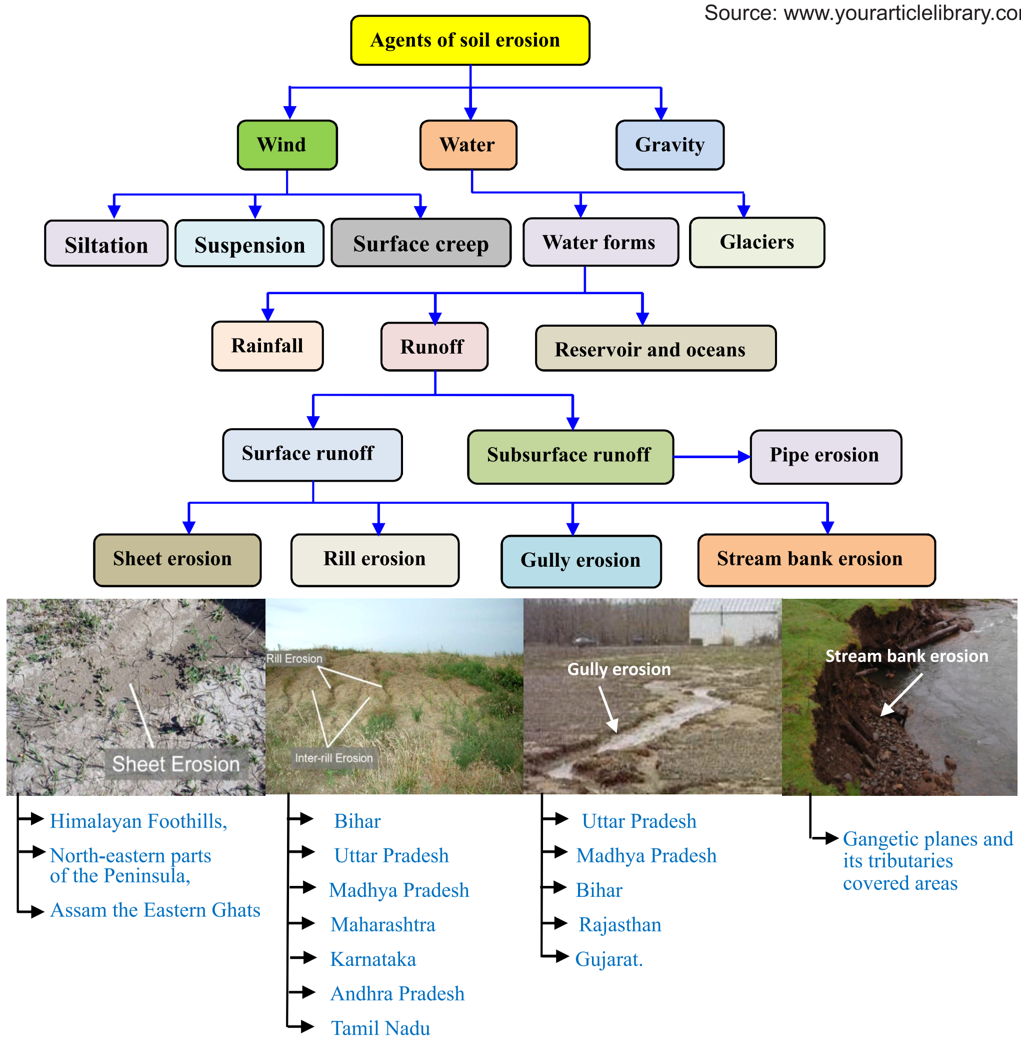

Figure 2: Process of Soil erosion

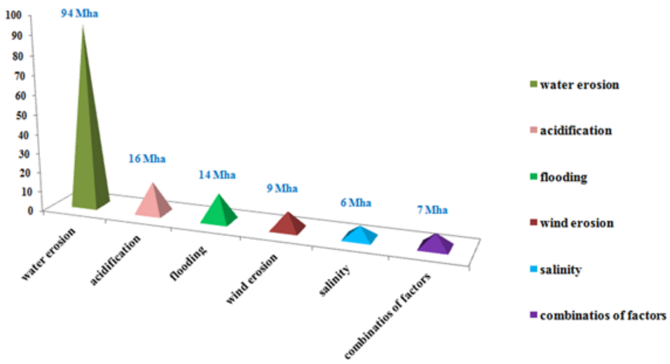

Figure 3: Factors contributing to soil erosion.

