Anti-Erosion Efficiency of Stands Installed On Degraded Land

Mircea Cristian Moldovan (moldo_mirk@yahoo.com)
National Institute for Research and Development in Forestry ”Marin Drăcea” https://orcid.org/0000-0002-8801-8488
Tăut Ioan
National Institute for Research and Development in Forestry ”Marin Drăcea”
Dîrja Marcel
The unversity of Agricultural Sciences and Veterinary Medicine Cluj-Napoca

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Research

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Abstract

Background: The naturally present erosion phenomenon has been active throughout the geological eras, shaping the land surface to date. Today, this phenomenon causes significant damage to the environment and human activities.

In the geographical conditions of Romania, where the sloping land represents up to 67% of the national territory and supported by a complex number of natural factors, as well as the intense human interventions from the end of the 19th century and the beginning of the 20th, the vegetation and soils face serious ecological imbalances. The afforestation of degraded lands gained momentum after 1948, and the most used species were pines, especially black pine and Scots pine.

Methods: In order to achieve the proposed objectives regarding the evaluation of stands in terms of anti-erosion effectiveness, were analyzed the consistency of trees, the number of trees on the surface, the weight of the seedlings, and surface runoff, from the perspective of rainfall and soil retention.

Results: Analyzing the influence of rain intensity, respectively 39% in compartment 49, 38% in 73 and ground retention on surface runoff, being 28% in both compartments, it results that the two parameters directly influence surface runoff. Thus, it can be stated that indirectly surface runoff is influenced by the consistency of the stands, by the degree of proximity of the crowns, which directly influence the intensity of rain and the number of trees and the vegetation that grows under them directly influences the retention in the soil through the litter that is formed, which promotes retention.

Conclusions: The results obtained suggest that indirectly surface runoff is influenced by the consistency of the tree, by the degree of proximity of the crowns, which directly influence the intensity of rain.

Also, the number of trees and the vegetation that grows under them directly influences the retention in the soil through the litter that is formed, which promotes retention and by creating areas that reduce the speed of water, favoring infiltration into the soil.

Background

The presence of the natural erosion phenomenon has been active throughout the geological eras, shaping the land surface to date. Today, this phenomenon causes significant damage to the environment and human activities (BĂDESCU, 1971, Julien, 2010). The latter accelerate the processes of erosion, transport and sedimentation, the most harmful being the deforestation, cutting and burning of vegetation (Govers, 2017) . In addition to sedimentation, erosion causes damage to agricultural land, reducing their productivity. In certain circumstances, the erosion rate can be 100 or even 1000 times higher than geological erosion (25 tons / km2 / year) (Giurgiu, 2004).

In the geographical conditions of Romania, where the sloping land represents up to 67% of the national territory and supported by a complex number of natural factors, as well as by intense human interventions from the end of the 19th century and the beginning of the 20th, the vegetation and soils face serious ecological imbalances (Constandache, 2010). Consequently, land degradation and the increasing frequency of torrential processes favor the emergence of areas with a typical semi-desert appearance (Julien, 2010) .

Ecological reconstruction is essential for the rehabilitation of degraded areas and for the protection of biodiversity, ecosystem services and human well-being. The use of functional features for planning improvement strategies has been suggested, as they are the main ecological qualities that underlie ecosystem processes and services. However, few studies have translated ecological theory into real reconstruction practices, which can be easily used by different stakeholders (Gianni, 2017).

Dîrja M. (2008) points out that, once started, land degradation accelerates over time, to the point where combating becomes difficult both technically and economically. That is why action must be taken in time to prevent and combat erosion at an early stage when the necessary work requires a low degree of difficulty and costs (Helmana, 2014).

Since ancient times, afforestation, associated with terracing, has been used to combat soil erosion (Voevod, 2015). If at the beginning the plantations were made following the spontaneous vegetation of the respective area, together with the new geographical discoveries and the movement of the population, various exotic species were acclimatized, which proved useful in combating erosion.

In Romania, afforestation of degraded lands gained momentum after 1948, and the most used species were pines, especially Black pine and Scots pine (Constandache, 2004).

