Determination of soil erosion in a steep hill slope with different land-use types: 
A case study in Mertesdorf (Ruwertal/Germany)

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Abstract: Inappropriate land use is one of the main reasons for soil erosion and land degradation. Vine growing plays an important role in many semiarid regions all over the world as a permanent plant cover in terms of preventing erosion, sustainable use of land and water resources, defense against desertification and settling population in rural areas. In this paper, in a steep hill slope of the village Mertesdorf (Ruwertal/Germany), Algemeine boden abtrags gleichung (ABAG) have been applied to determine and compare the soil erosion amounts between the different land use types such as vine growing, forest lands, grasslands, shrubs and new forestations. The results show that the soil erosion amounts differs in a high ratio between the land use types. Soil erosion amounts in the vine growing areas are the highest (5.47 t/ha/year), then comes with 1.19 t/ha/year the over grazed grasslands and the lowest erosion amounts have been determined, as expected, in the forest lands (0.66 t/ha/year).

Key words: Soil erosion, Land use, Vineyard, ABAG, USLE

Introduction

As human demands increase, the sustainable use of land becomes more important. Better land management involves identifying land use changes, understanding current land use patterns or features and assessing economic and ecological benefits and costs that arise from land use practices, as well as finding the best alternatives for each area (Wu et al., 2001).

Land use change may affect many natural phenomena and ecological processes (Turner, 1989), including water runoff, erosion (Burel et al., 1993; Fu et al., 1994) and soil conditions. It can drastically modify resistance of soil to environmental changes in particular, it can increase the vulnerability of semi arid ecosystems (Martinez Fernandez et al., 1995).

Inappropiate land use is one of the main reasons for soil erosion and nutrient loss in the hilly area (Fu et al., 2000).

Furthermore, vine growing plays an important role not only from the economic point of view, but also environmentally as a permanent plant cover in terms of preventing erosion, managing land and water resources in a sustainable way, defending against desertification and settling population in rural areas (Martin de Santa Olalla, 1994).

Vine growing plays an important role in many semiarid farming regions all over the world as a permanent plant cover in terms of preventing erosion, sustainable use of land and water resources, defense against desertification and settling population in rural areas.

Ecological soil functions are generally and frequently in change. Soil erosion not only affects soil functions and soil usage but also affects soil characteristics and plant nutrient economy in the neighborhood lands as well. Several studies have been realized to determine and reduce these negative effects. At the end of these studies, several equations were given for calculating the quantity of soil loss (Bork, 1996).

Especially Wischmeier and Smith’s (1978) studies in USA are the avant garde searches about this subject. The first formula about the soil erosion quantity is USLE (Universal soil loss equation) which has been developed and modified up to now several times was hold in the same period as well. Although several models and formulas were developed which calculates the soil erosion quantity. The most common model is still USLE, because of easy application and prediction reality. In this study obtained results and related statistical evaluations about the soil erosion values in a slope land with different land uses in Mertesdorf village in trier city in Rheinland Pfalz state in Germany were given by the model of ABAG (Algemeine boden abtrags gleichung) (Schwertmann, 1987) which is the form of USLE integrated to European conditions by turning into metric system.

Materials and Methods

Description of the study area: This study was realized in Mertesdorf village in trier city in Rheinland Pfalz state in Germany in a slope land with different land uses (Fig. 1). In this village there is a research station which was constructed by Prof. Dr. Gerold Richter in 1974 for soil erosion studies. Some data were obtained from this station for this study.

The Rhenish slate mountains are dissected by the deep Rhine and Mosel valleys, which are crossing the mountains on their way to the North sea. This valley system is favored by a warm climate especially during the summer months. Therefore, it
has two of German’s most famous vine growing regions called Mittelrhein and Mosel Saar Ruwer (Richter, 1991).

Study has been realized on a steep sloped hill side with different land use types (vineyards, over grazed grasslands, regeneration areas, scattered shrubs and forest areas) in 315 plots (Fig. 2).

In every plot, skeleton amounts, humus proportion, soil type, soil depth, aggregate sizes, permeability value, plot lengths, plot widths, plot slopes, land use types, soil treatment direction, plant type, position of the undergrowth were determined in study area and laboratory. Mertesdorf research station laboratory was used for determination of soil type and soil depth data.

As a consequence of the geomorphologic conditions a high percentage of the vineyards is growing here on steep slopes. About 75% of all vineyards have a slope of more than 35% (Jatzold, 1990).

Although the soils have a large permeability and additional protection by a rock content of 30-50%, these steep sites are highly susceptible to soil erosion (Richter, 1991).

General aspect of the research area is southwest (SW). Slope grades changes between 35%-50% (Fig. 2). Mean annual precipitation (except snow) is approximately 600 mm (340 mm in summer, 260 mm in winter). Measurements between 1974-1988 show that 370 mm of the precipitation pass through runoff and cause to soil erosion (Richter, 1979).

The soils, which have been developed on slates, are general rocky and of the acid brown earth types. In the study area, the rigosol on slate weathering has a depth of about one meter and consists of 1/3 stones, 1/3 of sandy fraction and 1/3 of silt and clay (Richter, 1991).

Soil erosion amount in every plot was calculated as ton/hectare/year by ABAG (Schwertmann et al., 1987). According to the land use types, relations and changes between soil erosion values were examined by the help of statistical program SPSS. ANOVA and Duncan test was used for the statistical evaluation.