b) Salinization:

Process of severe increase of water soluble salts in soil is called Salinization. The accumulated salts include sodium, potassium, magnesium and calcium, chloride, sulphate, carbonate and bicarbonate (mainly sodium chloride and sodium sulphate). There are two processes of Salinization Primary Salinization and Secondary Salinization. Salt accumulation through natural processes like high salt content of the parent material or in groundwater is called Primary Salinization Secondary Salinization is caused by human interferences such as unsuitable irrigation practices, like with salt-rich irrigation water and/or insufficient drainage.

In areas with shallow water tables, water containing dissolved salts may move upward into the rooting zone. This occurs by capillary action, where evaporation serves as the suction of water up through the soil. Water moves the farthest through finer clay and clay loam soils; it moves less in medium-textured soils (loams); and least in coarser, sandy soils.

The countries affected by salinization are mainly located in arid and semi-arid regions and include areas in North and South America, Australia, China, India, regions in the Mediterranean and Middle East, and Southeast Asia (Salama et al 1999). Different types of salinization with a occurrence of sodium salts influence about 30% of the land area in Australia (Rengasamy 2005).

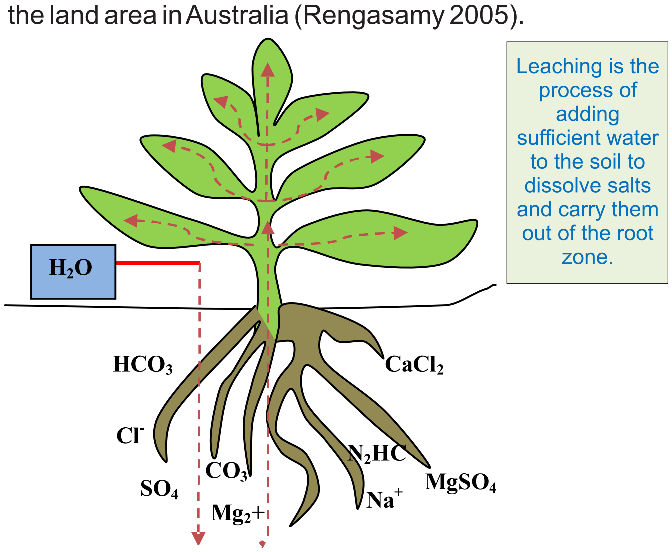

Figure 4: Representation of how water containing dissolved salts may move upward into the rooting zone

c) Nutrient Loss:

Nutrient loss often occurs in combination with Salinization. Deforestation along with laid-back agricultural processes directed soil degradation in the form of nutrient loss. Once soil becomes nutrient-poor, vegetation faces difficulty to growing in these areas. N and P are the main nutrients that restore soil fertility, and together with Ca, Mg, K and organic matter, are subject to losses by water erosion (Mello, 2002). The loss of nutrients like N, P, K, Ca and Mg by water erosion in crop fields contributes to soil degradation, especially under conventional tillage (Schick et al., 2000) and the P, under no tillage in natural fields. Ca and Mg losses by water erosion are usually high. In contrast to P, nitrate is highly soluble and generally does not adsorb to soils. Rather, when water infiltrates into soil, nitrate tends to move with water into the soil profile. Consequently, there are usually low nitrate concentrations at the soil surface during runoff events and in runoff.

Remediation of eroded soils:

Near the beginning many studies on the effects of soil erosion on crop productivity were focused on soil fertility. But various authors reported that reductions in yield caused by soil erosion could be restored by the use of nitrogen and phosphorus fertilizers in the field. Furthermore, these fertilizers became common. After that many researchers concluded that organic amendments should be used as restorative effects on soil structure and hydrologic function. A study on the same problem concluded that the relative advantage of organic amendments over inorganic fertilizers is inversely related to the organic matter content of degraded sites (Larney *et al* 2000). There are some following case studies which are showing detailed information on soil erosion management and rehabilitation:

1. Quesungual — an eco-efficient method of enhancing crop yields and soil quality

Location: Quesungual is a village in southwest Honduras whose name derives from indigenous words for soil, vegetation and a convergence of streams.