The strategies regarding afforestation on degraded lands from that time were, on the one hand, the improvement and introduction of these lands in the forest circuit, and on the other hand, it was the creation of forests with resinous species outside the natural area, fast growing, with short production cycles (about 50 years), intended for the pulp industry (Mircea, 2018).

Since 1990, these forests have been assigned the exclusivre role of protection, being managed according to functional group I, and the lifespan being until they can no longer fulfill their protection functions.

The aim of the research is to observe and quantify the anti-erosion efficiency of some pine stands, installed on degraded lands, in order to create new policies on afforestation, respectively the management of existing stands on degraded lands (Chen, 2019).

Materials And Methods

The improvement perimeters in which the research was carried out can be found in compartment 49, which is composed of subcompsrtments 49A and 49B, the main reason being north-western exposure in 49B, compared to the south in 49A and 73, managed by Forest District Gherla, within the locality of the Diviciori Mari (Fig. 1).

Field and lab studies

In order to achieve the proposed objectives regarding the evaluation of stands in terms of anti-erosion effectiveness, the consistency of stands, the number of trees on the surface, the share of seedlings, and surface runoff were analyzed, from the perspective of rain intensity and soil retention.

The determination of surface leaks was made within the runoffplots (GABRIEL M., 2014, YAN., 2019), which involves the collection of alluvial water, filtration and weighing in the laboratory (MOLDOVAN 2020).

Simultaneously with the leakage analysis, performed in the field, data were collected regarding the amounts of precipitation, with the help of rain gauges installed both inside the studied stands and outside them.

In order to determine as accurately as possible the level and intensity of rainfall, rainfall periods were measured in minutes and the intensity formula was applied: i = P / T, where P = volume of precipitation (l / m^2) and T = duration of rainfall (minutes) (Marcel Dîrja, 2010).

Figure 3. The intensity of rains in the forest and outside the forest expressed in l / sqm

Data analysis

In order to obtain conclusive results, linear regression, was used in order to quantify the influence of rainfall intensity and ground retention on surface runoff. These indicators were chosen because, indirectly, the anti-erosion effect of the stands can be quantified. In order to eliminate calculation errors, the Regression function in Excel was used.

Results

The consistency of the forest, associated with shrubs, flora, litter, have a very important role in preventing surface runoff and thus in reducing soil erosion (Constandache, 2010). These aspects could not be directly correlated, being necessary data regarding the water quantities from precipitations that reach the ground, represented by the intensity of the rains, which is directly influenced by the consistency and phytosanitary condition of the stand.

The consistency of compartment 49 is 0.8 (80% covering) , an average number of 15.6 trees per 200 square meters and 780 trees per hectare, and within plot 73, the consistency is 0.7 (70% covering), an average number of 21.11 trees per 200 square meters, and per hectare, of 1055 trees (fig. 4). The consistency are expressed in accordance with the existing forestry methodology in Romania.

Also, the seedling cover from the existing natural area in situ was highlighted. Thus, in subcompartment 49A, the species that make up the seedlings are approximately 40% sessile oak, 30% walnut and 20% false acacia. In subcompartment 49B, the species consisting the seedling cover are approximately 25%

beech, 15% sessile oak, 5% walnut and 1% false acacia, and in compartment 73 the species consisting the seedling cover are approximately 40% sessile oak, 50% Turkey oak, 30% ash, 40% pubescent oak (fig. 5).

In this sense, the influence of rain intensity on surface runoff was followed by simple linear regression, which has the formula: y = a + bx, where a = free term or incept, constant representing the height at which the line intersects the OY axis, b = regression coefficient (slope of the line), represents the value by which y changes, when x increases by one unit (Sestraș, 2019).

Within plot 49, the regression model obtained is as follows: y=206.73+448.19x**, being represented in figure 6. The adjusted r index is 0.39, meaning that the intensity of the rains influences in proportion of 39% surface leaks. The degrees of freedom for the experiments carried out are 14, and the theoretical “t” are: t 0.05 = 2,145, t0,01 = 2,977, and t0,001 = 4,140. The calculated “t” value is 3,282, higher than t0,01 = 2,977, which means that the results obtained are distinctly significant **.

