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# THE EFFECT OF LICHENS ON SOIL AGREGATE STABILITY

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## ABSTRACT

This study was carried out to investigate the effect of lichens on soil aggregate stability. In the study, lichen and non-lichen soil samples were taken from the forest areas of the Meulenwald region of Germany, consisting of *Picea abies* (L.) and *Pinus sylvestris* (L.) species, where lichens of *Cladonia furcata, Cladonia coniocraea, Peltigera rufescens* and *Baeomyces rufus* were detected. In this study, soil samples were evaluated in terms of soil pH, organic matter (%) content, soil permeability, texture analysis, and cation exchange capacity. In the study, it has been determined that the aggregate stability and water holding capacity of lichen soil is higher than that of non-lichen soil.

**Keywords:** Aggregate Stability, *C. furcata., C. coniocraea., P. rufescens., B. rufus*

## 1. INTRODUCTION

The structure of the soil is like a complex labyrinth consisting of the organization and regulation of soil particles and the resulting pores. In the soil, which is heterogeneous in terms of shape, size and chemical properties of the particles, the mechanisms that bind the particles are also extremely diverse. It is a hierarchical structure in which the smallest particles bind together to form secondary particles, and the secondary particles combine to form larger aggregates. It also has a dynamic feature that constantly changes as a result of some internal and external factors such as temperature and humidity changes, biological activity and anthropogenic intervention [1].

The physical, chemical and biological properties of the soil play a role in the realization of the substance cycles in the soil [2,3], and one of the factors affecting the physicochemical properties of the soil is the formation and stability of aggregates. Aggregate is the structure formed by small particles that come together through physical, chemical or biological factors, and aggregate stability is among the important physical properties that determine soil fertility [4,5]. Aggregate stability is considered one of the key soil properties that regulates soil erosion, as soil aggregate formation is associated with incrustation and sealing, which reduces infiltration capacity and increases flow [5-12].

The formation of aggregate structure in the soil occurs when the soil particles undergo physical or chemical changes. Aggregate formation is an active process and can change over time. Aggregation and structural stability are the two most important factors affecting soil fertility. The relationship of the soil with the seed, water conductivity, gas exchange, in short, everything related to the development of the plant changes depending on the aggregation in the soil. The aggregate forms a water-resistant structure, which is a precaution against erosion [13].

Mycorrhizal fungi are key players in promoting the development of protective vegetation, increasing plant growth rate and promoting plant growth, as well as soil and slope stability. They contribute to soil aggregate stability and have recently been proposed as suitable indicators to measure biological effects [14]. As a result of the research carried out to determine the effect of some fungal varieties on soil aggregate stability, it was determined that mycorrhizal fungi increased the aggregate stability and water holding capacity of the soil, and decreased erosion activities [15, 21]. Lichens, which we can consider as extraordinary organisms, exhibit completely different appearance and biological structures as a result of the symbiotic combination of algae and fungi that compose them, based on the principle of mutual benefit. While the fungus obtains organic nutrients as a result of the photosynthesis process performed by the algae, the algae are protected from drying out thanks to the water and mineral provided by the fungus from the substrate and live in a safe place for itself. Although microscopic algae cells can live freely in nature, they are faced with the threat of time drying [16].

The fungal components that make up the lichens are mainly *Ascomycetes* (98%), *Basidiomycete*s (0.4%) or *Deuteromycetes* (1.6%); algae components are generally from the *Chlorophyta* (90%) or *Cyanobacteria* (10%) group. The most striking point here is that fungi and algae cells not only have a morphological relationship, but also exhibit a physiological integrity. According to some researchers, lichens are seen as examples of fungal parasitism of algae. For this reason, lichens are sometimes called "lichenized fungi" because the fungal component has the main role in the classification and reproduction of a lichen [17]. Lichens are a rich group of creatures that can live in a wide variety of parts of the world. They can grow at the poles, on the equator, on the sea coast, on mountainous lowland rocky lands, in any area where even other organisms cannot survive. In addition, due to the combination of algae and fungi that make up lichens, they can easily live in difficult conditions [18].