Problem: The village's abundant soil and water resources were severely degraded by traditional slash and burn farming practices.

Plan: The silver lining is that a partnership between village farmers and development organizations in the early 1990s led to the development of a new 'eco-efficient' system of agriculture known as the Quesungual Slash and Mulch Agroforestry System (QSMAS). The system starts with selective harvesting and pruning of natural vegetation. Trunks and large branches are used for firewood and timber, while smaller vegetation is spread as mulch. During the first year, farmers broadcast pioneer crops like sorghum and beans, which grow up through the mulch. In subsequent years, maize is the primary crop. The trees and shrubs dispersed throughout fields are aggressively pruned several times a year to produce mulch and prevent excessive shading of crops. The decomposing mulch supplies crops with nutrients, although additional fertilizer is often used (*New Agriculturalist,* 2009).

Result: These layers dissipate the kinetic energy of raindrop impact, improve infiltration and increase water retention. The result is improved water availability for crops. Farmers view the Quesungual System as a method of enhancing crop productivity that also happens to minimize soil erosion (Hellin 2003).

Figure 5: Appearance of vegetation in the Quesungual system after planting

2. Stabilising a gully head

Location: A deep gully had formed, running from highly erodible land into Iron Pot Creek.

Problem: The head of the gully was dangerously undercut. A constantly wet track and stock access at the gully head encouraged further erosion and threatened productive cropping paddocks.

Plan: The area was fenced to exclude stock. A large concrete pipe was installed to deliver water from a collection sump behind the gully head to a concrete-lined 'stilling basin' on the bottom of the gully floor. The area around the stilling basin in the base of the gully was lined with concrete cores to protect the soil from turbulent water and to roughen the surface, reducing the speed of the water flowing from the basin.

Result: The gully head is now stabilised. The collection sump and stilling basin have reduced the erosive potential of the water coming through the gully. Less soil is washing into Iron Pot creek and the revegetated areas will help to link local vegetation corridors.

Figure 6. (a) Installing the concrete pipe, (b) Flood waters leaving the stilling basin, (c) The reshaped gully head area, (d)The end result; mostly grass to look at.

3. Rock reinforcements for shady orchard watercourses

Location: Macadamia orchard

Problem: An older Macadamia orchard with a nearly closed canopy had been established with little regard for natural watercourses. As a result there was extensive sheet erosion with exposed tree roots, and gullies had formed where water flows concentrated in the orchard. The damage to the orchard floor meant machine-harvesting in those areas of the orchard was ineffective. A new owner wanted to reduce the dramatic soil loss and improve machine-harvesting while maintaining existing production levels.

Plan: Gullies running down the inter rows were filled with large gravel. Some trees were removed and others pruned to assist grass cover to be established over the top of the gravel, permitting machine-harvesting. The filled gully functions as both a subsurface and surface drain. Where water flowed across the tree rows small rock check dams were installed to slow the water down and encourage sediment deposition. Selected trees growing in natural flowlines were removed. Windbreak trees causing excess shading were removed.

Result: Active gully erosion through the orchard has been greatly reduced. Extra light has improved groundcover, reducing sheet erosion. Sediment is being trapped within the orchard, rather than ending up in dams and watercourses. The orchard's production has not been interrupted or set back by the erosion control works.

Figure 7. (a) Low light levels and tree rows cutting across natural drainage lines (b) Rock fill in a gully protects against further erosion (c) A small check dam protects where water crosses the tree line

A dam to stop a gully head cut

Location: A grazing property with dispersive sub soils in North coast.

Problem: The landholders of this remote grazing property with dispersive sub soils were concerned about several active gullies. One of the worst gully heads had already cut its way over a kilometre up a broad valley, cutting a gully over 5m deep and often over 25m wide. We wanted to stop the advance of the head cut into productive pastures.