Within compartment 73, the regression model obtained is as follows: y=206.61+4380.408x**, being represented in figure 7. The adjusted r index is 0.38, meaning that the intensity of the rains influences in proportion of 38% surface leaks. The degrees of freedom for the experiments carried out are 14, and the theoretical “t” are: t 0.05 = 2,145, t0,01 = 2,977, and t0,001 = 4,140. The calculated “t” value is 3,219, higher than t0,01 = 2,977, which means that the results obtained are distinctly significant **.

Another indicator that influences surface runoff, which is indirectly influenced by the development of stands, is ground retention. It is defined by the quantities of water that are lost by infiltration and retention, data obtained analytically according to the formula S = P-Z-I (Dîrja, 2010), where S-leakage, P-precipitation, Z-retention, I-Infiltration, reported at 200 square meters.

Ground retention was calculated by the differences between the theoretical leakage determinations (P) (the amount of water that can drain per unit area without disturbance caused by retention and infiltration, from the amount of precipitation measured with the rain gauge) and the average basin runoff (S) determined following the measurements.

As in the case of rain intensity and in this case the influence on surface runoff was followed by applying simple linear regression.

In compartment 49, the regression model obtained is the following: y=192.12+0.0216x*, being represented in figure 8. Influence of ground retention on surface runoff in ua 49. The adjusted r index is 0.28, meaning that ground retention influences surface runoff by 28%. The degrees of freedom for the experiments carried out are 14, and the theoretical “t” are: t 0.05 = 2,145, t0,01 = 2,977, and t0,001 = 4,140. The calculated “t” value is 2,558, higher than t 0,05 = 2,145, which means that the results obtained are significant*.

In compartment 73, the regression model obtained is the following: y=192.81+0.0211x*, being represented in figure 9. Influence of ground retention on surface runoff in ua 73. The adjusted r-index is

0.28, meaning that ground retention influences surface runoff by 28%. The degrees of freedom for the experiments carried out are 14, and the theoretical "t" are: t 0.05 = 2,145, t0,01 = 2,977, and t0,001 = 4,140. The calculated "t" value is 2,513, higher than t 0.05 = 2,145, which means that the results obtained are significant *.

Analyzing the influence of the two parameters that directly influence the surface runoff, it can be stated that indirectly the surface runoff is influenced by the consistency of the tree, by the degree of proximity of the crowns, which directly influence the rainfall intensity (Delcampo, 2019). Also, the number of trees and the vegetation that grows under them directly influences the retention in the soil through the litter that is formed, which promotes retention and by creating areas that reduce the speed of water, favoring infiltration into the soil (Yu, 2019).

Discussions

In the present work, the anti-erosion efficiency of some stands planted on degraded lands, which were temporary, at the time of their design, was taken into account. Today, these stands are included in functional group I, respectively for soil protection.

The main reason that led to the study was the high density per hectare, associated with not conducting management work, due to the lack of economic efficiency. The growth of the trees was stronger in height than in diameter, which led to numerous isolated ruptures and fellings caused by winds.

Conclusions

The consistency of compartment 49 is 0.8 (80% covering), an average number of 15.6 trees per 200 square meters and 780 trees per hectare.

Within compartment 73, the consistency is 0.7 (70% covering), an average number of 21.11 trees per 200 square meters, and per hectare, 1055 trees

Within subcompartment 49A, the species that make up the seedling cover are approximately 40-50% sessile oak, 35% walnut and 30% false acacia.

In subcompartment 49B, the species consisting the seedlings are approximately 25% beech, 15% sessile oak, 5% walnut and 1% false acacia.

In compartment 73, the pieces that make up the seedlings are in the proportion of about 40% sessile oak, 50% Turkey oak, 30% ash, 40% downy oak.

In order to be able to appreciate the anti-erosion efficiency of the forest, the influence of the intensity of the rains was observed and quantified, respectively that of the ground retention on the surface runoff through the simple linear regression.

Within compartment 49, the intensity of the rains influences the surface runoff in proportion of 39%, and the ground retention in proportion of 28%. In the case of compartment 73, the intensity of the rains influences the surface runoff in proportion of 38%, and the ground retention in proportion of 28%.