The water holding ability of lichens, their role in maintaining desert moisture levels, the addition of phosphorus and nitrogen to the soil necessary for plants, the physical and chemical decomposition of stone minerals, the different adaptations of different lichens to weather conditions and the determination of environmental pollution can be given as examples of the ecological importance of lichens [12]. Lichens play a very important role in soil formation. Here, the decomposition feature of the fungus is extremely important. Lichens, taking advantage of this feature of their fungal partners, break down the rocks slowly and break them into pieces with some physical factors. The rocks that are broken into pieces in this way will contribute to the formation of the ground soil. Lichens, which can develop on bare rocks and provide soil formation, then prepare the environment for the development of mosses and accelerate the formation of soil in which higher plants can develop with the increase in the amount of organic matter, are considered as precursor organisms [19,20].

## 2. MATERIALS & METHODS

### 2.1. Material

The material of this study consists of soil and lichen samples taken from the Maulenwald region of Germany between 2013-2015 within the scope of the project numbered FEF.13.07 supported by Gaziantep University Scientific Research Unit.

### 2.2. Method

#### 2.2.1. Taking Soil and Lichen Samples

Lichen and soil samples were taken from the forested areas of Meulenwald, Germany, consisting of *P. abies* and *P. sylvestris*. Samples were taken as 5 g of lichen from 20x20 $cm^2$ plots.

#### 2.2.2. Determining the pH of the Soil

The pH value of the soil was determined with a Hanna brand (HI 83140 model) pH meter adjusted with a buffer solution in the saturation sludge saturated with pure water.

#### 2.2.3. Determination of Organic Matter (%) Content

According to the principles reported by Allison and Moodie (1965) (Walkley and Black 1934); Soil samples were passed through a 100 µ sieve, weighed 0.5 g and poured into 500 ml flasks. 20 ml of sulfuric acid and 10 ml of potassium dichromate ($K_2Cr_2O_7$) were added to them and heated on a magnetic heater set at 150°C. Waiting for the samples to cool, 200 ml of distilled water and 12-13 drops of barium diphenylamine sulfonate ($(C_{12}H_{10}NO_3S)_2Ba$) were added and titration was carried out with iron sulfate ($FeSO_4$) until the color turned green. By looking at the iron sulfate ($FeSO_4$) used in this process, first the carbon and then the organic matter content were calculated.

### 2.2.4. Determination of Soil Permeability

Percolation analysis of the soils of the study area was made according to Brunner and Sekara (1943) and Kainz and Becher (1983). Soil samples were passed through sieves of 1 mm and 2 mm, and 5 g of the obtained soil samples (soil aggregates between 1 and 2 mm) were weighed and placed in plastic transparent hoses with a length of 10 cm and a diameter of 1 cm, the lower part of which was tied with gauze. Coarse sand, which had passed through a 1-2 mm sieve, was added to these hoses, and then 5 g of soil was added, and coarse sand was added again. Finally, the upper part of the hose was again wrapped with a bandage. Since in this method, there must be at least 20 cm between the water height and the soil sample, the measurement phase was started by adhering to this measure. Then 15, 30, 45, 60... with a stopwatch. The amount of filtered (percolated) water was recorded every 15 seconds until the 600th second.

### 2.2.5. Texture Analysis Method

The particle size distribution of the soil was determined by the texture analysis. With the particle distribution size analysis, information was obtained about the properties of the soil such as nutrient content, ion exchange capacity, expansion, elastic properties, air capacity. size class. Detection of soil particles with a wide range is not achieved by a single method. Clay and silt fractions were determined by pipette analysis, while skeleton and sand fractions were determined by sieving analysis.

### 2.2.6. Cation Exchange Capacity

10 g soil sample passed through a 2 mm sieve, which was dried in air, was placed in a 125 mm flask. 25 ml of buffer solution was added to it and it was shaken by hand from time to time. After 1 hour, the soil mixture in the flask was soaked with buffer solution; It was transferred to a 5.5 cm diameter Büchner funnel filled with Whatman No.42 filter papers.

The suction power filtration was set to be completed for 30 min and the Erlen and Büchner funnel was washed 3 times with a total of 75 ml of buffer solution using 25 ml aliquots. The same procedure was continued with 100 ml of washing solution. 2 drops of bromocresol green indicator solution and 10 drops of mixed indicator were added onto approximately 200 ml of filter. Titration was carried out with HCl solution on the titration table until it turned pink from green color. For this, 100 ml of buffer solution and 100 ml of washing solution were mixed and 2 drops of Bromocresol green indicator solution and 10 drops of mixed indicator were added on it, and titration was done with the standard HCl solution in the same way.