Plan: A dam was designed to reduce the risk of tunnel erosion and deliver most water flow to the gully floor via pipe. Grass and topsoil were taken off the dam site and stockpiled. The base of the dam wall was keyed in to an excavated trench. Soil for the dam wall was mixed with gypsum to reduce dispersion. The dam wall was built in 200mm stages and track rolled.

A large trickle pipe was set into the dam wall to take flows up to greater than a 1 in 10 year flood event. A 3mm black plastic lining to prevent tunnelling was laid on the inside face of the dam wall, and then covered with 1½ m of soil and track rolled. Topsoil was re spread over the finished wall, then fertilised and seeded with perennial grasses and a cover crop of oats. The pipe outlet in the base of the gully was armoured with rock. The dam site and much of the downstream gully line were fenced off.

Result: The gully head has stopped progressing, protecting upslope farmland. Innovative techniques used to protect the embankment from tunnelling allow the dam to be used for water storage. Fencing off the flow line will allow increased vegetation to establish on the gully walls downstream of the dam, and reduce soil loss.

Figure 8.(a) Looking down the gully (b) Spreading seed and fertiliser (c) The finished dam

Source: Soil erosion projects completed in the Northern Rivers, NSW 2007/2008

Conclusion:

The most serious form of soil degradation is the accelerated erosion. A number of the world's most erodible soils have a topsoil layer that is from 10 to 40 centimetres deep, underlain by a layer of subsoil that is hardly permeable by water. Erosion reduces yield because it does not remove topsoil uniformly over the surface of a field. Soil treatment measures are required to mitigate the growing threat to their agricultural productivity from erosion, salinization, waterlogging, and general loss of fertility.

References:

1. Bhattacharyya R, Ghosh B N, Mishra P K, Mandal B, Rao C S, Sarkar D, Das K, Anil K S, Lalitha M, Hati K M and Franzluebbers A J (2015). Soil Degradation in India: Challenges and Potential Solutions. Sustainability, 7(4): 3528-3570
2. Hellin, J. From soil erosion to soil quality (2003). LEISA, 19.
3. Jain Sanjay K, Kumar Sudhir and Varghese Jose (2001). Estimation of Soil Erosion for a Himalayan Watershed Using GIS Technique. Water Resources Management, 15: 41–54
4. Larney, F.J. et al (2000). Early impact of topsoil removal and soil amendments on crop productivity. Agronomy Journal, 92.
5. Mello, EL (2002). Erosão hídrica em diferentes sistemas de manejo do solo sob chuva simulada. Lages: UDESC/CCA, 88. (Dissertação -Mestrado).
6. New Agriculturalist (2009).–Ancient lesson in agroforestry slash but don't burn.
7. Powlson David (2005). "Climatology: Will soil amplify climate change?" Nature 433 (433): 204–205.
8. Rengasamy Pichu (2005).World salinization with emphasis on Australia. Journal of Experimental Botany, 57 (5): 1017-1023.
9. Schick J, Bertol I, Balbinot JR AA, Batistela, O (2000). Erosão hídrica em Cambissolo Húmico alumínico submetido a diferentes sistemas de preparo e cultivo do solo: II. perdas de nutrientes e carbon orgânico. Revista Brasileira de Ciência do Solo, 24: 437-447.

ABSTRACTS

Responses of soil erosion processes to land cover changes in the Loess Plateau of China: A case study on the Beiluo River basin

Ni Chen, Tongyu Ma, Xiaoping Zhang
Catena (2015) doi:10.1016/j.catena.2015.02.022

Understanding the responses of soil erosion processes to land cover changes would benefit catchment ecological management. Landsat thematic mapper images in 1987, 1995, and 2007 were collected to obtain the historical normalized difference vegetation index and land cover data of the Beiluo River basin, one of the catchments in the Loess Plateau. The sediment load data of five subcatchments were collected in the corresponding periods. A set of location-weighted landscape contrast indices was used to analyze the effect of land cover changes on soil erosion processes, as specified by the following indices: slope gradient, flow path length, relative altitude, and relative distance. Results showed that vegetation cover (VC) notably increased from 41.12% to 63.43% in the basin from 1987 to 2007. The increased VC was mainly concentrated in the hilly-gully area from 18.40% in 1987 and 20.21% in 1995 to 41.65% in 2007. The mean annual sediment load modulus in the region over the same periods significantly decreased by 90%. All the indices for each subcatchment exhibited a decreasing trend. The change extent of the indices revealed a significantly positive correlation with that of sediment load modulus. Slope gradient and flow path length were the most important influential factors on soil erosion. Results implied that the improvement in land cover in the Beiluo River basin from 1987 to 2007 led to sediment entrapment in the sink area and changed the soil erosion processes, especially the slope gradient and flow length of the soil erosion source area. This study contributed to improving catchment ecological management and evaluating erosion control practices in the Loess Plateau.