Analyzing the influence of the two parameters that directly influence the surface runoff, it can be stated that indirectly the surface runoff is influenced by the consistency of the stands, by the degree of proximity of the crowns, which directly influence the rainfall intensity.

Also, the number of trees and the vegetation that grows under them directly influences the retention in the soil through the litter that is formed, which promotes retention and by creating areas that reduce the speed of water, favoring infiltration into the soil.

Declarations

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare that they have no competing interests.

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Authors' contributions MM installed the runoffplots, collected the field data and performed the necessary analyzes to obtain the data for processing. He also processed the data. DM analyzed the processed data, and TI elaborated the text of the paper. All authors participated in the review and editing of themanuscript. The authorsread and approved the final manuscript.

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Availability of data and materials

The data used in the elaboration of the paper are not available online, all the presented ones are obtained by the authors. These can be made available for further analysis if needed.

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Figures

Figure 1

Location of runoff plots (MOLDOVAN 2020) Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

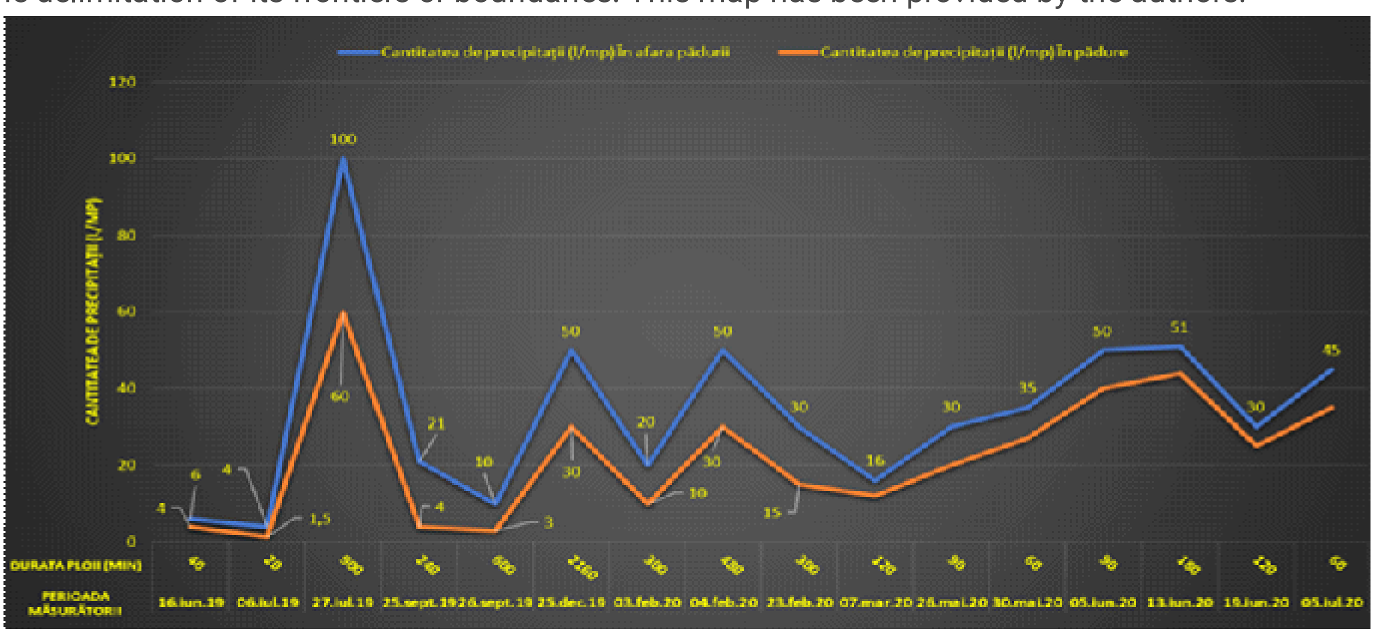

Figure 2

The amount of precipitation in the forest and outside the forest expressed in l / sqm