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### 2.3. Statistical Analyses

In this study, analysis of variance (ANOVA) was used for statistical operations (SPSS, 15.0 for Windows Package Program).

## 3. RESULTS and DISCUSSION

Soil samples were taken from the forest areas of the Meulenwald region of Germany, consisting of *P. abies* and *P. sylvestris*. Samples were taken as 5 g of lichen from 20x20 rectangular plots. The Ah-horizon of the soil in this region was textured from the horizon with the beginning of brown podsolization. The texture of the soil consists of 90% sand, 5% silt and 5% clay minerals. The soil bedrock consists of acidic sand rock.

While soil pH in the *P. abies* forest is acidic and between 5.01 and 3.97, soil pH in the *P. sylvestris* forest is between 4.66 and 3.38.

It has been observed that the amount of organic carbon (Corg) decreases from 50.02 to 1.01 as it progresses from the L horizon to a depth of 25-30 cm in the *P. abies* forest. It has been observed that the amount of Corg decreases from 49.54 to 3.19 as it progresses from the L horizon to a depth of 25-30 cm in the P. sylvestris forest.

It was observed that the carbon-nitrogen ratio (C/N) decreased from 50.18 to 17.28 as it progressed from the L horizon to a depth of 25-30 cm in the *P. abies* forest. It was observed that the C/N ratio decreased from 46.77 to 28.48 as it progressed from the L horizon to a depth of 25-30 cm in the *P. sylvestris* forest.

It was observed that the cation exchange capacity (CEC) decreased from 222.45 to 15.47 as it progressed from the L horizon to a depth of 25-30 cm in the *P. abies* forest. It was observed that the CEC decreased from 290.37 to 35.77 as it progressed from the L horizon to a depth of 25-30 cm in the *P. sylvestris* forest.

The change of leachate flowing over time in soils where *C. coniocraea* is present is shown in Table 1; The change of leachate flowing over time in soils where lichen is not present is also given in Table 2.

Considering the values in Tab.1., it was determined that the percolation average value in soils where *C. coniocraea* is present is higher than the percolation average value in soils where *C. coniocraea* is not present.

The change of leachate flowing over time in soils where *C. furcata* is present is in Table 3; The change of leachate flowing over time in soils where lichen is not present is given in Table 4.

Considering these values, it was determined that the percolation average value in soils where *C. coniocraea* is present is higher than the percolation average value in soils where *C. coniocraea* is not present.

**Table 1.** Percolation variance analysis of soils with *C. coniocraea*.

| | Minute | 1 R. 1 | 1 R. 2 | 1 R. 3 | Average | Standard deviation | Variance |
|---|---|---|---|---|---|---|---|
| Leachate flowing over time | 0,5 | 28,60 | 25,10 | 24,70 | 26,13 | 2,15 | 4,60 |
| | 1 | 21,40 | 18,90 | 19,80 | 20,03 | 1,27 | 1,60 |
| | 1,5 | 12,90 | 16,70 | 18,70 | 16,10 | 2,95 | 8,68 |
| | 2 | 23,10 | 15,20 | 17,90 | 18,73 | 4,02 | 16,12 |
| | 2,5 | 17,10 | 14,90 | 16,30 | 16,10 | 1,11 | 1,24 |
| | 3 | 16,30 | 14,30 | 16,30 | 15,63 | 1,15 | 1,33 |
| | 3,5 | 15,40 | 13,10 | 15,70 | 14,73 | 1,42 | 2,02 |
| | 4 | 15,10 | 13,20 | 14,90 | 14,40 | 1,04 | 1,09 |
| | 4,5 | 14,40 | 12,20 | 14,20 | 13,60 | 1,22 | 1,48 |
| | 5 | 13,20 | 11,80 | 14,10 | 13,03 | 1,16 | 1,34 |
| | 5,5 | 13,50 | 11,70 | 14,40 | 13,20 | 1,37 | 1,89 |
| | 6 | 12,70 | 10,70 | 12,70 | 12,03 | 1,15 | 1,33 |
| | 6,5 | 12,10 | 11,20 | 13,10 | 12,13 | 0,95 | 0,90 |
| | 7 | 12,40 | 10,20 | 12,60 | 11,73 | 1,33 | 1,77 |
| | 7,5 | 11,60 | 10,60 | 12,40 | 11,53 | 0,90 | 0,81 |
| | 8 | 11,70 | 9,60 | 12,00 | 11,10 | 1,31 | 1,71 |
| | 8,5 | 11,10 | 9,50 | 11,70 | 10,77 | 1,14 | 1,29 |
| | 9 | 11,00 | 9,30 | 11,10 | 10,47 | 1,01 | 1,02 |
| | 9,5 | 10,90 | 10,30 | 11,30 | 10,83 | 0,50 | 0,25 |
| | 10 | 11,10 | 8,10 | 11,40 | 10,20 | 1,82 | 3,33 |
| Total leachate | | 295,60 | 256,60 | 295,30 | 282,50 | 22,43055951 | 503,13 |
| Percolation | | 2,58 | 3,10 | 2,17 | 2,56 | 0,47 | 0,22 |