A meta-analysis of soil erosion rates across the world

José M. García-Ruiza, Santiago Beguería b, Estela Nadal-Romeroc, José C. González-Hidalgod, Noemí Lana-Renaulte, Yasmina Sanjuána

Genomophyology (2015) Vol 239.

Over the last century extraordinary efforts have been devoted to determining soil erosion rates (in units of mass per area and time) under a large range of climatic conditions and land uses, and involving various

measurement methods. We undertook a meta-analysis of published data from more than 4000 sites worldwide. The results show that there is extraordinarily high variability in erosion rates, with almost any rate apparently possible irrespective of slope, climate, scale, land use/land cover and other environmental characteristics. However, detailed analysis revealed a number of general features including positive relationships of erosion rate with slope and annual precipitation, and a significant effect of land use, with agricultural lands yielding the highest erosion rates, and forest and shrublanders yielding the lowest. Despite these general trends, there is much variability that is not explained by this combination of factors, but is related, at least partially, to the experimental conditions. Our analysis revealed a negative relationship between erosion rate and the size of the study area involved; significant differences associated with differing measurement methods, with direct sediment measurement yielding the lowest erosion rates, and bathymetric, radioisotope and modeling methods yielding the highest rates; and a very important effect of the duration of the experiment. Our results highlight that, when interpreting erosion rates, the experimental conditions involved must be taken into account. Even so, the data suggest that only order of magnitude approximations of erosion rates are possible, and these retain a very large degree of uncertainty. Consequently, for practical purposes such as calculation of global sediment budgets, empirical equations are not a substitute for direct measurements. Our results also show that a large proportion of the experiments have been short-term (less than 3 years), which reduces dramatically the reliability of the estimated erosion rates, given the highly non-normal behavior of soil erosion (time-dependency). Despite the efforts already made, more long-term measurement experiments need to be performed, especially in regions of the world that are under-represented in global datasets. In addition, protocols need to be established for standardizing the measurement methods and reporting the results, to enable data to be compared among diverse sites.

Loss of plant species diversity reduces soil erosion resistance

Frank Berendse, Jasper van Ruijven, Eelke Jongejans, and Saskia Keesstra

Ecosystems (2015) Vol 18

In many estuarine areas around the world, the safety of human societies depends on the functioning of embankments (dikes) that provide protection against river floods and storm tides. Vegetation on land-side slopes protects these embankments from erosion by heavy rains or overtopping waves. We carried out a field experiment to investigate the effect of plant species diversity on soil loss through erosion on a simulated dike. The experiment included four diversity treatments (1, 2, 4, and 8 species). In the third year of the experiment, we measured net annual soil loss by measuring erosion losses every 2 weeks. We show that loss of plant species diversity reduces erosion resistance on these slopes: net annual soil loss increased two fold when diversity declines four fold. The different plant species had strongly diverging effects on soil erosion, both in the single-species and in the multi-species plots. Analysis of the dynamics of the individual species revealed that the main mechanism explaining the strong effects of plant species diversity on soil erosion is the compensation or insurance effect, that is, the capacity of diverse communities to supply species to take over the functions of species that went extinct as a consequence of fluctuating environmental conditions. We conclude that the protection and restoration of diverse plant communities on embankments and other vegetated slopes are essential to minimize soil erosion, and can contribute to greater safety in the most densely populated areas of the world.