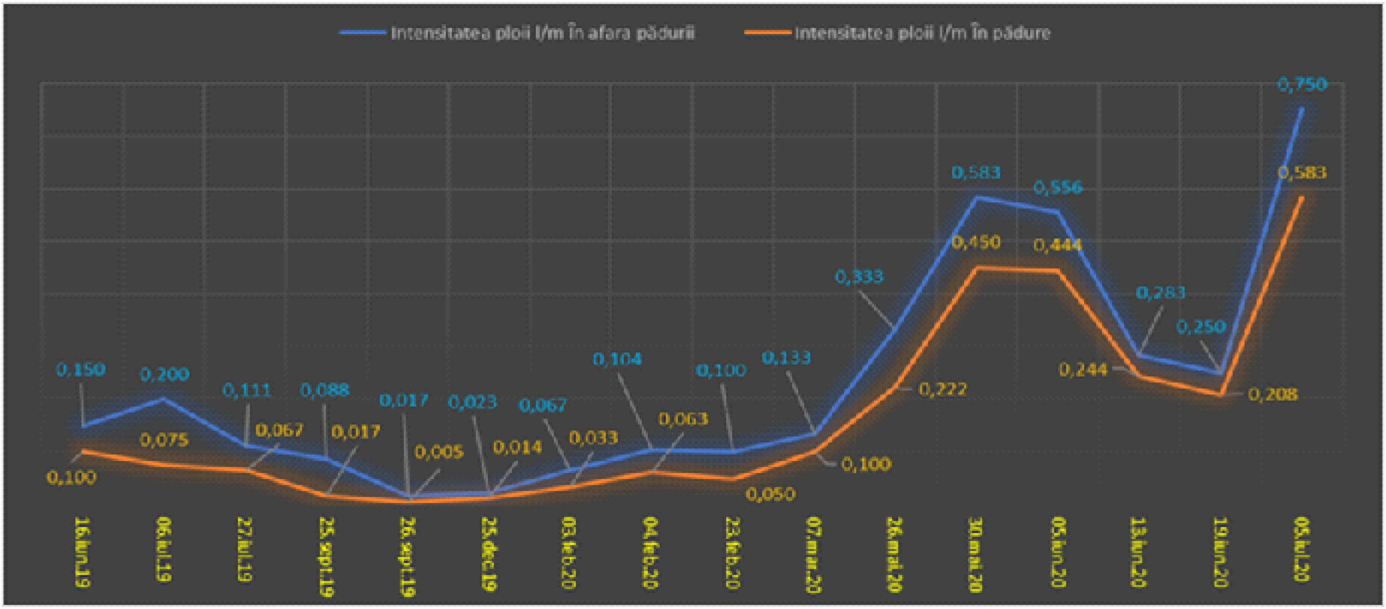

Figure 3

The intensity of rains in the forest and outside the forest expressed in l / sqm

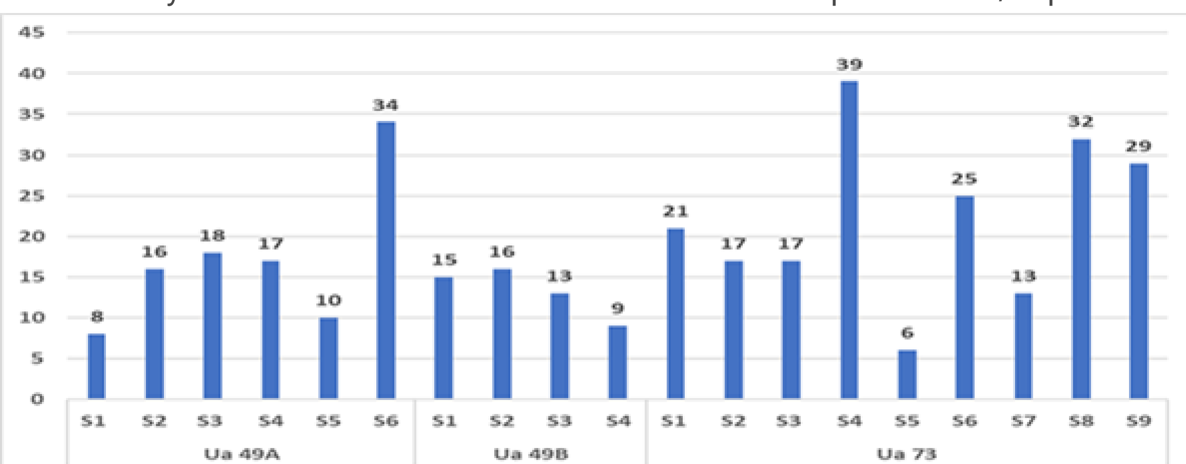

Figure 4