**Table 2.** Percolation variance analysis of soils without *C. coniocraea*

| | Minute | 1 R. 1 | 1 R. 2 | 1 R. 3 | Average | Standard deviation | Variance |
|---|---|---|---|---|---|---|---|
| Leachate flowing over time | 0,5 | 16,90 | 8,00 | 20,40 | 15,10 | 6,39 | 40,87 |
| | 1 | 12,80 | 5,90 | 18,40 | 12,37 | 6,26 | 39,20 |
| | 1,5 | 11,80 | 5,40 | 8,00 | 8,40 | 3,22 | 10,36 |
| | 2 | 12,00 | 5,20 | 11,30 | 9,50 | 3,74 | 13,99 |
| | 2,5 | 10,80 | 4,90 | 10,90 | 8,87 | 3,44 | 11,80 |
| | 3 | 9,80 | 4,60 | 10,40 | 8,27 | 3,19 | 10,17 |
| | 3,5 | 11,40 | 4,80 | 10,40 | 8,87 | 3,56 | 12,65 |
| | 4 | 9,90 | 4,50 | 9,00 | 7,80 | 2,89 | 8,37 |
| | 4,5 | 10,10 | 4,50 | 9,50 | 8,03 | 3,07 | 9,45 |
| | 5 | 9,50 | 4,40 | 8,80 | 7,57 | 2,76 | 7,64 |
| | 5,5 | 9,50 | 4,10 | 8,90 | 7,50 | 2,96 | 8,76 |
| | 6 | 9,00 | 4,40 | 8,30 | 7,23 | 2,48 | 6,14 |
| | 6,5 | 9,20 | 4,10 | 9,50 | 7,60 | 3,03 | 9,21 |
| | 7 | 8,50 | 4,10 | 7,50 | 6,70 | 2,31 | 5,32 |
| | 7,5 | 8,80 | 3,90 | 8,10 | 6,93 | 2,65 | 7,02 |
| | 8 | 7,90 | 4,00 | 7,70 | 6,53 | 2,20 | 4,82 |
| | 8,5 | 8,70 | 3,70 | 7,80 | 6,73 | 2,67 | 7,10 |
| | 9 | 8,00 | 3,70 | 7,60 | 6,43 | 2,38 | 5,64 |
| | 9,5 | 8,00 | 4,70 | 7,50 | 6,73 | 1,78 | 3,16 |
| | 10 | 7,80 | 4,40 | 7,20 | 6,47 | 1,81 | 3,29 |
| Total leachate | | 200,40 | 93,30 | 197,20 | 163,63 | 60,93146423 | 3712,64333 |
| Percolation | | 2,17 | 1,82 | 2,83 | 2,34 | 0,52 | 0,27 |