Monitoring soil erosion processes: The erosion plots at the Geocampus, University of Trier

Tamas Lassu, Jesús Rodrigo Comino, Manuel Seeger and Johannes B. Ries

Geophysical Research Abstracts (2015) Vol 17

Long term monitoring on erosion plots is one of the most reliable methods to quantify the actual soil erosion rates. Although the direct extrapolation of the measured data to regional scale is problematic, due to the high spatial and temporal variability of the soil erosion processes, they provide indispensable experimental data for soil erosion model conception, calibration and validation. At the University Trier in 2013 four test plots were put into practice on colluvial loess loam soil with dimension 3 x 10 m and similar properties. They are representative for the regional conditions. The plots are located 265 m above sea level and they have a general inclination of 12-13 . In 2012 on two plots sub soiling was applied in order to reduce the compaction caused by the heavy machinery used during the construction of the plots. The two other plots were not disturbed and no melioration measures were applied. In the first year of the experiment after the preparation of the parcels, they were left for a spontaneous revegetation. Total runoff and sediment removal data was collected weekly; additionally a meteorological station provides continuously data about climate conditions.

The data evaluation of the first year 2013/14 revealed big difference between the single plots. Total runoff was measured between 0 and 4.76 l m-2 (m=0.8 l m-2), total eroded sediment between 0 and 3.86 g m-2 (m=0.21 g m-2) weekly. The higher rates were recorded on the plots without sub soiling. After the first year, total eroded soil was calculated. The results were between 0.03 and 0.17 t ha-1a-1. With the help of the erosion plots at the University of Trier, the impact of the different soil use management concepts and cultivation techniques on runoff and erosion dynamics can be evaluated, additionally reliable data for modelling soil erosion can be generated as well.

NEWS

Farmers find healthy soil works for crops, bottom line

Doug Toussaint's field was in critical condition — and he was the one killing it.

The clay soil in the Red River valley an hour south of Fargo was compacted. He tried a form of extra-deep plowing known as ripping, but it only made the problem worse. For two straight years, the field was too soggy for planting because the soil couldn't absorb rainfall. He turned to North Dakota State University soil expert Abbey Wick, who quickly saw the problem: short-duration crops planted year after year with "nowhere for the water to go." The cure? Give the land a break. Don't plow it. Turning the soil over breaks it down and reduces organic matter — the decaying plants that feed the bacteria, fungi and other microbes — that helps prevent compaction and let's water move through the soil. This year Toussaint's field looks very different. He planted a cover crop last fall. Grasslike spears of rye are thick and green between rows of soybeans. Research shows healthy soil can reduce erosion, slow runoff into rivers and cut the need for fertilizer. Despite those benefits, observers say it remains hard to convince farmers to leave behind traditional tillage. No-till practices are used on less than .05 percent of Minnesota farm fields, according to the U.S. Department of Agriculture's 2012 census; reduced tillage happens only about 30 percent of fields. "It's a way of life, it's a culture, it's something that you do," Wick said of tilling the soil. "To stop doing that and to sit back at the shop while everybody else is out tilling is really tough for a guy to do." Toussaint is among those Red River farmers who've bought in to no-till and found good things come from changing practices. By expanding his crop rotation and using cover crops, he's cut fertilizer costs on some fields. That's especially important now when crop prices are low.

Part of this field on Doug Toussaint's farm near Wahpeton, N.D., is planted with cover crop to compare crop production methods

There are several projects in Minnesota aimed at changing farm tillage practices. A Minnesota Board of Water and Soil Resources project will encourage the use of cover crops in south eastern Minnesota starting this summer. The University of Minnesota is studying alternative cover crops and the USDA has a variety of soil health research and education initiatives. Some farm groups support the change. The Minnesota Corn Growers Association has two soil health research projects. Research director Paul Meints says farmer interest was reflected in turnout at a demonstration day he attended last summer in western Minnesota that drew farmers the Dakotas, Minnesota, Wisconsin and Iowa. Planting cover crops can be a challenge in Minnesota and the Dakotas where a short growing season doesn't leave much time to plant a second crop after the fall harvest. But farmers will adopt minimum or no till practices if they see it as a wise business decision, Meints added.

Source: www.mprnews.org

Doug Toussaint examined the soil surface in a small field he recently planted with a mix of grasses. Toussaint has also added Reed Canary grass to his crop rotation and says last year it was his most profitable crop.