Number of trees inventoried in the improvement perimeters

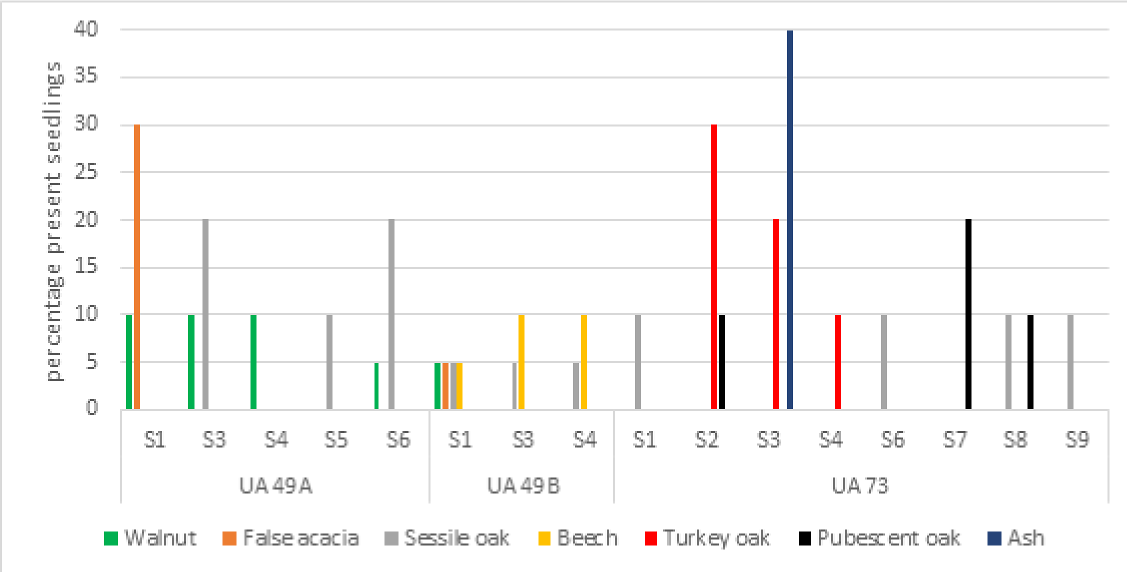

Figure 5

Percentage of seedlings participation in each sample plot

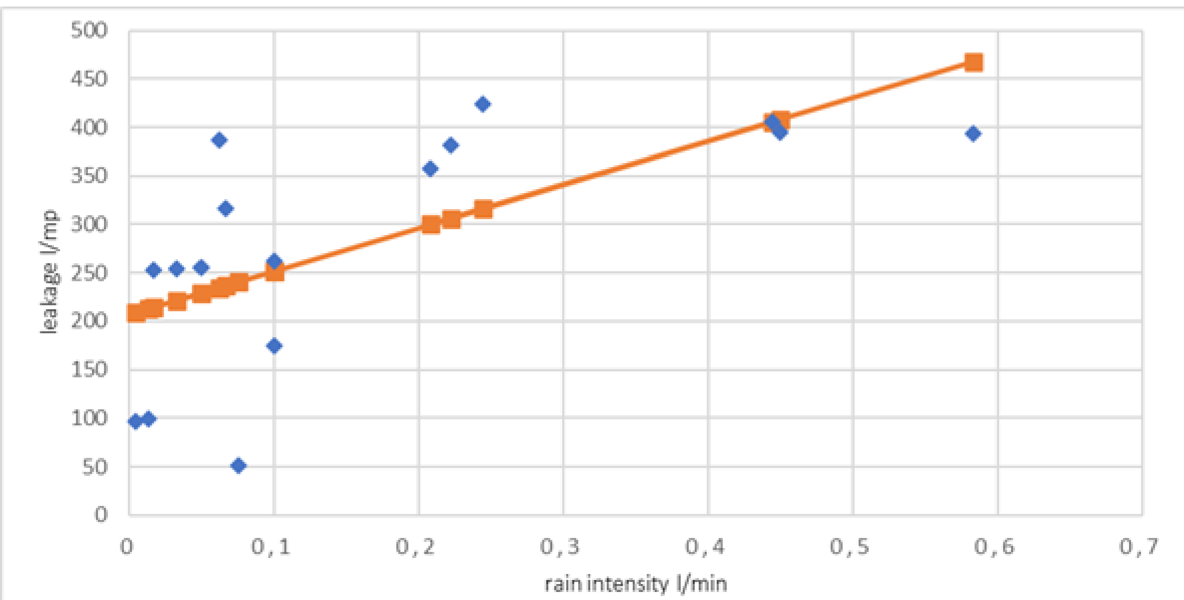

Figure 6