**Table 3.** Percolation variance analysis of soils with *C. furcata*

| | Minute | 1 R. 1 | 1 R. 2 | 1 R. 3 | Average | Standard deviation | Variance |
|---|---|---|---|---|---|---|---|
| Leachate flowing over time | 0,5 | 40,10 | 66,60 | 66,50 | 57,73 | 15,27 | 233,20 |
| | 1 | 22,00 | 34,90 | 31,70 | 29,53 | 6,72 | 45,12 |
| | 1,5 | 21,00 | 32,00 | 27,30 | 26,77 | 5,52 | 30,46 |
| | 2 | 18,80 | 33,70 | 24,50 | 25,67 | 7,52 | 56,52 |
| | 2,5 | 17,10 | 22,40 | 23,40 | 20,97 | 3,39 | 11,46 |
| | 3 | 16,80 | 24,00 | 21,60 | 20,80 | 3,67 | 13,44 |
| | 3,5 | 16,20 | 24,20 | 20,30 | 20,23 | 4,00 | 16,00 |
| | 4 | 15,50 | 23,40 | 19,70 | 19,53 | 3,95 | 15,62 |
| | 4,5 | 15,10 | 21,50 | 18,40 | 18,33 | 3,20 | 10,24 |
| | 5 | 14,40 | 21,10 | 18,40 | 17,97 | 3,37 | 11,36 |
| | 5,5 | 14,20 | 20,20 | 17,10 | 17,17 | 3,00 | 9,00 |
| | 6 | 13,80 | 21,00 | 16,70 | 17,17 | 3,62 | 13,12 |
| | 6,5 | 13,80 | 18,50 | 16,00 | 16,10 | 2,35 | 5,53 |
| | 7 | 13,60 | 18,50 | 15,70 | 15,93 | 2,46 | 6,04 |
| | 7,5 | 14,90 | 18,60 | 15,70 | 16,40 | 1,95 | 3,79 |
| | 8 | 9,50 | 17,10 | 14,00 | 13,53 | 3,82 | 14,60 |
| | 8,5 | 12,90 | 17,50 | 14,00 | 14,80 | 2,40 | 5,77 |
| | 9 | 11,40 | 17,60 | 11,80 | 13,60 | 3,47 | 12,04 |
| | 9,5 | 11,90 | 16,10 | 15,30 | 14,43 | 2,23 | 4,97 |
| | 10 | 11,30 | 16,50 | 13,60 | 13,80 | 2,61 | 6,79 |
| Total leachate | | 324,30 | 485,40 | 421,70 | 410,47 | 81,13533961 | 6582,943333 |
| Percolation | | 3,55 | 4,04 | 4,89 | 4,18 | 0,68 | 0,46 |

**Table 4.** Percolation variance analysis of soils without *C. furcata*

| | Minute | 1 R. 1 | 1 R. 2 | 1 R. 3 | Average | Standard deviation | Variance |
|---|---|---|---|---|---|---|---|
| Leachate flowing over time | 0,5 | 25,40 | 57,90 | 55,90 | 46,40 | 18,21 | 331,75 |
| | 1 | 13,00 | 37,80 | 36,20 | 29,00 | 13,88 | 192,64 |
| | 1,5 | 12,40 | 34,10 | 32,10 | 26,20 | 11,99 | 143,83 |
| | 2 | 12,30 | 30,60 | 29,00 | 23,97 | 10,14 | 102,72 |
| | 2,5 | 11,20 | 28,40 | 27,00 | 22,20 | 9,55 | 91,24 |
| | 3 | 11,60 | 27,80 | 26,00 | 21,80 | 8,88 | 78,84 |
| | 3,5 | 10,50 | 27,90 | 24,50 | 20,97 | 9,22 | 85,05 |
| | 4 | 10,70 | 23,10 | 24,60 | 19,47 | 7,63 | 58,20 |
| | 4,5 | 10,30 | 24,00 | 20,70 | 18,33 | 7,15 | 51,12 |
| | 5 | 10,20 | 23,20 | 21,20 | 18,20 | 7,00 | 49,00 |
| | 5,5 | 10,40 | 22,00 | 20,70 | 17,70 | 6,36 | 40,39 |
| | 6 | 10,30 | 21,50 | 19,20 | 17,00 | 5,92 | 34,99 |
| | 6,5 | 9,90 | 20,50 | 19,80 | 16,73 | 5,93 | 35,14 |
| | 7 | 9,80 | 21,80 | 17,30 | 16,30 | 6,06 | 36,75 |
| | 7,5 | 10,00 | 20,00 | 17,80 | 15,93 | 5,25 | 27,61 |
| | 8 | 9,40 | 17,40 | 17,10 | 14,63 | 4,53 | 20,56 |
| | 8,5 | 9,30 | 18,50 | 17,40 | 15,07 | 5,02 | 25,24 |
| | 9 | 9,10 | 17,70 | 15,20 | 14,00 | 4,42 | 19,57 |
| | 9,5 | 9,00 | 17,50 | 15,50 | 14,00 | 4,44 | 19,75 |
| | 10 | 2,90 | 17,30 | 15,30 | 11,83 | 7,80 | 60,85 |
| Total leachate | | 217,70 | 509,00 | 472,50 | 399,73 | 158,6983407 | 25185,1633 |
| Percolation | | 8,76 | 3,35 | 3,65 | 3,92 | 3,04 | 9,24 |

The change of leachate flowing over time in soils where *P. rufescens* is present is in Table 5; The change of leachate flowing over time in soils where it is not available is given in Table 6.