**ABAG (Algemeine boden abtrags gleichung):** ABAG is an equation (1) which was adapted to European conditions and into metric system by changing USLE, improved by Wischmeier and Smith (1978) in USA (Schwertmann et al., 1987).

\[
A = R \times K \times L \times S \times C \times P
\]

(1)

In the equation:

- **A** = Annual soil erosion including long period and its unit is ton/hectare/year.
- **R** = Precipitation and runoff factor. This factor shows effective degree of the precipitation in soil erosion and calculated by
Fig. 2: Study area and the 315 study plots with different land use types
Results and Discussion

Results from 315 plots in different land use types (vineyards, forests, regeneration areas, scattered shrubs, partly overgrazed grasslands) were evaluated statistically (ANOVA). Highest erosion amount (6.47 t/ha/year) was obtained in vineyards and it was determined that only between vineyards and other land use types there is a significant difference in soil erosion amounts at significant level p≤0.05 (Table 1, 2 and Fig. 3).

Evaluations between the areas except vineyards show that highest soil erosion amount is in the grasslands (1.19 t/ha/year) (Table 3, 4 and Fig. 4). Because of the over grazing and pressed soil surface due to animal impression, soils loose their infiltration ability and soil erosion amount could be increased (Bermudez et al., 1998).

Table - 1: Results of ANOVA for the soil erosion amounts in different land use types

<table>
<thead>
<tr>
<th>Land use</th>
<th>N</th>
<th>Mean of erosion (t/ha/year)</th>
<th>F-ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grassland</td>
<td>25</td>
<td>0.8657</td>
<td>1.1952</td>
<td></td>
</tr>
<tr>
<td>Shrub</td>
<td>106</td>
<td>0.7135</td>
<td>0.8657</td>
<td></td>
</tr>
<tr>
<td>Forest</td>
<td>60</td>
<td>0.6670</td>
<td>0.7135</td>
<td></td>
</tr>
<tr>
<td>Regeneration</td>
<td>23</td>
<td>0.6670</td>
<td>0.8657</td>
<td></td>
</tr>
<tr>
<td>Vineyard</td>
<td>101</td>
<td>6.4737</td>
<td>6.4737</td>
<td></td>
</tr>
</tbody>
</table>

Df = Degrees of freedom

Table - 2: Results of Duncan test

<table>
<thead>
<tr>
<th>Land use</th>
<th>N</th>
<th>Subsets for p≤0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>1</td>
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<td></td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Table - 3: Results of ANOVA in different land use types except of vineyards

<table>
<thead>
<tr>
<th>Sum of squares</th>
<th>Df</th>
<th>Mean square</th>
<th>F-ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>5.375</td>
<td>3</td>
<td>1.792</td>
<td>6.059</td>
</tr>
<tr>
<td>Within groups</td>
<td>62.091</td>
<td>210</td>
<td>0.296</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>67.465</td>
<td>213</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Df = Degrees of freedom

Table - 4: Results of Duncan test

<table>
<thead>
<tr>
<th>Land use</th>
<th>N</th>
<th>Subsets for p≤0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>1</td>
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</tbody>
</table>
and stems which prevents the direct falling of the precipitation on coverage (Table 6, Fig. 6). These events, soil erosion is increased at the ratio of 1/3. Between 1099.158 1 1099.158 43.805 0.000 groups Within 2484.108 99 25.092 groups Total 3583.266 100 Df = Degrees of freedom

Table - 5: Effects of the results of soil treatments in vineyards

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>Df</th>
<th>Mean square</th>
<th>F-ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>1099.158</td>
<td>1</td>
<td>1099.158</td>
<td>43.805</td>
<td>0.000</td>
</tr>
<tr>
<td>Within groups</td>
<td>2484.108</td>
<td>99</td>
<td>25.092</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3583.266</td>
<td>100</td>
<td></td>
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</table>

Df = Degrees of freedom

Fig. 5: Effects of the soil treatment on erosion in vineyards

When the vineyards, the most important agricultural activity in the research area, evaluated with each other (Table 5, Fig. 5), it was found that if soil treatment has been done between the vineyards, plant coverage did not occur on the soil surface. Soil surface stony structure which increases infiltration and decreases splash effect of rain could be decreased (Ruttimann et al., 1995; Komas et al., 1997; Huang et al., 2001) and due to these events, soil erosion is increased at the ratio of 1/3. When the effects of plant coverage existence on the soil surface examined, it was seen that soil erosion amount in areas with plant coverage is 6 times lower than in areas with no plant coverage (Table 6, Fig. 6).

The lowest soil erosion amount is calculated in the forest lands. In forest lands trees cause interception by leaves, branches and stems which prevents the direct falling of the precipitation on the soil surface (Hacisalihoglu et al., 2003). High amount of organic matter affects the soil characteristics positively. Consequently, soil erosion occurs in forest lands in low amounts (Bryan, 2000). If canopy and density of the forest areas decreases, erosion amounts increase (Bermudez, 1998).

In high slope lands, if protective plant coverage is removed from the soil surface or agricultural facilities are done without protective precautions, soil erosion amount could be increased. Land use type deal with soil erosion is the most important environmental problems. These problems can be solved with the help of useful land use and agricultural facilities by taking necessary protective precautions.

Acknowledgments

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