The influence of rainfall on surface runoff in the compartment 49

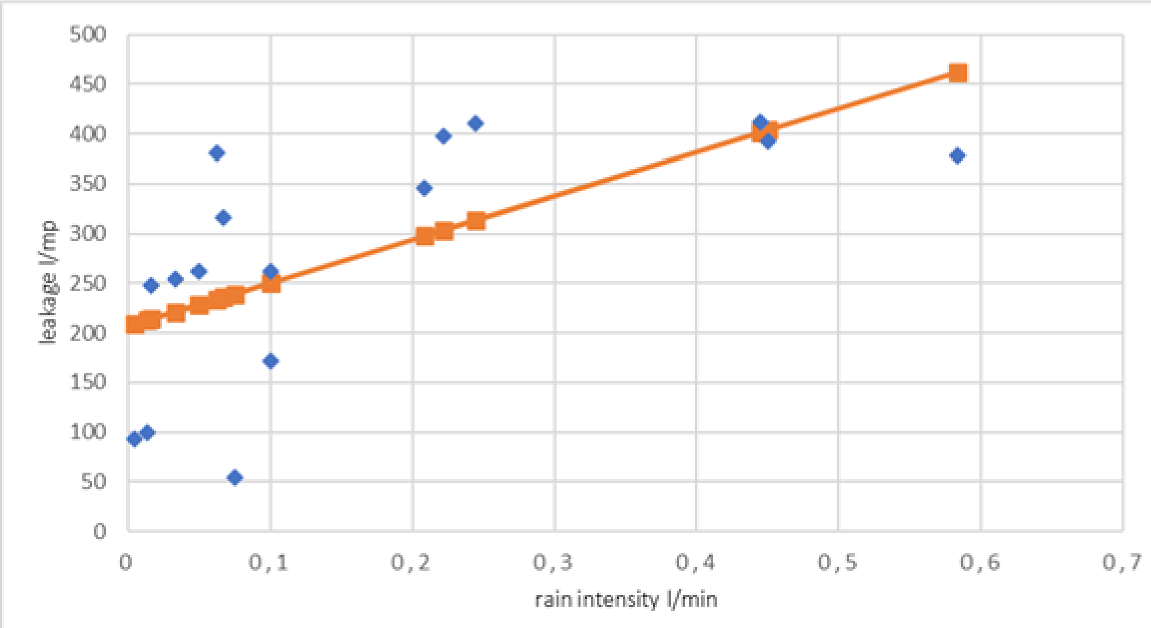

Figure 7

The influence of rainfall on surface runoff in the compartment 73

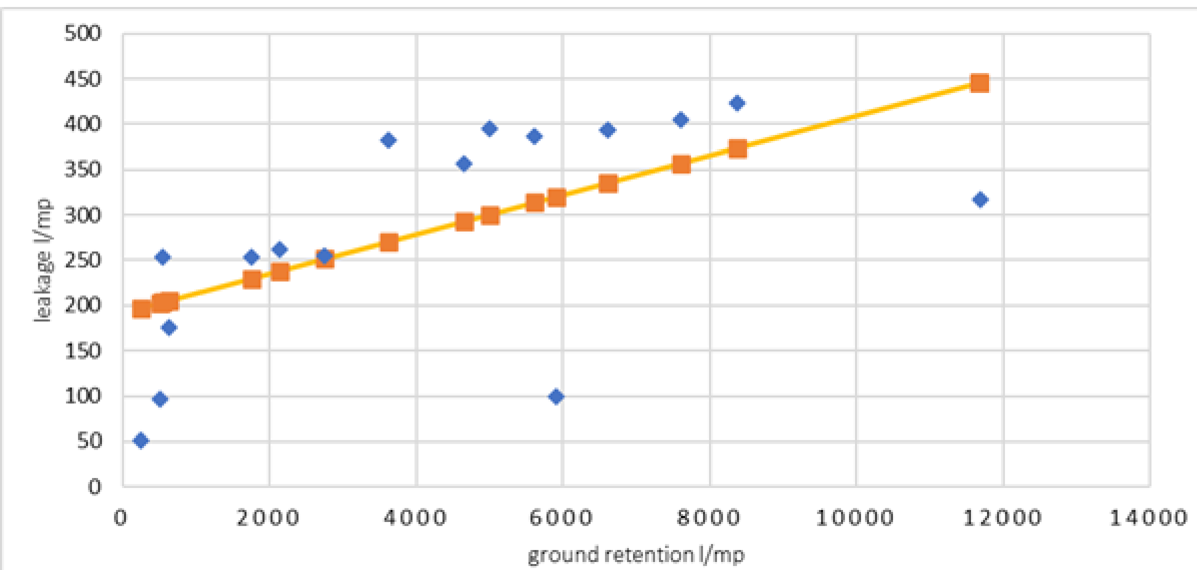