Considering these values, it was determined that the percolation average value in soils where *P. rufescens* species is present is higher than the percolation average value in soils where *P. rufescens* species is not present.

The change of leachate flowing over time in soils where *B. rufus* is present is in Table 7; The change of leachate flowing over time in soils where it is not available is given in Table 8.

Considering these values, it was determined that the percolation average value in soils where *B. rufus* species is present is higher than the percolation average value in soils where *B. rufus* species is not present.

**Table 5.** Percolation variance analysis of soils with *P. rufescens*

| | Minute | 1 R. 1 | 1 R. 2 | 1 R. 3 | Average | Standard deviation | Variance |
|---|---|---|---|---|---|---|---|
| Leachate flowing over time | 0,5 | 43,10 | 110,10 | 56,40 | 69,87 | 35,47 | 1258,26 |
| | 1 | 32,90 | 78,30 | 39,20 | 50,13 | 24,60 | 604,94 |
| | 1,5 | 31,20 | 71,50 | 37,90 | 46,87 | 21,59 | 466,32 |
| | 2 | 30,80 | 72,70 | 36,70 | 46,73 | 22,68 | 514,40 |
| | 2,5 | 30,30 | 68,10 | 35,00 | 44,47 | 20,60 | 424,42 |
| | 3 | 29,20 | 68,30 | 34,10 | 43,87 | 21,30 | 453,74 |
| | 3,5 | 30,20 | 65,00 | 32,00 | 42,40 | 19,59 | 383,88 |
| | 4 | 28,40 | 64,40 | 30,80 | 41,20 | 20,13 | 405,12 |
| | 4,5 | 28,60 | 58,50 | 30,60 | 39,23 | 16,72 | 279,40 |
| | 5 | 28,30 | 56,20 | 29,60 | 38,03 | 15,75 | 247,94 |
| | 5,5 | 28,20 | 56,80 | 29,20 | 38,07 | 16,23 | 263,45 |
| | 6 | 27,50 | 52,80 | 26,30 | 35,53 | 14,97 | 223,96 |
| | 6,5 | 27,60 | 51,00 | 27,70 | 35,43 | 13,48 | 181,74 |
| | 7 | 27,20 | 48,40 | 25,90 | 33,83 | 12,63 | 159,56 |
| | 7,5 | 26,40 | 47,90 | 23,90 | 32,73 | 13,19 | 174,08 |
| | 8 | 26,30 | 45,00 | 24,70 | 32,00 | 11,29 | 127,39 |
| | 8,5 | 26,80 | 46,10 | 23,50 | 32,13 | 12,21 | 149,02 |
| | 9 | 25,70 | 41,60 | 22,90 | 30,07 | 10,09 | 101,72 |
| | 9,5 | 25,90 | 41,80 | 22,50 | 30,07 | 10,30 | 106,14 |
| | 10 | 25,40 | 41,32 | 21,00 | 29,24 | 10,69 | 114,28 |
| Total leachate | | 580,00 | 1185,82 | 609,90 | 791,91 | 341,4663792 | 116599,288 |
| Percolation | | 1,70 | 2,66 | 2,69 | 2,39 | 0,56 | 0,32 |