Drought in western Kansas causing soil erosion

HUGOTON, Kan. -- Years of drought have taken its toll on the soil in western Kansas. Much of the area has had blowing dust and soil erosion following strong winds and no rainfall. "We have had less rainfall than the dust bowl had," said Stevens County Extension Agent Joshua Morris. Morris says that improved farming techniques are keeping the soil better anchored than in the dust bowl. "They are keeping more residues on the ground which helps it from blowing away," said Keri Morris, a district conservationist. Morris says that no-til farming - planting the crop into the soil without turning the soil over with tractors and equipment - is helping keep the soil anchored. Many farmers are using ground cover plants, such as grasses and wheat, and also leaving residue, or the remains from the previous crops, on the soil. If farmers were not doing that, the soil would likely blow even worse and decrease productivity even more.

"We anticipate that everywhere we see erosion, we are going to have slower growth, we are going to have plants that are less tolerant of diseases," said crop consultant Loren Seaman. Farmers are implementing some of the no-til techniques and keeping a ground cover. The issue with planting crops for ground cover is there is usually no money to be made. Steve Rome is a farmer in Stevens County. He says that about 25% of his families ground is without irrigation; those crops over the past five years have been in poor condition. "We plant just for cover, rather than worry if we are going to raise any grain or not, and that is not profitable long term," Rome said. Keri Morris and Joshua Morris both said that the only true solution to solving the blowing soil issue is to get some rainfall. Some suggest planting the ground back to grassland, but it could take 10 years for grass to get established if the current drought holds. Another issue with grassland is the fire danger in the winter when the grass is dry and dormant. Keri Morris says that there is no simple solution other than hoping for rain saying, "it is basically Mother Nature's vengeance that has kept us from keeping the soil where it needs to be, it's not because the producers are not doing a good job."

Source: www.kake.com

BOOKS

Soil Erosion
ISBN: 978-1632395610
Publisher: Callisto Reference
Author: Henry Wang

Soil: The Skin of the Planet Earth
ISBN: 13: 978-9401797887
Publisher: Springer
Author: Miroslav Kutílek, Donald R Nielsen

Building Soil: A Down-to-Earth Approach: Natural Solutions for Better Gardens & Yards
ISBN: 978-1-59186-619-0
Publisher: Quarto publishing group USA Inc.
Author: Elizabeth Murphy

Soil Fertility
ISBN: 13: 978-1632395634
Publisher: Callisto Reference
Author: Lester Bane

Soil for My Roots
ISBN: 978-9382536369
Publisher: LiFi Publication Private Limited
Author: Minal Sarosh

CONFERENCES

Soil Organic Matter Balance methods as practice-applicable tools for environmental impact assessment and farm management support
Venue: Rauischholzhausen/Germany
Date: Dec 8th - 10th 2015
Link: http://www.uni giessen.de/cms/fbz/fb09/institute/pflbz2/olb/aktuelles/veranstaltungen/sompatic2015

Ecology of soil Microorganisms 2015
Venue: Praha, Czech Republic
Date: Nov 29th -3rd Dec 2016
Link:http://www.biologicals.cz/conferences/index.php?template=conferences&page=conference_login&conference_id=22#bm169

Linking Soil Processes to Forest Productivity and Water Protection under Global Change
Venue: Fuzhou, China
Date: Oct 24th-28th 2015
Website: http://isfs2015.com/index.asp

International Youth Forum on Soil and Water Conservation (IYFSWC)
Venue: Nachang
Date: Oct 16th-18th 2015
Link: http://iyfswc.nit.edu.cn/

NBRI Director

Dr. C.S. Nautiyal director@nbri.res.in

NBRI-ENVIS Coordinator

Dr. Nandita Singh n.singh@nbri.res.in

Editors

Dr. Nandita Singh and Dr. Pankaj K. Srivastava

Compiled & designed by

Dr. Shivani Srivastava, Deepmala Yadav and Yashpal Singh

Book Post

To,

From:
The ENVIS Coordinator
NBRI-ENVIS Centre
Centre for "Plants & Pollution"
CSIR-National Botanical Research Institute
Rana Pratap Marg, Lucknow-226001