Figure 8

The influence of ground retention on surface runoff in compartment 49

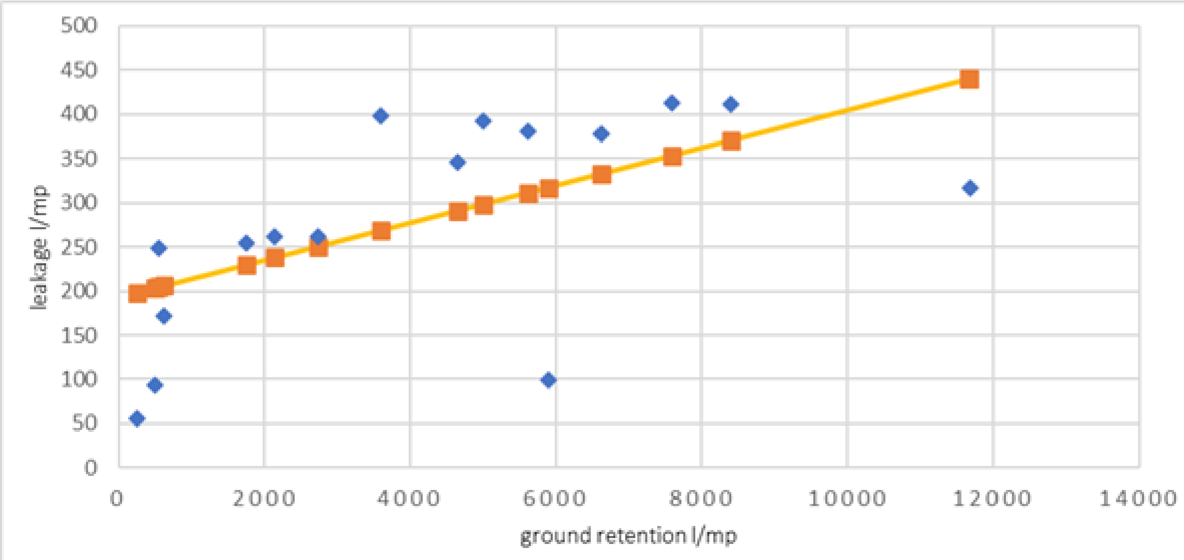

Figure 9

The influence of ground retention on surface runoff in compartment