**Table 6.** Percolation variance analysis of soils without *Peltigera Rufescens*

| | Minute | 1 R. 1 | 1 R. 2 | 1 R. 3 | Average | Standard deviation | Variance |
|---|---|---|---|---|---|---|---|
| Leachate flowing over time | 0,5 | 25,1 | 36,9 | 26,9 | 29,63 | 6,36 | 40,41 |
| | 1 | 17,2 | 25,7 | 18,7 | 20,53 | 4,54 | 20,58 |
| | 1,5 | 16 | 22,5 | 16 | 18,17 | 3,75 | 14,08 |
| | 2 | 12,9 | 18,1 | 14,9 | 15,30 | 2,62 | 6,88 |
| | 2,5 | 12,6 | 17,9 | 13,3 | 14,60 | 2,88 | 8,29 |
| | 3 | 10,7 | 16,8 | 12,4 | 13,30 | 3,15 | 9,91 |
| | 3,5 | 11,1 | 16,1 | 10,8 | 12,67 | 2,98 | 8,86 |
| | 4 | 10 | 14,3 | 11,5 | 11,93 | 2,18 | 4,76 |
| | 4,5 | 9,4 | 13,9 | 11,1 | 11,47 | 2,27 | 5,16 |
| | 5 | 9,3 | 13,2 | 8,4 | 10,30 | 2,55 | 6,51 |
| | 5,5 | 9,5 | 12,7 | 9,7 | 10,63 | 1,79 | 3,21 |
| | 6 | 8,8 | 12,1 | 9,1 | 10,00 | 1,82 | 3,33 |
| | 6,5 | 8,3 | 11,1 | 8,8 | 9,40 | 1,49 | 2,23 |
| | 7 | 8,1 | 11,6 | 8,2 | 9,30 | 1,99 | 3,97 |
| | 7,5 | 8 | 10,7 | 7,9 | 8,87 | 1,59 | 2,52 |
| | 8 | 7,3 | 11,7 | 7,8 | 8,93 | 2,41 | 5,80 |
| | 8,5 | 7,1 | 11,9 | 7,7 | 8,90 | 2,62 | 6,84 |
| | 9 | 7,2 | 8,7 | 7,1 | 7,67 | 0,90 | 0,80 |
| | 9,5 | 6,8 | 9,6 | 7,1 | 7,83 | 1,54 | 2,36 |
| | 10 | 7,5 | 9,5 | 9 | 8,67 | 1,04 | 1,08 |
| Total leachate | | 212,9 | 305 | 226,4 | 248,1 | 49,73700835 | 2473,77 |
| Percolation | | 3,35 | 3,88 | 2,99 | 3,42 | 0,45 | 0,20 |

**Table 7.** Percolation variance analysis of soils with *B. rufus*

| | Minute | 1 R. 1 | 1 R. 2 | 1 R. 3 | Average | Standard deviation | Variance |
|---|---|---|---|---|---|---|---|
| Leachate flowing over time | 0,5 | 47,90 | 26,90 | 13,40 | 29,40 | 17,39 | 302,25 |
| | 1 | 42,40 | 20,40 | 48,00 | 36,93 | 14,59 | 212,85 |
| | 1,5 | 41,50 | 18,60 | 47,00 | 35,70 | 15,06 | 226,87 |
| | 2 | 41,20 | 17,40 | 42,30 | 33,63 | 14,07 | 197,94 |
| | 2,5 | 37,90 | 16,10 | 41,40 | 31,80 | 13,71 | 187,93 |
| | 3 | 37,00 | 15,80 | 39,60 | 30,80 | 13,06 | 170,44 |
| | 3,5 | 36,10 | 14,70 | 40,70 | 30,50 | 13,88 | 192,52 |
| | 4 | 33,80 | 13,70 | 35,30 | 27,60 | 12,06 | 145,47 |
| | 4,5 | 33,30 | 13,20 | 32,30 | 26,27 | 11,33 | 128,30 |
| | 5 | 31,50 | 13,50 | 34,70 | 26,57 | 11,43 | 130,61 |
| | 5,5 | 31,30 | 11,70 | 29,90 | 24,30 | 10,93 | 119,56 |
| | 6 | 29,90 | 11,20 | 29,20 | 23,43 | 10,60 | 112,36 |
| | 6,5 | 30,60 | 11,30 | 29,60 | 23,83 | 10,87 | 118,06 |
| | 7 | 29,70 | 10,60 | 26,80 | 22,37 | 10,29 | 105,94 |
| | 7,5 | 22,40 | 10,50 | 26,50 | 19,80 | 8,31 | 69,07 |
| | 8 | 25,80 | 10,40 | 25,50 | 20,57 | 8,81 | 77,54 |
| | 8,5 | 24,60 | 9,60 | 27,10 | 20,43 | 9,46 | 89,58 |
| | 9 | 23,90 | 10,60 | 19,80 | 18,10 | 6,81 | 46,39 |
| | 9,5 | 23,20 | 12,70 | 22,50 | 19,47 | 5,87 | 34,46 |
| | 10 | 22,10 | 10,10 | 21,40 | 17,87 | 6,74 | 45,36 |
| Total leachate | | 646,10 | 279,00 | 633,00 | 519,37 | 208,266664 | 43375,0033 |
| Percolation | | 2,17 | 2,66 | 0,63 | 1,65 | 1,06 | 1,13 |

## 4. CONCLUSIONS

In this study, the mean, standard deviation and variance of the total leachate were determined at the highest value in the *P. rufuscens*, while the lowest value in the *C. coniocreae*. Percolation average was determined at the highest in the lichen of *C. furcata* and at least in the lichen of *B. rufus*. Percolation standard deviation and variance values were determined in *B. rufus* lichen, at least in *C. coniocreae*. The mean and standard deviation of the difference between the total leachate in the collections with and without lichens were determined the most in the *P. rufescens*, the least in the *C. furcata*, while the variance difference was determined the most in the *B. rufus* and the least in the *C. furcata*.

The difference in the mean of percolation in the soils with and without lichens was determined the most in the lichen of *C. furcata*, the least in the lichen of *B. rufus*, while the difference in standard deviation and variance was determined the most in the lichen of *B. rufus* and the least in the lichen *C. furcata*.

**Table 8.** Percolation variance analysis of soils without *B. Rufus*

| | Minute | 1 R. 1 | 1 R. 2 | 1 R. 3 | Average | Standard deviation | Variance |
|---|---|---|---|---|---|---|---|
| Leachate flowing over time | 0,5 | 21,00 | 17,20 | 20,90 | 19,70 | 2,17 | 4,69 |
| | 1 | 11,40 | 9,70 | 12,70 | 11,27 | 1,50 | 2,26 |
| | 1,5 | 9,20 | 8,90 | 12,00 | 10,03 | 1,71 | 2,92 |
| | 2 | 8,40 | 8,10 | 10,10 | 8,87 | 1,08 | 1,16 |
| | 2,5 | 7,90 | 7,80 | 9,80 | 8,50 | 1,13 | 1,27 |
| | 3 | 7,30 | 7,10 | 9,50 | 7,97 | 1,33 | 1,77 |
| | 3,5 | 7,80 | 7,10 | 9,00 | 7,97 | 0,96 | 0,92 |
| | 4 | 6,20 | 6,60 | 8,40 | 7,07 | 1,17 | 1,37 |
| | 4,5 | 7,00 | 6,50 | 9,00 | 7,50 | 1,32 | 1,75 |
| | 5 | 6,40 | 6,30 | 7,90 | 6,87 | 0,90 | 0,80 |
| | 5,5 | 6,30 | 6,30 | 7,80 | 6,80 | 0,87 | 0,75 |
| | 6 | 6,20 | 5,60 | 7,70 | 6,50 | 1,08 | 1,17 |
| | 6,5 | 6,00 | 5,90 | 7,50 | 6,47 | 0,90 | 0,80 |
| | 7 | 6,00 | 5,30 | 7,30 | 6,20 | 1,01 | 1,03 |
| | 7,5 | 6,10 | 5,60 | 7,10 | 6,27 | 0,76 | 0,58 |
| | 8 | 5,20 | 5,50 | 7,00 | 5,90 | 0,96 | 0,93 |
| | 8,5 | 5,60 | 4,80 | 6,80 | 5,73 | 1,01 | 1,01 |
| | 9 | 5,50 | 5,30 | 6,70 | 5,83 | 0,76 | 0,57 |
| | 9,5 | 5,30 | 5,20 | 6,80 | 5,77 | 0,90 | 0,80 |
| | 10 | 6,00 | 5,10 | 6,10 | 5,73 | 0,55 | 0,30 |
| Total leachate | | 150,80 | 139,90 | 180,10 | 156,93 | 20,78998156 | 432,223333 |
| Percolation | | 3,50 | 3,37 | 3,43 | 3,44 | 0,064 | 0,0041 |

In the study, it was determined that the infiltration rates of lichen soils were generally higher than those of lichen-free soils. This shows us that lichens have a positive effect on the soil infiltration rate. Likewise, we can say that it affects the soil water holding capacity positively.

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